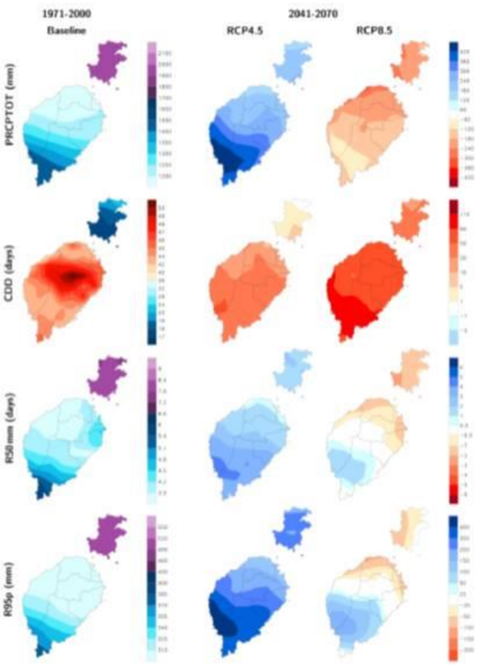
DEMOCRATIC REPUBLIC OF SAO TOME AND PRINCIPE

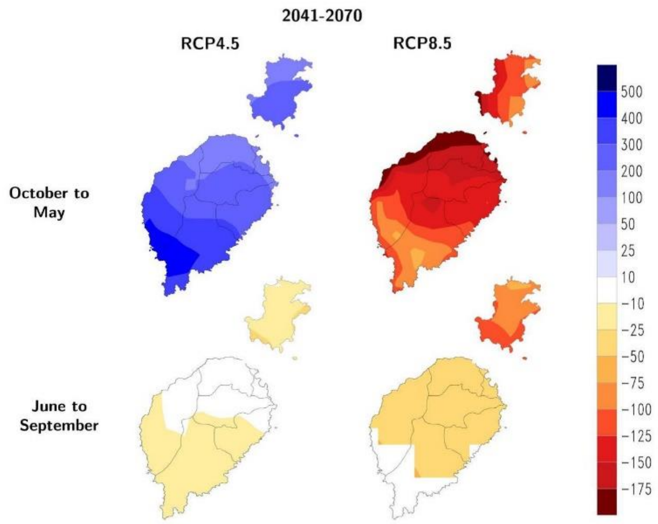
(Unity – Discipline - Work)

MINISTRY OF PUBLIC WORKS, INFRASTRUCTURES, NATURAL RESOURCES AND THE ENVIRONMENT



THIRD NACIONAL COMMUNICATION

Climate Change



MARCH 2019

PREFACE

Today climate change has become a major concern for everyone and a great challenge for decision-makers. For this reason, effective training tools are increasingly needed to better address the issue of climate change in national development policies.

By signing the 1992 United Nations Framework Convention on Climate Change, ratified in 1999, and the Kyoto Protocol in 1997, ratified in 2008, the Democratic Republic of Sao Tome and Principe demonstrated its firm commitment to tackle climate change and its harmful effects on mankind. The signing of the Paris Agreement in 2015 is another expression of the country's continued commitment and dedication to dealing with Climate Change and alleviating its consequences not only at the level of Small Island Developing States but also at the level of planet Earth and the well-being and survival of human beings.

Climate Change has already visible effects in Sao Tome and Principe. The accelerating pace of sea level rise is already causing severe coastal degradation and salinization, increased incidence of flash floods, decrease in rainfall and consequent decrease in river flows, more intense extreme weather events and a highly variable climate. Such impacts may jeopardize development initiatives aimed at alleviating poverty and fostering sustainable development and building a more resilient nation, as provided in Vision 2030 of the Democratic Republic of Sao Tome and Principe.

Despite its slow growth pace, Sao Tome and Principe has acted to mitigate the many social, economic and environmental constraints posed by climate change and implement its Nationally Determined Contribution (NDC) commitments.

Although the rate of greenhouse gas emissions (GHG) is very low, the country considers mitigation, adaptation and integration of climate change in all national activities as an opportunity to redesign its development in a sustainable way.

Sao Tome and Principe has progressively improved the content of its communications since the National Home Communication in 2005 using better-quality data, better analytical tools and a greater number of specialists with better levels of training.

This Third National Communication (TNC) comes after the country has submitted to the United Nations Framework Convention on Climate Change, the Second National Communication in May 2012 and the NDC presented in September 2015. Through this Third National Communication, STP aims to play its full role in joint action to combat climate change, bearing in mind that TNC studies provide an opportunity to measure progress and identify weaknesses in the implementation of the United Nations Framework Convention on Climate Change.

This Communication provided an opportunity to initiate the institutionalization process that covered the Greenhouse Gas Inventory (GHGI) and mitigation studies. The elaboration of this communication benefited from the technical and financial support of the Global Environment Facility (GEF) and the United Nations Environment Program (UNEP). The Government of Sao Tome and Principe, through my statement, expresses its gratitude to the GEF and UNEP for these supports.

I would like to take this opportunity to invite our development partners to continue to support the implementation of the actions identified in the TNC on adaptation, mitigation, technology transfer and capacity building to enable Sao Tome and Principe to contribute even more to the global fight against climate change. I would also like to congratulate and thank the national experts for their mobilization, dedication and professionalism with which they conducted the various studies.

Sao Tome and Principe will make every effort to fulfill its commitments to the United Nations Framework Convention on Climate Change and will seek to mobilize further technical, financial and human resources to continue its implementation in partnership with all stakeholders.

Sao Tome and Principe, March 2019

The Minister of Public Works, Infrastructures, Natural Resources and Environment,

Osvaldo António Cravide Viegas D'Abreu

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ACRONYMS

AR5	Fifth Assessment Report
ASAS	Alta Subtropical do Atlântico Sul
AWMS	Animal Waste Management System
BESM	Brazilian Earth System Model
CanESM2	Canadian Earth System Model Second Generation
CBO	Biochemical Oxygen Demand
CCCMA	Canadian Centre for Climate Modelling and Analysis
CCSR-NIES	Frontier Research Center for Global Change
CH_4	Metano
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CMORPH	Center Morphing Method
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CO_2 eq	Carbon Dioxide Equivalent
COCO	Ocean Component Model
COD	Carbono Orgânico Degradável
CPTEC	Center fo Weather Forecasts and Climate Studies
CQNUMC	United Nations Framework Convention on Climate Change
CQO	Chemical Oxygen Demand
CRU	Climatic Research Unit
CTEM	Canadian Terrestrial Ecosystem Model
DA	Customs Directorate
DBO5	Degraded Organic Component

DF	Forest Directorate (Direcção das Florestas)
DGA	Directorate-General for Environment
DGP	Directorate-General for Fisheries
DGRNE	Directorate-General for Natural Resources and Energy
DI	Industry Directorate
DIm	Directorate of taxes
DJF	December, January, February
DP	Livestock Department
DPs	Directorate of Fisheries
DTT	Land Transport Directorate
ECMWF	European Centre for Medium-Range Weather Forecasts
EMAE	Water and Electricity Company
ENAPORT	National Port Administration Company (Empresa Nacional de Administração dos Portos)
ENASA	National Airport and Air Safety Company (Empresa Nacional de Aeroporto e Segurança Aérea)
ENCO	National Fuel and Oil Company (Empresa Nacional de Combustível e Óleo)
ENRP	National Poverty Reduction Strategy (Estratégia Nacional de Redução da Pobreza)
EPI	Equipments for individual safety (Equipamentos de Protecção Individual)
ETARs	Wastewater Treatment Plants
FAO	United Nations Food and Agriculture Organization
FCM	Methane Correction Factor
FDP's	Probability Distribution Functions
GBP	Best Practice Guides

GHG	Greenhouse Gases
GFDL	Geophysical Fluid Dynamics Laboratory
Gg	Gigagram
GPCP	Global Precipitation Climatology Project
ha	Hectare
HadGEM2-ES	Earth System
HS	South hemisphere
IDE	Foreign Direct Investment
GHGI	National Greenhouse Gas Inventory
INAE	National Roads Institute
INE	National Institute of Statistics
INM	National Institute of Meteorology
INPE	National Institute for Space Research
IPCC	Intergovernmental Panel on Climate Change
IPCC AR5	Fifth Assessment Report of the Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
JJA	June, July, August
kg	Kilogram
kha	Kilohectare (1 000 ha)
km	Kilometer
kt	Kilotonne
kt ms	Kilotonnes of dry matter
kW	Kilowatt

LULUCF	Land Use Change and Forests
MAM	March, April, May
MAPDR	Ministry of Agriculture, Rural Development and Fisheries
MDL	Clean Development Mechanism
Mg	Megagram (1 000 000 g)
MIRNA	Ministry of Infrastructure Natural Resources and Environment
MIROC5	Model for Interdisciplinary Research, version 4
MOM4	Modular Ocean Model version 4
MW	Mega Watt
MWh	Mega Watt hour
N_2O	Nitrous oxide
NA	Not applicable
NAPA	National Adaptation Programs of Action
ND	Not determined
NMVOC	Nonmetallic Volatile Organic Compounds
NO	Does not occur
Nº	Number
NO_X	Nitrogen oxides
O	Ocurrs
ODS	Sustainable Development Goals
ONG	Non-governmental organization
OPEX	Custo Operacional
PAG	Global Warming Potential
PAGIRSU	Integrated Urban Solid Waste Management Action Plan

PC	Calorific Power
PIB	Gross Domestic Product
PNASE	National School Food and Health Program (Programa Nacional de Alimentação e Saúde Escolar)
PNDF	National Forest Development Plan (Plano Nacional de Desenvolvimento Florestal)
PNMM	Pressure at mean sea level (Pressão ao Nível Médio do Mar)
PNO	Natural Park Obô (Parque Natural Obô)
PNOST	Natural Park Obô of Sao Tome (Parque Natural Obô de São Tomé)
PNP	Príncipe Natural Park (Parque Natural de Príncipe)
PNUD	United Nations Development Program (Programa das Nações Unidas para o Desenvolvimento)
PNUMA	United Nations Environment Program (Programa das Nações Unidas para o Meio ambiente)
POP	Persistent Organic Pollutants (Poluentes Orgânicos Persistentes)
PRODOC	Project Document (Documento de Projecto)
PSL	Pressure Surface Level
RCP	Representative Concentration Pathway
RDSTP	Democratic Republic of Sao Tome and Principe (República Democrática de São Tomé e Príncipe)
RMSE	Root Mean Square Error
RSU/MSW	Municipal Solid Waste (Resíduos Sólidos Urbanos)
SNC	Second National Communication
SON	Setembro, Outubro e Novembro
Std	Dobras
STP	Sao Tome and Principe
TNC	Third National Communication

TJ	Toneladas Julio
Ton	Tonelada
Ton eq.	Tonelada Equivalente
TRI	The Restoration Initiative (A Iniciativa de Restauração)
TRIFFID	Top-down Representation of Interactive Foliage Including Dynamics
TSM	Sea Surface Temperature (Temperatura da Superfície do Mar)
UE	European Union
UICN	The Internacional Union for Conservation of Nature (União internacional para Conservação da Natureza
UNFCCC	United Nations Framework Convention on Climate Change
USD/US$	US dollar
USGS	United States Geological Survey
UVEL	Zonal Component of
V&A	Vulnerability & Adaptation
VVEL	Southern wind component
ZCIT	Intertropical Convergence Zone

EXECUTIVE SUMMARY

To comply with its commitments to the United Nations Framework Convention on Climate Change, ratified in 1999, the Democratic Republic of Sao Tome and Principe issued its Third National Communication (TNC) in 2019, after having drafted the Second National Communication (SCN, 2012) and its Initial Communication (CNI, 2005). This executive summary presents the sectoral studies carried out within the scope of TNC, having 2012 as its basis year.

The TNC is structured in four (4) parts and comprises seven (7) chapters.

The **first part** contains Chapter I and refers to the **National Circumstances** (NC), which presents an overview of the Country in an approach to assess the aspects of the sectors identified, their vulnerability to climate change or relative influence greenhouse gas emissions, in agreement/conformity with the country's priorities. The chapter on National Circumstances describes the geographic, climatic, social, economic and institutional characteristics of the country likely to be affected by the climate's evolution and / or the application of response measures.

The **second part** covers Chapter II and refers to the third Greenhouse Gas Inventory serving as an update of the second and first greenhouse gas inventories completed in 2004 and 2010, respectively.

The **third part** includes Chapter III on the Climate-Based Situation, Chapter IV on vulnerability analysis and measures implemented or proposed in order to achieve the Convention's objectives, and Chapter V on Mitigation.

The **fourth and final** part of this Communication comprises Chapter VI, which presents measures to facilitate better adaptation to climate change and the seventh chapter on constraints, gaps and institutional capacity building.

Lastly, the findings that show that STP is not emitting greenhouse gases, thanks to its forests that have a certain capacity for carbon sequestration. However, there is a tendency to increase emissions, mainly from three direct gases: CO_2, CH_4 and N_2O, although at a slow rate. CO_2 emissions come from the Energy and Transport, Agriculture and Waste sector. CH_4 emissions come from the trading and institution / building sector, and N_2O emissions come from agricultural soils.

Located in the Gulf of Guinea at 0° 25'N latitude and 6° 20'E longitude, about 380 km west coast of the African Continent, the archipelago of S. Tomé and Príncipe is of volcanic origin and consists of two islands and several islets. The islands occupy a surface of 1,001 km², 859 km² for the island of S. Tomé and 142 km² for the island of Príncipe. Next to the south end of the island of Sao Tome is the Isola das Rolas where there is a landmark indicating the passage of the Line of the Equator that crosses the archipelago.

The climate is characterized by two seasons during the year, with the rainy season being the hottest and longest with frequent rainfall during most of the year (about nine months from September to May) and the shorter dry season known as gravana, which lasts about three months (from June to August) and with less hot temperatures. However, there is a period of about two months called "Gravanito" that oscillates[1] between December and January, in which there is a slight precipitation reduction.

The average surface temperature of the archipelago is 25.6° C and tends to vary with altitude and time of year, though slightly. Therefore, temperatures decrease as the altitude increases, given that the mountain regions are slightly cooler than the coastal regions.

In Sao Tome and Príncipe, the orographic effects of the volcanic massifs are what determine rainfall abundance and prompt precipitation to display great rainfall gradient and offer very important water potential in altitude. Thus, given the characteristics of the relief, many microclimatic zones predominate, mainly as a function of rainfall, temperature and relief.

The country has a variety of microclimates, defined mainly by rainfall, temperature and location. The temperature varies according to altitude and relief which is very distinct in the islands. The culminating point being Pico de Sao Tome, which is located in the center-west of the island with 2,024 m of altitude, and Pico do Príncipe in the south region with 948 m of altitude, the highest point on the island.

The islands of Sao Tome and Príncipe are located on the Cameroon Mountains Line (Fitton, 1980), which form a volcanic chain of about 1,600 km, stretching from the inner NE African continent (Mount Cameroon on the coast of West Africa) to the island of Pagalu (Good Year) SW, in the Gulf of Guinea.

The country has a relatively large coastal zone that extends from the border of the exclusive economic zone (EEZ), which starts 200 nautical miles to 100 m above sea level, from the coastline[2] where several ecosystems can be found, namely marine, terrestrial and the intermediate zone, where there is a diverse fauna and flora. Most of the coast is rocky with very rugged relief, but there are numerous sandy bays that constitute a whole system of beaches along the coast.

Like other islands of the Cameroon Mountains Line, the STP islands are essentially basaltic in nature.

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[1] MRNA - First National Communication - S. Tomé and Príncipe - S. Tomé, 2004

[2] Anonymous - First National Communication on Climate Change - Ministry of Natural Resources and Environment - S.Tomé, 2004

Regarding land use, its system is characterized by an "ecological arrangement of crops" characterized by the natural adaptation of each type of crop to the ecological space that is most appropriate to it, and consequently, each land is occupied in the form that most suits the sustainable exploitation of the country's agricultural resources. On the other hand, Sao Tome and Principe has several forest ecosystems, whose characteristics vary according to several factors, among which relief, altitude and microclimate characteristic of each region.

The major forest ecosystems found on the islands of Sao Tome and Principe are divided into forest ecosystems in the low-lying region, which consist of mangroves, shrubby and herbaceous savanna, shade forest and secondary forest, and forest ecosystems of altitude region consisting of an altitude forest between 1,000 and 1,800 m, another altitude forest between 1,800 and 2,000 m and a fog forest (above 1,800 m).

The country’s wood resources are used mainly as a source of energy, but also as lumber for constructing houses and for manufacturing furniture and to a lesser extent for the manufacture of utensils and objects of art and spatial planning (poles and stakes for the public lighting).

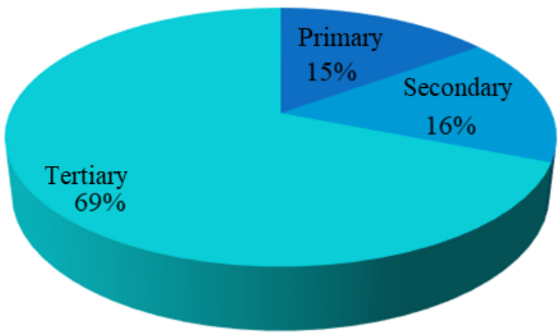
With a population of about 178,739 and a population density of 178.7 inhab / km^2, (annual average growth rate is 2.45% per year), the population is very young with a birth rate of 26, 6 per thousand, an infant mortality rate of 38 per thousand and an average life expectancy of 66 years. (INE, 2012).

As a small island developing state with a low average income, with a fragile economy and high vulnerability to exogenous shocks and a Gross National Income (GNI) per capita of 1,970 USD, the country ranks 143rd in the Human Development Index (HDI) with a value of 0.589. (UNDP, 2017).

The country's economy is based on the agricultural export sector, characterized by the production of cocoa, the main export product once produced on large farms called roças (plantations). Today, with the process of division and distribution of large cocoa plantations started in the 1990s, most agricultural production have been carried out by small farmers. As cocoa alone does not guarantee subsistence, many small farmers find additional income in growing vegetables, fruits, vanilla and pepper for export. Despite the immense importance of cocoa in Sao Tome and Príncipe's economy, the country's export share in the world market was estimated at only 0.11% between 2000 and 2005 by the International Cocoa Organization (ICCO).

In terms of the share of activities in GDP, the largely informal tertiary sector accounts for almost 60% of GDP and employs 60% of the active population, while the primary and secondary sectors each contribute about 20% of GDP, according to the most recent data (Planning Division, 2017).

Figure 1 - The sectors' contributions in GDP



Source: D. Planing, 2017. Adapt

The country is therefore considered vulnerable because of its low territorial size, insularity, ecosystems fragility and exposure to strong human pressure on natural resources and global financial crises as it is largely dependent on external aid. It is a country in poverty due to the fragility of its economic fabric and small domestic capacity to produce wealth and create jobs that can guarantee better living conditions for its population.

The agricultural sector employs 60% of the labor force, but represents only 17% of GDP (INE, 2017). It is characterized by deficient infrastructure, almost no public support services and a small number of farmers, which explains its poor productivity. With very fragile and poorly organized subsistence agriculture, the country imports a large part of its food consumption.

As to the livestock sector, it appears that the food deficit in terms of animal protein is declining. Nonetheless, the production parameters must be further improved, and the Livestock Department's intervention must be ongoing in order to allow an increase of meat production, seen as the population tends to increase and the local production of meat is still very incipient.

Fishing is a relatively important sector for the country's economy, as it is a source of employment and foreign exchange, which contributes about 3.7% of the national GDP and represents 22% to 35% of the non-fiscal state revenues budget during the past years despite the fact that the continental shelf around the islands of Sao Tome and Principe is very narrow and limited to 5 - 10 km due to its volcanic origin (US, 2017).

According to operators and technicians of the sector, marine fishery resources show a constant and substantial reduction. This trend is mainly due to overfishing and the abandonment of traditional fishing techniques in favor of unsustainable practices such as the use of explosives, unsuitable fishing nets and underwater fishing. The potential to catch fish has been estimated at around 11-12,000 tonnes per year in 2016 and 2017, with catches made up primarily of various pelagic species, including tuna and other tuna species (EU, 2017).

According to the Tourism Strategic Plan of 2017, the tourism sector with a considerable growth registered a 263% increase in tourists visiting the country, whose economic contribution represents 14% of the national GDP, therefore constituting a key setor but an insufficiently exploited one. In fact, the country benefits from important natural attractions: rich biodiversity and exceptional fauna and flora of great scientific interest. Twenty-seven species of rare birds[3], meaning 30% of resident species (distributed in five genera) are endemic in the islands[4].

Due to the country's richness in terms of the uniqueness of its biodiversity, Princípe Island was considered by UNESCO on July 11, 2012, World Biosphere Reserve. This set of factors creates the conditions for the development of ecotourism, considering the potential that the country has in this aspect.

The country has only one seaport and an airport of strategic importance for establishing connections with other countries. Trade in goods and merchandise is carried out almost exclusively through these infrastructures.

Being that it is a port of small size, it has a certain vulnerability to the adverse effects of Climatic Changes, namely by sea level rise which can cause flooding throughout the port area. According to the IPCC forecast for the 2100 horizon, sea levels are expected to rise from 0.18 m to 0.56 m in the A2 scenario (SRES).

With respect to energy, the country depends almost exclusively on its production supplied by fossil fuel source. The production sector is highly deficient in energy terms, as it currently requires 31 MW to meet its basic operating needs, while only producing 15 MW.

The total installed power in the national electricity sector in 2017 was 35 MW and comprised a hydroelectric power station and five interconnected power plants, in addition to the station in the Princípe Island region and decentralized systems.

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[3] P.J. Jones, J.P. BURLISON e A. TZE - Conservação dos ecossistemas florestais da RDSTP- S.Tomé, 1991

[4] ECOFAC (2002) – Lucienne Wilme – Balade sur les jeunes îles du plus vieux continent

The energy produced and injected into the interconnected network at S. Tomé in 2017 was 109.072,57 MWH, corresponding to 5.045,61 MWH for hydroelectric plants and the remaining 104.026,97 MWH for diesel-based thermoelectric plants. In relation to 2015, there was an increase in production in the order of 7.654,31 MWH, corresponding to about 3.7% in production.

The industrial sector has little statement in the national economy, contributing with about 13.3% to the formation of GDP, of which 6.4% is attributable to the construction industry. Currently, this branch is very active due to the great recovery, maintenance and construction of new economic and social infrastructure projects.

It should also be noted that, although emergent, this industry is responsible for GHG emissions, mainly in bakery and artisanal production of alcoholic beverages, which generally use firewood as an energy source.

Contrary to what happens in other countries of the Gulf of Guinea, STP is still not considered an oil-producing country, despite its geographic location in a well-known oil zone. The country's hydrocarbon potential is in three distinct areas, known as "Zones": Zone ZDC (Joint Development Zone with Nigeria); Zone ZEE; (Exclusive Economic Zone), Onshore Zone of the sea coast (consisting of land up until the coast line) of Sao Tome and Principe.

From the social standpoint STP has made progress in improving some social indicators. The country has a gross schooling of 118%, the gross enrollment rate for women is 114% and the gross enrollment rate for men is 122% (MECCC, 2017 - Bulletin Statistical); an infant mortality rate of children under 5 years of age from 51 per 1,000 live births, access to a source of improved water for 97% of the population and access to electricity for 80% of the population. The poverty prevalence rate is around 62.6% (Family Budget Survey, 2010), with poverty affecting women more (71.3%) than men (61.4%) due to the level of education.

Although the STP's epidemiological profile is currently characterized by the predominance of noncommunicable diseases (cardiovascular diseases, endocrine diseases such as diabetes mellitus, chronic respiratory diseases, tumor diseases, musculoskeletal diseases, oral health and ophthalmological diseases), in which the tendency is high, communicable diseases continue to be a public health problem, with a high incidence of acute respiratory diseases, diarrheal diseases and other diseases that are transmissible or linked to the environment and are the main causes of morbidity and mortality.

Malaria, which was responsible for 40 percent of child mortality cases in the 1980s, is currently experiencing a 90 per cent reduction, thanks to the implementation of the first National "Roll Back Malaria Action Plan 2001-2010", which was geared towards prevention and early treatment in health centers, with the support of cooperation with Taiwan for a malaria eradication program through household spraying with chemicals.

With regard to HIV / AIDS, more recent data show a trend towards reducing this epidemic. New infections had an incidence rate of 0.6% in 2013 (UN / SIDA report 2014 annex 9). Currently, STP has a low HIV / AIDS prevalence: in the population aged 15-49, it increased from 1.5% in 2008 to 0.5% in 2014 and from 15 to 24 years of age went from 0.8% in 2008 to 0.1% in 2014.

The RDSTP has made some progress in meeting some of the Millennium Development Goals (MDGs), including Goal 2: "Ensuring access to primary education for all", Goal 3: "Promoting gender equality and empowering women" "and Goal 4: "Reducing child mortality ". Despite not having fulfilled in full the other 5 MDGs, significant steps were taken in this direction. Under the Sustainable Development Objectives (ODS) that replaced the MDGs, the country prioritized 7 ODSs that it intends to implement, namely ODS1: Ending poverty in all its forms, everywhere, ODS8: Promoting sustained economic growth , inclusive and sustainable, full and productive employment and decent work for all, ODS9: Building resilient infrastructures, promoting inclusive and sustainable industrialization and fostering innovation, ODS13: Take urgent action to combat climate change and its impacts. ODS14: Protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing degradation and to prevent loss of biodiversity; and ODS16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels.

Determined to face the environmental problems that are currently facing the country and the world, as a development challenge, STP has been given a legal framework that allows it to take care of the main ramifications of climate change.

In 2007, the country created, through Presidential Decree No. 2/2007, the Directorate General for the Environment (DGA), a structure under the current Ministry of Public Works, Infrastructures, Natural Resources and Environment, as the body responsible for implementation and coordination of all government policies and strategies on the environment and has, among other things, a mission to implementation of all environmental Conventions.

Likewise, in May 2012 STP created, through Decree nº13 / 2012, the National Committee for Climate Change, with the objective of coordinating, managing, training and raising awareness of the various Sao Tomean agents in matters related to climate change , including policies and measures that promote or result in the reduction of greenhouse gas emissions, as well as measures that reduce the vulnerability of Sao Tome and Principe's economy and populations, increasing their resilience and adapting them to the impacts of climate change.

With regard to the specific physical interaction of land use change and impacts on inland water ecosystems, current trends in STP reveal that deforestation and unsustainable land use practices are at the origin of soil erosion which, in return, lead to the concentration of large amounts of sediment in many river basins. These conditions, in association with other natural phenomena, result in: 1) increased erosion and flooding along river basins; 2) reduced river flow; and 3) the degradation of the quantity and quality of water for industrial and domestic purposes.

Moreover, endemic species whose habitat is found in forests also have some vulnerability to climate change. The increase in temperature and the decrease of precipitation, climatic impacts identified in the climate-based study on Sao Tome and Príncipe, are elements that may contribute to migration in a different way and condition the survival of the species.

Fortunately, the country has adopted a set of measures to fight this situation, having created in 2006 the National System of Protected Areas, through the creation of the Obô Natural Parks of São Tome and Príncipe.

Greenhouse Gas Inventory Chapter

Sao Tome and Principe ratified the United Nations Framework Convention on Climate Change (UNFCCC) on 29 September 1999, thereby becoming a Party to the Convention and committed to develop, update, publish and communicate to the Conference of the Parties (COP) the national inventories of emissions and removals of greenhouse gases (GHG) as an integral part of its National Communication.

As a result, the third STP greenhouse gas emission and removal inventory (GHGI) for the year 2012 was prepared based on methodology established by the Intergovernmental Panel on Climate Change (IPCC, 1996) guidelines and the Guide to Good Practices (GBP) for calculating GHG emissions. For the calculation of emission and removal estimates, the IPCC software and the standard emission factors presented by the IPCC were used.

According to these guidelines, the GHGI of STP covers the following sectors: Energy; Industrial processes; Agriculture; Land Use, Land Use Change and Forestry (LULUCF); and Waste. Regarding Use of Solvents and Other Products sector, no GHG emission estimates were made due to lack of data.

In order to calculate the GHG emissions, the following gases were considered: Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), Nitrogen Oxides (NOx), Carbon Monoxide (CO) and non-methane volatile organic compounds (NMVOCs).

An assessment of the level and trend of emissions and removals has also been carried out in order to identify the main sources and sinks of GHGs consisting of 95% of the country's total emissions, thus identifying the key categories.

Greenhouse Gas Emissions

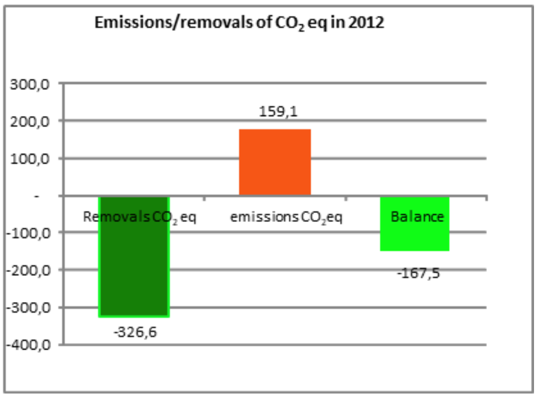
In STP the GHG emissions expressed in gigagrams (Gg) of carbon dioxide equivalent (Gg CO_2eq) in the year 2012 were estimated at 153.3 Gg of CO_2eq. (excluding LULUCF), which represents an increase of 50.9 Gg of CO_2eq and corresponds to a 50% increase over the value of the last inventory carried out in 2005, while in the removals there was a decrease of about 14%. As can be seen in Table 1, the energy sector is the largest emitter with 118.4 Gg CO_2eq, followed by the agriculture sector and the waste sector.

Table 1- CO_2 Emissions by Sector

Year	1998		2005		2012	
Sector	CO_2 eq. emissions (Gg)	CO_2 eq. removals (Gg)	CO_2 eq. emissions (Gg)	CO_2 eq. removals (Gg)	CO_2 eq. Emissions (Gg)	CO_2 eq. removals (Gg)
1 Energy	55,3		71,7		118,4	
2 Industrial Procs.	---		---		---	
3 Use of solventes and other products	NE		NE		NE	
4 Agriculture	26,3		22,9		24,5	
5 Land Use and Forest Change (LULUCF)	1,1	-358,0	1,1	-381,0	5,8	-326,6
6 Waste	6,6		7,8		10,4	
TOTAL (excl LULUCF)	**88,2**		**102,4**		**153,3**	
TOTAL (incl LULUCF)	**89,3**	**-358,0**	**103,5**	**-381,0**	**159,1**	**-326,6**
Balance (incl LULUCF)	**-268,7**		**-277,5**		**-167,5**	

The LULUCF sector works at CO_2 sequestration in an amount calculated at -326.6 Gg CO_2eq. Although there is a 40% decrease in net removal in relation to 2005, STP continues to be a GHG sinking country, as shown in Figure 2 below.

Figure 2 - GHG Emissions Balance in 2012



The **energy industry** subsector with 56.7 Gg CO_2eq emissions is the largest emitter subsector, followed by the **transport** subsector with 37.6 Gg CO_2eq., other subsectors with 20.4 Gg CO_2eq and others with 3.7 Gg CO_2eq, totaling an emission value of 118.4 Gg CO_2eq.

Among the categories potentially considered as GHG emitters in the inventories related to the **Industrial Process subsector** and referenced in the IPCC manual, only three of them can be considered in STP, namely: food production, alcoholic beverage production and use of asphalt in road paving. The remaining categories do not apply because they do not occur, since the country does not have other types of industrial processes. Therefore, for this sector the country does not have the main sources of direct GHG emissions (CO_2, CH_4, N_2O). The only sources considered are non-methane volatile organic compounds (NMVOCs).

It was not possible to estimate GHG emissions from the subsector of refrigeration and air conditioning equipment. The lack of information did not make it possible to estimate the emissions of HFCs, the family of gases used in this case, thus being a gap in the GHG inventory.

It should be noted that the PCFCs gases, and SF_6 were also not subject to inventory due to the unavailability of statistical data and reports that would make it possible to mention their situation at national level.

Therefore, in relation to NMVOC emissions, the asbestos paving sector emitting 0.3 Gg NMVOC and the beverage producing sector emitting 0.1 Gg NMVOC, total only a 0.4 Gg NMVOC emission.

In the **Agriculture subsector**, GHG emissions come from enteric fermentation, manure management, agricultural soils, Savanna burnin and burning of agricultural wastes, representing a total of 24,5 Gg CO_2eq. The main emitters are agricultural soils corresponding to 16,5 Gg CO_2eq, enteric fermentation 4.9 Gg CO_2eq and manure handling 2.7 Gg CO_2eq. Both the savanna burning, and waste sectors have a negligible emission.

Concerning the **Soil Use, Land-Use Change and Forest subsector**, the main sources of categories and their GHG emissions and removals were discussed, namely, changes in forests and other stocks of woody biomass, conversion of forests and fields, abandonment of exploited lands and changes of carbon in the soil, in which results of the emissions and removals of the sector are presented in Table 2.

Table 2 - CO_2eq emissions and removals for Land Use, Land Use Change and Forests sector

Subsector	Emissions	Removals
	Gg CO_2eq	
5A Changes in forests and other woody biomass stocks	-435,3	
5B Forest and field conversion	161,0	
5C Abandoned farmland	-116,7	
5D Soil carbon changes	70,2	
TOTAL	**-320,8**	

In the **waste subsector**, emissions from municipal solid waste treatment were analyzed, as well as domestic / commercial and industrial wastewater. The waste treatment presented an emission of 6.5 Gg CO_2eq and treatment of the waste 3,9 Gg CO_2eq, totaling 10.4 Gg CO_2eq. for this sector.

Vulnerability and exposure to climate risks

STP climate regimes are determined by the annual migration of the InterTropical Convergence Zone (ITCZ), also called the InterTropical Front (FIT), when it is located on the continents. Although the pluviometric STP regime is determined fundamentally by the displacement of the ITCZ, the Santomean climate is quite complex, since it is a small archipelago endowed with a very singular orography, which includes elevations of more than 2,000 m (Pico de Sao Tome), in an area of only 1,001 km_2.

At STP, air temperature and precipitation data are available for only five meteorological stations, four of which are located on the island of Sao Tome and one on the island of Príncipe. Of these five stations, only the Sao Tome Airport weather station can be used to detect climate change due to its longer time series (57 years) and data consistency. In other meteorological stations the data series are less than 10 years, which prevents the identification of a clear tendency from the study of observed data.

The climatic scenarios were made using the so-called RCPs (Representative Concentration Pathway - IPCC, 2013), which consist of different trajectories of GHG concentration, one in which GHG concentration continuously increases in the atmosphere over the years and reaches a change in the radioactive balance at the top of the atmosphere at 8.5 Wm^{-2} at the end of the XXI century, denominated RCP8.5 and another in which the scenario of concentration trajectory is moderate, denominated RCP4.5.

According to these scenarios, the average annual temperature trend (Airport weather station), calculated from the linear trend, indicates an increase of 0.6 °C between the years 1960 and 2016, representing an average warming rate of approximately 0.01 °C per year. For the precipitation trend analysis, the annual totals of the data sets observed from the Climate Prediction Center MORPHing technique (CMORPH, Joyce et al., 2004) and the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS, Funk et al., 2015) were taken into consideration, in addition to the series observed in order to reduce the uncertainty regarding observation. There is a tendency to reduce annual rainfall over the observed series and CMORPH data. The CHIRPS data do not show this trend; however, they present values compatible with the observations.

According to these scenarios, the projections indicate a warming throughout the study area, being more noticeable between the months of October to May. In the RCP4.5 scenario, projections of changes in precipitation for both islands indicate a rainier climate from October to May and slightly drier and / or normal conditions in other months of the year. In the RCP8.5 scenario according to the projections, a reduction of precipitation occurs in both periods: rainy and dry. However, analyzing the changes from month to month, the months of December and January present an increase in precipitation on the island of Sao Tome in scenario RCP8.5

Regarding climatic extremes that indicate scenarios of climate change, projections indicate an increase in total annual rainfall in the RCP4.5 scenario and an increase in rainfall intensity in both scenarios. It is verified that this increase is always more pronounced in the southwestern region of Sao Tome Island. Although there is an increase in total precipitation and its intensity, there is also an increase in the number of consecutive dry days, which indicates an extension of the gravana and poor temporal distribution of precipitation in the region. In relation to climatic extremes of temperature in both scenarios, climatic projections indicate warming, with increases in heat waves on hot days, for annual maximums in maximum temperatures and an increase in annual minimum temperatures.

The elaborated climate change scenarios have made it possible to assess the vulnerability of the most sensitive sectors such as agriculture, energy and coastal zones.

Regarding **agriculture**, studies on the risk index of taro (matabala), maize, cocoa and pepper crops were carried out, with reference to low risk areas in the reference period or historical period, which are currently some of the cultivated areas. For each crop, the projections indicate areas of greater risk in relation to the current climate. For taro, the projections indicate an increased risk of crop due to thermal stress (South of the Caué district). The risk due to susceptibility to the taro-burning disease of taro is now moderate to very high in most of the island of Sao Tome, especially on the eastern coast where the index is very high. For the first corn crop, the border regions between the districts of Caué and Lembá present a high production risk due to susceptibility to rust (scenario RCP4.5). For the RCP8.5 scenario there is an increase in the area classified as very high risk due to increase in thermal stress and susceptibility to rust disease. In the second corn crop, it is worth noting that some coastal regions had a change in risk classification from very low to high, associated with low productive potential.

In relation to cocoa, in the RCP8.5 scenario, the regions north of Lembá, west of Lobata and Mé-Zóchi, which are of great importance for local production, are exposed to very high risk due mainly to water stress. Other regions of the island, in which risk classification increased, are also the main cause of water stress. In the future scenario RCP4.5, the risk of production of pepper crop is very high, mainly due to water stress. However, in the Lembá, Caué and Mé Zóchi districts division, the greatest risk is due to thermal stress caused by low temperatures. In the RCP8.5 scenario, the southernmost region of the Caué district presents a moderate risk due to water stress.

Regarding **water resources**, the study of the main hydrographic basins of STP showed that projections in the scenario of emission RCP4.5 indicated an increase in the mean of the average annual flows. However, projections in the RCP8.5 scenario indicated an increase in the flows in the wet years and a decrease in the dry years, implying an increase in the interannual variability of the flows. In general, projections of changes in flow potential range from a small reduction in the RCP8.5 scenario to a significant increase in hydroelectric potential in the RCP4.5 scenario.

The hydrological and hydroelectric potential projections in the scenarios analyzed suggest a high sensitivity to climate change. Considering the divergence between scenarios, especially in drier years, of greater sensitivity of the water system, it is necessary to carry out more in-depth studies and with a greater number of scenarios to guide the development of long-term policies in resources management. This is because the lack of long series of hydrometeorological data limits the studies of these hydrographic basins, preventing the definition of the current hydroclimatic characteristics and the evaluation of the uncertainties in the future projections.

Regarding Coastal Areas, small islands were not the subject of a separate chapter in the first IPCC report (1990), although they were discussed in the chapter on "Global Oceans and Coastal Areas" (Tsyban et al., 1990). Since 1990, two points have been emphasized: the first, that a Sea Level Rise (SLR) of 30 to 50 cm projected by 2050 would threaten the islands of low altitudes and the second, that the costs of protection work to combat rising sea levels would be extremely high for small island nations (Tsyban et al., 1990; Bijlsma et al., 1996).

In the fifth IPCC assessment report (AR5) (2014) it was pointed out that the projected increases in average sea level towards the end of the 21st century in the moderate scenario RCP4.5 range from 0.36 to 0.71 m [average of 0.53 m] and in the more severe scenario, RCP8.5, range between 0.52 m and 0.98 m [mean 0.74 m] - see Nurse *et al*. (2014); Wong *et al.* (2014). This increase, coupled with extreme events affecting the coastal zone, such as storms and storm surge, presents severe risks of flooding and maritime erosion to low-lying areas (Nurse et al., 2014; Wong *et al*. ., 2014), effects that may lead to reduction of the territory and harming of the coastal activities that are essential for the population of STP.

This study did not consider issues related to biodiversity, although it is a subject of great relevance to the country. In a 2017 survey it was observed that there is still little specialized information on biodiversity, although the biodiversity action plan has been published (STP, 2017). For example, there is no survey of rocky shores along the coastal perimeter, important areas for nesting birds and turtle feeding, as well as other marine species. It is also crucial to highlight the significance of mapping mangroves that function as an important ecosystem in the transition between land and sea and, along with their particular fauna and flora, as they play an important role of balance and maintenance of the quality of the coastal environment.

Adaptation measures

The vulnerability analysis of the sectors shows that **agriculture**, **water resources** and **coastal areas** sectors are the most vulnerable to climate change, for which some adaptation measures have been proposed.

Considering the importance of the **agriculture** sector for the country's economy and the great sensitivity to climate change, as seen in the analysis of the vulnerability scenarios (RCP4.5 and RCP8.5), both in relation to thermal stress such as water stress, adaptation measures are aimed at:

1. Studying and developing cultural practices to reduce the impacts of water stress and / or thermal stress;
2. Studying and developing cultural varieties resistant to water stress and / or thermal stress indicated by the climatic changes projections;
3. Adopting the use of improved seeds adapted to climate change, based on each crop's need, its degree of resistance to thermal or water stress, diseases and pests, among others;

4. Studying and implementing an irrigation system for crops in the regions where the greatest rainfall reductions are projected;
5. Studying and developing biological processes and products in the fight against pests and diseases of plants and crops that do not present harmful effects on the environment, soil, biota, especially in those areas where favorable conditions for disease occurrence are indicated (for example, southern regions of Sao Tome and Princípe Island);
6. Implementing a distribution program to the culture seed communities that are more resistant to disease, water stress or thermal stress;
7. Studying other more productive agricultural crops for food security and developing adequate techniques of cultivation in sloping areas and other risk areas, adopting CSA procedures and techniques, such as terracing, construction of dikes and sidewalks to reduce soil erosion due to activities.

Concerning the **water resources** sector, given their sensitivity to climate change, the measures are aimed at:

1. Deepening knowledge and creating a database for the study of river basins;
2. Studying the current and future availability and demand of water resources in STP while incorporating different scenarios of climate change;
3. Making an overall assessment of the available hydrological potential, including groundwater resources;
4. Preventing all forms of misuse and contamination of water, whether chemical or biological;
5. Promoting the reforestation and planting of protection trees in the Hydrographic Basins.

Coastal areas are a highly sensitive sector to climate change, so the measures are as follows:

1. Formulate contingency plans considering areas susceptible to flooding by sea level rise and river runoff, and considering areas of overcrowding (monitoring, warning and communication) to reduce damage,
2. Strengthen the articulation between the different sectors of governments and civil society that are in the coastal territory in order to develop studies and actions of monitoring, risk management and adaptation that have an ecosystemic and holistic vision on that territory,
3. To implement, validate and operate regional numerical model of ocean circulation to estimate ocean currents and temperatures,
4. To implement, validate and operate regional numerical model of waves, to estimate the height and direction of the waves, to define construction patterns in coastal zones, such as height, elevation and resistance of materials,

5. Implement an alert system for offshore fishing navigation and maintain mechanisms to guarantee fish production, especially in the fishing communities of Príncipe, south of Sao Tome Island (Caué District).

Given the low availability of reliable and consistent data with long series, which is a shortcoming in the analysis of sectoral situations, it was considered that the country should have this data in the future, for a better analysis of vulnerability and adaptation, therefore, the following actions are proposed:

1. To implement permanent mechanisms for collecting and processing data at the national level, with the direct involvement of the competent authorities, in particular the Ministries of Environment and Finance.
2. Develop a scientific methodology through a coherent approach to the collection and processing of data on the environmental evolution trends as well as trends in society in interconnection.
3. Create a national data platform, among other things, on the productivity of each crop, areas of production, registration of diseases associated with records of climatic extremes and effects on agricultural culture;
4. To elaborate the agricultural zoning for diverse cultures and to carry out in the field experimentation on the optimal conditions of development of the cultures used in STP, as well as favorable conditions for the spread of diseases;
5. Carry out mapping of the physical-water properties of soils to better identify the water storage capacity in the soils.
6. Develop and validate productivity models for the main island cultures;
7. Carry out the agricultural census to obtain more information from farmers and thus support mitigation and adaptation measures;
8. Provide institutions responsible for producing information about hardware and software capable of supporting storage, processing and energy efficiency.

Mitigation measures

In order to determine GHG mitigation options for the **energy**, **waste** and **building** sectors which are the ones that emit most, the mitigation scenarios for these sectors were calculated and reference scenarios were constructed, as well as scenarios for each of the previously identified priority mitigation options.

The focal measures for the **energy** sector are the installation of systems to exploit water resources and hydroelectric potential according to existing studies, studies to evaluate the potential of producing alternative energy (wind, solar, biomass), the expansion of the power distribution network to make use of the increase in the Yô Grande river flow, considering the projections of 2041-2070, in the RCP4.5 scenario and development in a coordinated way, of the production of alternative energies, particularly solar energy, therefore benefiting from the temperature increase.

The results indicate fifteen (15) mitigation options that the country should prioritize considering the time horizon 2012-2030. These options include the short term construction of an Organic Waste Recovery Center - Composting Center of 2 Ton / day processing capacity , the installation of 900 bio-digesters for biogas production, 94 kg / day of processing capacity and the construction of 1 landfill with methane gas capture and flaring system for the waste sector; the replacement of 39,600 traditional stoves for improved ones and 198,000 incandescent lamps for low-energy LED lamps for the buildings sector and the replacement of a thermal power plant by small hydro plants connected to the main grid (14 MW), isolated mini-hydro plant (2 MW), solar PVs (12 MW), on-shore wind power plant (3 MW), in efficient LED lighting (5 lamps / 20 thousand houses in more poverty during 10 years, 100 thousand units), in the installation of efficient lamps in public lighting with LED (2,000 bulbs in total for 10 years), in the installation of more efficient grid (reduction of losses of 1 GWh), in the replacement of 1,000 taxis, being 500 gasoline and 500 diesel, for the energy sector.

As to measures that facilitate a better fight against climate change, the chapter on other relevant information to achieve the objective of the Convention on Climate Change stands out. Therefore, for Sao Tome and Príncipe to achieve a sustainable, resilient and low-carbon development, an assessment of the needs for technology transfer was carried out, which allowed the elaboration of a set of adaptation and mitigation measures that should be based on a technology transfer strategy in accordance with national circumstances.

The assessment of technological needs as a component of the technology transfer process is one way through which the assessment and response to the development of climate needs and opportunities are integrated together.

It is a complex and continuous process of learning that leads the beneficiary to fully assimilate the new technology and to be able to use it, reproduce it and eventually be able to resell it. It encompasses the assessment of the national needs of the two types of technologies: greenhouse gas mitigation technologies and adaptation technologies.

Regarding the study on technology transfer within TNC, the traditional sectors with the highest level of GHG emissions were considered, namely: Energy and Transport, Agriculture and Forestry.

Priority needs for technology transfer have been identified for the **energy** sector (renewable energy, energy efficiency - equipment and buildings - efficient lighting, high energy performance building materials, energy efficient household appliances), for the transport sector fuels, hybrid or gas vehicles, improvement of road infrastructures for the decongestion of urban areas, development of public transport; for the **agriculture** sector agricultural land management, integrated irrigation system for agricultural production and greenhouse and terracing, and the sustainable management of natural resources, biodiversity conservation and reforestation were identified for the **forest and soil** sector.

Systematic Research and Observation

The RDSTP does not have a national policy on research on climate change. However, the National Institute of Meteorology (INM), which is the institution responsible for systematic observation in the field of Climate in Sao Tome and Príncipe, ensures the essential observations and research on climate and climate change in the country. In addition to INM, there are other institutions that are involved in the research and systematic observation process, such as the Directorate General of Natural Resources and Energy responsible for the national hydrological network and CIAT responsible for agronomic research.

On the other hand, there are some research activities on climate change that are being developed in the context of some projects, such as the WACA Project, with the specialized studies of geomorphology and sediment transport, Rural Communities for Adaptation to the Effects of Climate Change in STP and AMESD Project developed by ITRA and AGRHYMET.

The systematic observation of climate change aspects concerns the climatological and hydrological networks, considering that the country does not yet have an oceanographic network. The **weather network** is relatively modest with some national STP stations to be managed by INM.

In STP the **hydrological observations** are under the responsibility of the Directorate General of Natural Resources and Energy. After many years of inutility, some hydrological stations were installed, and hydrological data observations and records resumed.

Currently, STP has 31 automatic stations, with 28 hydrometeorological stations installed under the SAP project and 3 stations previously installed, which allows a good coverage of hydrological information at the national level.

Synoptic stations contribute to WMO's global weather monitoring program through observations and hourly data records that are transmitted 24 hours a day to the regional center of Brazzaville.

The meteorological variables recorded in these stations are essentially the following: temperature, atmospheric pressure, relative humidity, direction and wind speed, cloudiness, quantity and intensity of precipitation, sunshine duration, as well as global radiation.

As part of Sao Tome and Príncipe's contribution to the global meteorological network, in addition to the hourly information provided 24 hours a day by the synoptic stations, a monthly message called CLIMAT, containing climatological information, is produced and sent to the aforementioned regional center that is responsible for its worldwide diffusion.

In addition to the contribution of stations 61931 and 61934 mentioned before, a weather station was installed on the Rolas Islet, which registers the local data and transmits them via satellite for the coordination of the African Monsoon Study Project (AMMA).

In the last 10 years there has been some effort by the state to improve the national weather network. To this end, within the framework of the Public Investments Program of the Government of the RDSTP for 2010, INM acquired two classic climatological stations that were already installed and in the same Program for 2011, despite the context of the economic crisis, two more classic weather stations were acquired. These acquisitions demonstrate the importance that the country's authorities attribute to climate issues and their changes.

Under the Adaptation Project for Africa, financed by the Government of Japan and implemented by PNUD in the National Execution modality, 8 climatological stations were installed, 4 automatic and 4 classic, as well as 20 hill stations.

Two of the agro-meteorological stations that make up the national meteorological network are under the jurisdiction of the Center for Research and Agronomy of Potó (CIAT).

Today, unlike the existing classical stations, the 28 automatic hydrometeorological stations installed in the ambit of the SAP project and the 3 previously installed, transmit data every 15 minutes to the different control centers, installed in the INM, in the DGRNE and in the INM delegation in Princípe Island. In addition to the pace of which the information can be seen, this data is stored on the servers installed in said institutions, thus allowing them to be quickly accessed and treated.

Education, training and awareness

Climate change is currently a reality that can not be ignored. There are changes in traditional climate systems around the world, and we need to be aware of these changes that have implications for the socio-economic and even cultural life of populations.

At the perception level, STP has developed awareness activities throughout the country and mainly in rural and coastal areas, through the technical services of the Ministries responsible for the environment and agriculture sectors of Civil Society Organizations implemented through projects in the various districts and the Autonomous Region of Princípe Island.

Also noteworthy are the awareness actions made through the media, especially National Radio (RNSTP), National Television (TVS), Local Radios (Community Radio and Príncipe Regional) that develop programs for the general public on climate change.

STP does not yet have a National Program for the integration of Climate Change into national development policies. However, some actions related to the incorporation of this theme in primary and secondary school curricula can be highlighted, considering the existence of a discipline called Environmental Education in the secondary education where the incorporation will be done, whose manual has already been elaborated and is in the stage of experimentation.

At the Higher Education level there are also initiatives aimed at integrating this subject into teachers' pedagogical training.

Constraints, gaps and needs of institutional, technical and financial capacities related to the elaboration of the Third National Communication in STP

As a Party to the UNFCCC, STP must honor its specific commitments under this Convention. The TNC drafting process considered lessons and experiences gained during the SNA elaboration. However, some gaps persist and need to be addressed in view of the importance of National Communications in terms of information and decision-making at both national and international level.

The UNFCCC recognizes that due to lack of financial and human resources and institutional and technological capabilities, Small Island Developing States (SIDS) like STP face the challenge of mainstreaming climate change concerns into national policies.

However, while some progress has been made in the development of TNC in relation to previous communications, there are some difficulties and gaps related to data quality and availability, including specific data and statistics on complete and regular forest inventories, lack of disaggregated activity data in all sectors, the lack of emission factors and conversion factors adapted to STP, predetermined expansion factors for biomass in order to estimate biomass in forests.

Concerned with global warming and climate change issues as a consequence, and as a member of the international community, the Democratic Republic of Sao Tome and Príncipe adhered to and ratified the United Nations Framework Convention on Climate Change (UNFCCC), respectively in 1992 and in 1999, and amended the Kyoto Protocol in 2008.

In accordance with the provisions of Articles 4 and 12 of the UNFCCC and the directives of Decision 17 / CP.8, STP prepared its Initial Communication (CNI) and its Second National Communication (SNA) which were submitted to the Secretariat of the Convention, respectively in 2005 and in 2012 in terms of the Conference of the Parties.

STP's Third National Communication (TNC) is presented below and is composed of four parts, divided into seven chapters.

The elaboration of national communications has led to a growing awareness of the national actors in STP on the issue of climate change and has led to reflection on the integration of this issue in national development policies.

The Third National Communication on Climate Change, which is a summary of the thematic and sectoral studies carried out during the process, comprises several chapters, namely "National Circumstances", "Greenhouse Gas Inventories", "Mitigation Measures Aimed at Emission Eeduction"," Climate Change Adaptation Measures "and" other information "relevant to the effective implementation of the UNFCCC.

The TNC elaboration process began with a self-assessment of the SNA and the elaboration of the TNC Project. The implementation of this project was done in accordance with guidelines of the Intergovernmental Panel on Climate Change (IPCC / IPCC) and within the framework of the recommendations of decision 17 CP / 8. This process has made it possible to update the information contained in the SNA, to improve data quality, to strengthen the capacities of national experts in various fields related to the elaboration of national communications, and to create a sustainable institutional framework for the development of national inventories an greenhouse gases and mitigation studies.

TNC is structured in four parts as follows:

The **first part** is part of Chapter I and refers to the National Circumstances where an overview of the Country is presented, with a purpose of assessing the aspects of the sectors identified as vulnerable, their levels of vulnerability to climate change or their relative influence on greenhouse gas emissions, in accordance with the country's priorities.

The **second part** covers Chapter II and refers to the Third Greenhouse Gas Inventory, consisting of the update of the second and first, completed in 2004 and 2010, respectively.

The **third part** includes Chapter III on the Climate-Based Situation, Chapter IV on Vulnerability Analysis and Measures implemented or proposed in order to achieve the objectives of the Convention and Chapter V on Mitigation.

The **fourth and final part** of this Communication comprises Chapter VI, which presents Measures to Facilitate Better Adaptation to Climate Change and the seventh chapter on Constraints, Gaps and Institutional Capacity Building.

Lastly, the findings show that STP is not a greenhouse gas emitter, thanks to its forests that have a certain capacity for carbon sequestration. However, there is a tendency to increase emissions, mainly from three direct gases: CO_2, CH_4 and N_2O, although at a slow rate. CO_2 emissions come from the Energy and Transport, Agriculture and Waste sector. CH_4 emissions come from the trading and institution / building sector, and N_2O emissions come from agricultural soils.

Like previous national communications, TNC reflects an important message that the national expert panel who conducted the study of the different chapters addresses to the authorities and policy makers.

The methodology used includes the compilation of various parts of the national communication report, previously elaborated in a phased manner. According to the IPCC guidelines, the compilation of these various parts presupposes the identification of a common axis focusing on the main vulnerabilities, impacts, adverse factors and sensitivities, without overlooking the adaptation and mitigation measures, considering the country's self-sustaining development priorities.

The impacts identified, i.e., the increase in temperature and decrease in precipitation, reflect the climate-based situation presented, as well as future scenarios, projected through the Global Circulation Model (GCM) based on verified climate trends.

1ST PART: NATIONAL CIRCUMSTANCES

CHAPTER 1: NATIONAL CIRCUMSTANCES

The National Circumstances (NC) describe the geographic, climatic, social, economic and institutional characteristics likely to be affected by climate change and / or the application of response measures. This information forms the basis of analysis for the various sectoral studies, namely Greenhouse Gas Inventories (GHG), Vulnerability and Adaptation Studies as well as Mitigation studies carried out under the United Nations Framework Convention on Climate Change Climate Change (UNFCCC).

1.1. Geographical situation of Sao Tome and Príncipe.

Figure 3 - Geographical situation of São Tomé and Príncipe

Located in the Gulf of Guinea at 0^{o} 25'N latitude and 6^{o}20'E longitude, about 380 km west of the coast of the African Continent, the Republic of S. Tomé and Príncipe is an archipelago of volcanic origin and is made up of two islands and several islets (figure 3).

The islands occupy a surface of 1,001 km^2, i.e., 859 km^2 for the S. Tomé island and 142 km^2 for the island of the Príncipe and are located at the cross line of the Equator. Next to the south end of Sao Tome is the Ilhéu das Rolas where there is a landmark that indicates the passage of the Equator.

1.2. Climatic characteristics

The climate is characterized by two seasons during the year, with the rainy season having frequent precipitations during most of the year (about nine months, from September to May) and the shorter dry season known as gravana, of three months (from June to August) and with less hot temperatures. There is however, a period of about two months called "Gravanito" that oscillates[5] between December and January in which there is a slight reduction in precipitation.

[5] MRNA-First National Communication - Sao Tome and Principe - Sao Tome, 2004

The average sea level temperature of the archipelago is 25.6 ºC, with a slight tendency to vary with altitude and time of year. In this sense, temperatures decrease with increasing altitude, due to mountainous regions being slightly cooler than coastal regions.

The average air temperature is 26.2 ºC, taken from the Sao Tome Airport station, the only station with a data series of the last 50 years in the period from 1992 to 2009. There is not a great variation between the annual averages, being the maximum temperature of 30,5 ºC and the minimum of 20,6 ºC, in 2017.

Rainfall in the STP archipelago varies significantly with altitude, especially between the North and South, being 1,000 mm to the North and 7,000 mm to the South of the island of Sao Tome and 2,000 mm to the North and 5,000 mm to the South of the island of Príncipe. This substantial precipitation difference is caused by the orographic distribution of the islands, which determines the precipitation values and their distribution.

In Sao Tome and Príncipe, the orographic effects of the volcanic massifs are what determine precipitation abundance and prompt precipitation to display great rainfall gradient and offer very important water potential in altitude. Thus, given the characteristics of the relief, many microclimatic zones predominate, mainly as a function of rainfall, temperature and relief.

1.3. Geomorphological aspect

1.3.1. Relief

On the island of S. Tomé, the relief is very uneven, with the Sao Tome Peak as the culminating point. It is located in the center west, measuring 2,024 m of altitude, in addition to other peaks that exceed 1,000 m altitude. The north of the island is less mountainous, and for this reason the first growers settled there.

On Príncipe Island, where the North is also less hilly, the highest peak reaches 948 m in altitude and the relief there is also very bumpy.

The country is made up of two islands of volcanic origin that are from a part of an eruptive chain that extends across the Gulf of Guinea, from the Cameroon Mountains to Anobom and continues to St. Helena.

In the western half, in the NW and SW quadrants, the relief is uneven until near the coast, while in the eastern half in the NE and SE quadrants, the relief forms are softer, with a vast settling slightly inclined to the ocean, mainly in the area of Água Izé to Plancas, bounded by the coast line and by a curve of 300-400 meters of altitude. In the SE quadrant and in the South, flat lands are observed in the areas of Ribeira Peixe and Porto Alegre. Throughout the western half of the island, there are mountain ranges and high elevations, namely the Sao Tome Pico, Pico Calvário, Pico of Ana Chaves and Pico Cigar and, below, Cabumbé with slopes descending abruptly to the sea and south. This mountainous massif descends in a barrier of the Cabumbé to the Green Village so that it connects to the smaller elevations of Cão Grande and Novo Brazil and involves notable accidents of Lagoa Amélia, Macambrará, Bombay, Guaiaquil and dependencies of the interior of the Company Água Izé, easing down in Angra Toldo.

Figure 4 - STP Relief

The Príncipe island, by contrast, is less rugged. From a geomorphological point of view, Príncipe can be divided into two regions: the North presents a platform of an altitude of 120-180 meters and prominent relief, with small elevations and slopes that face the sea; the South region is the most rugged and is represented by Pico do Príncipe (948 m). This peak is inserted in a Chain of Serranias from East to West that begins in the Morro de Este and the Pico de Mencorne, descends to the West to the Carriote and later to the Mesa, already almost separated of the mountainous formation. This serrania extends a little to the north with the Papagaio, João Dias Pai and João Dias Filho peaks.

1.3.2. Geo-pedological composition

The islands of Sao Tome and Príncipe are located on the Cameroon Mountains Line (Fitton, 1980), which constituted a volcanic chain of about 1,600 km, extending from the NE of the interior of the African continent (Mount Cameroon on the coast of West Africa) to the island of Pagalu (Good Year) SW of the Gulf of Guinea.

From a geological point of view, like the other islands of the Cameroon Mountains Line, the STP islands are essentially basaltic in nature, predominantly trachytic to phonolitic composition. Sediments of various types intercalate the volcanic rocks in many places of the islands.

On the island of Sao Tome, the rocks are particularly volcanic. The predominant elements are basalts, whose elements in the North are agglutinated because there is little rain. In the south and center, the basalts are washed by abundant and torrential rains and form the highest elevations of the island (Picos).

The geological composition of the island of Príncipe is identical to that of Sao Tome. Basalts predominate in the North and are infused with some laterite deposits and trachy tufts. The South zone is dominated by phonoliths. There are also outcrops of Miocene limestone and crystalline limestone.

Soils are one of the most prominent resources of Sao Tome and Príncipe and are, in general, highly fertile and favorable to agriculture, although they sometimes present significant stoniness. They are usually acidic (pH 5-5,7) with deficiencies in phosphorus and potassium.

1.3.3. Hydrology

Regarding hydrological, the total capacity of the country is estimated at 2.1 million m^3 of water per km^2, equivalent to 10,000 m^3 per year per inhabitant (Hidroconseil, 2011).

The distribution of water courses follows a radial network from the center of the islands towards the coastline. The network has more than 50 water courses, of an average length between 5 and 27 km and an unevenness of 1,000 to 1,500 meters of altitude.

The watercourse regime is irregular but not of a torrential nature. It is connected to the rainfall distribution, according to the zones and the seasons of the year. In the dry season, from June to September, the river flow does not represent more than 10% of the annual total. The spatial distribution of the rivers is, however, uneven: more than 60% of the river flow is in the Southwest and South of the islands. This is due to the higher rainfall recorded in these areas.

1.3.4. Coastal Zone

Comprised between the Exclusive Economic Zone (EEZ) boundary, which extends up to 200 nautical miles and the continental limit that is situated at a height of 100 m from the coastline. The country has a coastal area of about 260 km long and a large exclusive economic zone of 160,000 km^2, in other words, the continental shelf is relatively small, with about 1,500 km^2, where two thirds (1,023 km^2) belong to the island of Príncipe and only 436 km^2 belong to the island of Sao Tome [6].

[6] National Environment Plan for Sustainable Development (Vol.II) - UNDP / RDSTP

Most of the coast is rocky with very rugged relief, but there are numerous sandy bays that constitute a whole system of beaches along the coast.

The ecosystem of the transition zone formed by brackish water and mangrove swamp (mangroves) is very peculiar and is characterized by the existence of great biodiversity consisting of abundant fauna and flora, as well as mineral and water resources.

1.3.5. Forest and land use

The land use system is characterized by an "ecological arrangement of crops". It is a matter of the natural adaptation of each type of crop to the ecological space that is most appropriate to it, and consequently, each land is occupied in the form that most suits the sustainable use of the country's agricultural resources.

Sao Tome and Principe has an abundant forest in which its characteristics vary according to several factors including relief, altitude and consequently the microclimate characteristic of each region.

The major forest ecosystems found on the islands of Sao Tome and Príncipe are divided into forest ecosystems in the **low-lying region**, which comprises mangroves, shrubby and herbaceous savanna, shade forest and secondary forest, and forest ecosystems in **altitude zone**, which comprises the altitude forest of between 1,000 and 1,800 m, the altitude forest of between 1,800 and 2,000 m and the fog forest (above 1,800 m).

There was a total volume of standing timber of 12.8 million m^3 in 1999, the date of the second (and last) National Forest Inventory carried out so far in the country, considering all species, and a commercial volume of species of 2.7 million m^3.

Sao Tome and Principe’s wood resources are used primarily as a source of energy, but are also used for housing construction, manufacturing furniture and, to some extent, for manufacturing utensils, art objects and land planning (stakes and poles for public lighting).

1.4. Population and social indicators of development

1.4.1.Population structure and evolution

Sao Tome and Principe has 178,739 inhabitants with a population density of 178.7 inhabitants / km^2 and the average annual growth rate is 2.45% per year. The population is eminently young, with a birth rate of 26.6 per thousand and an infant mortality rate of 38 per thousand. The average life expectancy is 66 years. (INE, 2012).

1.5. Economic context

Sao Tome and Principe is a small, low-income, developing island state with a fragile economy and high vulnerability to exogenous shocks and a GNP per capita of 1,970

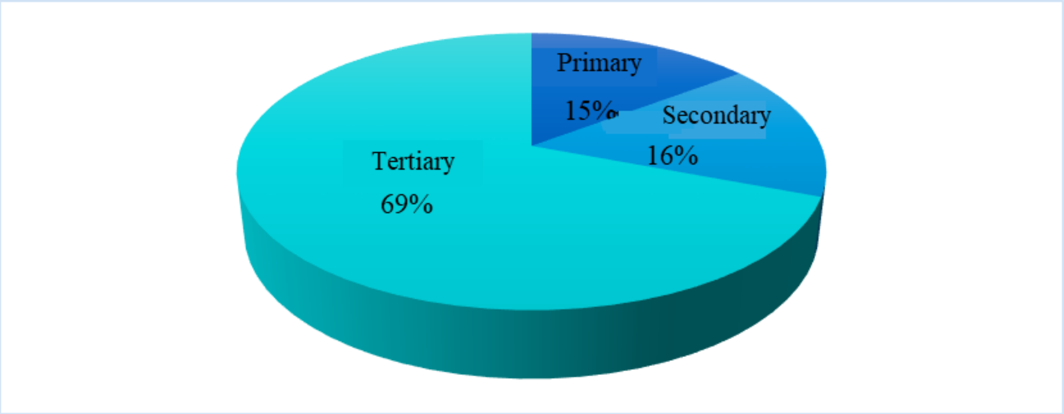
USD. The country ranks 143rd on the Human Development Index (HDI) with a value of 0.589 (UNDP, 2017).

The economic activity performance has been strongly dominated by the tertiary sector. From 2008 to 2017, this sector grew by an average of 4.4% and represents 69.2% of GDP. It was driven mainly by the commerce, transport, storage and communications and the public administration sectors. The secondary sector accounts for an average of 16.1% of GDP, growing by an average of 5.6% over the same period, and the greatest growth occurred in the activities of Production, Distribution of Electricity, Gas and Water. Lastly, the primary sector grew by an average of 2.9%, and contributed 9% of GDP (INE - DCN, 2017).

STP has limited resources. Its export base is not diversified and consists essentially of cocoa and an emerging tourism industry.

In terms of the share of activities in GDP, the largely informal tertiary sector accounts for almost 60% of GDP and employs 60% of the active population, while the primary and secondary sectors each contribute about 20% of GDP, according to the most recent data (Planning Division, 2017). Figure 5.

Figure 5 - Contribution of sectors to GDP



Source: Planning Directorate, 2017. Adapted

The frail diversification of the Sao Tomean economy and its strong sensitivity to demand and world prices for cocoa, the main export product, causes the current account balance, with official export transfers, to be structurally deficient, even though there has been a progressive improvement since 2012. Therefore, Table 3 shows that it went from 39.4% of GDP in 2012 to 36.6% in 2014, followed by 25.2% in 2015 and 20.5% in 2016 (Planning Division, 2017).

Table 3 - Evolution of main macroeconomic indicators between 2012 and 2016

	2012	2013	2014	2015	2016
Growth rate (%)	4,5	4	4,5	4	4,1
Inflation rate (%)	6	8,4	5,9	5,3	4,6
Overall budget balance (% of GDP)	-10,9	1,9	-5,5	-6,3	-2,8
Current account balance (official transfers excluded, % of GDP)	-39,4	-38,3	-36,6	-25,2	-20,5
VAN external debt (% of GDP)	30,7	27	30,1	39,7	36,2
External debt service (% of exports)	7,3	9,5	5	3,8	3,2
International currency reserves (in months of imports)	3,5	3,4	3,9	5,2	4,2

Source: IMF estimate, World Bank Database and MFCEB, quoted by DP (PND, 2017 - 2022).

Despite its low average income, the country still has the characteristics of a country in poverty, due to the fragility of its economic fabric and the small domestic capacity to produce wealth and create jobs that can guarantee better living conditions for its population. The country is considered vulnerable mainly due to its small territorial dimension, insularity, ecosystems fragility and its exposure to strong human pressure on natural resources and global financial crises as it is largely dependent on foreign aid.

The challenges that STP faces highlight the need for the country to continue efforts to achieve the Sustainable Development Goals (ODS).

1.5.1. Agriculture and Livestock

The agricultural sector is characterized by cocoa production, the main export product produced on large farms, called plantations. Since the redistribution of large cocoa plantations in the early 1990s, most agricultural production has been carried out by small farmers. As cocoa alone does not guarantee subsistence, many small farmers find an additional income by growing vegetables, fruits, vanilla and pepper for export. Despite the immense importance of cocoa in STP's economy, the country's export share in the world market was estimated at only 0.11% between 2000 and 2005 by the International Cocoa Organization (ICCO). However, santomense cocoa is appreciated for its high quality and is often mixed with lower quality cacao to improve the final product, which is chocolate. There is also an expanding "organic" cocoa sector, whose export in 2015 was about 1,020 tonnes (CECAB, 2015).

Table 4 below shows the main export crops in STP:

Table 4 - Summary of Agricultural Production 2013-2017.

Designation	2013	2014	2015	2016	2017
Cocoa	2617.0	3193.0	2794.2	3000.8	3501.1
Coconut	540.5	799.1	714.8	785.7	798.705
Coffee	3.9	12.0	4.4	1.2	5.9
Chili Pepper	3.5	12.0	7,7	14.0	14.3
Palm Oil	66.0	67.0	68	70.0	165.9
Others	904.6	866.9	851.3	816.3	874.5

Source: INE, 2017.

The agricultural sector employs 60% of the working population but accounts for only 17% of GDP in 2017. It is characterized by deficient infrastructure, almost nonexistent public support services, and a small number of farmers, which accounts for its poor productivity. With very fragile and poorly organized subsistence agriculture, the country imports a large part of its food consumption.

Structural measures for sustainable economic growth and job creation are at the heart of the government's reform program.

With regard to the livestock sector, it appears that the food deficit in terms of animal protein is declining, though the production parameters must be further improved, and the intervention of the Livestock Department must be continuous in order to allow the increase of meat production, as the population tends to increase.

Nevertheless, this direction has shown technical and economic efforts to combat the food deficit.

Table 5 - Livestock Production in quantity 2013-2017

Designation	Unit of measurement	2013	2014	2015	2016	2017
Cattle	Head count	1158,0	1262,0	1349,0	1362,0	1363,0
Beef	Tonne	15,0	10,0	5,0	8,0	9,6

Swine cattle	Head count	28230,0	29350,0	31105,0	35319,0	35320,0
Pork meat	Tonne	361,0	363.0	408,0	482,0	483,1
Sheep / Goat Cattle	Head count	33670,0	3569,0	34220,0	34947,0	34049,0
Lamb	Tonne	4,8	5,0	6,2	7,6	10,1
Poultry	Head	231190,0	231190,0	231190,0	231190,0	231190,0
Poultry meat	Tonne	385,0	435,0	485,0	594,0	595,2
Eggs	Thousand units	1264,1	1636,0	3560,2	3590,0	4863,4

Source: INE, 2017.

1.5.2. Food Safety

At the national level, about 36,000 people are food insecure, of whom 16,000 (10.2% of households) have low food consumption and 20,000 people (12.6% of households) have limited food consumption.

The country has made progress in terms of child nutrition (children under 5 years), but recent data show that there are still considerable challenges. Chronic malnutrition (slow growth) affects 17.2% of children of which 4.5% are of severe cases. Acute malnutrition (dwarfism) affects 4% of children, including 0.8% of severe form. Low weight affects 8.8% of children, of whom 1.8% are severely ill.

1.5.3. Fishery

The continental shelf around the islands of Sao Tome and Principe is characterized as being very narrow and limited to 5 - 10 km. Despite the relatively small continental shelf due to its volcanic origin, fishing is quite an important sector for the Sao Tomean economy, as it is a source of employment and foreign exchange, which contributes about 3.7% of the national GDP and represents 22 to 35 % of non-fiscal revenue from the state budget over the last five years (EU, 2017).

Table 6 - Breakdown of non-tax revenue in the 2013-2017 State Budget

In Percentage	2013	2014	2015	2016	2017
Fishery Revenue	22%	35%	32%	23%	22%
Other Natural Resources Revenues	0	0	0	41%	6%

Other equity income	68%	29%	29%	15%	28%
Other non-tax revenues	10%	36%	39%	21%	44%

Marine fishery resources show a constant and substantial reduction, according to operators and technicians of the sector. This trend is mainly due to fishing and the desertion of traditional fishing techniques in favor of unsustainable practices such as the use of explosives, the use of nets with inadequate mesh and underwater fishing.

Fishing in Sao Tome and Principe is exploited with two types of fleet: traditional fishing and semi-industrial fishing. Industrial fishing is practiced in the santomean sea by foreign vessels through bilateral fisheries agreements.

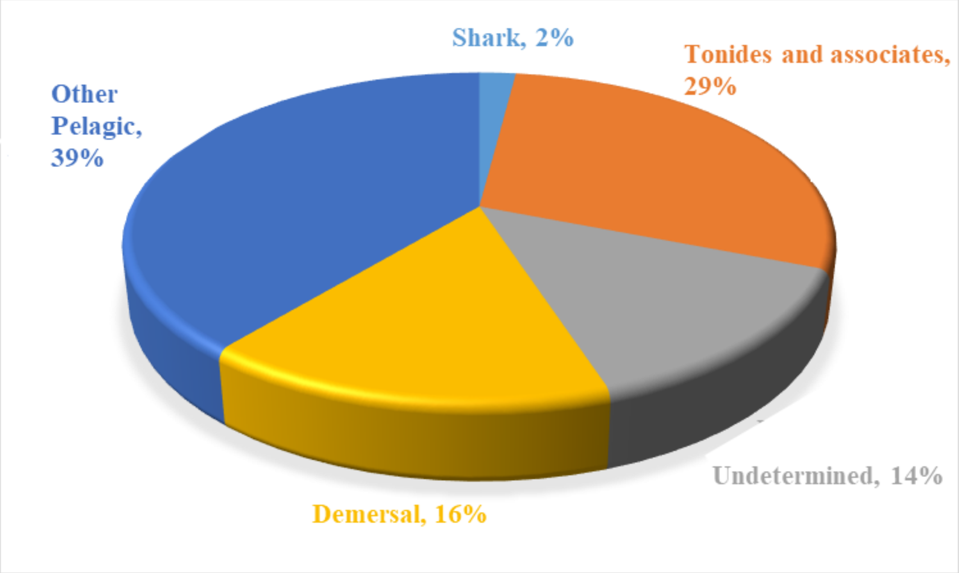
The artisanal fishing sector represents 25% of the country's labor force, consisting of men who work in the catching activities and the women (Palaiés) who practice the sale, mainly in markets. Some 3,051 artisanal fishermen operate at 44 landing sites, 29 of which are located in Sao Tome and 15 in Principe.

STP is a country with a long tradition of fish consumption, with a mean of 23.6 kg / hab / year, which is well above the world average (17 kg per capita) and above the other African countries that have an average of 8.3 kg per capita. According to data from the Fisheries Department, this consumption represents 70% of the animal protein consumed by the population, which in the world average is only 15%.

However, despite the relatively large size of the EEZ of 160,000 km^2, the estimated fishery potential is around 29,000 tonnes.

The capture potential was estimated at about 11 to 12 thousand fills per year in 2016/2017. These catches consist of 16% of demersal species and about 70% of various pelagic species, of which about 29% are tuna and other tuna species.

Figure 6 - Artisanal fish catch composition in STP 2015.



1.6. Services Sector

1.6.1. Tourism

The tourism sector has grown considerably between 2010 and 2016, registering a 263% increase in tourists visiting the country, whose economic contribution represents 14% of the national GDP.

According to the Strategic and Marketing Plan for Tourism of Sao Tome and Principe (2017), the strategic vision foresees STP in 2025 as "the most preserved tourist island destination in Equatorial Africa, with a unique nature and biodiversity, paradisiacal beaches, where the santomean hospitality, based on its historical and cultural legacy of coffee and cacao plantations, shares its way of life and warm reception. "

Tourism has the potential to be one of the main drivers for the country’s sustainable development. As shown in the chart below, the flow of tourists over the last 16 years has a steady and consolidated trend, but is subject to significant fluctuations, mainly due to air transport and international factors such as the crisis that particularly affected Europe, which is the largest source of the national tourist flow.

Figure 7 - Tourist flow in the last 10 years

Source: Tourism Directorate, 2018.

Tourism is thus a key sector, but insufficiently exploited. In fact, the country benefits from important natural attractions: rich biodiversity, exceptional fauna and flora being of great scientific interest. Twenty-seven species of rare birds[7], corresponding to 30% of resident species (distributed in five genera) are endemic in the islands[8].

In Sao Tome and Principe there are 895 higher plant species, 134 of which are endemic, 63 bird species (25 endemic), 16 reptiles (seven endemic) and 9 amphibians (all endemic) (DGTH, 2017).

Due to the country's richness in terms of its biodiversity uniqueness, the island of Principe was considered by UNESCO, on July 11, 2012, World Biosphere Reserve. This set of factors creates the conditions for the development of ecotourism, considering the potential that the country has in this aspect.

1.6.2. Seaport

As a result of the country's insular nature, the links established with the other countries as well as trade in goods and merchandise are normally carried out via the main seaport of Sao Tome situated in Ana Chaves Bay, on the eastern coast of the island.

However, this port, through which normally most of the national loading and unloading of ships has been carried out, is not to be used, which is why we have turned to tugboats

[7] P.J. Jones, J.P. BURLISON e A. TZE - Conservação dos ecossistemas florestais da RDSTP- S.Tomé, 1991

[8] ECOFAC (2002) – Lucienne Wilme – Balade sur les jeunes îles du plus vieux continent

and barges for the clearance of goods that are imported and exported out of the country, of a great distance from the coast[9] (140 km, about 8h).

Sao Tome and Principe does not have its own sea fleet. The ships come mainly from Europe (Portugal, Spain and Belgium). The connection between the country and the world by sea is carried out by large vessels transporting goods to and from Europe, by fishing boats (industrial and semi-industrial) and by small vessels that transport passengers and goods between Sao Tome and Principe and the ports of Angola, Gabon, Cameroon and Nigeria.

The connection between the two islands is deficient. It is made by small vessels that are very vulnerable. However, the establishment of regional relations with countries bordering the African coast could become a beneficial strategy for diversifying the economy and creating a future platform for integration into the world economy.

The vulnerability of the "Ana Chaves" port comes from the probable action of the adverse effects of Climatic Changes, namely from sea level rise, that could cause floods in the entire port area. According to the IPCC forecast for the 2100 horizon, sea levels are expected to rise from 0.18 m to 0.56 m in the A_2 scenario (SRES).

1.6.3. Energy and Transport

In terms of energy, Sao Tome and Príncipe's electricity production sector is in a highly deficient state, as the country currently has a capacity of 31 MW to meet its basic operating needs while only producing 15 MW. However, 30% of STP's energy production plant is inoperative and most are obsolete, according to the Castalia Advisory Group report (2010).

From a historical point of view, energy production in Sao Tome, which rose from 23.5 GWH in 1997, to 42.8 GWH in 2006, represents on average, a growth of 10.5% per year. However, in the same period, hydro energy production decreased by 4.2%, which means that thermal production and its consequences in terms of greenhouse gas emissions have grown in a proportion of approximately 19% per year.

[9] Ogimatech Portugal – Study on insularity and insularity costs in S.Tomé and Príncipe- S.Tomé, 2010

Figure 8 - - Evolution of São Tomé and Príncipe's electricity production

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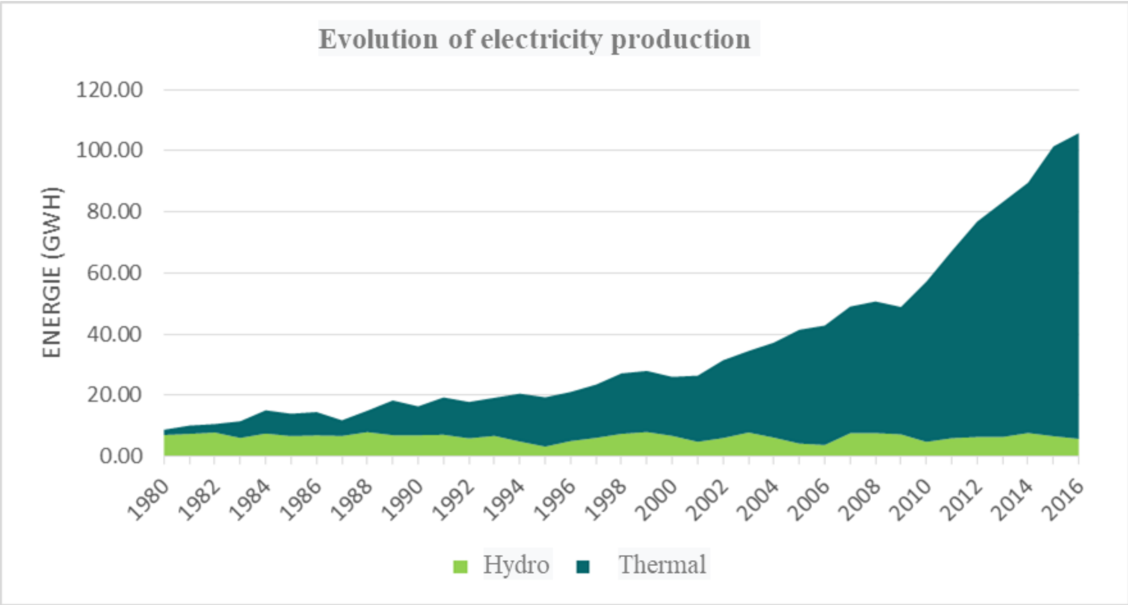
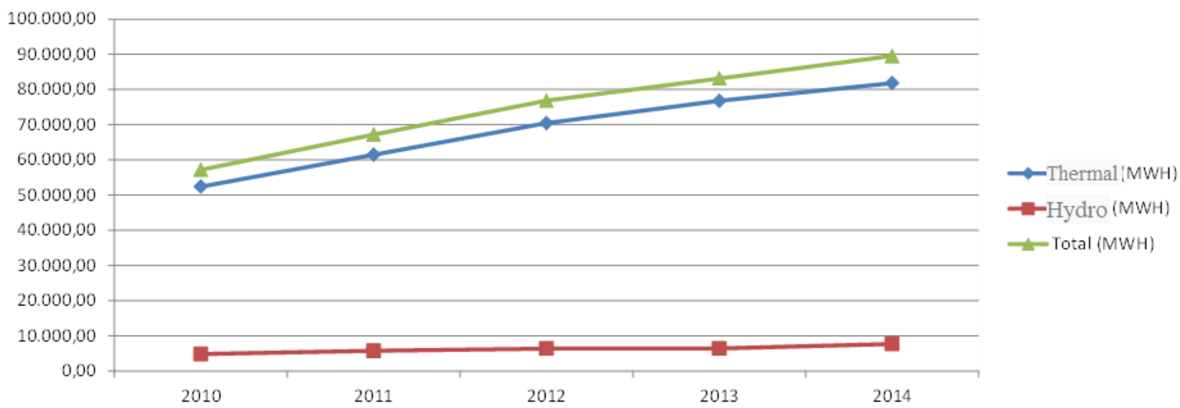




STP electricity production has been increasing due to the increasing demand in recent years, as shown in figure 8.

The hydroelectric power currently produced at the small power plant located on the Contador River north of the island of Sao Tome represents a very small part of the country's actual needs. Thermal energy is mainly obtained using imported fuel, ie diesel. This results in a high cost of production in thermal power stations, a high consumer price, combined with a meager and obsolete network of production and distribution of energy with technical and non-technical losses in an approximate value of 34.5% in the electrical system.

Up until December 31, 2017, the total installed capacity in the national electricity sector was 35 MW and comprised a hydroelectric plant and five interconnected thermoelectric power plants, in addition to the plant in the Príncipe Region and the isolated systems of Porto Alegre, Malanza, Ribeira Peixe and Santa Luzia.

Accordingly, EMAE's production system, in 2017, comprised the Contador hydroelectric plant (1.9 MW) and thermoelectric plants of S. Tomé (9.9 MW), Bobô-Forro 2 (3.2 MW) and Santo Amaro 1 (8.5 MW), Santo Amaro 2 (6.0 MW) and Príncipe (2.8 MW), five (5) small isolated power stations in Malanza and Porto Alegre, Santa Catarina, Santa Luzia and Ribeira Peixe), with a power of 32.9 MW and the remaining 2.2 MW corresponding to Bobô Forro's private power plant 1.

EMAE's own production in 2017 was 105.5 GWh. The production of electricity from thermoelectric origin totaled 100.5 GWh and contributed 92%, while the hydroelectric system in service corresponded to a production of 4,6 GWh. Purchases of electric energy were 3.6 GWh, of thermoelectric origin entirety.

In 2017, energy injected into the transmission and distribution networks reached 104.9 GWh, which included 3.6 GWh of energy purchased from the Independent Producer.

The electricity produced and injected into the interconnected network at S. Tomé in 2017 was 109,072.57 MWH, corresponding to 5,045.61 MWH for hydroelectric plants and the remaining 104,026.97 MWH for diesel-based thermoelectric plants. As can be seen in the table below, in relation to 2015, there is an increase in production of approximately 7,654.31 MWH, corresponding to about 3.7% in production. The total volume of electricity billed was 68.7 GWh, so it is concluded that there was a volume of electricity loss, technical and non-technical, corresponding to about 34.5%.

Table 7 - Evolution of STP energy data from 2015-2017

Energy Data Summary						
YEAR	**Electricity Production**			**Diesel Consumption**		**Lubricating Oil (liters)**
	Thermal (MWH)	**Hydro (MWH)**	**TOTAL (MWH)**	**Power Plants (litros)**	**TOTAL (litros)**	
2015	94 771,00	6 647,26	101.418,27	23 497 348,00	23 497 348,00	58 533,00
2016	99 955,25	5 800,25	105.755,50	26 884 374,00	26 884 374,00	104 182,00
2017	104 026,97	5 045,61	109.072,57	29 657 375,00	29 657 375,00	105 506,00

Source: EMAE, 2018.

1.6.3.1. Air Transport

The connection between São Tome and Príncipe and the world is made mainly by air. Globally, only 2 airlines have secured direct flights to and from Europe.

With regard to the African region, the link is also very limited and established with about four African capitals that have a direct link with Sao Tome and Principe.

The country does not have its own air routes, which is a great constraint on the level of connection and prices practiced, however, there is a flag airline that uses aircraft from other companies to carry out domestic and international flights. Domestic connections between the two islands are carried out by small private aircrafts.

1.6.4. Industry and Buildings

The secondary sector is not very significant in the national economy, contributing only about 20% to the GDP, of which 6.4% is due to the construction sector. This branch is currently very active owing to the great projects of recovery, maintenance and construction of new economic and social infrastructures.

In addition to civil construction, the other branches consist of the food industry (beer and baking), wood processing, shipbuilding, energy production, confections, furniture production and some artisanal production of alcoholic beverages.

It should also be noted that, although incipient, this branch of activity is responsible for the emission of greenhouse gases, mainly in the bakery and artisanal production of alcoholic beverages, since they generally use firewood as an energy source.

As far as buildings are concerned, considering the traditional habits of housing construction, cooking food and lighting, it is urgent to find alternative solutions that replace the use of wood and sand and other inert beach material for construction. This way in the near future we can start taking safer steps toward mitigation in this sector.

1.6.5. Mineral Resources (Oil)

Contrary to what has been verified in the other countries of the Gulf of Guinea and despite its location in a well-known oil zone, the country is not yet an oil producer.

The country's hydrocarbon potential is in three distinct areas, called "Zones":

- ✓ Zone ZDC (Joint Development Zone with Nigeria);
- ✓ Zone ZEE; (Exclusive Economic Zone)
- ✓ Onshore zone of the sea coast (includes the land side to the coast line) of Sao Tome and Principe

The National Petroleum Agency of STP (ANP-STP) was created in 2004 by Decree-Law no. 5/2004, of June 30, which is responsible for the management and control of the exploration and production of petroleum and gas.

As for mineral resources, the country is considered impoverished, as the existing minerals are disseminated in rocks, commonly known as gravel, stone, clay, that appear in the outcrops in various lands of the country. Table 8 below shows the total estimated reserves.

Table 8 - Estimate of the country's total mineral resource reserves per cubic meter.

Type of material	Total quantity in m^3
Tout-Venant	40.000
White clay	10.000
Sandy	80.000
Clay	30.000
Breccia	10.0000

Source: *Directorate of Natural Resources and Energy*

The exploitation of these natural resources is mainly done in the quarries[10] and the sand dredge on the seabed.

1.7. Social context

According to the PND (2017 - 2022), Sao Tome and Principe has made some progress in improving some social indicators. It has a gross schooling of 118%, with 114% being the gross female enrollment rate and 122% being the gross male education (MECCC, 2017 - Statistical Bulletin); a life expectancy of 68.6 years for women and 64.5 years for men according to the UNDP HDR 2017; an infant mortality rate of children under five years of 51 per 1,000 live births, access to an improved water source for 97% of the population and access to electricity for 80% of the population.

The poverty prevalence rate is estimated at 62.6% in 2015, according to the 2010 Household Budget Survey (IOF). Poverty affects women more (71.3%) than men

[10] A quarry is a type of open pit mining from which rocks or minerals are mined. Quarries are used to extract building materials, such as decorative stones. Quarries are generally shallower than other types of open pit mines.

(61.4%) because of the level of education. It is also related to the employment situation where its predominance is more modest in the employed assets than in the inactive unemployed who constitute the poorest socio-economic group. The average size of poor households is 5.3 individuals while that of non-poor households is only 3.3%. Finally, the analysis of the inequality indices shows that 20% of the poorest accumulate only 7.9% of the total national income, while the 20% of the richest monopolize 41% of this income.

1.7.1. Development Challenges

For the foreseeable future, STP will continue to face significant challenges in overcoming the disadvantages of insularity, the small size of the internal market, vulnerability to natural shocks and climate change, limited human capital and scarce tradable resources in order to generate inclusive sustainable growth and reduce poverty.

The authorities intend to implement an ambitious and comprehensive reform agenda presented briefly in the 2017-2022 National Development Plan, based on the recently completed review of the progress made in implementing the ENRP-II. The priority continues to be: (1) the promotion of good governance and public sector reform; (2) promoting sustainable and inclusive growth; (3) strengthening human capital and providing social services; and (4) the intensification of social cohesion and social protection.

1.7.1.1. Health

The epidemiological profile of Sao Tome and Principe is marked by the predominance of noncommunicable diseases, in which the tendency is increasing. Communicable diseases continue to be a public health problem, with a high incidence of acute respiratory diseases, diarrheal diseases and other communicable diseases or such linked to the environment. These are the main causes of morbidity and mortality. The country has been vulnerable to epidemics, with an outbreak of rubella in 2015, an outbreak of rotavirus diarrhea in 2016 and an outbreak of necrotizing cellulitis in 2016/2017.

Maternal mortality in Sao Tome and Principe has been declining substantially in recent years. Several factors contributed to this reduction, namely the combination of services and measures to strengthen the system, increase in the number of assisted births, maternal death audits, improvement in the referral chain to the community level, set ups of obstetric care facilities and several awareness-raising campaigns for women to go to health centers closest to their area of residence.

Acute respiratory diseases, fever and dehydration due to severe diarrhea are the main causes of morbidity and child mortality. According to the latest data from the Expanded Program on Immunization (EPI), infant mortality in children under 5 years of age has been declining. Immediate demand for medical care from pregnant women and mothers and prompt medical attention to children suffering from the above-mentioned diseases is crucial for increasing the well-being of children and reducing child mortality.

Sao Tome and Principe has maintained very high and equitable coverage of vaccination against preventable childhood diseases in recent years. According to the MICS 2014, 65.8% of children 12 to 23 months of age are fully immunized and have complied with the recommended vaccination plan before the first year of life, as recommended by the WHO.

The fertility rate in STP has declined in the last 10 years, currently being 4.4 children per woman. There are regional variations with urban-rural disparities, where rural women have higher fertility rates than urban women.

The use of modern contraceptive methods among women at the national level has increased. The most used contraceptive methods are injectable and oral contraceptives, representing 17.9% and 18.5% of current users; the IUD represents 4.1% of choices, female sterilization 3.5%, male condom 1.5% and subcutaneous implant 1.2% (PSR, 2016).

Noncommunicable diseases (NCDs) are an emerging problem in STP, as in many developing countries. The noncommunicable diseases program includes cardiovascular diseases, endocrine diseases (such as diabetes mellitus), chronic respiratory diseases, tumor diseases, musculoskeletal diseases, as well as oral health and ophthalmological diseases. The increase in NCDs is due to multiple factors, such as the adoption of unhealthy lifestyle, and the increase in the average life expectancy of the population.

With regard to HIV / AIDS, more recent data show a trend towards reducing the epidemic. The new infections had an incidence rate of 0.6% in 2013 (UN / SIDA report 2014 annex 9). STP currently has an epidemic situation with a low HIV / AIDS prevalence: the population between 15 and 49 years of age went from 1.5% in 2008 to 0.5% in 2014 and from 15 to 24 years old went from 0, 8% in 2008 to 0.1% in 2014.

In the 1980s, malaria accounted for 40% of infant mortality cases. The first National Plan of actions "Roll Back Malaria 2001-2010" was oriented to the prevention and early treatment in health centers. Its implementation has led to a compliance of various Development Partners, thus producing a reduction in mortality caused by malaria by 90%.

The country is currently considered hypo-endemic (with low transmission). However, according to the WHO, despite progress in reducing prevalence, disease still contains a high epidemic potential.

The success of malaria control in Sao Tome and Principe has been internationally recognized as a result of strong ownership, leadership and vision on the part of the country, as well as a coordinated partnership aligned with the priorities and needs of successive governments.

The Strategic Plan for Combating Malaria aims to eliminate this disease throughout the country by 2025 and prevent its reintroduction. The Strategic Plan also aims to reinforce and expand prevention and control interventions such as universal coverage of long-term insecticidal nets, indoor spraying, and a prompt and correct treatment with rapid diagnosis at the community level, integrated case management in the community and in malaria in pregnancy.

1.7.1.2. Access to drinking water

Access to adequate water sources and household sanitation are two factors that have a major influence on the health and well-being of the population. Diarrhea is the second cause of mortality in children 0 to 5 years of age, and this is a disease directly related to drinking water and sanitation.

The prevalence of diarrhea in Sao Tome and Príncipe is higher than in all West and Central Africa. The vast majority of the Sao Tome an population has access to improved water sources (93.9%). However, it should be noted that an improved water source does not mean that it is necessarily potable. According to officials of the Directorate General for Natural Resources and Energy, most of the water available in Sao Tome and Príncipe is contaminated with fecal coliforms.

1.7.1.3. Sanitation

The sanitation situation in Sao Tome and Principe shows very slow progress over time and a widespread lack of infrastructure. About 48.4% of the population defecate in the open air, a fact that has improved compared to 2009 (57.7%). Only 4.3% use unimproved facilities, being the income level the most significant factor.

The level of wealth and education of the head of the family are the two most important determinants of hygiene practices. Therefore, if only 24.6% of the households whose head of the family has no education, no water and soap, the number of cases of heads of households with a higher level of schooling rises to 66.9%.

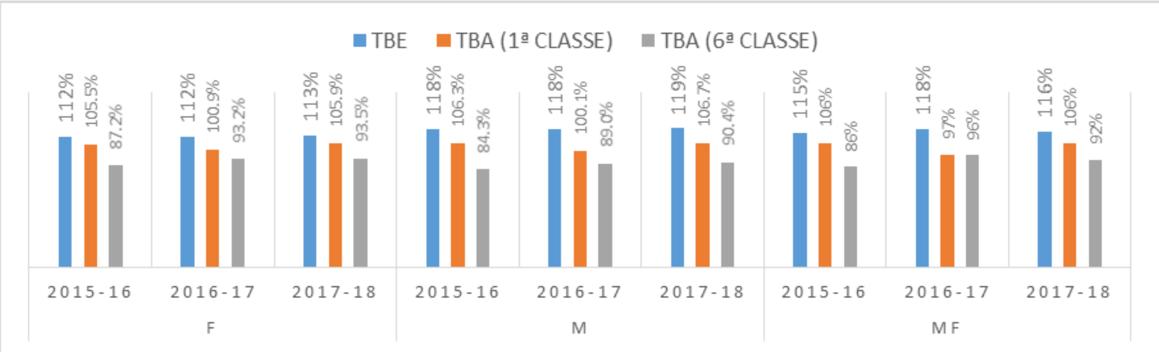
1.7.1.4. Education

Sao Tome and Principe's Educational System has undergone several changes over the years. School education is the central axis of the National Education System, which is organized and governed by the Basic Law of the Educational System (Law no. 2/2003) and includes in its structure the following levels of education: i) Pre-school education (

0-6 years): Daycare and Kindergartens; ii) Basic education: 1st cycle: 1st to 4th grade and 2nd cycle: 5th to 6th grade; iii) Secondary education: 1st cycle: 7th to 9th grade and 2nd cycle: 10th to 12th grade; iv) Professional Technical Education and v) Higher Education.

The Sao Tomean educational system has made remarkable progress in recent years, particularly in the areas of access and gender equity. The gross enrollment ratio (TBE) in basic education is above 100% between the academic year of 2015/16 and the academic year of 2017/18, with the ratio of girls to boys (IPS) being around 1% according to the following table.

Figure 9 - Evolution of Gross Schooling Rates (TBE), Admission (TBA) and Access (TBA) and IPS



Source: MECCC/DGPIE/DEP

There has been progress in the Higher Education level in recent years, particularly with the creation of Sao Tome and Principe Public University (USTP) composed of three units: Faculty of Science and Technology (FCT), Victor Sá Higher Institute of Health (ISC) and Higher Institute of Education and Comunication (ISEC) and the existence of three private higher education establishments operating in the country, namely the University Institute of Accounting and Informatics (IUCAI), Universidade Lusíada de Sao Tome e Principe and the University of Évora (UÉvora).

1.7.2. Evolution of the main indicators of education

Overall, school coverage has shown some improvement from the academic year 2001-2002 to 2014-2015 at all levels of education. However, there was a decline in school enrollment in Pre-School in 2012-2013 (Gross Rate 23.6%), but a positive recovery in the following years (Gross Rate 26.5% and 27.3%), more specifically in the years 2013-2014 and 2014-2015.

Table 9 - Evolution of the main education indicators.

Ensinos	Indicadores	2014/2015	2015/2016	2016/2017	2017/2018	META (2018)
Pré-Escolar	Taxa de Cobertura para crianças de 4 anos de idade	49%	60%	57%	82	82%
	Taxa de Cobertura para crianças de 5 anos de idade	52%	59%	63%	75	82%
	Nº de crianças por Profissionais	40	32	17	17	30
	Professores com formação pedagógica	31%	19.7%	19%	18%	90%
Básico	Nº de escolas com seis classes (1ª-à-6ªclasse)	33%	36%	39%	25%	40%
	Nº de alunos por turma no 1ºciclo	34	35	33	35	30
	Nº de alunos por turma na 5ªclasses	49	51	49	46	43
	Nº de alunos por turma na 6ªclasses	50	49	47	43	43
	Taxa bruta de escolarização	117%	115%	118.1%	119%	116%
	Taxa de promoção	85%	85%	86.9%	88%	89%
	Taxa de repetência	13%	14%	11.6%	10%	9%
	Taxa de abandono	2%	1%	1.5%	2%	2%
	Professores com formação pedagógica	36%	29,2	26%	31%	70%
Secundário	Nº alunos por turma no 1º ciclo	63	54	50	47	45
	Nº alunos por turma no 2º ciclo	75	54	51	49	45
	Taxa bruta de escolarização no 1º ciclo	111%	114%	122.5%	107%	120%
	Taxa bruta de escolarização no 2º ciclo Secundário via Geral	62%	63,40%	77.8%	86,3%	61%
	Taxa de acesso ao 1º ciclo	85%	95%	90.4%	80,2%	107%
	Taxa de promoção	79%	75%	68%	63%	84%
	Taxa de repetência	13%	20%	29%	23%	11%
	Taxa de abandono	8%	5%	3%	14%	5%
	Taxa de repetência no 1º ciclo	22%	27%	27.6%	25,4%	17%
	Taxa de repetência no 2º ciclo	2%	13%	29.7%	20,5%	2%
	Taxa de conclusão do 12º ano	21%	48%	41.9%	44,7%	25%
	Professores com formação pedagógica	40%	44%	44%	40%	70%

MECCC, 2018.

1.7.2.1. Literacy

Sao Tome and Principe's level of literacy is already quite high when compared to some similar countries[11]. The current literacy rate is 90.1%, a small increase compared to the 2001 rate of 83.1% (INE, 2012).

This high rate however, disguises the differences between urban and rural areas, where there is a rate of 91.4% in the urban area and 87.6% in rural areas. Likewise, the differences between the sexes are significant, being 94.9% for men and 85.5% for women. Hence it can be seen that the illiteracy phenomenon affects mainly the older population, the female population and the rural population, which means that future policies should aim to reduce these disparities.

[11] Comparable countries : Cape Verde : 84.9%, Angola: 70.4%, Guinea-Bissau: 55.3%, Gabon: 88.4%, Mozambique: 56.1%, Ivory Coast: 56.2% Seychelles : 91.8%

Aware of this situation and of the weight it represents for the Sao Tomean economy, the country set as its objective by the year 2022, its eradication, through the expansion of access network, improvement of quality and learning efficiency and of the fight against illiteracy. The objective aims to strengthen the institutional capacities of the Technical and Vocational Education and Youth and Adult Education Department (DETPEJA).

1.8. Climate Change and Sustainable Development Goals

Sao Tome and Principe has made some progress in meeting a few SDG targets, including Goal 2: "Ensure access to primary education for all"; Goal 3: "Promote gender equality and empower women"; and Goal 4: "Reducing child mortality.

In the Agenda 2030 framework, in 2015, the MDGs were replaced by the Sustainable Development Objectives (SDGs), of which are broader and more inclusive, and have as a main goal to eradicate poverty in all its forms. The SDGs encompass the economic, social and environmental elements and, within the framework of the commitments assumed, Sao Tome and Principe has been guided by the expansion of the work begun by the MDGs.

However, it should be noted that the implementation of SDG is a huge challenge for any country, especially for STP, because of the number of objectives (17), the number of targets (169) and the number of indicators (231). It was therefore fundamental that the country prioritize 7 SDG that it intends to implement, namely ODS1: End poverty in all its forms, everywhere, ODS8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all, ODS9: Build resilient infrastructures, promote inclusive and sustainable industrialization and foster innovation, ODS13: Take urgent action to combat climate change and its impacts. ODS14: Protecting, restoring and promoting the sustainable use of terrestrial ecosystems, sustainably managing forests, combating desertification, halting and reversing degradation and to prevent loss of biodiversity; and ODS16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels.

1.8.1. Institutions and Legal Framework in the field of Climate Change

Decidedly committed to addressing the environmental problems facing the country and the world today, as a development challenge, the country has been given a legal framework that allows it to take care of the main consequences of climate change. This process was first adopted by the Basic Law on the Environment, Law No. 10/99, which lays down the basis for a sustainable development policy, followed by a legislative package consisting of the following main legislation:

- Law on the Conservation of Fauna, Flora and Protected Areas, Law no. 11/1999;
- Law on Forests, Law no. 5/2001;
- Law of the National Park Obô of Sao Tome and Principe Park, Law nº 6 and 7/2006;

- Law on Fisheries and Fishery Resources, Law no. 9/2001;
- Law on Sea Turtles, Law No. 6/2014,
- The Hunt Law, Law nº01 / 2016;
- Water Framework Law, Law No. 07/2018;
- Regulation on Environmental Impact Assessment, Regulation No. 37/1999;
- Decree on Extraction of Inerts in Coastal Areas and Rivers, Law no. 35/1999,
- Decree on the Management of Urban Solid Waste, Decree No. 36/1999, among others.

From an institutional standpoint, the country created in 2007, through Presidential Decree No. 2/2007, the Directorate General for the Environment (DGA), a structure protected by the Ministry of Infrastructure, Natural Resources and Environment. It is the body responsible for the implementation and coordination of all policies and government strategies on environmental issues and has, among other things, as a mission, the implementation of all environmental Conventions.

Likewise, in July 2012, through Decree 13/2012, the country created the Committee on Climate Change (CNMC), which aims to coordinate, manage, train and raise awareness among the various Sao Tomean agents in matters related to Climatic Changes. It also aims to include policies and measures that promote or result in the reduction of greenhouse gas emissions, as well as measures that reduce the vulnerability of the economy and the population of Sao Tome and Principe, adapting them to the adverse impacts of climate change. Activities to train and improve the CNMC's performance are underway, especially with regard to the coordination of all the activities carried out in the country in the field of climate change. These activities also aim to strengthen the institutional framework and competencies in the field of climate change, prepare legal proposals for better integration of climate change into policies, programs and legal mechanisms, and provide the CNMC with a national communication plan for climate change.

1.8.2. Data source

Regarding the main sources of information on Climate Change in Sao Tome and Principe, it is important to highlight the Ministries' technical services, especially the National Institute of Meteorology (INM), the General-Directorate for the Environment (DGA) and the National Institute of Statistics (INE), Civil Society Organizations (CSOs), Grassroots Communities and International Sources. Under the TNC, the documents resulting from the process will be archived in digital and printed versions in INM and DGA.

1.9. Motivation

Due to their climatological and orographic characteristics, the islands of Sao Tome and Principe have a diverse vegetal heritage, with different forest formations that play an important role in the economic, ecological and social life of the country. According to the National Forest Development Plan (PNDF, 2018-2030), the country has a forest heritage rich in biodiversity, both in quantitative and qualitative terms, that to make full use of it in a sustainable way could constitute a basis for its economic, social and environmental development.

According to Exell, cited by PNDF, the island of Sao Tome has an endemic genus and 87 endemic species of this unique island, representing 14.5% of the indigenous flora. The Autonomous Region of Príncipe also has an endemic genus and 32 endemic species of this unique island (10.2% of the total) and four other endemic species, shared with the island of Sao Tome.

Despite the collective recognition of this potential, the country has known a process of land degradation that has occurred since the colonial period and that in the last 10 - 20 years has known significant exacerbation. The Government began in 1993 the Land Distribution Program, whose negative effect on the country's forest cover was considerable. During the period of this program, 27,121 ha of land were distributed, of which 10,362 ha were allocated to family agriculture and another 7,759 ha to medium-sized agricultural enterprises.

While this Program has contributed to the emergence of a small group of independent farmers and increased production from an environmental standpoint, their impacts have been very negative in terms of preserving the environment, forests and biodiversity. Land distribution has been affected by illegal logging, including areas with declining tree population and forest areas (up to 1,400 m).

According to PNDF 2018-2030, one of the main causes of this deforestation in STP has to do with the fact that a large part of the dwellings is made of wood, (80.1% of the dwellings are made of wood - INE, 2012) and that a large number of secular trees are cut for constructing canoes for fishing activities. The housing sector represents the largest consumption of sawnwood in the country, which has directly contributed to deforestation and forest degradation. In fact, timber and non-timber forest resources have been experiencing growing exploitation, a situation that would have a direct relationship with population growth and, consequently, the demand for housing.

On the other hand, according to statistical data from the Directorate of Forests and Biodiversity, wood for construction is mostly exploited illegally and irrationally without complying with any technical criteria. This illicit form of exploitation produces about 75% of the wood consumed in the country and will undoubtedly be the practice that has contributed most to the process of deforestation and degradation of our forests and consequent increase in soil erosion.

However, it is important to note that forest degradation is more evident than deforestation as a result of increasing anthropogenic pressure in secondary forests, shade forests, savannah and mangroves.

Despite this finding, there are no studies to date that clearly demonstrate the effects of climate change on forests in Sao Tome and Principe. However, the country is exposed to the consequences of climate change and is experiencing extreme climatic events, which often affect the most vulnerable sectors of the climate, such as agriculture and livestock, forests, fisheries, coastal zones, water resources and health.

The preservation of Sao Tome and Principe's flora and fauna has positive effects on the country's economy and consequently on the life of its population, as they are exceptional tourist attractions, hence the need to adopt adequate measures to preserve this natural heritage.

On the other hand, because it is an island country, the pressure on coastal areas that constitute the habitat of some endangered species is even greater as they are subject to coastal erosion.

Similarly, endemic species whose habitat is in forests also present some vulnerability to climate change. The increase of temperature and decrease of precipitation, climatic impacts identified in the climate-based study on Sao Tome and Principe, are elements that could contribute to mitigation in a different way and condition the survival of the species.

2ND PART:

GREENHOUSE GAS INVENTORY

CHAPTER 2: GREENHOUSE GAS INVENTORY

2.1. Introduction

The first two Greenhouse Gas Inventories (GHGI) were produced in 2003 and 2009 respectively with 1998 and 2005 as reference years. This chapter aims to inventory greenhouse gas emissions and removals in the Energy, Industrial Processes and Residues, Land Use, Land Use Change and Forests sectores, referring to the year 2012 in the framework of the Third GHGI of STP, as a result of a compilation of the various sectoral inventories.

2.1.1. Inventory Methodology

The inventorying process began with the development of national frameworks to strengthen capacities in the areas of Methodologies of the Intergovernmental Panel on Climate Change (IPCC) using NAI software and Good Practice Guides (GBP), and methodology for data collection and processing, in which the following working groups were constituted: Energy, Industrial Processes and Waste, Forestry and Land Use Change and Agriculture and Livestock.

In order to carry out the greenhouse gases inventory, a panel of national experts was set up under the coordination of the Ministry of Public Works, Infrastructures, Natural Resources and Environment, which involved various sectors of national life, that permitted the elaboration of a series of sectoral reports describing the level of gas emissions emitted by those sectors.

In fact, a group of national staff engaged in a process of data collection and processing, both in the office and on the field, with the participation of various sectors of national life, of which central government agencies, the private sector, organized civil society, socio-professional groups such as farmers, charcoal farmers, charcoal sellers and housewives, who collaborated in data provision.

2.1.2. Sources of data used

In order to carry out the calculations of GHG emissions and removals, the following gases were analyzed, as in previous inventories: Carbon dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and indirect gases, such as Nitrogen Oxides (NOx), Carbon Monoxide (CO) and Non-Methane Volatile Organic Compounds (NMVOC). The data used were collected from different public and private institutions and from traditional databases.

An analysis of the Third National Greenhouse Gas Inventory, the identification of the different institutions related to the inventoried sectors, as shown in Table 10, and the collection and data analysis allowed to compile information and organize a database, which facilitated GHG calculations using the UNFCCC (United Nations Framework Convention on Climate Change) software.

Table 10 - Sources of data used

Sectors	Data Sources
Energy	EMAE, ENCO, DGRNE, VOA, HBD, ENASA, Customs, Fisheries Directorate, Land Transport Directorate, Tax Directorate, National Statistics Institute, STP AirWays,
Industrial processes	National Institute of Statistics, General Directorate of Environment, Livestock Directorate, Fisheries Directorate, National Roads Institute, Rosema Brewery, artisanal producers of alcoholic beverages
Use of Solvents and Other Products	Lack of data sources
Agriculture	Ministry of Agriculture, National Institute of Statistics, General Directorate of Agriculture, Environment, Livestock Directorate, artisanal producers of alcoholic beverages
Land Use, Land Use Change and Forests	National Institute of Statistics, Directorate-General for the Environment, Directorate-General for Agriculture, Directorate of Forests, Department of the Regional Forest Service, Farmers' Associations, etc.
Waste	National Institute of Statistics, General Directorate of Environment, Directorate of Livestock, Fisheries Directorate, Rosema Brewery, artisan producers of alcoholic beverages, NGO TESE, etc.

2.1.3. Source categories

The main categories of GHG emission sources identified in STP are presented in Table 11 below as being the most significant, accounting for 95% of national emissions - key categories. These were identified following the IPCC Guidelines on Good Practices, using the software provided by the UNFCCC Secretariat.

Table 11 - Main categories of CO_2eq emission sources.

IPCC source category	Sector	Source categories to be evaluated in the main source category analysis	Gas	Emission Estimate (2012), excl. LULUCF) (Gg CO2eq)	Level Assessment excl. LULUCF (%)	Accumulated Level excl. LULUCF (%)
1.A.1	Energy	Fixed Combustion CO_2 Emissions	CO_2	56,5	33,2%	33,2%
1.A.3	Energy	CO_2 Combustion: Road Vehicles	CO_2	30,4	17,9%	69,8%

4.D	Agriculture	N_2O (Direct and Indirect) Emissions from Agricultural Soils	N_2O	31,9	18,7%	52,0%
1.A.4	Energy	Other Sectors: Residential CO_2	CO_2	11,7	6,9%	76,7%
6.A	Waste	CH_4 emissions from solid waste disposal sites	CH_4	6,5	3,8%	80,5%
1.A.3	Energy	CO_2 Combustion: Maritime Navigation	CO_2	6,3	4,1%	83,4%
1.A.4	Energy	Outros setores: Residencial CH_4	CH_4	6,2	4,1%	87,5%
4.A	Agricultura	Emissões de CH_4 provenientes da Fermentação Entérica na Pecuária	CH_4	4,9	3,2%	90,7%
1.A.5	Energia	Other Sectors: Residential CH_4	CO_2	3,7	2,4%	93,1%
6.B	Waste	N_2O Emissions from Wastewater Treatment	N_2O	3,1	2,0%	95,1%

2.1.4. Quality control / quality assurance

The process of control and quality assurance of collected data and information includes the following procedures: data documentation, process of archiving data sources and results. In the latter, it was verified that the values presented in the worksheets coincided with the values outlined in the reports, as well as in the tables.

For the quality control of data activity, a data collection procedure was prepared in advance to ensure their reliability and a cross-checking of the values provided by the different institutions was carried out.

The quality control and assurance procedure also include:

- A comparative analysis between current and previous inventories in order to determine inconsistencies in GHG estimates, gaps and possible errors or use of some non-standard data;
- The present inventory has counted with the support and constant revision of a Brazilian consultant and a review by other international consultants, since the initial phase of its elaboration;
- Observation of the considerations and recommendations issued during the GHGI 2005 review by the sectoral teams, in a judicious way, in order to improve the quality of this inventory;
- Verification of the inventory by the Monitoring and Evaluation Committee;

- Inventory review by international experts in the review of GHG inventories;
- Inventory checking by specialists in the Global Program to Support National Communications;
- Inventory correction based on reviewers' recommendations;
- Official inventory validation.

2.2. Estimate / General emissions Situation

2.2.1. Estimated emissions by sector in 2012

The main sectors of GHG emissions according to the inventory based on the reference year 2012 are energy, agriculture, waste and LULUCF. However, the LULUCF sector, despite being an emitter, is involved in sequestration, so in terms of energy balance, the country is not an emitter. Emissions by sector are as follows:

Table 12 - Evolution of the main GHG emission sectors.

Sector	Amount of CO_2 Eq	%
Energy	118,4	74,4
Industrial processes	-	
Agriculture	24,5	15,4
LULUCF	5,8	3,6
Waste	10,4	6,5
TOTAL	**159,1**	**100**
Removal (LULUCF)	**326,6**	

2.2.2 Evolution of the emissions of GHG of STP

Table 13 below shows the evolution of emissions between 1998 (ICN) and 2012 (TNC), in CO_2eq.

Table 13 - Emissions Evolution (1998-2012)

Year	1998	2005	2012

Sector	CO_2 eq. emissions (Gg)	CO_2 eq. removals (Gg)	CO_2 eq. emissions (Gg)	CO_2 eq. removals (Gg)	CO2 eq. emissions (Gg)	CO2 eq. removals (Gg)
1 Energy	55,3		71,7		118,4	
2 Industrial procs.	---		---		---	
3 Use of Solvents and Other Products	NE		NE		NE	
4 Agriculture	26,3		22,9		24,5	
5 Land Use and Forest Change (LULUCF)	1,1	-358,0	1,1	-381,0	5,8	-326,6
6 Waste	6,6		7,8		10,4	
TOTAL (excl LULUCF)	**88,2**		**102,4**		**153,3**	
TOTAL (incl LULUCF)	**89,3**	**-358,0**	**103,5**	**-381,0**	**159,1**	**-326,6**
Balance (incl LULUCF)	**-268,7**		**-277,5**		**-167,5**	

From the analysis of the contribution emissions of the different inventoried sectors in 2012, the energy sector is the largest emitter of CO_2eq with 118.4 Gg in the country, followed by Agriculture and Waste, with 24.5 Gg and 10, 4 Gg, respectively. Regarding the Land Use and Forestry sector, there was a sequestration of 320.8 Gg CO_2eq.

Although there was a reduction in the CO_2 balance of around 40% in 2012, the country continues to have a CO_2 sequestration capacity higher than the amount of emissions due to its forests. However, this sequestration capacity tends to decrease, due on the one hand, to the increase in emissions, mainly in the energy sector and, on the other hand, to the reduction of the sequestration capacity of our forests as a result of deforestation. This may constitute a future concern of the country in relation to the problem of climate change.

2.3. Energy

2.3.1. Characteristics of the Sector

STP's energy sector is fundamentally characterized by use of fossil fuels (100% import), electricity generation, transportation, industry and other domestic uses, representing 57% of the primary energy balance in 2012, while biomass represents about 42%, especially for cooking and some small industry. Hydroelectricity is very low, with a contribution of 1% (Table 13).

The main fuels imported and used in 2012 are Diesel, Gasoline, Jet A1, lubricants and butane gas.

Biomass, which comprises firewood and charcoal, is a source of energy widely used by most of the population in kitchens, in the baking industry in industrial drying.

2.3.2. National Energy Balance

The National Energy Balance (BEN) data indicates that the main sources of energy used in the country are firewood and diesel fuel, representing respectively 41.1% and 37.5% of total consumption in 2012, as shown in Table 14.

Table 14 - Energy consumption in STP, year 2012.

Designation	TJ	TEP/TJ	TEP	Percentage%
Diesel	1 100,70	23,88	26 284,72	37,53
Gasoline	246,00	23,88	5 874,48	8,39
Oil	171,50	23,88	4 095,42	5,85
JetA-1	9,20	23,88	219,70	0,31
Lubrication oil	198,10	23,88	4 730,63	6,76
Gas	1,10	23,88	26,27	0,04
Firewood	1 206,00	23,88	28 799,28	41,12
Hydraulic energy	23,00	23,88	549,24	0,78
Total	**2 955,60**	**23,88**	**70 579,74**	**100,00**

Source: Adapted from BEN (National Consultants, 2016).

In 2012 the total energy consumption in STP reached 2,955.60 TJ. The main sources of energy consumed were diesel and firewood, 1,100.70 TJ and 1,206.00 TJ respectively. This is because the country's electricity generation is of thermal origin through diesel oil-fired power stations and that the majority of the population makes use of firewood as a domestic energy source for cooking.

Given the weak utilization of the country's potential in hydropower, this renewable energy source represented a consumption of only 23.00 TJ.

In 2012, wood consumption was 92.63 kt, of which 68.29 kt were used directly for domestic and industrial consumption and 24.34 kt for coal production. The consumption of coal was 11.82 kt, according to Table 15.

Table 15 - Distribution of biomass consumption, year 2012

Designation	Estimated consumption in kt in 2012
General Used Wood:	92,63
Wood used as firewood	68,29
Coal wood	24,34
Coal [12]	11,82

Source: *INE, DF-MADR, DI-MECI*

One of the difficulties encountered at the energy sector level was the compilation of biomass consumption data, as there are no statistical data available. To overcome this situation, the team used data from the Industry Directorate regarding the number of small bakery industries, as well as the volume of consumption of firewood used in their activities during the year 2015, from which extrapolation was made of energy consumption based on population growth.

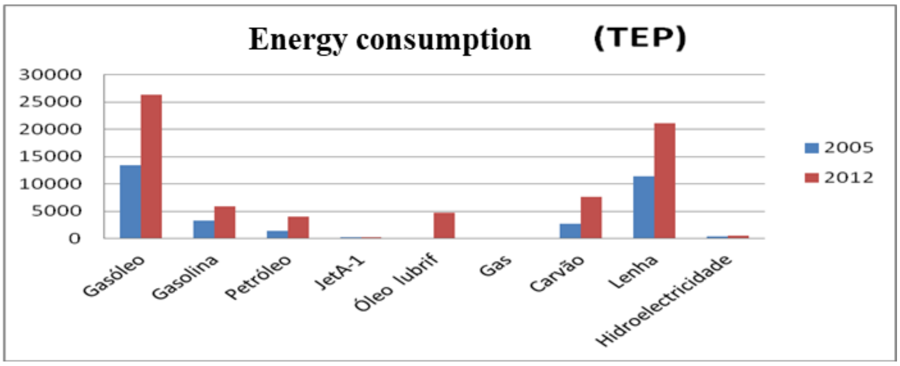
In the case of domestic consumption of firewood and coal, the methodology applied by FAO was used. According to FAO 2010, in sub-Saharan Africa the firewood consumption estimate is 0.99 m^3/inhabitant. Therefore, to obtain domestic consumption, statistical data on population growth for the year 2012 were used.

2.3.2.1. Consumption comparison 2005-2012.

Figure 10 shows the comparison of the country's energy consumption for the years 2005 and 2012.

[12] Result of wood used for coal

Figure 10 - Energy consumption 2005-2012



According to figure 10, in 2012 energy consumption doubled in relation to 2005 in almost all types of fuel, especially in the case of gas oil and firewood. This is due to the fact that, as population grows, there is more demand and the country continues to rely heavily on gas oil for electricity generation as well as the use of wood destined directly for domestic consumption and industrial and coal production, the latter being one of the means of subsistence of the population.

Butane gas represents a source still very little used for domestic consumption. In comparative terms this trend does not differ much from the year 2005.

2.3.3. Sources of emissions categories

According to the IPCC guidelines, this category is divided into two main categories, the burning of fuel in fixed and mobile sources and fugitive emissions.

In the case of STP, only fuel burn is applied. The following subsectors were considered:

- Energy industry
- Manufacturing and construction industries
- Transportation:
  - Terrestrial
  - Civil Aviation
  - Shipping
- Other Sectors (Residential, Agriculture / Forestry / Fishing and Self-Generation)

Activities considered as sources of fugitive emissions, according to the IPCC, are exploration and handling of mineral coal and those related to the oil and natural gas industry and oil refining. Because these activities are not developed in the country, they are not considered in this inventory.

2.3.3.1. Electricity Production Sub-sector

In 2012, the installed capacity[13] for electricity production was 29.6 MW, of which 27.3 MW were of thermal origin and 2.3 MW of water, that is, only 8% of the total installed capacity. However, due to technical restrictions, most of the generators of the thermoelectric power plants were inoperative, and so the system was not able to meet the 16 MW demand.

The annual production of thermoelectric electricity was 70,470 MWh and the electricity production of hydric origin was only 6,386 MWh, as indicated in Table 16.

Table 16 - Electricity generation in STP from 2005 to 2014

Year	Electricity Production		
	Thermal (MWh)	Hydraulic (MWh)	Total (MWh)
2005	37 206,00	4 248,00	41 454,00
2006	39 058,19	3 767,76	42 825,95
2007	41 415,51	7 629,99	49 045,50
2008	43 040,44	7 668,11	50 708,55
2009	41 658,79	7 260,66	48 919,45
2010	52 416,12	4 788,62	57 204,74
2011	61 487,02	5 739,30	67 226,32
2012	70 470,87	6 386,00	76 856,87
2013	76 785,11	6 390,00	83 175,11
2014	81 846,67	7 696,20	89 542,87

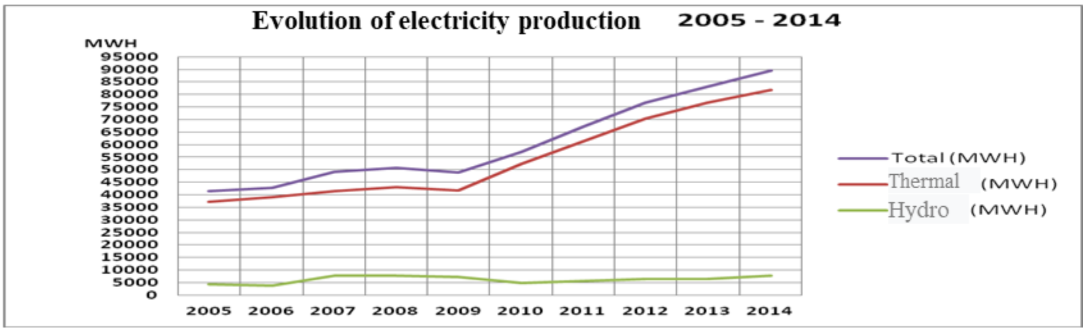
Source: *EMAE, DGRNE, 2016*

As shown in Figure 11, electricity production from 2005 to 2009 grew moderately. In the following years this tendency increased significantly with the installation of more

[13] Installed power data provided by EMAE

thermal power stations. Consequently, with the increase in installed capacity, as previously mentioned, fuel consumption has also increased. However, hydroelectricity generation did not increase significantly, showing a weak evolution in production from 4,248 MWh in 2005 to 6,386 MWh in 2012.

Figure 11- Evolution of electricity production from 2005 to 2014



2.3.3.2. Transportation Sub-Sector

Transportation plays a key role in the socio-economic development of any country, as it ensures the mobility of people and goods, hence enabling exchanges and trade.

The impact of the transport sector is even greater if we consider the fact that it is the second largest consumer of fossil fuels, totaling 12,848.87 TEP, corresponding to 28.7% of general consumption.

For the present study, the following means of transportation were considered, considering the specific characteristics of the country: Air Transport, Maritime Transport and Road Transport.

2.3.3.2.1. Air Transportation

In the air transport subsector, there has been an increase in the number of flights, both domestic, internal connections between the islands, as well as international. The average national energy consumption in 2012 was 9.2 TJ of Jet A1.

For international flights, there was an average annual consumption of 147.5 TJ Jet A1. However, the burning of Jet A1, despite being accounted for, was not reflected in the GHG emissions for the country, thus being considered Bunkers and reported as memo items.

2. 3.3.2.2. Maritime transportation

Maritime transport is not very significant regarding GHG emissions. There are only small passenger and cargo vessels linking the islands, as well as small fishing boats and motor canoes that are supplied by STP, representing an average energy consumption in 2012 of 90.9 TJ.

Vessels which establish long-distance international connections and large-scale fishing vessels are not supplied in the country and do not even land at national ports. Therefore, there is no record of their fuel consumption.

2. 3.3.2.3. Road Transportation

The road transport subsector, represented by motorcycles, light and heavy passenger and cargo vehicles, registered a growth up to the year 2010, from which there was a decrease in imports, as shown in figures 12 and 13.

Light and heavy vehicles are usually imported from Europe, being mainly used cars, with more than 5 years of use. Most of these cars are used as private taxis and cars. However, motorcycles are new vehicles, usually imported from African coast countries.

Figure 12 - Evolution of imports of motor vehicles by class

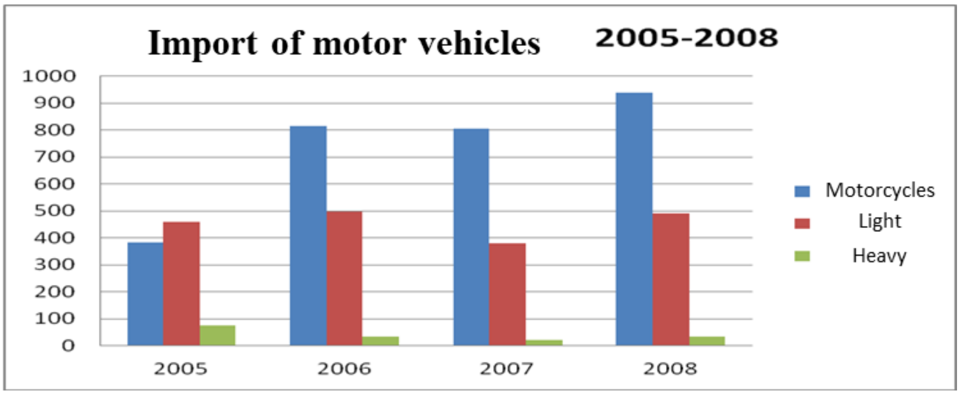
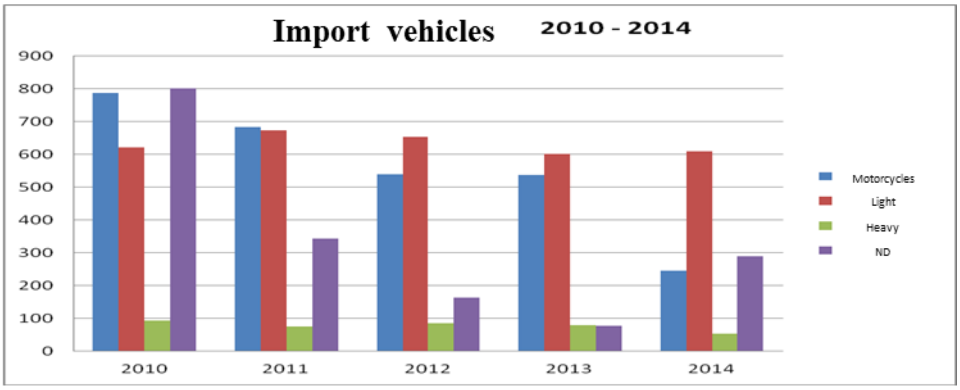


Figure 13 - Evolution of imports of motor vehicles by class



Considering the non-existence of a mandatory and regular vehicle inspection system as well as vehicle tax avoidance of, it was not possible to account for the number of vehicles in circulation, using only the estimates made by consultants, based on the information provided by the institutions involved.

Estimates were made by crossing data collected from the Land Transportation Office, Tax Office and Customs Directorate, where the vehicle numbers were obtained by type and by type of fuel. According to characteristics of the country's car park, it was possible to estimate the average consumption of the different classes. Data on total consumption for the road transport subsector are given in Table 17.

The average energy consumption for the road subsector was estimated at 429.8 TJ in 2012, representing, therefore, 81% of the consumption of the transport sector.

2.3.3.3. Other sectors

Other sectors considered are Residential, Agriculture / Forestry / Fishing and Self-generation. It should be noted that, despite representing the third largest GHG emitter at the energy level, after the energy industry and transport sector, these sectors have a very important representation regarding energy consumption, especially in the case of oil, gas butane and biomass. The consumption of these forms of energy is registered in its entirety by the residential or domestic, commercial and institutional sectors, as can be seen in Table 18, which shows the distribution of consumption per subsector.

The average energy consumption for the "other sectors" category was estimated at 1,444.3 TJ corresponding to 49.2% of total consumption in 2012.

2.3.4. Estimation of GHG emissions, energy sector

In order to obtain the GHG emissions result, the conversion and emission factors presented in Table 17 were used, according to the guidelines of the "IPCC Revised Guidelines for National Greenhouse Gas Inventories" manual.

Table 17 - Conversion and emission factors

Items	Fuel	TJ / Unit Conversion Factor	TC / TJ Carbon Emission Factor	Oxidized Carbon Fraction
1	Gasoline	44,8	18,9	0,99
2	Diesel	43,3	20,2	0,99
3	Lubricant oil	40,19	20	0,99
4	Jet A1	44,59	19,5	0,99

5	Kerosene	44,75	19,6	0,99
6	Butane gas	48,15	15,3	0,995
7	Coal	29,308	29,9	0,87
8	Firewood	16,477	29,9	0,87

Source: IPCC 1996.

According to data on fossil fuel and biomass consumption by sectors, in terms of fossil fuels, diesel is the most consumed fuel used for energy production and for transport (1,100.7 TJ), while for biomass, wood is the most consumed fuel, according to Table 18.

Table 18 - Distribution of consumption by subsector (TJ)

	FOSSIL FUELS									
	Burning for energy production					**Transport burning**				**Total TJ**
			Other Consumptions					Air Transport		
	Electricity generation	Domestic Consumption	Comercial institucional	Agriculture Forest	Others	Road Transport	Sea transportation	Interna l Flights	International flights (Bunkers)	
Diesel	770,1				19,84	261,17	49,590			**1100,7**
Gasoline		2,9	6,6	1	23,2	141,5	70,1			**245,9**
Jet A1								9,2	147,5	**156,7**
Oil		161,8			9,7					**171**
Lubrificant	190,7				0,8	4,7	1,8			**198**
Butane Gas		0,5	0,5		0,1					**1,1**
					BIOMASS					
Firewood		836,1	62,3							**1060,8**
Coal		243,4	76,3							**319,7**

Source: Adapted from BEN.

2.3.5. Results of GHG emissions for the energy sector

Table 19 shows GHG emissions for the energy sector. According to the results, energy industry and transport sectors account for almost all emissions.

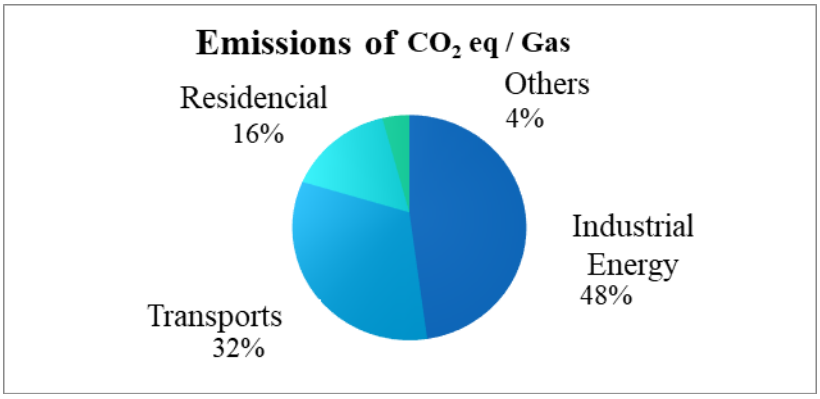
Table 19 - GHG calculation results, year 2012

GHG SOURCE AND CATEGORIES	CO_2	CH_4	N_2O	NOx	CO	NMVOC
Total Energy	109,77	0,339	0,005	0,745	8,351	0,886
A. Fuel Use Activities (Sector Approach)	109,77	0,339	0,005	0,745	8,351	0,886
1 Energy Industry	56,47	0,002	0,000	0,154	0,012	0,004
2 Manufacturing & Construction Industry	NE	NE	NE	NE	NE	NE
3 Transport	37,39	0,01	0,00	0,45	1,66	0,32
a Civil Aviation	0,65	0,00	0,00	0,00	0,00	0,00
b Road transport	30,40	0,00	0,00	0,31	1,57	0,30
c Rail transport	NO	NO	NO	NO	NO	NO
d Sea transport	6,35	0,00	0,00	0,14	0,09	0,02
4 Other sectors	12,23	0,33	0,00	0,14	6,67	0,56
a Commercial / Institutional	0,46	0,03	0,00	0,01	0,85	0,05
b Residential	11,70	0,30	0,00	0,12	5,83	0,52
c Agriculture / Forest / Fishing	0,06	0,00	0,00	0,00	0,00	0,00
5 Others (Self-generation)	3,67	0,00	0,00	0,01	0,00	0,00
B. Fugitive Emissions of Fuel	NO	NO	NO	NO	NO	NO
Memo Item						
International Bunkers	10,44	0,00	0,00	0,04	0,01	0,01
Aviation	10,44	0,00	0,00	0,04	0,01	0,01
Maritime	NO	NO	NO	NO	NO	NO
CO_2 emissions from biomass	115,03					

It should be pointed out that emissions from biomass and Bunkers were calculated in the energy sector for information purposes, and to avoid double counting, emissions from biomass are considered only in the forest sector, since the Bunkers are not part of the country's net issuance.

Regarding emissions for the energy sector, there was a total of 118.4 Gg CO_2eq, in which the energy industry subsector contributed with 48%, the transportation subsector with 32%, followed by the residential sector and others with 16% and 4% respectively, according to figure 14.

Figure 14 - Distribution of CO2 eq emissions from the energy sector



2.3.5.1. Comparison between the sectoral method and the reference method

Calculations of CO_2 emissions from fuel combustion can be made at three different levels referred to as levels 1, 2 and 3 in the IPCC Guidelines. Level 1 methods focus on the estimation of emissions starting from the amount of carbon from fuels supplied to the country as a whole (the Reference Approach) or from the main fuel combustion activities (Sector Approach). This latter method was developed in parallel with its equivalent to calculate non-CO_2 gas emissions from fuel combustion and responds to the need for emissions data by sector for the formulation of mitigation and monitoring policies.

For this inventory, method from level 1 was used, permitting a comparison between the calculation of CO_2 emissions for the Reference Approach and Sector Approach. Table 20 shows the emissions result using the two methods.

Table 20 - Fuel combustion: CO_2 emissions (Gg) using reference and sectoral methods

Sector	Method	2005	2012
Energy	Reference	66,49	110,51
	Sectoral	66,32	109,77
DIFFERENCE		-0,17	-0,74

The comparison of the results of CO_2 emissions obtained using the reference method and the sectoral method allow to verify the validity of the calculations made. The reference method uses the total values of the national energy statistics, while the sectoral method uses biased values for each source category, which together add up to a total of the Energy sector. The source of information, in both cases, was BEN.

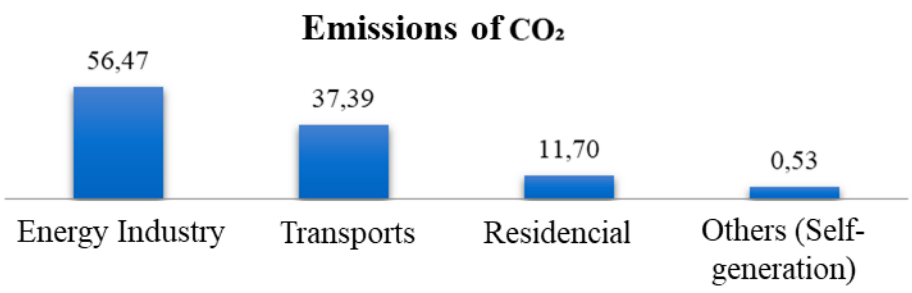
It should be noted that the GHG emissions between the two methods do not present significant differences (Table 20), being of approximately less than 1% of the CO_2 emissions. This is an acceptable difference, lower than that required by the IPCC Guidelines, which may be up to 5%.

2.3.5.2. Emissions of greenhouse gases by sub-sectors

According to figure 15, CO_2 emissions reached 111.52 Gg. The energy industry sector with 56.47 Gg and the transport sector with 37.39 Gg account for almost all carbon dioxide emissions due to the direct burning of fossil fuels.

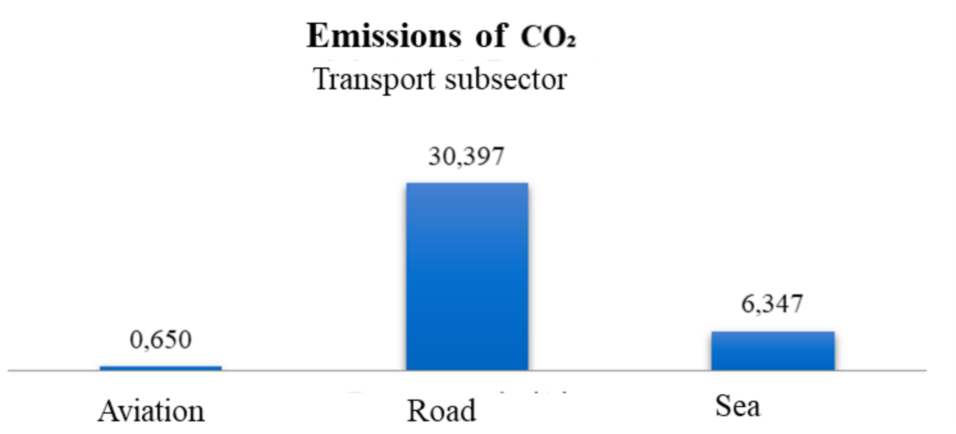
It should be noted that emissions from biomass and bunkers were accounted for but were not considered emissions for the energy sector.

Figure 15 – CO_2 emissions from the energy sector in Gg



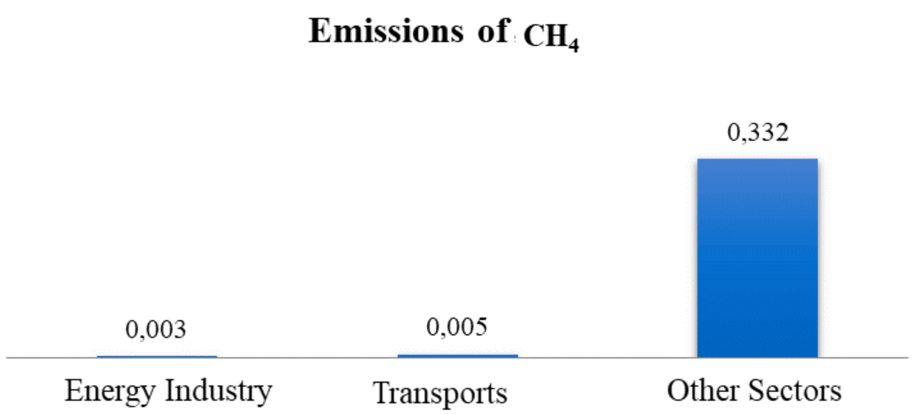
Among the transport subsectors, road is the one that emits more CO_2 with around 30,397 Gg, followed by maritime navigation with around 6,347 Gg, as shown in figure 16.

Figure 16 – CO_2 emissions from the transport subsectors in Gg



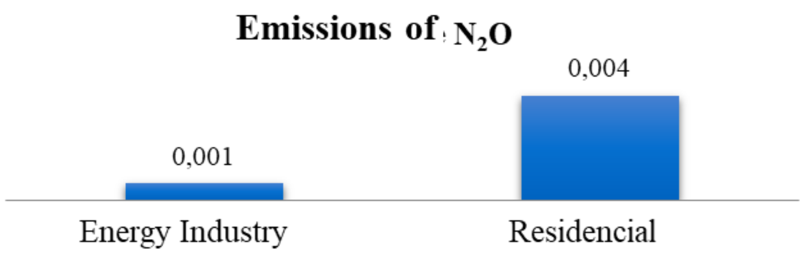
The total methane (CH_4) emission is 0.339 Gg, with the residential sector as the main emitter, with 0.298 Gg, due to the consumption of coal and firewood as household energy, corresponding to almost all emissions, followed by the transport subsector with 0.005 Gg, as shown in Figure 17.

Figure 17 – CH_4 emissions by subsector, in Gg



The residential sector emitted 0.004 Gg of N_2O, according to figure 18, which constitutes almost all emissions, and is explained by biomass burning in domestic activities.

Figure 18 - N_2O Emissions by sector in Gg



The transport sector is the largest emitter of NOx, with a special highlight for terrestrial transport with an emission of 0.307 Gg. The energy industry, maritime transport and residential subsectors are the subsequent largest emitters, with 0.154 Gg, 0.136 Gg, 0.123 Gg, respectively, as shown in Figure 19 below.

Figure 19 - NOx emissions by sector in Gg

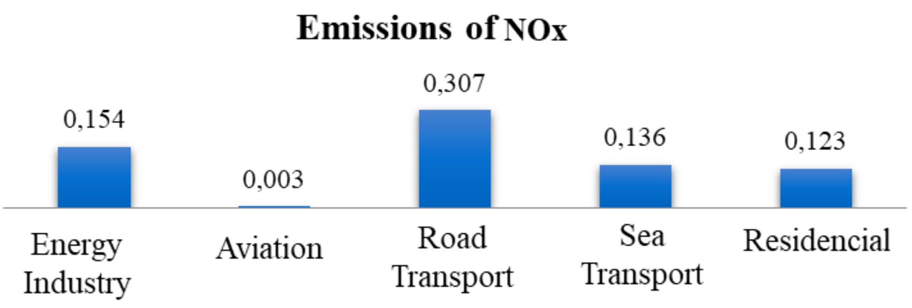
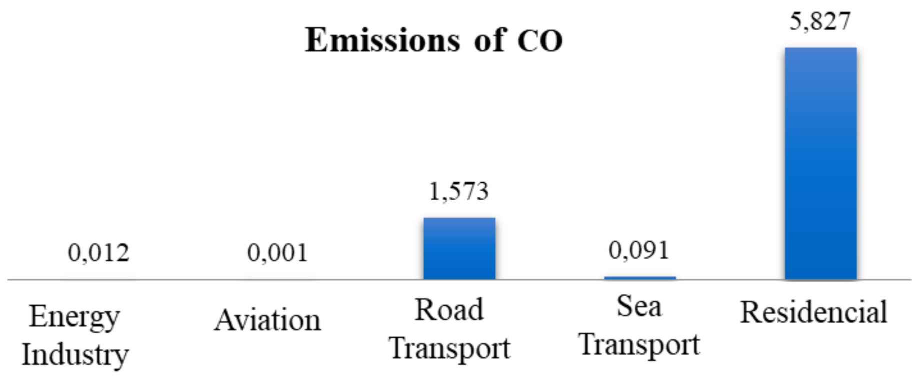


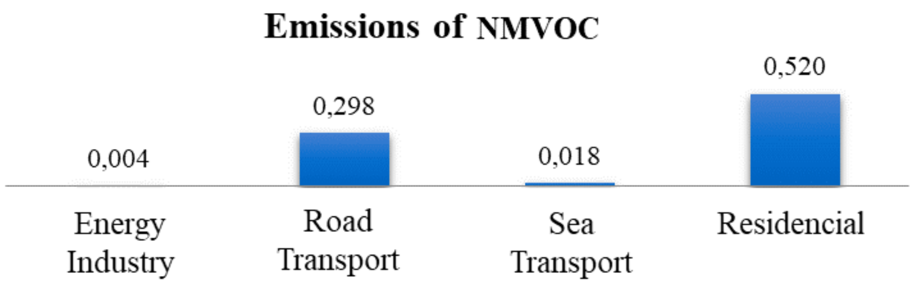
Figure 20 shows that the residential subsector is responsible for 5.827 Gg of CO emissions, followed by the terrestrial transport's subsector with 1,573 Gg.

Figure 20 - CO Emissions by sector in Gg



According to Figure 21, the residential subsector emits more than 50% of NMVOC emissions, ie 0.520 Gg, followed by land transport subsector with 0.298 Gg. Firewood and coal burning are the main activities responsible for NMVOC emissions for the residential subsector.

Figure 21 - NMVOC emissions, by sector in Gg



2.3.6. Comparison of total emissions of 2012 with those of previous years

Table 21 shows the total GHG emissions for reference years 1998, 2005 and 2012. There was little evolution of emissions between 1998 and 2005, as opposed to the year 2012 when there was a variation of 46.7 CO_2eq, compared to 2005, corresponding to an increase of 65%.

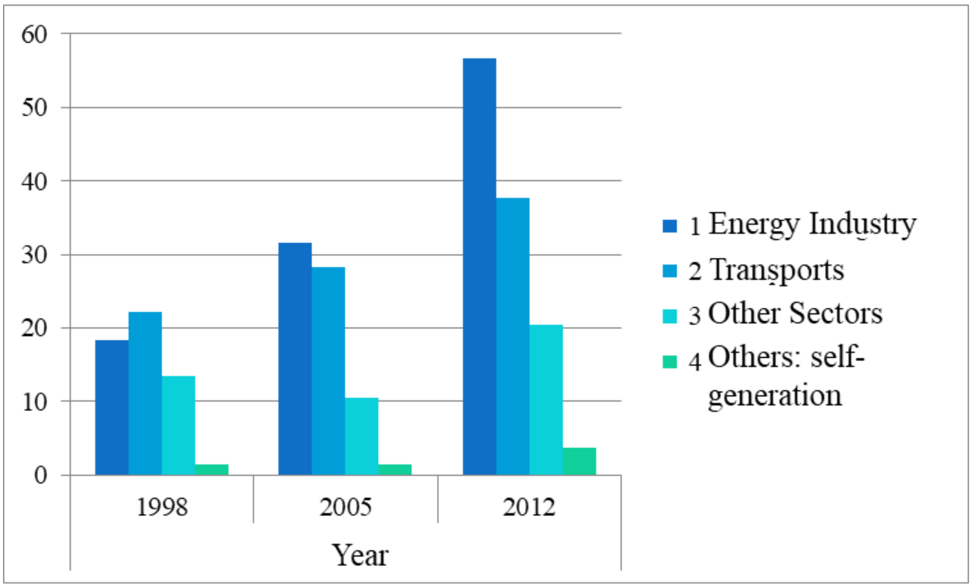
It should be noted that recalculations were carried out for the previous inventories, where a data analysis was performed, resulting in a better distribution of fuel consumption by sectors, as shown in Table 21.

Table 21 - Evolution of GHG emissions from the Energy Sector

Categories / Emission CO$_2$ eq (Gg)	Year			2012-2005	
	1998	2005	2012	Variação	%
1 Energy industry	18,3	31,5	56,7	25,2	80%
2 Transports	22,3	28,3	37,6	9,3	33%
a Air Transport	0,4	0,6	0,7	0,0	4%
b Land transportation	21,5	22,8	30,6	7,8	34%
c Sea Transport	0,3	4,9	6,3	1,5	30%
3 Other sectors	13,4	10,4	20,4	10,0	96%
a Commercial / Institutional	0,2	0,1	1,3	1,2	1200%
b Residential	13,2	10,3	19,0	8,7	84%
c Agriculture / Forest / Fishing	0,0	0,0	0,1	0,1	756%
4 Others: Self-generation	1,4	1,4	3,7	2,3	164%
Total energy	55,3	71,6	118,4	46,7	65%

Figure 22 shows the evolution of GHG emissions between 1998 and 2012, where there is an increase in all sectors, with a stronger emphasis on the Energy Industry sector.

Figure 22 - Evolution of emissions from the Energy sector in t CO$_2$ eq



2.3.7. Recalculation of inventories from previous years and their differences.

According to Table 22 below, and following the same 2012 methodology mentioned before, the results of the GHG emissions of the energy sector in CO_2eq and their differences after the recalculations are presented.

Table 22 - Recalculation of GHG emissions for previous Inventories

Categories / CO_2 eq emission (Gg)	Year			
	1998	1998 Recalculation	2005	2005 Recalculation
1 Energy Industry	19,0	18,3	32,5	31,5
2 Transports	22,2	22,2	28,3	28,3
a Air Transport	0,4	0,4	0,6	0,6
b Land transportation	21,5	21,5	22,8	22,8
c Sea transportation	0,3	0,3	4,9	4,9
3 Other sectors	14,2	13,4	10,9	10,4
a Commercial / Institutional	NE	0,2	NE	0,1
b Residential	14,2	13,2	10,9	10,3
c Agriculture / Forest / Fishing	NE	0,0	NE	0,0
4 Others: Self-generation	NE	1,4	NE	1,4
Total energy	**55,4**	**55,3**	**71,7**	**71,6**

An analysis of the results presented in Table 22 shows that only the Transport category has maintained the same. For the other categories, there were slight changes, considering that data were updated based on a better distribution of fuel consumption by sectors, using data projection, based on the energy balance of 2012.

The previous data were reassessed with their respective sources, namely the EMAE and the Directorate of Industries, resulting in an improvement and allowing the team of national consultants to carry out recalculations in order to facilitate comparisons of GHG emissions.

2.4. INDUSTRIAL PROCESSES

2.4.1. Industry Characteristics

In STP the industrial activity is not significant in the country's economy, seeing as the industrial park is very incipient. It is characterized by low diversification, low production and a limited number of small and medium-sized enterprises, and their contribution to GHG emissions is insignificant.

The main industrial establishments are: food industry (beer, baking, fish and palm oil), saponification industry, wood processing, furniture construction, shipbuilding and metal-mechanics. Other light industries such as building blocks manufacture and the printing industry are also of importance.

2.3.2. Source categories

The categories of sources traditionally considered as GHG emitters in the industrial processes sector are: Chemical industry, mineral production, metal production, production and consumption of fluorinated gases, etc.

In national terms, the categories of GHG emission source for the industrial processes sector do not have great significance. The lime and cement, metallurgical and steel industries are not represented here.

Although STP does not have the main sources of direct GHG emissions (CO_2, CH_4, N_2O), there are other emission sources in the country, which were used in the preparation of this inventory, whose production processes generate non-methane volatile organic compounds (NMVOC), as shown in Table 23.

Table 23 - Main categories and subcategories of GHG emission sources for the industrial processes sector

Categories	Subcategories	GASES (Gg)	GHG emission
Mineral Production	Use of asphalt for road paving	NMVOC	O
Other Productions	Food production	NMVOC	O
	Alcoholic beverage production	NMVOC	O
Consumption of (HFC, PFC and SF6)	Refrigeration and air conditioning	HFC, PFC e SF_6	NE

Regarding the source of GHG emission through refrigeration and air conditioning equipment, it was not possible to make an estimation from this subsector. The lack of information did not make it possible to estimate emissions of HFCs, the family of gases used in this case, thus leaving a gap.

PCFCs gases, and SF_6 were also not subject to inventory due to the unavailability of statistical data and reports that could mention their position at the national level.

Regarding industrial production of soap, animal feed and palm oil, the activity is not currently practiced in the country, as the production of palm oil only began in 2017/2018. Therefore, they did not serve as basis for calculating emissions in this inventory.

2.3.3. Calculation of GHG emissions

2.3.3.1. Paving with asphalt

The use of asphalt in the repair and construction of roads is of great importance for the country. Roads are classified as national and secondary. In rural communities most of the roads are not paved, and due to its poor condition, it makes it difficult the flow of the products by the population, mainly when precipitations occur.

During road maintenance and repair process, bituminous concrete is used and NMVOCs are emitted.

The calculations were made from data provided by the National Highway Institute (NHI). In 2012, only 37.25 km of national and secondary roads were paved throughout the country.

The total emissions estimated for this subsector were 321.84 tons of NMVOC as shown in Table 24.

Table 24 - GHG emissions derived from the use of asphalt

Asphalt road km	Amount of asphalt material used (t)	NMVOC emission factor (kg / t)	NMVOC emission (t)
37,25	1.005,75	320	321,84

Source: IPCC-1996, INAE

2.4.3.2. Beverage Production

With respect to the alcoholic beverage subsector, STP has a brewery and some artisanal sugarcane distillates. During the manufacture of both beer and distillate, NMVOCs are issued.

The total emissions estimated for this subsector were 0.33 tons of NMVOC as shown in Table 25.

Table 25 - Main categories and subcategories of GHG emission sources for the industrial processes sector

Products	Hectoliter Quantity (hl) / year	NMVOC emission factor (kg / hl)	NMVOC emission (t)
Beer	5136,90	0,035	0,18
Brandy	103,28	15,00	0,15
Total			**0,33**

Source: IPCC-96, DI, DPc, DPs, Rosema Brewery

2.4.3.4. Food production

Regarding food production activity, production of bread, cakes, biscuits and roasting of coffee for the NMVOC estimates for 2012 was taken for emissions calculations.

The total emissions estimated for this subsector were 61.8 tons of NMVOC as shown in Table 26.

Table 26 - Food production and respective GHG emissions

Products	Quantity (t/year)	Emission factor for NMVOC	Emission of NMVOC (t)
Meat, fish and poultry	5 908,40	0,3	1,773
Bread	7 450,96	8	59,608
Cakes and biscuits	465,44	1	0,465
Coffee Roasting	6,22	0,55	0,003
Total			**61,849**

Source: IPCC-1996, INE, DA

2.3.4. Total GHG emissions for the Industrial Processes sector in 2012

Table 27 shows the emission totals for the Industrial Processes sector, where asphalt pavement is the activity that represents the largest source of emissions for NMVOC.

Table 27 - Total Emissions of Industrial Processes Sector

Categories	NMVOC emission (t)
	NMVOC
2A. ASPHALT PAVING	321,84
2D. OTHER PRODUCTS:	65,20
1. ALCOHOLIC BEVERAGE PRODUCTION	3,35
2. FOOD PRODUCTION	61,85
Total emissions	**387,04**

Source: IPCC1996, INE, DA.

2.3.5. Total Comparative Emissions for the Industrial Processes Sector

Table 28 shows the evolution of GHG emissions with some changes in results in relation to previous inventories, as it was verified the need to carry out its recalculation, considering some data update after a careful analysis done by the team in line with data sources.

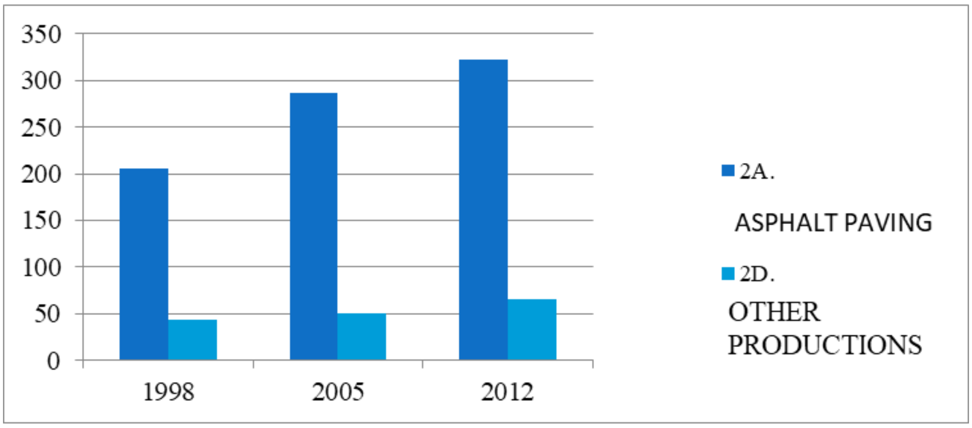
Table 28 - Evolution of CO_2eq emissions from industrial processes

NMVOC emission (t)					
Categories	**NMVOC**			**Variation**	
YEAR	**1998**	**2005**	**2012**	**Valor**	**%**
2A. ASPHALT PAVING	205,92	286	321,84	35,84	13%
2D. OTHER PRODUCTIONS:	43,80	50,19	65,20	15,01	30%
1. ALCOHOLIC BEVERAGE PRODUCTION	0,67	2,94	3,35	0,41	14%
FOOD PRODUCTION	43,13	47,25	61,85	14,60	31%

Total emissions	**249,72**	**336,19**	**387,04**	**50,85**	**15%**

Figure 23 shows the evolution of emissions for the subcategories of the industrial processes sector.

Figure 23 - Evolution of NMVOC emissions for the years 2005 and 2012



There is an increase in NMVOC emissions in all subcategories of this sector, with a greater emphasis on food production, where there was an increase of 36%, according to Table 28.

2.3.6. Recalculation of inventories from previous years and their differences.

According to Table 29 shown below and following the same 2012 methodology, as previously mentioned, the results of GHG emissions from the industrial processes sector and their differences after recalculation are presented.

Table 29 - Recalculation of Emissions for Previous Inventories

Categories / Emission NMVOC (t)	Year			
	1998	1998 Recalculation	2005	2005 Recalculation
2A. ASPHALT PAVING	NE	205,92	2133, 22	286,00
2D. OTHER PRODUCTS:	80,93	43,80	185,61	50,19
1. ALCOHOLIC BEVERAGE PRODUCTION	37,80	0,67	138,36	2,94
2. FOOD PRODUCTION	43,13	43,13	47,25	47,25

Total emissions	80,93	249,72	2318,23	336,19

Analyzing the results of Table 29, it turns out that only the Food Production subcategory did not suffer any changes in the results. As for the other categories, there were significant changes due to data update, especially in the total of asphalted roads and production of brandy, which experienced a significant decrease.

2.5. Agriculture

2.5.1. Sector characterization

2.5.1.1. Livestock sub-sector

Animal production is one of the human activities that can produce gases that contribute negatively to the environment and to the greenhouse effect and global warming.

Therefore, with the development of livestock activity in Sao Tome and Principe there will be an increase in the number of ruminants that may contribute to an increase of greenhouse gas emissions and, consequently, to the degradation of ecosystems.

In the national context, the dominant species are: non-dairy cattle, goats, sheep, pigs and chickens. These species are raised in a system of small family farms. Table 30 shows the evolution of the species in recent years.

Table 30 - Evolution of livestock numbers in STP (2010-2014)

Year / Especies	2010	2011	2012	2013	2014
Bovine	1 221	1 223	1 274	1 382	1 501
Goat	26 990	26 973	28 931	31 954	33 911
Sheep	2 783	2 786	2 855	3 270	3 462
Swine	31 243	31 267	31 826	31 854	32 683
Galliformes	291 164	220 055	226 250	242 439	307 220

Source: Livestock Division of Sao Tome and Principe / MAPDR.

2.5.1.2. Agricultural land use sub-sector

The islands of Sao Tome and Principe can be divided into three main zones of agricultural production:

- The coastal zone, where palm trees, coconut trees and horticulture with the presence of some cacao plantations, are predominant;
- The main area of cocoa production, between 100 and 600 m, and
- The area of coffee production, between 600 and 1000 m.

Many of the marginal areas formerly occupied with cocoa and coffee have been progressively abandoned in recent decades, giving room for secondary forest formations or "capoeiras".

The cultivated area throughout the country in 2012 totaled 50,908.6 hectares, with cocoa accounting for 26,724.1 ha, equivalent to 52.5% of the total (GEPMADR). The remaining area is distributed by other industrial crops, such as coconut, palm, coffee, pepper and sugarcane, with 16,726.5 ha equivalent to 32.86% of the area, and food crops occupying 7,458 ha. which is equivalent to 14.64%.

The use of nitrogen fertilizers is frequent in STP and for this reason they are considered in the current report, along with calculations of possible emissions of nitrous oxide in agricultural soils.

2.5.1.3. Savanna Burning Subsector

The savanna of Sao Tome occupies a section that borders the island's maritime coast, from the airport to Roça Praia das Conchas and Lagoa Azul, in variable width.

This edaphoclimatic formation constitutes an exceptional vegetation that was developed in the space left by the tropical dry forest of the North and Northeast of the island, probably as a result of the destruction of the original vegetation for plantations during the sugarcane cycle of the past century.

It is a flat region where the predominant vegetation is grassy plants, scattered trees and isolated shrubs in small groups, characterized by scarce (semi-arid) water, two seasons - one hot and rainy, and one relatively cold and dry - with fertile soils where concentrations of trees are not frequent, even though there is a good presence of animals of different species (mammals, birds and insects).

Savanna burning occurs mainly in the coastal zone, where herbaceous type vegetation predominates. The vegetative cover within the savanna, is shrub and usually resistant to fire (Forest Management, 2016).

Savanna burning usually occurs naturally, but it is also man-made in the agricultural practice, according to interviews with farmers and charcoal farmers.

2.5.1.4. Subsector for Burning of Agricultural Residues

The main crops in which waste is burned and thus contribute to the increase of GHG emissions to the atmosphere are sugarcane, corn and tomato.

The country has an estimated sugarcane plantation area of 231 hectares and an annual production of approximately 11,550 tons (Directorate of Agriculture, 2009). In 2012, there was a 10% increase in cultivated area and production, considering the growing number of farmers engaged in the production and sale of brandy. Therefore, the estimated cultivated area is 254.1 ha and the estimated production is 15,638 t (Table 31).

Regarding corn cultivation in 2012, the cultivated area was estimated at 482.5 ha distributed in the north, center and other regions of the country, and production was 2,359 t (Table 31).

As for tomato, a plant of tropical origin, the climatic characteristics of our country provide conditions widely favorable to its development, enabling up to four production cycles per year.

Table 31 - Production of Tomato, Sugarcane and Maize in Tons

Year	2010	2011	2012	2013	2014
Crops					
Tomato production (t)	1 488	1 636	1 799	1 978	2 175
Sugar cane production (t)	12 925	14 217	15 638	17 201	18 921
Corn Production (t)	1 474	1 769	2 359	2 555	2 949

Source: CADR, Food Crops Project, Ministry of Agriculture, 2016.

The practice of burning crop residues has always been used in agriculture to clear crops, to facilitate harvesting, to combat pests or to clear pastures. However, this technique, from the point of view of the protection of the environment, is counterproductive in that it contributes directly to an increase in emission of gases to the atmosphere and reduces the content of organic matter in the soil.

2.5.2. Source Categories

The main categories of GHG emission sources from activities arising from the Agriculture sector are:

- Enteric Fermentation;
- Manure Management;
- Agricultural Soils;
- Burning of Savannas;
- Burning of Agricultural Residues.

2.5.3. Greenhouse gas emissions calculations

2.5.3.1. Enteric fermentation (CH_4)

The methane (CH_4) emissions from enteric fermentation in animals results from the production of this gas as a by-product generated during the microbial digestion process of hydrocarbons in the digestive system. This process occurs mainly in ruminant animals (cattle, sheep and goats), but also occurs in smaller quantities in monogastric animals (swine, horses and rabbits).

Table 32 shows the data and default factors used for the calculations of GHG emission estimates for that subsector.

Table 32 - CH_4 gas emission through enteric fermentation

Type of Animals	Animal herds (head count)	Emission Factors (kg CH4 / animal / year)	CH_4 Emission (t)
Non-dairy cattle	1 274	32	40,77
Sheep	2 855	5	14,28
Caprine	28 931	5	144,66
Swine	31 826	1	31,83
Galliformes	226 250	-	-
Total CH_4 Emission			**231,52**

Source: Livestock Division, IPCC 1996.

The total GHG emissions resulting from the enteric fermentation subsector for the year 2012 was 231.52 t CH_4.

2.5.3.2. Manure Management: (CH_4) and (N_2O)

Methane (CH_4) emissions from livestock effluents occur when organic matter decomposes during storage or treatment in anaerobic environments by the action of metallogenic bacteria. Methane formation is very common in anaerobic effluent management systems such as anaerobic ponds, anaerobic digesters, nitrates or fossas.

Nitrous oxide (N_2O) emissions occur during the management or storage of effluents because of nitrification and denitrification processes that involve the nitrogen portion of the ammonia in the effluent. This biological process consists of the oxidation of ammonia in nitrites and nitrates in an aerobic environment (nitrification) and, later, in the reduction of nitrates in nitrogen and in N_2O in an anaerobic environment (denitrification).

In the national context, for the estimation of N_2O emissions, the following manure management systems were considered: Solid storage and dry plots, and pastures and prairies.

N_2O emissions from pasture and grassland systems (grass) are not considered in this subsector but are instead considered in the Agricultural Soils subsector.

For the calculation of CH_4 and N_2O emissions from manure management systems, the IPCC 1996 data and default factors were used, as shown in Table 33 and Table 34.

Table 33 – CH_4 emission through manure management

Type of Animals	Nº of herds of animals	Emission Factors (kg / animal / year)	CH_4 emission t
Non-dairy cattle	1 274	1	1,27
Goat	2 855	0,21	0,60
Caprine	28 931	0,22	6,36
Swine	31826	2	63,65
Galliformes	226 250	0,023	5,20

Total Emission	**77,09**

Source: Livestock Division, IPCC 1996.

Table 34 - N_2O emission through manure management

Type of Animals	Nº of herds of animals	Nex (kg / animal / yr)	AWMS manure management fraction (100%) (kg / animal / yr)	EF3 (kg N2O–N/kg N)	N_2O emission (t / yr)
Non-dairy cattle	1 274	40	0,04	0,02	0,06
Goat	2 855	12	0	0,02	0
Caprine	28 931	12	0	0,02	0
Swine	31 826	16	0,2	0,02	3,20
Galliformes	226 250	0,6	0,05	0,02	0,21
Total Emission					**3,48**

Source: Livestock Department, IPCC 1996.

According to Table 33 and Table 34, estimates of GHG emissions from the manure management subcategory were 77.09 t of CH_4 and 3.48 t of N_2O for the year 2012.

2.5.3.3. Agricultural soils (N_2O)

According to the IPCC Guidelines for the Development of National Greenhouse Gas Inventories, Guidelines 1996, N_2O emissions can be direct and indirect.

Direct N_2O emissions occur through the addition of synthetic fertilizers and organic fertilizers, by cultivation of N_2O-fixing plants, by the incorporation of crop residues into the soil, and by mineralization of nitrogen associated with the cultivation of organic soils.

Indirect N_2O emissions are calculated by the amount of nitrogen (N - N) added to the soil as fertilizers, which is volatilized as NH_3 and NOx and deposited into the soil. Emissions can also be calculated by the amount lost by leaching. Disposal of excreta (faeces and urine) from pasture animals should be reported as direct and indirect N_2O emissions.

In this context, the following data were considered for calculations of N_2O emissions from agricultural soils in 2012:

- Nitrogen fertilizers imported and used in agricultural soils;
- Animal manure applied to agricultural land;
- Surface of organic soils cultivated in the country (Surface / ha);
- Data from the FAO database;
- Residues from the harvesting of dried vegetables and dried products from other crops, considering the production of nitrogen fixing and non-fixing crops. However, due to the absence of soybean production in that year and reduced production of other crops, the factors provided by FAO were used.

2.5.3.3.1. Estimates of direct N_2O emissions

In the national context, the direct emissions of N_2O from management of agricultural soils by nitrogen application, come from the following sources:

- By addition, to any type of non-organic soil (No Histosols), synthetic fertilizer, animal manure deposited in soils and crop residues;

- By nitrogen mineralization associated to the cultivation of organic soils (Histosols); and,

- By excreta deposited in meadows and prairies (grass).

For the calculation of direct emissions using artificial fertilizers, animal excreta and crop residues applied to agricultural soils, the IPCC default data and factors were used, as follows:

1. Non-organic soil (No Histosols):
   - ➢ Nitrogen fertilizer

Table 35 - Activity data and default factors used

Nitrogen Fertilizers (Nfert) kg / year	% of Nfert emited directly	EF1 direct emission factor (kg N_2O – N / kg N)
8550 *	90%	0,0125

Source: Simplified IPCC Handbook. * MAPDR.

➢ Animal manure deposited in the soil

The data were treated by applying the N excretion fraction multiplied by the number of livestock and the respective default factor, in the manure management sub-sector in the two systems practiced in the country (solid storage and application in pastures and prairies), resulting in a total production of animal excreta of 1,077,358.00 kg N / year. The nitrogen fraction values by Animal Waste Management System (AWMS) (% / 100) used are: Non-dairy cattle (0.96), Sheep (1), Swine (0.8), Galliformes (0.95) and others (1). The N fraction excreted during grazing of 0,94371[14]. was applied. Other factors used were EF1 (0.0125) and N fraction excreted as NOx and NH_3 (0.2).

➢ Crop residues

Table 36 - Activity data and default factors used

Production of non-N-fixing crops Kg dry biomass / year	N fraction of N non-fixing crops (kg N / kg dry biomass	N-fixing crop production Kg dry biomass / year)	N fraction of N non-fixing crops (kg N / kg dry biomass	Minimum fraction of waste removed from the field	Minimal fraction of field burnt waste
3 962 105	0,015	9 310 050	0,03	0,55	0,75

After the calculations were carried out, the results for direct N_2O emissions were obtained, as indicated in the following table:

Table 37 - Direct Emissions of N_2O (No Histosols)

Source	Direct emission of N_2O in t
Synthetic fertilizer	0,15

[14] Ratio of animal excreta deposited in pastures and agricultural soils / Total animal excreta

Manure applied to soil	0,95
Crop residues	5,49
Total direct emission of N_2O (NO HISTOSOLS)	**6,59**

- Organic soil (**Histosols):**

Table 38 - Activity data, default factors and direct N_2O emissions (Histosols)

Cultivated Area (ha)	EF2 direct emission factor (kg N_2O–N/ha/yr)	Conversion factor	Direct emission of N_2O in t
5,2	10	44/28	0,082

Source: IPCC 1996, module IV, page 4-40, Table 4-18.

- **Estimation of N_2O emissions through excreta deposited in pastures and meadows**

Data were calculated by applying the N excretion fraction multiplied by the number of animals and their default factor in the manure management subsector (Grassland and Grassland Systems), resulting in a total production of animal excreta from 966 688 kg N / year. The values of the Nitrogen Fraction by AWMS (% / 100) used are: Non-Dairy Cattle (0.96), Sheep (1), Swine (0.8), Galliformes (0,95) and others (1).

N_2O estimation through excreta deposited in pastures and prairies, when applying the emission factor EF_3 (0,02) and conversion (44/28), was 30,38 t of N_2O.

2.5.3.3.2. Estimation of indirect emissions of N_2O

The indirect emissions of N_2O considered in this subcategory are as follows:

- Volatilization (as NH_3 and NOx) of N applied as synthetic and organic fertilizers, and
- Leaching of N using synthetic and organic fertilizers.

For calculations of indirect emissions of N_2O through the two subcategories mentioned above, data and default factors were used as indicated in Table 39.

Table 39 - Activity data and default factors used

Subcategories	Use of Synthetic Fertilizer (Nfert) kg N / year	Total Animal Excreta kg N / year	* Fraction /[15] Default Factors		
Volatilization (NH_3 and NO_x)	8550	1 077 358,0	FracGASFS	FracGASM	EF4
N leaching and dispersion			FracLEACH	EF5	

After calculations were carried out for the estimation of indirect emissions of N_2O, the following results obtained are presented in the table below:

Table 40 - Estimation of indirect emissions of N_2O (t)

Source	VOLATIZATION	Leaching
	Indirect N_2O emission in t	Indirect N_2O emission in t
Synthetic fertilizer	0,01	0,10
Manure applied to soil	3,39	12,70
Subtotal	**3,40**	**12,80**
Total N_2O Indirect Emissions (t)	**16,20**	

Table 41 - Recap of default values for parameters

Factors	Values	UM	Emission Factors	Values	UNIT OF MEASUREMENT (UM)

[15] Fraction - data were extracted according to Table 36.

FracBurn	0,25	kg N/kg N	EF1	0,0125	kg N_2O - N/Kg
FracFUEL	0,0	kg N/kg N	EF2	10	kg N/ha/an
FracGASFS	0,1	kg N/kg N	EF3	0,02	
FracGASM	0,2	kg N/kg N	EF4	0,01	kg N_2O–N/kg N
FracGRAZ	0,02		EF5	0,025	
FracLEACH	0,3	kg N/kg N			

Source: Adapted from IPCC 1996, Simplified Manual, revised 1996 version.-.

2.5.3.3.3. Total estimation of N_2O emissions

The total nitrous oxide emissions attributed to cultivated soils were calculated by summing the direct emissions of the soil and adding the animal waste emissions and the indirect emissions of the soil, as shown in the table below.

Table 42 - Estimated total N_2O emissions

Source	N_2O emissions in (t)
Direct emission	37,05
Indirect emission	16,20
TOTAL EMISSIONS	**53,25**

The N_2O emissions of agricultural soils in STP during 2012 were estimated at 53.25 t, with 37.05 t of direct N_2O emissions and 16.20 t of indirect N_2O emissions.

2.5.3.4. Savanna burning (CH_4, N_2O, CO e NOx)

According to the IPCC guidelines (1996), the main GHGs resulting from savanna burning are: CH_4, CO, N_2O and NO_x.

In order to calculate the GHG emissions resulting from the Savanna Burning subsector, data and default factors from the IPCC 1996 were used, according to Table 43.

Table 43 - Activity data and default factors

Burnt savanna area	Savanna biomass density	Fraction burned	Fraction of living biomass burned	Oxidation fraction of living biomass	Oxidation fraction of dead biomass
1250 ha	6,6	0,9	0,55	0,65	1,00
Carbon fraction of living biomass	Carbon fraction of dead biomass	Carbon to Nitrogen Ratio	Emission ratio	Conversion Ratio	
0,45	0,40	0,006	CH_4=0,004 CO=0,060 N_2O=0,007 NO_x=0,121	CH_4=16/12 CO=28/12 N_2O=44/28 NO_x=46/14	

Source: IPCC 1996.

After calculations were carried out for the estimation of GHG emissions resulting from savanna burning, the results were obtained according to the following Table 44:

Table 44 - Greenhouse gas emissions from savanna burning

GHG(t)						
	CO_2	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOC**
Savanna Burning	-	13,5	0,2	6,0	354,3	-
Total emission		**13,5**	**0,2**	**6,0**	**354,3**	**-**

2.5.3.5. Burning of agricultural waste (CH_4, N_2O, CO and NOx)

The gases considered as GHG in the Agricultural Waste Burning Subsector are CH_4 and N_2O and other precursor gases such as CO and NO_x. Although CO_2 emissions resulting from the in situ burning of crop residues occurred, they did not generate a net emission of CO_2 in the atmosphere because the vegetation is growing again between fire cycles.

For the estimation of GHG emissions resulting from the Agricultural Waste Burning subsector, the activity data and IPCC-1996 default factors for the corn case were used. In the case of sugarcane and tomatoes, because they were not included in the list of crops in the IPCC, some factors used in the Brazilian inventory were used.

Table 45 - Activity data and default factors

Crop	Production (Gg)	Waste and production ratio	Dry matter fraction	Fraction burned in the field	Carbon fraction in waste	Nitrogen / Carbon Ratio	Oxidation Fraction
Corn	2,359	1	0,4	0,8	0,4709	0,2	0,9
Sugar cane	15,638	0,18*	0,8	0,8	0,4246	0,0299	0,9
Tomato	1,799	1	0,3	0,3	0,5	0,01	0,9

Source: IPCC1996, * Brazil inventory / 2006

Table 46 - Emission and conversion ratio

Emission ratio	Conversion Ratio
CH_4=0,005 CO=0,060 N_2O=0,007 NO_x=0,121	CH_4=16/12 CO=28/12 N_2O=44/28 NOx=46/14

Source: Table 4-16 (IPCC 1996)

After calculations were carried out for the estimation of GHG emissions resulting from the burning of agricultural waste, the results were obtained according to the following Table 47:

Table 47 - Result of GHG emissions from the burning of agricultural residues.

	GHG (t)					
	CO_2	CH_4	N_2O	NO_x	CO	NMVOC
Agricultural waste burning	-	4,4	0,1	5,3	92,7	-

Total emission	**4,4**	**0,1**	**5,3**	**92,7**	-

In 2012, CH_4, CO, N_2O and NO_x emissions resulting from the burning of agricultural residues in STP, presented relatively low values with emphasis on nitrous oxide that registered an almost zero emission, as shown in Table 47.

2.5.4. Total GHG Emissions from the Agriculture Sector 2012

Table 48 presents GHG emissions in 2012 for the Agriculture sector including Livestock.

Table 48 - GHG emissions from the agricultural sector in the year 2012

Subcategories	GHG (t)			
	CH_4	**N_2O**	**NO_x**	**CO**
4A. Enteric Fermentation	231,5			
4B. Manure Management	77,1	3,5		
4D. Agricultural Soils		53,2		
4E. Savanna Burning	13,5	0,2	6,0	354,3
4F. Agricultural waste burning	4,4	0,1	5,3	92,7
Total emissions	**326,5**	**57,0**	**11,3**	**447,0**

2.5.5. Comparison of GHG Emissions from 2005 and 2012 Inventories

Table 49 shows the evolution of CO_2eq emissions from the agricultural sector from the first inventory, with some changes in the results in relation to previous inventories. This is due to recalculations considering the updating and collection of some data, using the same methodology of 2012, in accordance with the recommendations of the GHGI reviewers of STP.

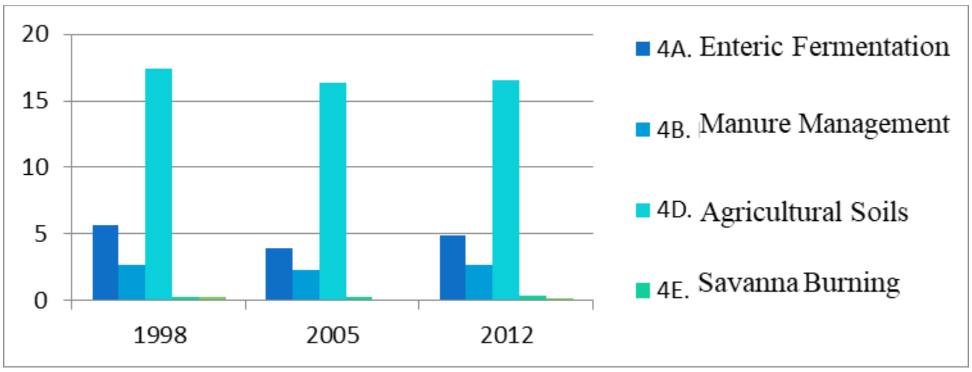
Table 49 - Evolution of total GHG emissions

Subsectors	CO_2 emissions eq (t)				
	1998	**2005**	**2012**	**Variation**	
4A. Enteric Fermentation	5,63	3,93	4,86	0,93	24%
4B. Manure Management	2,70	2,24	2,70	0,46	21%

4D. Agricultural Soils	17,41	16,35	16,50	0,15	1%
4E. Savanna Burning	0,22	0,28	0,34	0,06	21%
4F. Agricultural waste burning	0,29	0,07	0,14	0,07	100%
Total emissions	**26,25**	**22,87**	**24,54**	**1,67**	**7%**

According to Table 49, it can be said that the evolution of CO_2eq emissions does not show great variations, having registered some decrease in 2005 due to a drastic reduction of the ovine species. Nonetheless, there is a slight increase in total emissions in 2012 of around 7%.

Figure 24 - Evolution of emissions from the Agriculture sector in t CO_2 eq



2.5.6. Recalculation of inventories from previous years and their differences.

According to the following Table 50 and following the same methodology of 2012 mentioned above, the results of GHG emissions from the Agriculture sector in CO_2eq and their differences after the recalculations are presented.

Table 50 - GHG Emission Recalculation for Previous Inventories

Categories/Emission CO_2eq (Gg)	Year			
	1998	1998 Recalculation	2005	2005 Recalculation
4A. Enteric Fermentation	5,63	5,63	3,93	3,93
4B. Manure Management	1,64	2,70	1,35	2,24
4D. Agricultural Soils	**NE**	17,41	**NE**	16,35

4E. Savanna Burning	0,49	0,22	0,83	0,28
4F. Agricultural waste burning	0,50	0,29	0,43	0,07
Total emissions	**8,26**	**26,25**	**6,53**	**22,87**

Analyzing the results of Table 50, it is verified that only the enteric fermentation category did not suffer any changes in the results. As for the other categories, there were slight changes considering that new emission factors were used, and that some data were updated.

In 1998 and 2005 the default factors of 40 were used for the ovine species considered as other animals, and 2 for the Residue Ratio / sugar cane production. In both cases, it was corrected using the 12 and 0.18 factors respectively, as used in the Brazilian inventory, 2006.

For agricultural soils, due to lack of data at the time, their emissions were not estimated. The fact that it was possible to collect most of the data through targeted sources and others through estimates based on the 2012 data projection, enabled the team of national consultants to carry out recalculations in order to facilitate comparisons of GHG emissions.

2.6. Land Use, Land-Use Change and Forestry (LULUCF)

2.6.1. Sector characteristics

The vegetation that covered the islands of STP from sea level to the top of the mountains was probably originally made up of tropical forests (Salgueiro & Carvalho, 2012). However, due to changes in land use, these forests have undergone alterations, from which new formations have emerged, resulting from excessive agricultural exploitation of the colonial era and from the agrarian reform policy around 1992. Thus, the country now has a diversity of forest ecosystems, such as:

- Obô or primary forest;
- Secondary forests;
- Shade forests;
- Savannas;
- Mangroves.

Following the implementation of the privatization of agricultural enterprises policy in 1991, logging and forest conversion (especially shade forests) activities in agricultural areas and housing / urban areas have increased significantly. This increase was evident in the surveys carried out in the first and second GHGI.

In the absence of a public housing policy, each citizen has tried to arrange their home, using wood, which is the building material mostly used in the country. Thus, the increase in population directly implies an increase in wood consumption and, consequently, increasing pressure on forest resources resulting in deforestation. Another socio-economic phenomenon that has led to a decrease in the sequestering capacity of Sao Tomean forests, also linked to the demographic increase, is the increasing demand for land for agricultural activities, mainly to produce subsistence goods. Consequently, areas of primary forest outside PNO (Obô Natural Park), secondary forest and shade forest have been cleared by private individuals for the cultivation of bananas, coffee, pepper and horticulture, without any control by authorities.

The phenomenon that most threatens to reduce CO_2 sequestration capacity of forest cover in STPs is the allocation of Agricultural Concessions to foreign companies for large-scale export crops. The tendency of these companies is often to clear hectares of secondary forests in search of new lands for the cultivation of palm trees, cocoa, coffee, among others. The attraction factor of these companies has been the excellent quality of these products of international recognition.

Therefore, the third GHGI for the LULUCF sector should have as its main mission, through calculations, to demonstrate that these phenomena really have had a negative influence on the removal of carbon dioxide. The results will certainly serve to reorient national decision-makers in their procedures for sustainable development of the agricultural and forestry sectors.

2.6.2. Source categories

The LULUCF sector analysis focuses CO_2 emissions and removals that occur as a result of changes in land use and management.

In the national context, the GHG emission source categories analyzed, according to soil type and their use, are:

- Changes in Forest Stocks and other Woody Biomasses
- Conversion of Forests and Pastures
- Abandonment of Exploited Lands
- Emissions and Removals of CO_2 from Soil.

2.6.2.1. Changes in Forests and Other Stocks of Woody Biomass

In accordance with the IPCC (1996) Guidelines for National Greenhouse Gas Inventories (GHGI), only the formations presented in Table 51 were considered in this category. These data were obtained based on the area of forest formations presented in the ENPAB II (2015) and subtracting the areas converted into other uses, namely for pepper, palm and cacauzal (CEPIBA / BIO / STP, 2015, Agripalma, 2015 and SATOCAO, 2015).

Table 51 - Surface of forest formations of the GHGI.

Forest Formation	Area (ha/year)		
	2010	2011	2012
Secondary Forest	30 000,0	29 120,0	28 735,4
Shade Forest	31 940,5	31 951,7	31 738,5
Savanna	4 140,0	4 140,0	4 140,0

Source: Forest Directorate, 2016.

On the other hand, for Salgueiro & Carvalho (2002), estimates of annual biomass growth in STP forests are 2 m^3 / year in secondary forests and 3.5 m^3 / year in shade forests. According to the same authors, the annual increase in productive forests in the 1989 and 1999 is around 7.5 m^3 / ha. In this sense, by calculating the mean value between these two estimates, values of 4.7 m^3 / year for secondary forests and 5.5 m^3 / year for shade forests and savanna were defined.

Regarding logging, although there is no exact data, it is estimated that 90% of the wood harvested on Sao Tome Island is illegal. In this sense, 90% of the wood harvested with the legal authorization of the Forestry Department was added, corresponding to the illegal exploitation. In Príncipe island, given its better control and inspected, the operating records presented were consistent. Table 52 summarizes the total logging in the country.

Table 52 - Total wood exploitation in Sao Tome and Principe

Region	Volume of wood harvested (m^3 / year)		
	2010	**2011**	**2012**
Sao Tome Island (legal)	651,90	3 859,00	407,00
Príncipe Island	2 709,70	2 800,40	1 312,48
Sao Tome Island (ilegal)	5 867,10	34 731,00	36 684,00
COUNTRY TOTAL	**9 228,70**	**41 390,40**	**42 072,48**

Source: Forest Management, 2016

Concerning the consumption of wood for firewood or coal production (Table 52), data on the consumption of firewood and charcoal by the population were used. They were obtained from the general census of population and housing by the National Institute of

Statistics (INE), 2012). These data were then calculated for the remaining years, based on the estimated population growth.

According to FAO (2010), for Central Africa each inhabitant consumes an average of 0.99 m^3 of wood as an energy source. In the absence of reliable data in the country on the consumption of wood by inhabitants or by households, FAO database was used, as recommended in the IPCC (1996) GHGI Guidelines. Considering that each cubic meter (m^3) of wood weighs between 450 kg and 1300 kg, the density of 700 kg / m^3 was chosen, considering that a large part of the wood consumed in the country corresponds to this range, according to the bank of global wood density data from Zanne *et al*. (2009).

Table 53 - Total consumption in tons, of wood for firewood and coal

	2012	2013	2014
Population (total)	178 739	182 328	186 024
Population using wood and / or charcoal	102 954	105 021	107 150
Wood consumed (t / yr)			
Domestic consumption of firewood and coal	71 347	72 780	74 255
Wood consumption in bakeries	4 785	4 881	4 980
Total consumption (wood, firewood and coal)	**76 132**	**77 661**	**79 235**

Source: Forest Management (2016); Directorate of Industries (2015), INE

2.6.2.2. Conversion of Forests and Fields

Given the lack of a database with information on forest statistics at national level, and given that the statistical department of the institution responsible for forest policy (DF) is not sufficiently organized to overcome this difficulty, it was established as a methodology, (Agripalma and SATOCAO), the Pimenta Project and the Agriculture Directorate, in order to carry out data estimates as indicated in Table 54.

Table 54 - Sown areas for crop establishment

Forest Formation	2010	2011	2012	2013	2014
Secondary forest (palm) (ha)	1 240,0	878,0	286,0	428,0	272,0
Secondary Forest (Cocoa) (ha)	--------	--------	98,6	506,8	634,5
Subtotal Secondary Forest (ha)	1 240,0	878	384,6	934,8	906,5
Shade Forest (Chili Pepper) (ha)	29,5	22,8	5,2	7,0	10,8
Shade Forest (Food Crops) (ha)	0,5	--------	208,0	50,0	9,0
Subtotal Shade Forest (ha)	30,0	22,8	213,2	57,0	105,8
TOTAL (ha)	**1 270,0**	**900,8**	**597,8**	**991,8**	**1 012,4**

Source: MADR Agriculture Directorate, 2015, Pimenta Project Directorate, Agripalma Directorate and SATOCAO Directorate.

On the other hand, it is also necessary to calculate the reduced emission of other assimilated gases, in this case of some portions of the primary forest outside the park, of the secondary forest and of the shade forest that are sometimes harvested with fire.

2.6.2.3. Abandonment of Explored Lands

Confronting Sao Tome and Principe's agrarian realities with the IPCC Guidelines (1996), in calculations of sequestration / carbon absorption by the abandonment of exploited lands, the use of the Palmares and coconut trees areas is suggested, considering them as abandoned pastures, and the Shade Forests spaces abandoned by their owners in the last 20 years.

Abandoned pasture areas were estimated at about 3955 ha, resulting from the subtraction of 4,140 ha (savannah area) from 8,095 ha corresponding to the other lands. It should be recalled that "other land" is a category of land use adopted in the National Forest Inventory and essentially encompasses palms, coconut palms and savanna.

2.6.2.4. Changes in Agricultural Soils

Given the difficulty of accurately identifying the different soil types that support each land management system in Sao Tome and Principe, it was based on an analysis of the main types of land management system in the rural area that the shaded forest areas for agricultural crops and a portion of the primary forest outside of PNOST deforested for agricultural purposes were considered as non-intensive management systems for calculations concerning this sub-sector.

Table 55 shows the total area cultivated for horticultural purposes, according to the survey of the associations of producers at national level.

Table 55 - Activity data and default factors used in calculations

CropZones	Number of Producers	Total Field Area (ha)
Portions of Primary Forests Outside the Park	377	81,8
Portions of belched shade forests	5.000	312,5
Total national	**5.377**	**394,3**

2.6.3. Results of emissions and removal calculations

2.6.3.1. Emissions and Removals Relating to Changes in Forests and Other Biomass Stocks

According to the characteristics of the forest typologies, secondary forests were included in the category of wetlands, contrary to the previous GHGI classification; the shade forests in the category of seasonal forests and savannas in the category of dry forests, the latter in agreement with the previous GHGI.

Table 56 shows the activity data and the various default factors used in the calculations of this subsector.

Table 56 - Activity data and default factors used in calculations

	Forest Area / Biomass Stock (kha)	Annual Growth Rate (t dm / ha)	Carbon fraction of dry matter	
Damp	28,74	4,7	0,5	
Seasonal	31,74	5,5	0,5	
Dry	4,14	5,5	0,5	
Collection Categories	**Commercial Harvest (1000 m^3 of wood in logs)**	**Conversion Ratio / Biomass Expansion (t dm / m^3)**	**Total wood as a source of energy (ktdm) FAO date**	**Carbon fraction**
Bark Trunks	42,07	0,95	76,13	0,5

Source: IPCC 1996, FAO.

After the calculations were carried out, the total annual amount of removal of 435.33 Gg CO_2 from the Forest Heritage Changes and the Biomass Stock in 2012 was obtained.

2.6.3.2. Emissions and Removals Relating to the Conversion of Forests and Fields

2.6.3.2.1. CO_2 emissions and removals related to Forest combustion

For the calculation of this subsector the following data and factors were employed, as indicated in Table 57.

Table 57 - Activity data and default factors used in calculations

		Surface converted annually (kha)	Biomass before Conversion (t ms/ha)	Biomass after Conversion (t ms/ha)	Biomass fraction Burned in place	Fraction of on-site oxidized biomass	Carbon fraction of Biomass on the ground
Tropical	Humid, short dry season	0,21319	140	10	0,2	0,9	0,5
	Montanhosas humid	0,38462	105	10	0,8	0,9	0,5
					Off-site burned biomass fraction	Off-site Oxidized Biomass Fraction	Carbon fraction of soil biomass (burned off site)
					0,5	0,9	0,5
					0,2	0,9	0,5
		Surface average converted annually	Biomass before conversion (t ms/ha)	Biomass after conversion (t ms/ha)	Fraction left for decomposition	Carbon fraction of Biomass on the ground	

		(average of 10 years) (kha)					
		0,21319	140	10	0,2	0,5	
		0,38462	105	10	0,8	0,5	

Source: IPCC Guidelines (1996), country data according to the table.

2.6.3.2.2 Non-CO_2 emissions from forest fires

For the estimation of emissions of other gases assimilated to CO_2, the default factors presented in Table 58 were used.

Table 58 - Default Factors

Nitrogen / carbon ratio	Non-CO_2 Gases	Non-CO_2 Gas Emission Ratio
0,01	CH_4	0,012
	CO	0,06
	N_2O	0,007
	NO_X	0,121

Source: IPCC 1996.

The results of emissions of other CO_2-related gases from forest combustion are presented in the table below

Table 59 - Emissions of other gases assimilated to CO_2

GHG Emissions (Gg)		
CO_2-equivalent gas emissions from burning forests in STP	CH_4	0,2504
	CO	2,1908
	N_2O	0,0017
	NO_x	0,0622

According to Table 59 it can be concluded that, of the rare fires that occurred in the forests in 2012, very insignificant amounts of the other gases, assimilated to CO_2, were emitted.

2.6.3.2.3. Land abandonment emissions and removals Explored/Cultivated

For the estimates of emissions and removals related to the abandonment of exploited / cultivated lands, the data and default factors presented in Table 60 were used.

Table 60 - Data and default factors used.

Vegetation Type		Total surface abandoned after 20 years with vegetation regeneration (kha)	Annual rate of soil biomass growth (t ms/ha)	Carbon fraction of soil biomass
Tropical	Wet, short dry season	11,58	5,3	0,5

Source: Forest Directorate, 2016; IPCC 1996.

After calculations of the subsector of emissions of the abandonment of exploited land in Sao Tome and Principe, it was concluded that there was an absorption of 116.76 Gg of CO_2.

2.6.3.2.4. Emissions and Removals Relating to Changes in Agricultural Soils

For the calculation of emissions and removals related to changes in agricultural soils, the data and default factors presented in Table 59, Table 60 and Table 61 were used.

Table 61 - Data and emission factors and default removal used.

Land Use / Management Systems	Soil Types	Soil carbon (t) (Mg C/ha)	Land Areas (t-20) (Mha)	Land Areas (t) (Mha)	Base Factor	Planting Factor	Input Factor
Primary forest outside Obô Park	Low activity soils	60,00	0,003416	0,002995	1	1	1
Primary forest with recent and	Low activity soils	39,60	0	0,000421	0,6	1,1	1

low human intervention							
"Shade" Forest	Low activity soils	60,00	0,022838	0,021622	1	1	1
"Shade" Forest with low human intervention	Low activity soils	39,60	0	0,001216	0,6	1,1	1

Source: IPCC 1996.

Table 62 - Data and default factors used

Agricultural use of organic soils		Land Area (ha)	**Annual Loss Rate (default)** (Mg C/ha/yr)
Tropical	Highland Cultivation	479,14	20
	Pastures / Forests	1580,34	5

Source: Forest Directorate, 2016; IPCC 1996

Table 63 - Data and default factors used

Total net change in soil Carbon in mineral soils	-50
Total net carbon loss from organic soils	0,001

Source: IPCC 1996.

The total CO_2 emissions / removals of soils disturbed by agriculture in STP in the year 2012 was 70, 23 Gg CO_2.

2.6.4. Total emissions and removals results

The summary of results presented in Table 64 highlights that the greenhouse gas absorption continues to have a higher proportion than emissions.

Table 64 - Total GHG emissions and removals through changes in land use and forests

Module Subsectors Land and Forest Use Changes	Gas Type					
	Subsector Emissions and Absorption (in Gg)					
	CO_2		**CH_4**	**CO**	**N_2O**	**NO_x**
5A. Changes in forests and other woody biomass stocks		- 435,330				
5B. Forest and field conversion	155,224		0,250	2,191	0,002	0,062
5C. Abandonment of handled land		- 116,759				
5D. Soil carbon changes	70,232					
Total emissions and absorptions	**225,456**	**- 552,088**	**0,250**	**2,191**	**0,002**	**0,062**
Balance between emissions and absorption	**- 326,632**		**0,250**	**2,191**	**0,002**	**0,062**

Note: Negative values mean CO_2 removals.

2.6.5. Comparison with previous inventory

Table 65 shows the evolution of CO_2eq emissions with some changes in results in relation to previous inventories, as they were recalculated using, in some cases, new emission factors following the same methodology of 2012, in accordance with the recommendations of the last revision, aiming at the improvement of the present GHGI.

In the same table, although slightly, the tendency of the country's GHG emissions sequestration capacity is decreasing, with a decrease of 16% in 2012 compared to the 2005 inventory.

In this comparison, the relative increases in CO_2 emissions caused by the conversion of forests and fields and the change of carbon in soils are also highlighted, with an increase of about 317% in the first category and the second of about 17%.

In general, there are some significant changes in the results of GHGI 2012 regarding the Changes in forests and other biomass stocks sector, considering that, this time, there was more research in data collection due to certain improvements in the inventories.

The results obtained in the Greenhouse Gas Inventory for the LULUCF sector show that Sao Tome and Principe, although showing a decrease in its absorption capacity, continues to be a carbon dioxide (CO_2) sink country.

Table 65 - Evolution of CO2eq emissions and removals

Sub-sectoral absorption and emissions in CO_2 eq (Gg)					
Land Use and Forest Change Sector	**1998**	**2005**	**2012**	**Variation**	
5A. Changes in forests and other woody biomass stocks	-415,9	-438,9	-435,3	3,6	-1%
5B. Forest and field conversion	37,6	38,6	161,0	122,4	317 %
5C. Abandonment of handled land	-78,3	-39,9	-116,8	-76,9	193 %
5E. Soil carbon changes	60,2	60,2	70,2	10	17%
CO_2 eq emissions / removals in Gg	- 396,4	- 379,9	-320,8	59,1	-16%

2.6.6. Recalculation of inventories from previous years and their differences.

According to the following table and following the same methodology of 2012 as mentioned previously, the results of GHG emissions of the LULUCF sector in CO_2eq and their differences after recalculations are presented.

Table 66 - Recalculation of GHG emissions for previous Inventories

Categories/Emission CO_2 eq (Gg)	Year			
	1998	**1998 Recalculation**	**2005**	**2005 Recalculation**
5A. Changes in forests and other woody biomass stocks	-666,1	-415,9	-689,1	-438,9
5B. Forest and field conversion	37,6	37,6	38,6	38,6
5C. Abandonment of handled land	-38,4	-39,9	-38,4	-39,9
5E. Soil carbon changes	58,7	60,2	60,2	60,2
CO_2 eq emissions / removals in Gg	**-608,2**	**- 358,0**	**-628,7**	**- 379,9**

An analysis of the results of Table 66 reveals that the major changes occur in the category of changes in forests and other woody biomass stocks, where there was a noticeable decrease in results after the recalculations. This is due to the fact that a very high annual growth rate of biomass (6.8) was used in the previous calculations against (5,3) for the characteristics applicable to the Santomean forest. Subsequently, the sequestration of CO_2 by the Santomean forests was - 628.7 Gg of CO_2eq. in 2005 changed to - 379.9 Gg of CO_2eq which represents a change of about 60% due to the different default factor used in the calculations.

2.7. Waste

2.7.1. Sector Characteristics

The Waste Sector comprises the subsectors of municipal solid waste, domestic and commercial wastewater and industrial effluents. Emissions from this sector originate from the treatment and final disposal of both solid and domestic and industrial waste.

2.7.1.1. Waste treatment

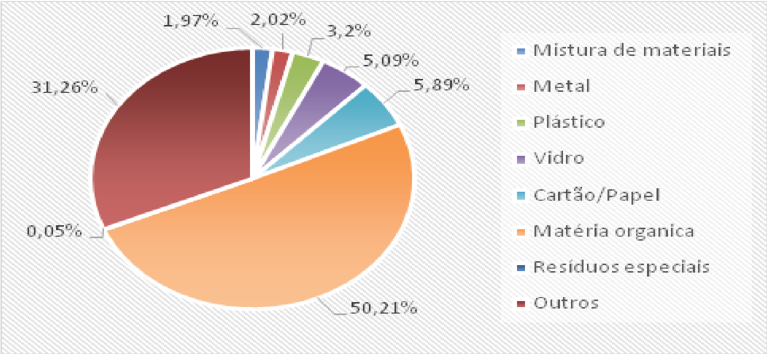
There is still no solid waste treatment practice in STP. In general, waste is deposited undifferentiated in different dump sites mixed with hazardous waste and then burned in the open. This practice contributes to the emission of CO_2 into the atmosphere, as well as emitting other local pollutants, such as dioxins and furans, which are considered persistent organic pollutants, and which harm the health of the population and harm the environment.

There is poor collection of waste at all district levels. There are no adequate treatment facilities, thus difficulting proper waste management. The collection and treatment of municipal solid waste (MSW) is done at Local Government level, but this collection is not done in rural areas. The disposal is usually done wildly in nature without any kind of treatment, thus constituting sources of environmental pollution and risks to public health.

The country's largest rubbish dump is situated in the district with the largest population density, and it is a significant contributor to GHG emissions, since it is an open dump site without any kind of treatment.

Waste is distributed by category into various classes such as organic matter 50.21%, paper / paper 5.89%, plastic 3.20%, glass 5.09%, metals 2.02%, special waste (batteries, electrical and electronic material) 0.05% and others unknown and fine residues 31.26% (PAGIRSU, 2012), as shown in figure 25.

Figure 25 - Physical composition of waste in STP - Adapted from PAGIRSU



It is verified that about 50.21% of the waste produced in the country is organic, corresponding to the production of about 15,026 t / year. Thus, organic recovery is also a key process, since a large majority of methane emissions are due to the degradation of organic matter in controlled dumps and would be a good alternative to avoid methane emissions that occur in the absence of oxygen, by the activity of methanogenic bacteria.

2.7.1.2. Effluents Treatment (sewage)

In STP, the conventional effluent treatment system is not used. The country does not have appropriate technologies or systems for wastewater treatment (ponds, biological filters, anaerobic reactors and wastewater treatment plants). There are, however, alternative treatment systems such as septic tanks and sinks derived from autonomous sanitation through latrines and conventional toilets with discharge and treatment in infiltration boxes and septic tanks with infiltration drain.

The industrial effluents produced in the country come from different sectors such as, for example, the beverage industry. There are no treatment systems for these types of effluents. They are discharged directly into waterways.

2.7.1.3. Waste Incineration

The waste incineration process is not applied in the country. It is an uncontrolled open-burning of undifferentiated waste. As there is no adequate incinerator, the waste produced in the country's hospitals and health centers are deposited and burned out in the open. This practice also applies to other types of hazardous waste produced in the country.

Efforts are being made to install a nationwide treatment system through incinerators that will have the capacity to incinerate hazardous waste from hospitals, health centers and waste from the spraying process. The incinerator will thus guarantee 100% burning efficiency, that is to say, complete combustion, avoiding the release of CO_2, CO and other pollutants into the atmosphere. Only afterwards should the ash deposition be guaranteed safely.

For this inventory, the CO_2 and NO_2 emissions from this subsector were not calculated because there is no practice of incineration of fossil fuel waste, such as plastic and others.

2.7.2. Source categories

In this sector the main source of emissions is methane gas (CH_4) produced during the anaerobic decomposition of the organic matter contained in MSW in the treatment or deposition of domestic and industrial waste and waste water.

The amount of N_2O produced during domestic sewage trajectory and that of CO_2 produced in open flaring of waste causes GHG emissions, depending on the waste composition, which is the only alternative used in the country to treat waste.

In the national context, the main categories of sources of GHG emissions from activities arising from the waste sector are: Deposition of solid wastes (CH_4), Industrial Effluents (CH_4) and Domestic and Commercial Effluents (CH_4 and N_2O).

2.7.3. Calculation of emissions from the waste sector

2.7.3.1. Solid waste disposal (CH_4)

In order to estimate CH_4 emissions by the disposal of RSU in the soil, data were taken on the urban population, climate, the amount of waste produced and their composition.

➢ **Waste Generation Rate**

The daily waste generation per inhabitant in 2012 was 0.35 kg / inhab / day (PAGIRSU, 2012), as shown in Table 67.

Table 67 - Waste production at the country level in 2012

Population	Per capita (kg/day)	Quantity (t/year)
119 781[16]	0,35	15 302,02

➢ **Factors**

For the estimation of CH_4 emissions, the default factors of IPCC1996 were used, as indicated below.

[16]Source: RGPH. INE 2012

Table 68 - Factors used to calculate GHG emissions.

CH_4 correction factor MCF	COD Fraction in MSW	COD Fraction degraded	CH_4 fraction recovered at landfill	Oxidation factor
0,6	0,11	0,77	0,5	1

Source: IPCC, 1996

The default emission factor for the unclassified provision was considered as 0.6 since the country does not have a landfill infrastructure for the destination of the waste.

➢ **Recovered methane (R)**

The amount of recovered methane has not been calculated since there is no landfill that can recover the methane.

➢ **Estimates of CH_4 emissions**

After using the software, CH_4 emissions for the year 2012 were estimated at 311.06 t CH_4, as shown in Table 69.

Table 69 - Emissions of CH4 by solid waste disposal in 2012

Urban population	CH_4 emissions (t)
2 119 781[17]	311,06

2.7.3.2. Industrial Effluents (CH_4)

CH_4 emissions is estimated from the organic matter present in the effluent, expressed in terms of chemical oxygen demand (COD), which measures the total amount of matter available for oxidation (both biodegradable and non-biodegradable).

The system used to estimate methane emissions was the release of effluents in a waterbody, since it is the same treatment used by the only national brewing industry. The plant does not have a wastewater treatment plant, so the wastewater is thrown directly into the sea.

[17]Source: RGPH. INE 2012

Table 70 - Types of treatment used in the country

Treatment Type	Methane Conversion Factor (MCF) [18]	Fraction of treated effluents
Release into water bodies	0,1	0,2

Source: IPCC 1996.

The amount of organic water produced by the industrial source was 441,980.3 kg COD / year, resulting in an estimated methane emission of 2.21 t CH_4, as shown in Table 71.

The value obtained from organic waters is insignificant due to the number of industrial units in the country.

Table 71 - CH_4 emissions by industrial wastewater treatment

Total organic effluent kg COD / year	CH_4 emissions (t)
441 980,3	2,21

2.7.3.3. Domestic and commercial effluents: (CH_4 and N_2O)

2.7.3.3.1. Domestic and commercial effluents: (CH_4)

The treatment system used to estimate CH_4 emissions was an alternative treatment in septic tanks and sinks and sewage discharge into non-collected watercourses.

In order to estimate emissions from the above-mentioned types of treatment, use was made of the default values of the 2006 IPCC Methane Correction Factor. For treatment of septic tank and sinks it was 0.5 and for the release in water courses without collection was 0.1. This use was because there are no IPCC 1996 values for the treatment system identified in this inventory.

[18] Source IPCC 2006

Table 72 - Types of treatment used in the country.

Treatment Type	Methane Conversion Factor (MCF) [19]	Fraction of treated effluents
Septic tank and sinks	0,5	0,1
Release into watercourses without collection	0,1	0,1

Source: IPCC 1996.

The default value of 0.25 kg CH_4 / kg CBO was used for the maximum production capacity of CH_4 (B0) (IPCC, 1996).

For the generation of daily organic load per inhabitant (Ddom), the value of 0.037 kg CBO_5 / inhab / day was used, considering the evaluation of the fraction of sewage treated, the type of treatment in septic tank and launching watercourses without collection. The default value of the degraded organic component (BOD_5) was the IPCC 1996 specific value of 13,505 for Africa, since the country has no official data. The emission factor of 0.02 kg CH_4 / kg BOD_5

The total value obtained from organic waters is 2,413,870.2 kg CBO_5 / year. The total amount of CH_4 emission estimated for domestic / commercial organic waters in the country was 36.21 t CH_4 in 2012.

Table 73 - CH_4 emissions from treatment of domestic / commercial effluents

Total organic effluent kg CBO_5 / year	CH_4 emissions (t)
2 413 870,2	36,21

Because the country does not have a treatment system for sludge resulting from this type of treatment, methane emissions from this source were not calculated.

2.7.3.3.2. Domestic and commercial effluents: Human debris (N_2O)

Emissions of N_2O were estimated from per capita protein consumption based on data from the Food and Agriculture Organization (FAO, 2015), which identifies the value of 61g / person / day which corresponds to 22.27 kg / person / year. The per capita protein value of the closest year 2011 was used for the calculation of emissions in 2012 due to lack of information.

[19] Source IPCC 2006

The IPCC 1996 default factors for nitrogen content and subsequent emission of N_2O, namely the nitrogen fraction in the protein ($Frac_{NPR}$ = 0.16 kg N / kg protein) and the Emission factor (EF_6 = 0.01 kg N_2O-N / kg of wastewater - N produced).

In 2012, the total number of the country's population was about 178,739 inhabitants, according to data IV RGPH, 2012 published by INE.

According to the calculations, the annual total of N_2O emissions in 2012 was 10.01 t according to Table 74.

Table 74 - N_2O Emissions from human debris - 2012

Country Population	CH_4 emissions (t)
178.739	10,01

Source: INE, 2012.

2.7.4. Total GHG Emissions for the Waste Sector, 2012

In order to calculate the total GHG emissions, the waste sector was categorized, with solid waste disposal and domestic and commercial effluents representing the categories with the highest amount of CH_4 emissions, as can be seen in Table 75.

Table 75 - Total GHG Emissions in 2012

Categories	GHG (t)	
	CH_4	**N_2O**
6A1. Solid waste disposal	311,06	
6B1. Industrial Effluents	2,21	
6B2. Domestic and Commercial Effluents	36,21	10,01
Total emissions	**349,48**	**10,01**

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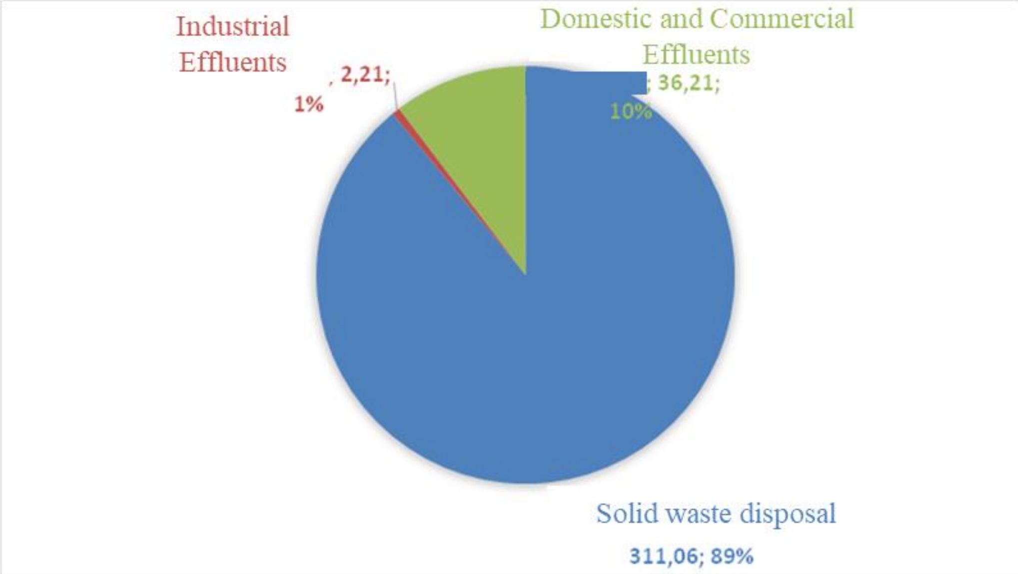
Figure 26 - Share of sources of total methane emissions for the STP Waste sector in 2012



2.7.5. Total comparative emissions for the waste sector

In order to compare the results obtained in this inventory in relation to the previous one, recalculations of GHG emissions of previous years were carried out first.

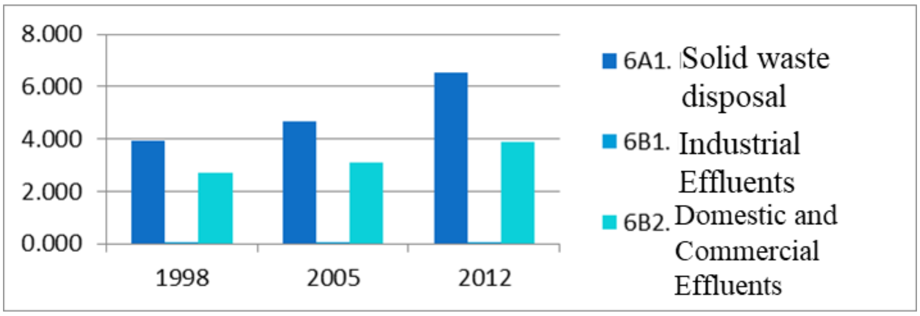
Table 76 and Figure 27 shows the actual evolution of GHG emissions for the Waste sector with recalculations already incorporated.

Table 76 - Evolution of CO_2eq emissions.

Subsectors	CO_2 eq emissions (Gg)				
	1998	2005	2012	Variação	
6A1. Solid waste disposal	3,925	4,684	6,532	1,848	39%
6B1. Industrial Effluents	0,008	0,041	0,046	0,005	12%
6B2. Domestic and Commercial Effluents	2,691	3,092	3,862	0,770	25%
Total emissions	**6,624**	**7,817**	**10,44**	**2,623**	**34%**

Figure 27 shows the evolution of GHG emissions for the sub-sectors mentioned above.

Figura 27 - Evolution of waste sector emissions in t CO_2eq.



2.7.6. Recalculation of inventories from previous years and their differences

According to Table 77 and following the same methodology of 2012 as mentioned previously, the results of GHG emissions from the Waste sector in CO_2eq and their differences after the recalculations are presented.

Table 77 - Recalculation of GHG emissions for previous inventories

Categories/ CO_2 eq emission (Gg)	Year			
	1998	1998 Recalculation	2005	2005 Recalculation
6A1. Solid waste disposal	2,617	3,925	3,568	4,684
6B1. Industrial Effluents	0,000	0,008	0,182	0,041
6B2. Domestic and Commercial Effluents	1,845	2,691	2,120	3,092
Total emissions	**4,462**	**6,624**	**5,870**	**7,817**

Analyzing the results of Table 77, there are changes in all categories of this sector after recalculations, due to the existence of the following new premises :

- Solid waste disposal - the recalculations were carried out with the updating of factors and data, being that in 1998 and 2005 the recalculated results showed some increase according to the table above.

- Household and Commercial Effluents and Industrial Effluents - recalculations were performed considering the same type of treatment used in the 2012 inventory. Data were also updated, being as in 1998 and 2005 almost all the results recalculated had increased, with the exception of effluents where there was a decrease in 2005, as shown in the table above.

- Human debris - In 1998 and 2005 the per capita protein value of 18.25 kg was used, information obtained from the Nutrition Services / Health Care Direction / Ministry of Health. In the recalculation of the data, the official data of FAO of 58g / person / day were used, which corresponds to 21.17 kg / person / year.

2.8. Total GHG emissions results from STP

In accordance with decision 17 / CP.8, non-Annex I Parties to the Convention (NAI) it is encouraged to use Table 1 and Table 2 of these Guidelines to report their GHGI, taking into account paragraphs 14 to 17 decision. It has been taken into account that the second decision concerns the emission of HFCs, PFCs and SF6 gases, which were not the subject of an inventory in this report, as mentioned previously.

Table 78 summarizes the emissions / removals of the main GHGs by the country's sector.

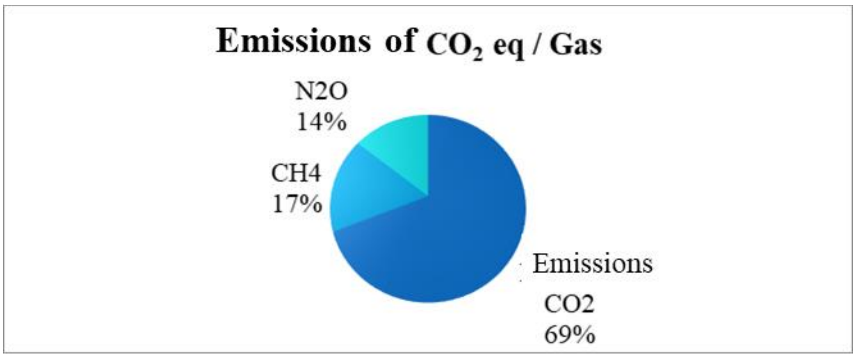
Table 78 - Summary of GHG and Other Gases Emissions by Sector (t)

Sectors	Gases (t)						
	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	NO_x	CO	NMVOC
1. Energy	109769,21		339,45	4,79	744,66	8 350,92	885,70
2. Industrial Processes	-	-	-	-	-	-	387,04
3. Use of Solvents and Other Products	NE	NE	NE	NE	NE	NE	NE

4. Agriculture			326,53	57,05	11,30	447,04	
5. Land and Forest Use Changes	-	-326 631,99	250,37	1,72	62,21	2.190,77	-
6. Waste	-	-	349,48	10,01	-	-	-
Total emissions	**109.769,21**	**-326.631,99**	**1.265,83**	**73,56**	**818,18**	**10.988,72**	**1.272,73**

Figure 28 shows the contribution of the main GHGs to national emissions in 2012, with carbon dioxide (CO_2) being the most significant, accounting for about 69% of national GHG emissions (excluding LULUCF). The second most important gas is nitrous oxide (N_2O), followed by methane (CH_4), representing respectively 17% and 14% of total emissions in 2012.

Figure 28 - Contribution of CO2 eq emissions by gas in 2012 (excl. LULUCF)



3RD PART:

CLIMATE-BASED SITUATION AND SCENARIOS

CHAPTER 3 : CLIMATE BASED SITUATION AND SCENARIOS

3.1. The climate-based situation

Due to its geographic location located in Ecuador, STP presents a humid tropical type climate with two periods : a dry period and a rainy period throughout the year. These periods are determined by the performance of the Inter - Tropical Convergence Zone (ITCZ), also called the Inter - Tropical front, when located on the continents. The ZCIT normally migrates north and south throughout the year following the seasonal shift of the sun, with a 2-3 month lag. In this way, the most rainy periods occur, on average in the months of February to May (when the ZCIT migrates from the southern hemisphere to the North) and from October to December (when the ITCZ moves south).[20]

The start date and / or duration of these periods, as well as the magnitude of precipitation, may vary due to changes in the position and intensity of the ITCZ due to the occurrence of atmospheric disturbances or anomalies in sea surface temperature. The dry season, known in the country as gravana, usually occurs from June to September.

Although the pluviometric STP regime is fundamentally determined by the migration in the ITCZ latitude, the Santomean climate is quite complex, since it is a small archipelago endowed with a very singular topography, that includes elevations of more than 2,000m (Pico de Sao Tome), in an area of only 1,001 km^2.

The most amount of rainfall occurs in the Southwest part of the island of Sao Tome (Quijá and Xufe-xufe river basins) reaching 7,000 mm per year. In this region there is a dense tropical forest. In the northeast part of the island, rainfall is less than 1,000 mm per year, which explains vegetation similar to the savanna (Hydroconseil, 2011). During the dry season, water scarcity is frequent in this area (Oliveira, 2009). The gravana is particularly strong in the north of the island of Sao Tome, at low altitudes. All areas where the precipitation level is less than 50 mm / month during the gravana are located in the north of the island of Sao Tome, in the districts of Água Grande and Lobata. In these areas, it is difficult to maintain horticultural crops without irrigation. In these regions, the highest population densities are also found (Democratic Republic of Sao Tome and Príncipe, 2011).

The identification of changes in observed meteorological records is of great importance to evidence local climate change. Thus, series of observational data are essential for the development of the study. In the STP region, air temperature and precipitation data are only available in five meteorological stations, four of which are located in Sao Tome and one in Príncipe. Of these, only the Sao Tome Airport weather station can be used to detect climate change because it presents the longest time series (57 years) and data

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[20] Sao Tome and Principe Climate Based Situation Report and Scenarios, (2017)

consistency. In other meteorological stations, the data series are less than 10 years, which prevents the identification of a clear tendency from observed data (Table 79).

Table 79 - Information on observational sites located in Sao Tome and Príncipe

Station Name	Observational Data Periods	Observational Sites		
		Latitude (ºN)	Longitude (°E)	Altitude (m)
Airport	1960-2016	0,370	6,720	12
Amélia Lagoon	2009-2014	0,283	6,599	1.360
Santa Catarina	2011-2014	0,250	6,483	245
Angolares	2008-2015	0,130	6,650	11
Príncipe	2008-2010	1,650	7,450	185

3.1.1. Climate Trends

The trend of the annual average temperature for the Sao Tome Airport weather station (figure 29), calculated from the linear trend, indicates an increase of 0.6 ° C between the years 1960 and 2016, that is, an average of about 0.01 ° C per year. The year 1998 had the highest annual average temperature (26.2 ° C) and the year 1964 had the lowest annual average temperature (24.7 ° C), that is, an increase in interannual variability. The five warmest years have occurred in the last 20 years.

For the precipitation trend analysis (figure 30), the annual totals of the observed data sets of the Climate Prediction Center MORPHing technique (CMORPH, Joyce et al., 2004) and the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS, Funk et al., 2015), in addition to the observed series, in order to reduce uncertainty regarding observation. There is a tendency to reduce annual rainfall over the observed series and CMORPH data. The CHIRPS data do not show this tendency, however, it presents values compatible with the observations at the Airport.

Figure 29 - Time series of annual average air temperature (° C) from local observations of São Tomé airport station

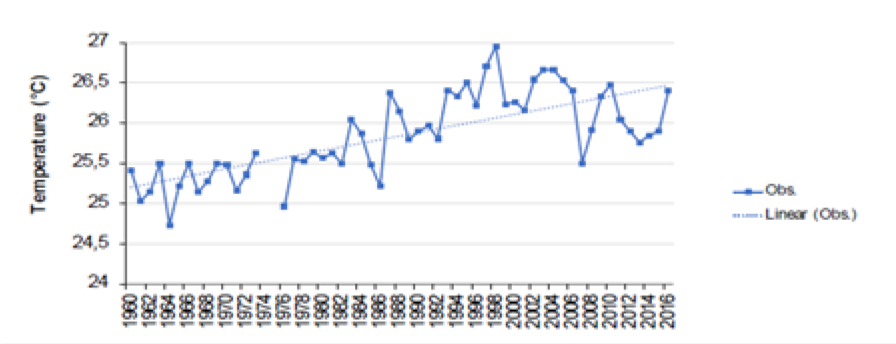
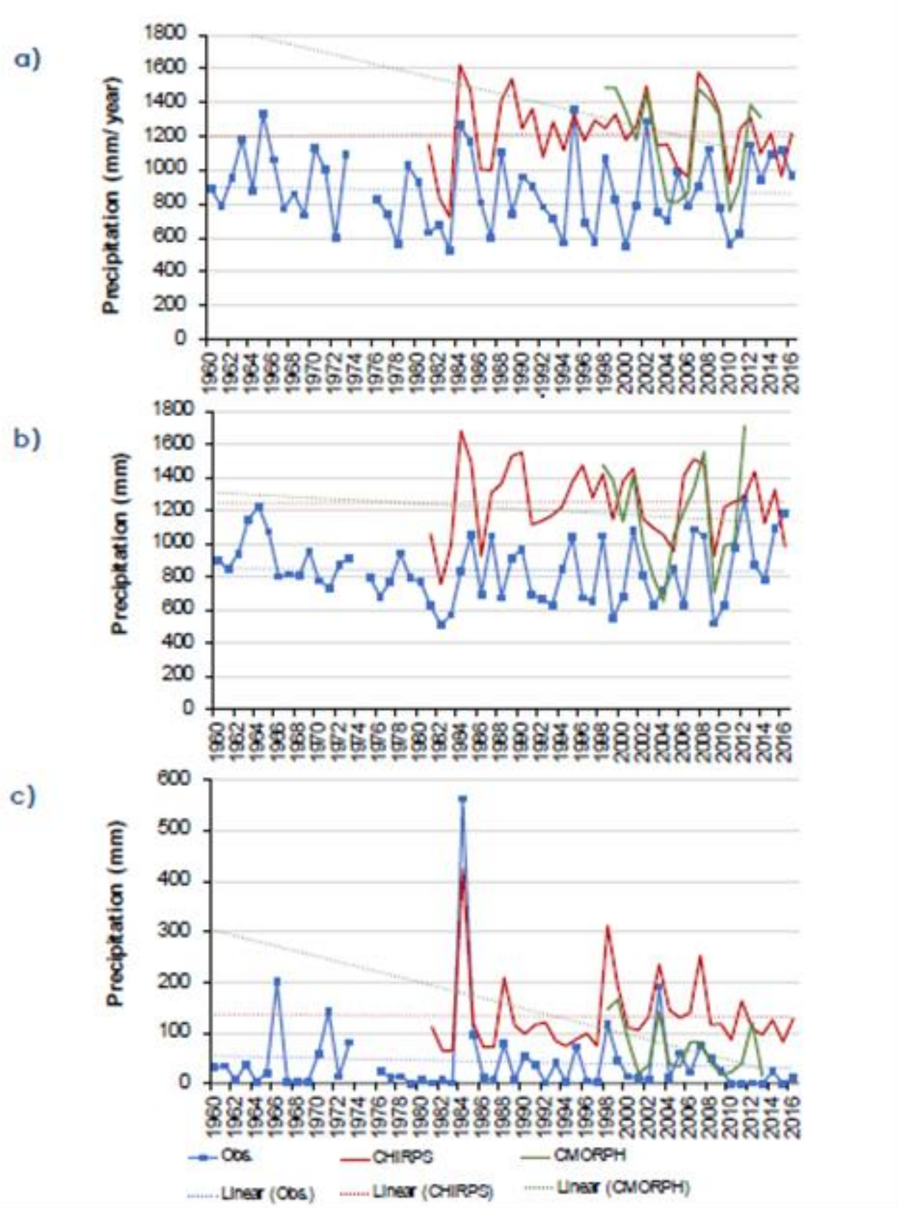


Figure 30 - Time series of precipitation a) annual (mm / year), b) rainy season (October to May) and c) dry season (June to September) from local observations (blue curve), from CHIRPS (red curve) and from CMCRPH (green curve) to the airport station.



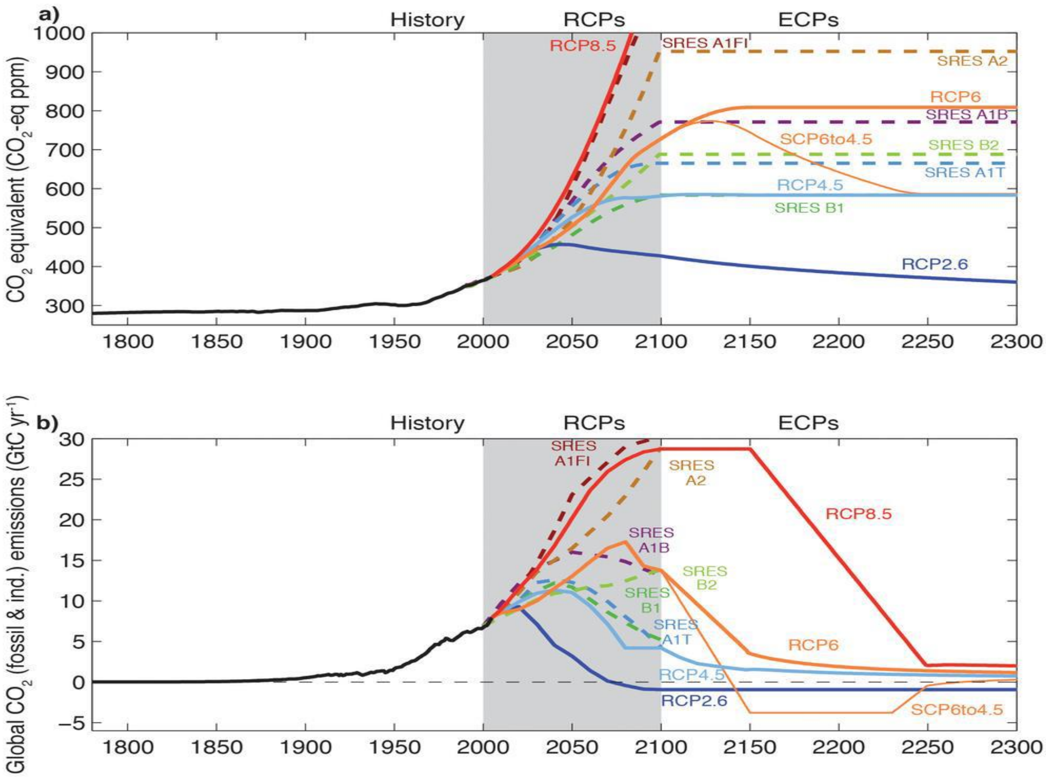
3.1.2. Climate Change Scenarios in STP

The Initial National Communication of Sao Tome and Principe was published in 2006 and used the 1992 scenario of the Intergovernmental Panel on Climate Change (IPCC) scenarios for 1992a - IS92a (RDSTP, 2006).

The Second National Communication was produced in 2010 and used scenarios B1 and A2, low and high IPCC (RDSTP, 2010) emissions, respectively).

The current GHG concentration scenarios proposed by the IPCC are called RCPs (Representative Concentration Pathway - IPCC, 2013). These scenarios consist of different trajectories of GHG concentration as of 2006, with four concentration trajectories assumed : RCP8.5, RCP 6.0, RCP4.5 and RCP2.6. These trajectories of GHG concentration were constructed from socioeconomic models that evaluate in an integrated way the demographic growth, the use of the land and the new technologies of generation of energy.

Figure 31 - Scenarios of different GHG concentration paths from 2006.



3.2 Climate models

The projections of the IPCC-5 (5th Assessment Report of the Intergovernmental Panel on Climate Change) in general show increased rainfall in the tropical regions and strong warming over the continents. However, global climate models have horizontal resolutions of approximately 200 km x 200 km, which is a very crude dimension to identify any spatial climate variability in the islands of Sao Tome and Principe (STP). Vulnerability identification and the study of adaptation measures are related to local problems. Therefore, due to the specific characteristics of a small island state as STP, the impact, vulnerability and adaptation study requires a high spatial detail description of the climatic characteristics in the region. Two ways to get this detail is to use statistical downscaling and dynamic downscaling. The first approach was adopted in the

Second National Communication of Sao Tome and Principe using the global model ECHAM4 and the observed series of the airport station. This approach has the advantage of requiring fewer computational resources but, on the other hand, requires long historical series observed that are not available in the STP islands, which prevents a more detailed spatial description. The dynamic approach requires high computational power, on the other hand it can provide spatial detail around the islands. In this case, the meteorological variables have dynamic consistency in their variations, they respond to the detailed description of the surface and can provide the climatic state through variables that are not necessarily measured in meteorological stations. Therefore, it is necessary to use numerical models of high resolution to generate projections and detailed climatic analysis of the future climate scenarios of the country.

The following climate projections are the result of global climate models, whose meshes range from 100 to 300 km, regional climatic models of 50 km meshes, and finally a 4 km local or mesoscale model. This last model was applied in very high resolution especially to capture the climatic variations in the diverse regions of the islands of STP.

3.3. Regional projections

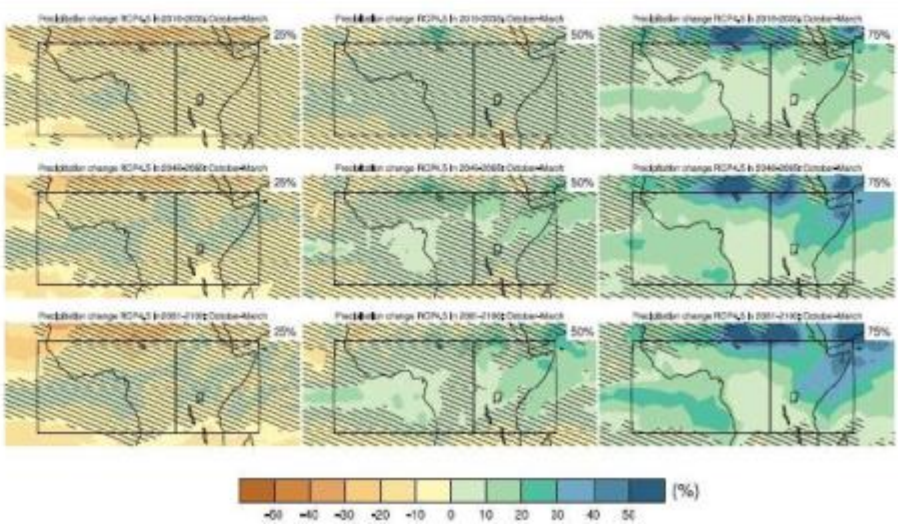
From the AR5, an atlas of projections of global IPCC models (IPCC Annex I, 2013) was included. This atlas was constructed from the projections of some 46 global climate models.

In general, global models project an increase in precipitation in the west of Africa, from October to March, and in the three future periods under the RCP4.5 emission scenario. This increase in precipitation varies about 10% to 20% over the reference period. The shaded areas indicate that these projections present a large discrepancy in the signal and intensity of precipitation changes in the western region of Africa in future climates, in the moderate scenario RCP4.5, although in the Gulf of Guinea region, in the upper percentiles, there is a greater agreement between the models (IPCC AR5, 2013).

On the other hand, it is noteworthy that the tendency of rainfall increase in the rainy season from October to May is not detected in the current series of the Sao Tome airport station, on the contrary, it is observed the tendency of precipitation decrease, as illustrated in figure 32.

Maps of 2016–2035, 2046–2065, and 2081–2100 precipitation changes from 1986–2005 in scenario RCP4.5 [21]

Figure 32 - Maps of 2016–2035, 2046–2065, and 2081–2100 precipitation changes from 1986–2005 in scenario RCP4.5

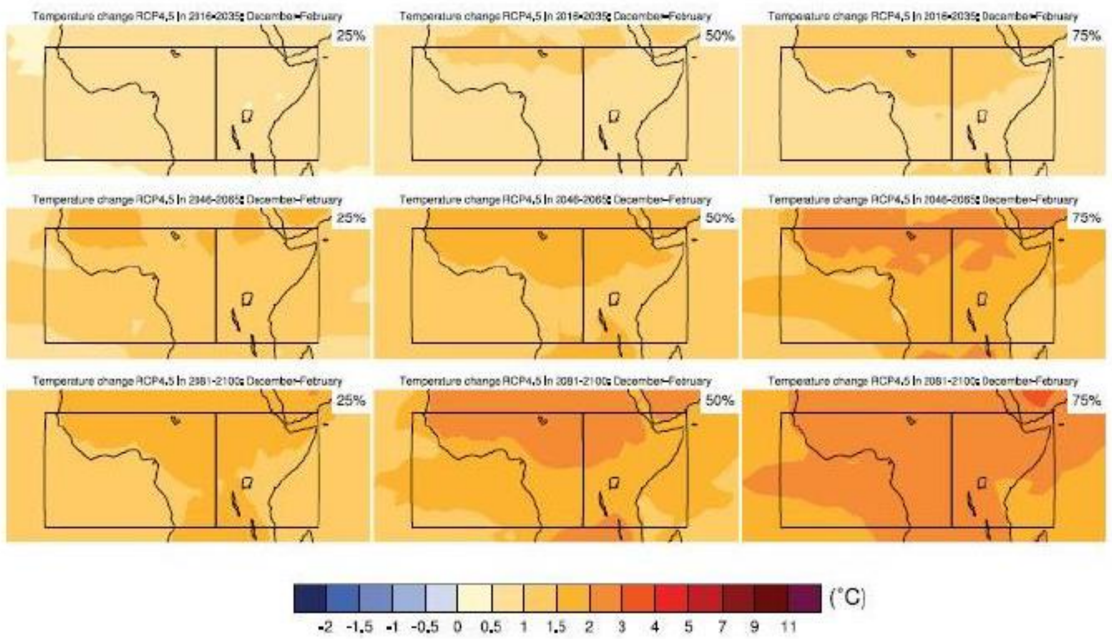


Source: IPCC (2013)

Changes in temperature are the same between models. In the middle of the 21st century, between 2045 and 2065, the average temperature increase ranged from 1° to 2°C in the Gulf of Guinea region.

[21] For each point, the 25th, 50th, and 75th percentiles of the CMIP5 set distribution are shown ; This includes both natural variability and variation between models. Shading illustrates the areas where the 20-year mean percentile differences are smaller than the standard deviation of the current natural variability estimated by the 20-year mean difference model.

Figure 33 - Maps of temperature changes in 2016–2035, 2046–2065 and 2081–2100 compared to 1986–2005 in scenario RCP4.5. Source: IPCC (2013).



Some studies based on only one model (Sylla et al. 2015) and multiple regional models (Sylla et al. 2016) of the CORDEX project (Coordinated Regional Downscaling Experiment) showed a small increase in average precipitation values in the period 2036-2065 between the months of May to September, the gravana period, in the region near the Gulf of Guinea and islands of STP. Global IPCC models also show increased precipitation in the gravana period but for a larger area. In the Gulf of Guinea, regional models also show great accordance regarding air temperature near the surface, indicating heating around 1.5 to 2 ° C in the period 2036-2065 in the RCP4.5 scenario.

3.4. Local Projections

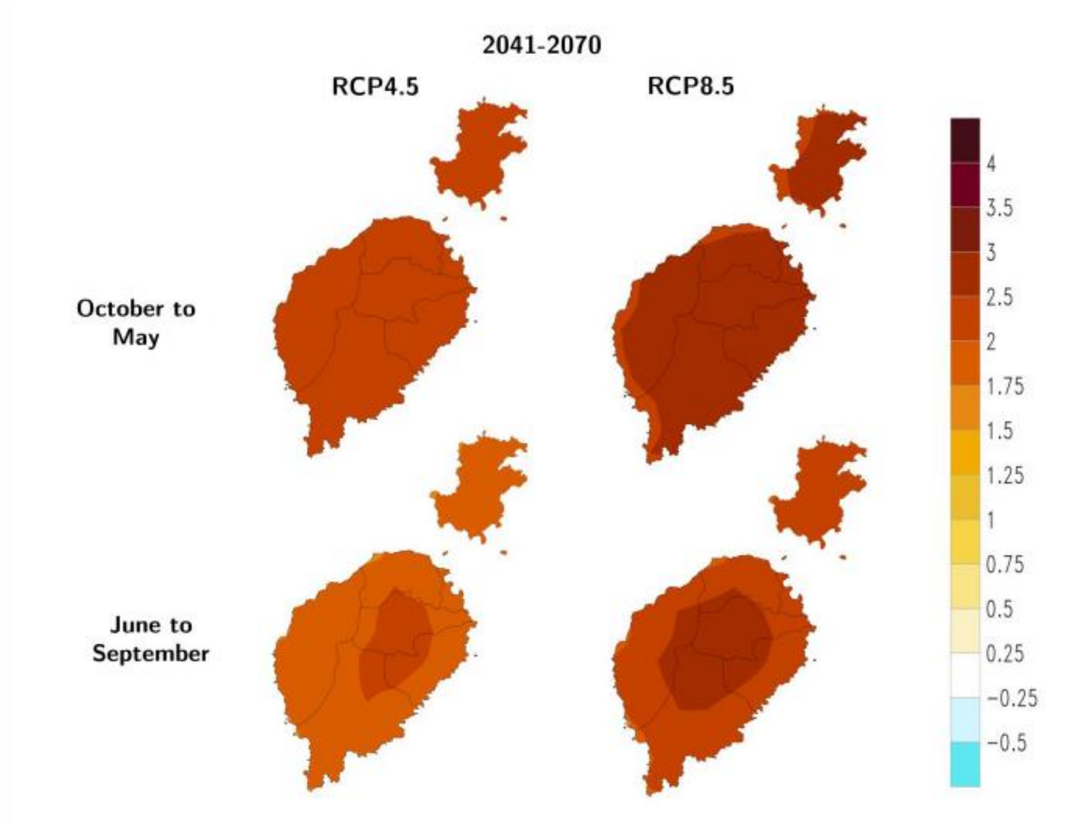
The local scale projections were produced by the Eta model (Mesinger et al., 2012; Chou et al., 2012; Lyra et al., 2017) fixed to the global climate model CanESM2. This global model has shown the ability to reasonably reproduce the climate around STP-West Africa. The technique of regionalization (downscaling) was produced in two levels. The first level was the Eta model in the spatial resolution of 20 km fixed to the global model CansESM2. The second was produced at a resolution of 4 km, from the fixation to the Eta model in 20 km resolution.

Projections for climate change were produced for the future period from 2041 to 2070, targeting the central period from 2050 to 2060. These projections of local climate change were based on the simulated climate for the period 1971-2000. Projections in two greenhouse gas emission scenarios were produced, RCP4.5 and RCP8.5. As all numeric models presented systematic errors, these errors were reduced by applying bias correction methodologies in the variables of average, minimum and maximum air temperature (° C), wind speed (m / s) and precipitation (mm / month).

3.4.1. Temperature at 2 m

The projections indicate heating throughout the study area, being more distinct between the months of October to May. In the gravana period the warming is higher in the central part of the Sao Tome Islands where the highest altitudes are located (Figure 34). Note that the heating pattern in both scenarios (RCP4.5 and RCP8.5) is quite similar, with the most intense temperature increase in RCP8.5. Changes in temperature in both islands reach values of about 2.5 ° C in RCP4.5 and 3 ° C in RCP8.5, both in the rainy season and in the dry season. Therefore, the local scale projections do not indicate changes in the annual temperature cycle in the islands.

Figure 34 - - Temperature changes at 2 m average (° C) from October to May (rainy season) and from June to September (dry season) projected by the Eta-4km model for the period 2041-2070 in the RCP4 scenarios .5 and RCP8.5 for the period 1971-2000 for the São Tomé and Príncipe Islands.

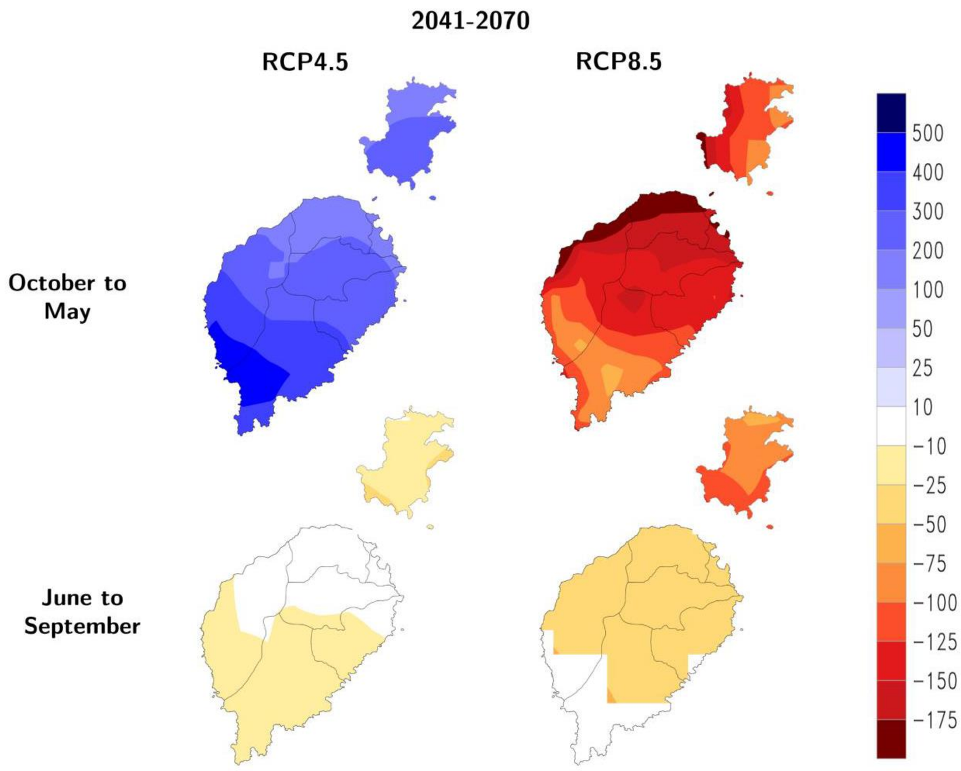


3.4.2. Precipitation

In the RCP4.5 scenario (Figure 35), projections of precipitation changes for both islands indicate a rainier climate from October to May and slightly drier and / or normal conditions in the other months of the year. The highest precipitation increases (+150 mm / month) occur in the southwestern part of Sao Tome Island, in the Caué and Lembá districts, where the highest rainfall totals also occur. In the RCP8.5 scenario (Figure 35), the projections indicate otherwise, precipitation reduction occurs in both rainy and dry periods. However, analyzing the changes from month to month, the months of December and January present an increase in precipitation on the island of Sao Tome in scenario RCP8.5. The reduction of precipitation in this emission scenario is very marked in the month of April on the island of Sao Tome, reaching the rate of -100mm / month.

In the SNA of Sao Tome and Principe, the more pessimistic A2 scenario also showed a decrease in precipitation during the months of March, April and May, although in the same scenario it also showed an increase in rainfall from September to November. In relation to scenario B1, the projections indicate an increase in precipitation in both quarters. The new projections based on the scenarios RCP4.5 and RCP8.5 show some similarities, with a trend of increasing rainfall in a low emission scenario and a tendency to reduce rainfall in high emission scenarios.

Figure 35 - Change in cumulative precipitation (mm) from October to May (rainy season) and from June to September (dry season) projected by the Eta-4km model for the period 2041-2070 in scenarios RCP4.5 and RCP8.5 for the period 1971-2000 for the São Tomé and Príncipe Islands.



3.5. Climatic extremes

Climate change is often detected by changes in average values or long-term trends. On the other hand, changes in climatic extremes are more severe and more difficult to find adaptation measures. Climate extremes index were calculated according to the ETCCDI (Expert Team on Climate Change Detection and Indices) recommendation (Alexander et al., 2005). There are about 26 indexes that include extremes of precipitation and extremes of air temperature, e.g. higher value of daily maximum temperature (TXx), lower value of daily minimum temperature (TNn), heat waves (WSDI), number of days in the year with precipitation above 50 mm (R50 mm), consecutive dry days (CDD), total annual precipitation above the 95th percentile (R95p) and total annual precipitation (PRCPTOT).

Climatic extremes indexes were calculated for the Sao Tome Airport station. The projections indicate a tendency to increase the maximum precipitation in one day (RX1DAY) and the mean intensity of precipitation in the region (SDII) in both scenarios. However, there is a downward trend of consecutive rainy days (CWD). There is also an increase of consecutive dry days (CDD), which may be indicative of prolongation of the period of gravana in the region. In contrast to the RCP4.5 scenario, the RCP8.5 scenario indicates a decrease in accumulated rainfall (PRCPTOT), maximum accumulated rainfall in 5 days (RX5DAY) and heavy rains (R10mm, R20mm, R50mm). In relation to other variables, it is possible to identify, from the projections for the airport region, the increase of the maximum and minimum of the maximum and minimum temperature, increase of the thermal amplitude, and decrease of the winds (average, maximum and minimum), in both scenarios.

Figures 36 and 37 show, in the left column, the spatial values of the indexes in the period 1971-2000, while in the middle and right columns are shown the differences of the indexes between the future period, 2041- 2070, and the reference period, 1971-2000, as a way of identifying future trends. In the reference period, the total annual precipitation index, PRCPTOT, has the highest annual accumulations in the island of Príncipe, around 2,000 mm / year (Figure 36). On the island of Sao Tome, the highest values of PRCPTOT occur in the southwestern region of the island, in the districts of Caué and Lembá, with values close to 1,500 mm / year. In the projections for the future climate, 2041-2070, the PRCPTOT index presents different trends in each emission scenario. While in the RCP4.5 scenario there is an increase in annual rainfall accumulations, mainly in the southwestern region of the island of Sao Tome, in the RCP8.5 scenario there is a reduction of annual rainfall accumulations in both islands, especially in the northern region of Sao Tome, district of Lobata.

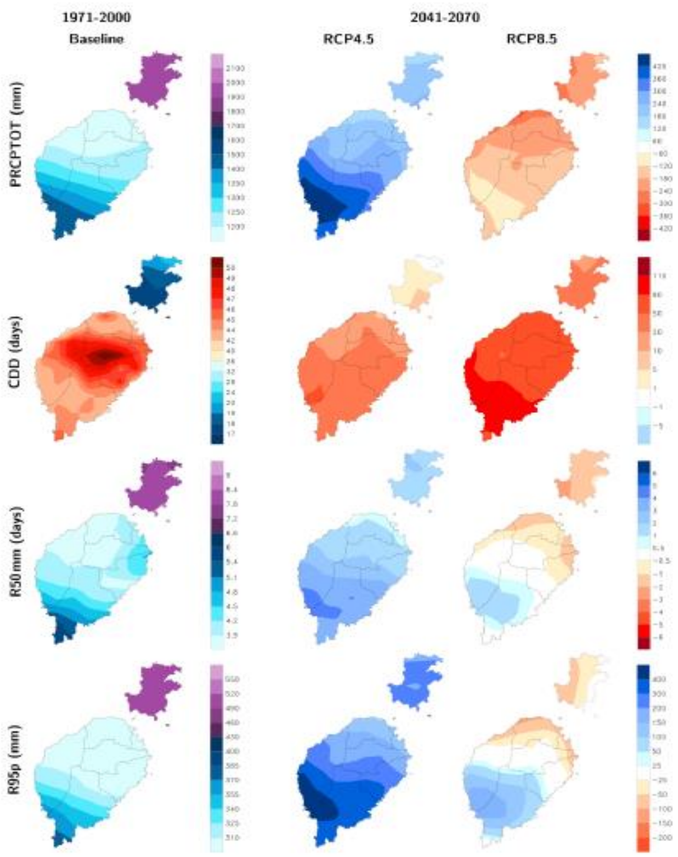
The index that measures the extent of consecutive dry days, CDD, shows a declining trend in the reference period, in less than 20 days in the year in the Princípe Island, which probably occurs between June to September, period of the gravana. However, in Sao Tome, periods of consecutive dry days are higher, especially in the central part of the island, in the district of Mé Zochi, reaching up to 50 days without precipitation. In the future, both emission scenarios indicate an increase in consecutive dry days in the entire study area, although this increase is even more intense in the RCP8.5 scenario and mainly in the south of Sao Tome. In the RCP8.5 scenario, CDD indicates that the consecutive days without precipitation are prolonged and can reach up to 110 days.

Some indexes identify the frequency of heavy rains as the R50mm index. This index counts the number of days in the year with rainfall above 50 mm / day, which represents extreme events of rain with potential to cause damage, for example, in agriculture. In the reference period, there are high values of this index in Príncipe and in the south-west of Sao Tome. The change between the future climate and the climate of the reference period is an increase of intense precipitations in the whole area of the country, according to the scenario RCP4.5. However, under conditions of higher concentrations of greenhouse gases in the RCP8.5 scenario, there is a tendency for rainfall to decrease in Príncipe and in the northern region of Sao Tome Island, and a tendency for increased precipitation in the south-southwest region of Sao Tome. Another index that measures the intense precipitations is the R95p. This index considers the upper percentile of the precipitations and presented a pattern very similar to the R50mm.

Figure 37 shows the temperature extremes indexes calculated for Sao Tome and Príncipe region. The highest values of maximum temperature (TXx) and the lowest values of minimum temperature (TNn) occur in the central region of Sao Tome Island. This greater thermal amplitude is due to the mountainous region, where the altitudes reach about 1,600 m. Climatic projections in both GHG concentration scenarios indicate trends for increasing these rates across the study area.

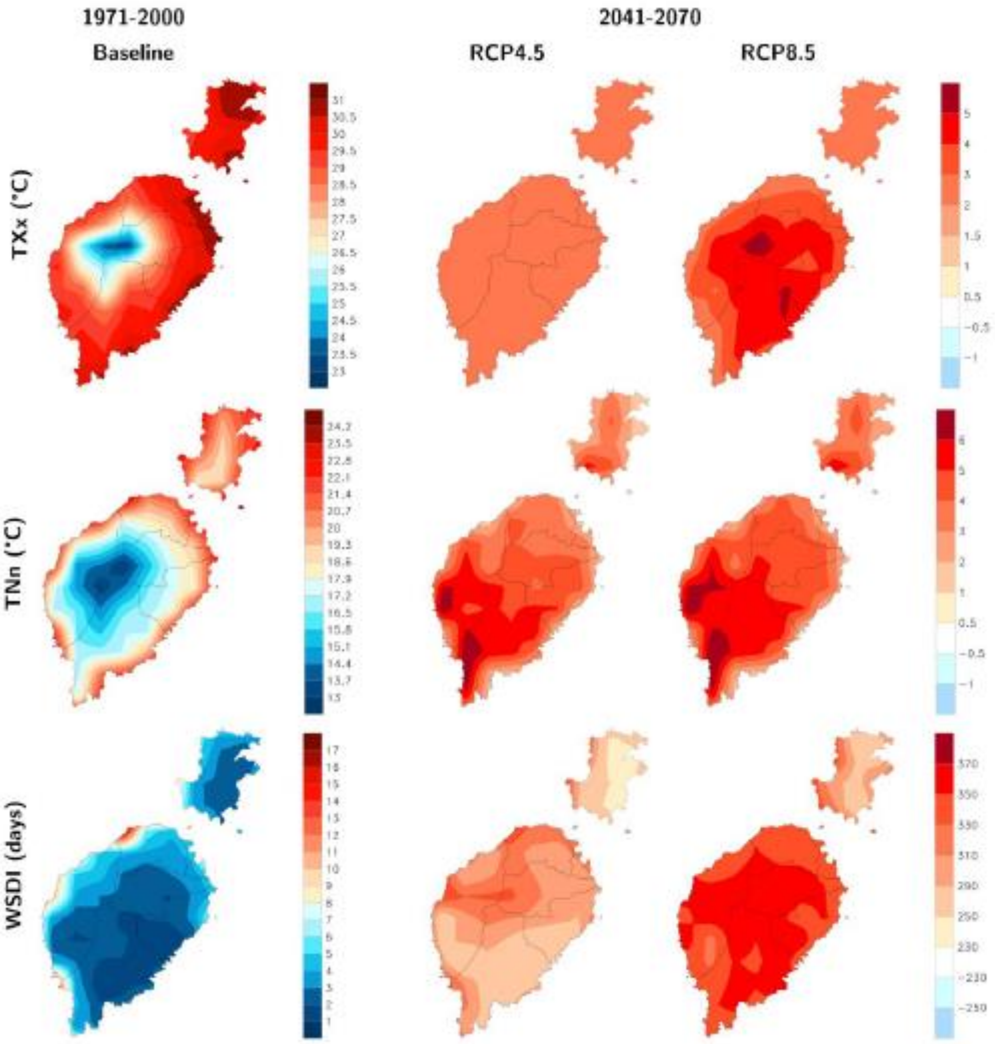
Therefore, the projections indicate an increase in accumulated precipitation per year in the scenario RCP4.5 and also an increase in intense rainfall in both scenarios. It is verified that this increase is always more significant in the southwest region of Sao Tome Island. Although there is an increase in precipitation accumulation and intense precipitation, there is also an increase in the number of consecutive dry days, which indicates an extension of the gravana and poor rainfall distribution in the region. In relation to climatic extremes of temperature in both scenarios, climatic projections indicate warming, with increases in heat waves, on hot days, at maximum annual maximum temperatures and increasing annual minimum temperatures.

Figure 36 - Indexes of climatic extremes of precipitation. The left column indicates the index values calculated for the reference period (1971 to 2000) and the other columns indicate the differences between the future climate projections (RCP4.5 and RCP8.5 between the years 2041-2070) and the reference (1971 to 2000). PRCPTOT (mm), CDD (days), R50mm (days) and R95p (mm).



Climatic extremes of temperature indexes. The left column indicates the index values calculated for the reference period (1971 to 2000) [22]

Figura 37 - Climatic extremes of temperature indexes. The left column indicates the index values calculated for the reference period (1971 to 2000)



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[22] As demais colunas indicam as diferenças entre as projecções climáticas para o futuro (RCP4.5 e RCP8.5, entre os anos de 2041 a 2070) e o histórico (1971 a 2000). TXx (°C), TNn (°C) e WSDI (dias).

CHAPTER 4 : VULNERABILITY ANALYSIS AND ADAPTATION TO CLIMATE CHANGE

4.1. Introduction

The small size of the STP archipelago situated off the Atlantic Ocean in the Gulf of Guinea makes the country very vulnerable to the effects of global climate change. The average sea level rise is one of the effects that can lead to the loss of territory and damage coastal activities that are essential for the population of Sao Tome and Principe.

The country's economy is based on agriculture, livestock and fisheries. Tourism and the use of offshore oil fields are new emerging sectors in the Santomean economy. On the other hand, the country's future energy generation will depend heavily on hydroelectricity. These activities are associated with climate-dependent economic sectors and are thus vulnerable to climate change. Given the above, impact studies, vulnerabilities and measures to adapt to climate change in Sao Tome and Principe are necessary and urgent.

This chapter aims to assess the vulnerability of three sectors most sensitive to the adverse effects of climate change in Sao Tome and Principe, based on the regionalized projections (downscaling) in high spatial resolution produced by the Eta Model (Chou et al. 2012 ; Mesinger et al., 2012; Lyra et al., 2017). The elaborated climate change scenarios have made it possible to assess the vulnerability of the following sectors : agriculture, hydroelectric power and coastal zones. The local scale projections allow us to capture the spatial variations in the climate of Sao Tome and Principe.

4.2. Vulnerability of the Climate Change Sectors

4.2.1. Agriculture

In STP, agriculture plays an important role in the production of food and products for export. Sao Tomean agriculture has a great importance in the distribution of the Gross Domestic Product by sector, representing 22.4% of the total Gross Domestic Product (INE, 2017). For the study of impacts of climate change on the agricultural sector, two crops were selected for food production, Taro (Colocasia esculenta (L.) Schott) and Corn (Zea mays), and two crops as export products, Cocoa (Theobroma cacao L.) and chilli pepper (Piper nigrum L. / Piper guineense).

4.2.1.1. Agricultural Production Risk Index (IRC)

The assessment of the impacts of climate change on crops was carried out through the Culture Risk Index (IRC). This index was created from the combination of indicators that estimate thermal stress in crop, water stress, susceptibility to diseases and the productive potential of crops. It is emphasized that each crop requires optimal soil and climatic conditions for its development and growth and therefore, the effects of the indicators were evaluated individually for each crop.

Indicators of water stress, thermal stress and susceptibility to diseases were determined from thresholds expressed literature and defined for each culture. These thresholds determine values on which the crop is undermined due to climatic action. However, in some cases, due to lack of studies in the STP region, the thresholds were used according to those recommended by work performed in regions with similar climate.

The IRC construction follows the OECD (Organization for Economic Co-operation and Development) proposal (Nardo et al., 2005), with the following steps: (i) standardization of the selected indicators, in order to obtain values between zero and one, representing respectively the worst and the best situation of each locality, according to the aspects related to the risk of producing and, (ii) calculation of said index, which consisted in determining the indicator with the greatest impact on production, which was attributed category. In this way, the IRC can be classified according to the intervals for its possible gradations (between the extreme values), as shown in Table 80.

Table 80 - Risk classification for agricultural crops

Very high risk	Less than or equal to 0.2
High risk	Greater than 0.2 and less than or equal to 0.4
Moderate risk	Greater than 0.4 and less than or equal to 0.6
Low risk	Maior que 0.6 e menor ou igual a 0.8
Very low risk	Greater than 0.8

4.2.1.2. Taro (Colocasia esculenta (L.) Schott)

Taro, known locally as matabala, is used for food in Sao Tome and Principe, also contributing to families' incomes. The average crop yield between 2005 and 2014 was approximately 6,000 kg ha -1. The culture presents good adaptability to different soil and climatic conditions. This fact allows its cultivation from marshy areas to high slope (Nolasco, 1994). The cycle of this crop can be influenced by several factors, such as temperature, incidence of luminosity, availability of water and nutrients, besides the cultivar used. Therefore, these variations depend mainly on the geographic region of the plantation and there is no great demand on soil and fertilization, dispensing with the application of fungicides and insecticides (Santos, 1998; Murayama, 1999). According to Filgueira (2000), the best development of taro occurs in regions with annual rainfall above 2,000 millimeters and with high values of relative air humidity. In literature, some studies have determined a water stress condition in years with a precipitation of less than 810 mm. With respect to temperature, the culture is best adapted to temperatures between 21 and 27 ° C.

Leaf-burning disease, caused by Phytophthora colocasiae, is one of the most severe taro diseases. According to Plucknett and De La Peña (1971), this disease is related to large losses in the sector and can be treated as a limiting factor for taro production. It was therefore considered that susceptibility to the occurrence of leaf-burning disease, which is more susceptible in days with a temperature between 25 and 28 ° C and relative humidity of more than 95%, represents a limiting factor for the taro culture.

Based on the climatic conditions ideal for taro production, as well as the ideal conditions for the occurrence of diseases, risk factors were considered (or indicators). Table 81 lists the proposed risk indicators.

Table 81 - Description of risk indicators of water, thermal stress and disease susceptibility in taro culture.

Description	Unit
Risk index due to water stress considering the years in which the accumulated annual precipitation was less than 810 mm.	Number of years
Risk index due to thermal stress considering days when the average temperature was below 21 ° C or above 27 ° C.	Number of days
Risk index for *leaf burn* disease due to average temperatures between 25 and 28 ° C and relative humidity greater than 95%.	Number of days

In addition to these indicators, potential productivity was also calculated. In the case of taro crop, the average coefficient of the culture used was 1.1, being an average value among those suggested by Fares (2013).

The risk associated with the cultivation of taro in the STP islands (Figure 38) was calculated for the reference period (left column) and for the projections in the period 2041-2070, in the two emission scenarios, RCP4.5 and RCP8.5.

In the reference period, taro culture presents a very high risk of production in the mountainous region of Sao Tome Island and in great part of its coastal zone. In the mountainous region this risk occurs due to temperatures below 21 ° C and in the coastal areas the very high risk is due to the susceptibility to leaf burning disease. However, in much of the island of Sao Tome, the risk can be classified as low or very low.

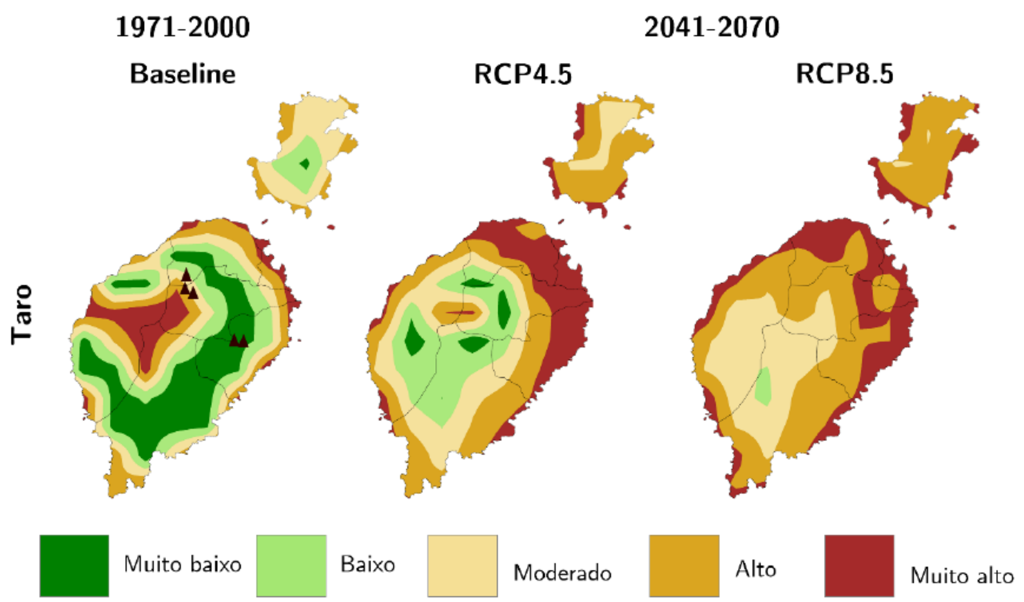
Considering the island of Príncipe, the risks for the production of taro go from very low to moderate in almost all the island, and the cause factor of this risk is susceptibility to the occurrence of the burning of the leaves illness. At some points in the coastal region this risk may be even higher, being classified as high risk in production.

The projections in the RCP4.5 and RCP8.5 scenarios indicate an increase in the risk of taro culture in Sao Tome and Principe, which is more prominent in RCP8.5 and in Sao Tome Island. Regions in the southern end of the island and in points isolated in the coastal zone present a high or very high risk due to the occurrence of temperatures above 27 ° C. The risk due to susceptibility to the disease varies from moderate to very high in much of the island of Sao Tome, especially on the east coast.

In Príncipe island, in both scenarios, there is a region in the south of the island where there is a high risk of susceptibility due to *leaf burning* disease.

Tarot culture risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5[23].

Figure 38 Tarot culture risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5



[23] The triangles shown in the figure refer to some regions where taro is currently grown.

4.2.1.3. Corn (Zea Mays)

Corn has a strategic importance in human and animal feeding in STP (SCN - Sao Tome and Príncipe, 2010). This culture needs specific climatic conditions for full development, which is mainly limited by water, temperature and solar radiation (Fancelli and Dourado, 1997). However, it should be noted that ideal climatic conditions vary according to the maize phenological stage, which makes it difficult to study the climatic constraints of the crop.

Air temperature plays an important role in the metabolic processes of the culture. When the temperature is higher, the metabolic process is more accelerated and in occasions of low temperature, this process is reduced (EMBRAPA, 2010). In relation to precipitation, different productivity responses to water stress can be observed, being higher or lower, according to the phenological stage and the intensity of the deficit (Cunha and Bergamaschi, 1992). In relation to the susceptibility of corn to the disease, rust (Puccinia sorghi), one of the diseases that most compromise maize crop, was evaluated. Its occurrence is recorded in tropical and subtropical areas (Melching, 1975; Shurtleff, 1992). Rust-causing fungus has development favored by moderate temperatures in the range of 23 to 28 ° C, together with high values of relative humidity (Balmer and Pereira, 1987; Juliatti, 2005, Rhind et al., 1952. Melching et al., 1975; Dudienas et al., 2013). For the calculation of the productive potential indicator, coefficients described by Doorenbos and Kassan (1979) were used.

The selected indicators, as well as the thresholds used for each of them, are presented in Table 82.

Table 82 - Description of risk indicators of water, thermal stress and disease susceptibility in maize crop

Description	Unit
Water stress risk index which considers the years in which the cumulative annual rainfall is less than 550 mm or more than 5,000 mm.	Number of years
Risk index due to thermal stress considering days when the average temperature was below 24 ° C or above 30 ° C.	Number of days
Risk index for the occurrence of rust disease, due to the occurrence of average temperatures between 23 and 28 ° C and relative humidity above 95%.	Number of days

Since corn is grown in two distinct crops, IRC was calculated separately for the 1st crop, which occurs from October to January and for the 2nd crop, which occurs from February to May. The IRC for both harvests of maize crop is presented in figure 39.

The simulation of the reference period shows that the districts of Sao Tome Island, in the 1st maize crop, present a moderate to very high risk, especially in the central region of higher altitudes where the high risk is due to low temperatures, while in the 2nd crop the risk goes to high and very high. In Príncipe island, in the 1st crop, the risks are classified as moderate to high, and in the 2nd crop, risks vary from high to very high, due to the susceptibility to rust disease.

The projections in scenario RCP4.5, for the period from 2041 to 2070, considering the 1st maize crop of Sao Tome and Principe islands, show reduction of areas classified as high risk, possibly due to the increase in air temperature. In the boundaries between the districts of Caué and Lembá the susceptibility to rust becomes the main cause of high risk. In the RCP8.5 scenario, there is an increase in the area classified as very high risk due to the increase in thermal stress and susceptibility to rust. For Príncipe island, the areas classified as moderate risk increased, being the predominant cause low productive potential and susceptibility to rust.

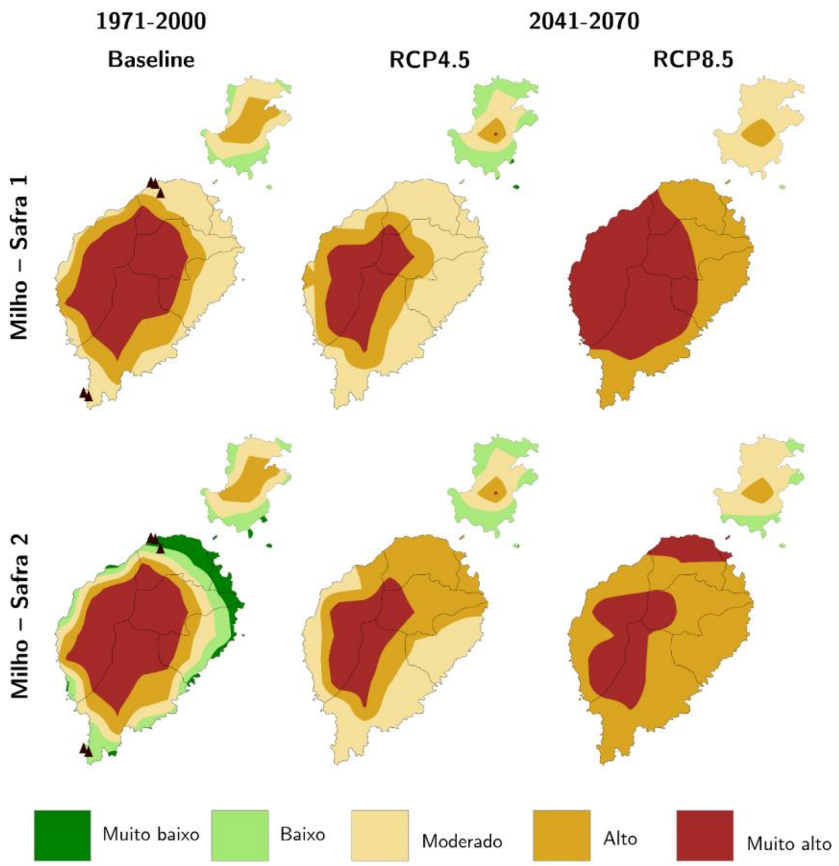
Projections in scenario RCP4.5 for the 2nd corn crop indicate reduction of areas classified as high risk, possibly due to increase in air temperature. However, in the coastal region risks range from low or very low to moderate to high risk, especially in the coastal regions of Lobata, Mé-Zóchi, Água Grande and Cantagalo districts that had a change in classification of very low risk to high. The cause is associated with low productive potential. In Príncipe there was a reduction in areas with high and moderate risk, due to decrease of the areas susceptible to rust.

Projections in the RCP8.5 scenario of the 2nd corn harvest raise the risk rating to high because of the low productive potential, which was already predominant in the RCP4.5 scenario in Sao Tome Island, but maintains the high risk classification in the central region of Sao Tome and Principe.

Corn crop risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5[24].

[24] The triangles shown in the figure refer to some regions where corn is currently grown.

Figure 39 Corn crop risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5



4.2.1.4. Cocoa (Theobroma cacao)

Cocoa is an important export crop in Sao Tome and Principe, accounting for about 17% of the Gross Domestic Product (GDP) of the islands (INE-STP, 2016). Even suffering a reduction in productivity in the last decades, the islands have an average productivity of around 120 kg. ha-1, considering the period 2005-2014 (FAOSTAT, 2016).

According to Leitão (1983), cocoa is a species that adapts well to different conditions. Although it adapts to different temperatures throughout the year, some studies indicate that minimum temperatures close to or below 15 ° C can lead to changes in the seeds, compromising the final quality of the product. The literature also indicates that water stress is induced in the crop when annual precipitation values are less than 1,200 millimeters or greater than 2,800 millimeters (Carr et al., 2011; Schroth et al., 2016).

An important disease that affects cacao fruits is called *brown rot*, which is closely related to climatic conditions. Phytophthora species that cause brown rot of cacao attack the crop from the direct germination of sporangia, which are usually produced in environments almost saturated with humidity, that is, between 95 and 97% (Duniway, 1983), at high temperatures, ranging from 30 to 34 ° C (Clerk, 1972).

The limiting indicators of cocoa were calculated according to the risk of hydric and thermal stress induced in the crop (Table 83), as well as susceptibility to the occurrence of brown rot disease.

Table 83 - Description of risk indicators of water, thermal stress and disease susceptibility in cocoa crop

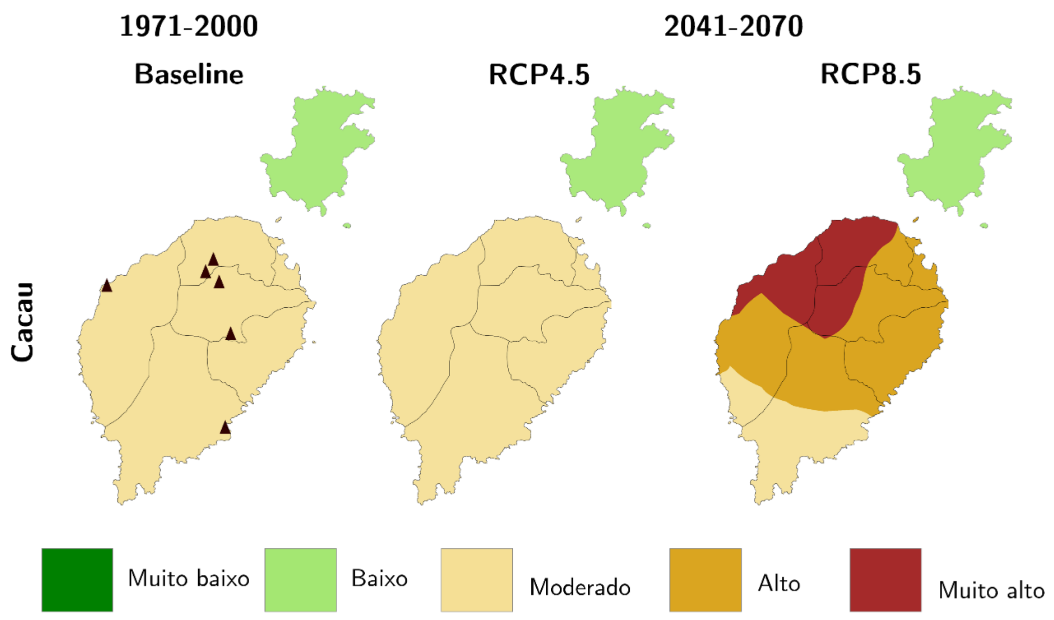
Description	Unit
Water stress risk index which considers the years in which the cumulative annual rainfall is less than 1200 mm and more than 2800 mm.	Number of years
Risk index due to thermal stress considering days when the minimum temperature was below 15 ° C and days when the average temperature was above 36 ° C.	Number of days
Risk index for brown rot disease due to maximum temperatures between 30 and 34 ° C and relative humidity above 95% and below 97%.	Number of days

For the calculation of the productive potential indicator, the average coefficient of the crop (Kc) of 1.05 was considered, being an average value among those suggested by Allen et al. (1998).

Simulations of the reference period show a moderate risk in Sao Tome and a low risk in Príncipe (Figure 40). The moderate risk in Sao Tome is mainly due to low productive potential and water stress. Projections in the RCP4.5 scenario maintain this risk rating in the region. On the other hand, in the scenario RCP8.5, the risks pass to the very high class in the regions north of Lembá, west of Lobata and Mé-Zóchi, due to water stress. The other regions of the island that had their risk classification increased, have as main cause water stress, justified by the reduction of precipitation in this scenario. These results are in accordance with those presented in the Second National Communication of Sao Tome and Principe (2010), which already warned of the risk of reduction of cocoa production areas due to the reduction of precipitation in the future (2040-2060), with lower annual totals to 1,500 mm.

Cocoa risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5[25].

Figure 40 - Cocoa risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5



Chili Pepper (*Piper nigrum* L./ *Piper guineense*)

The cultivation of chili pepper, which is destined for export, has shown itself to be an alternative for agricultural diversification in the country. Above all, this is an alternative to the low yield obtained by cocoa in recent years (Almeida, 2012). The cultivation of chili pepper requires a climate with high temperatures for its better development and fruiting (Lopes et al., 2007). According to Silva and Souza (1999), another factor essential to the good development of this crop is an adequate water supply during the entire crop cycle, that is, from 600 to 1250 mm according to Doorenbos et al. (1979). Water stress in pepper crop causes fruit drop and flower burn (Jones et al., 2000).

Regarding the incidence of pests and diseases, Silva and Souza (1999) warn of the fact that pepper bush is extremely susceptible. Among the diseases that affect the culture,

[25] The triangles shown in the figure refer to some regions where cocoa is currently grown.

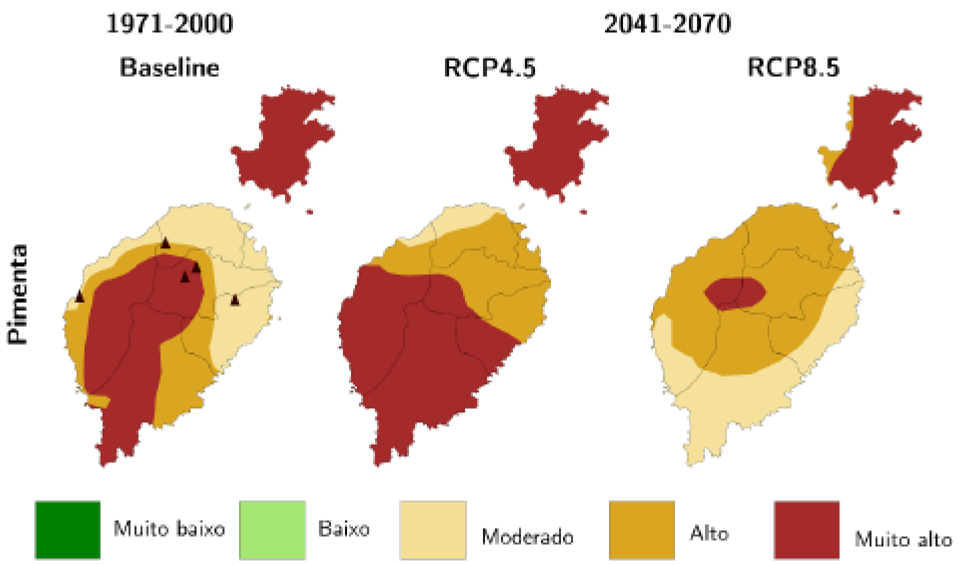
whose climatic condition favors its dissemination, Lopes et al. (2007) cite the spot of cercospora, caused by the fungus Cercospora capsi, a disease favored by temperatures above 25 ° C and air humidity above 90%. The proposed indexes, based on literature, are shown in Table 84.

Table 84 - Description of risk indicators of water, thermal stress and disease susceptibility in pepper crop.

Water stress risk index which considers the years in which the cumulative annual precipitation is less than 600 mm or more than 1,250 mm.	Number of years
Risk index due to thermal stress considering days when the average temperature was below 23 ° C or above 32 ° C.	Number of days
Risk index for occurrence of cercopora spot disease, due to the occurrence of average temperatures above 25 ° C and relative humidity above 90%.	Number of days

Pepper crop risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5[26].

Figure 41 - Pepper crop risk indexes for the reference period (1971-2000, first column) and for future climate projections (2041-2070) in scenarios RCP4.5 and RCP8.5



[26] The triangles shown in the figure refer to some regions where pepper is currently grown.

Simulation of the reference period shows high risk and very high risk regions in the districts of Caué, Lembá, the western part of the district of Mé Zóchi and southwest of the district of Lobata (Figure 41). These regions include some pepper producing communities. The high risk occurs in the confluence zone between the districts of Lembá, Caué, Mé Zóchi and Lobata, due to thermal stress where temperatures are generally below 23 ° C. There are very high risk areas due to the occurrence of cercospora disease spot in the districts of Lemba and Caué. In the coastal regions, and in the southern part of the island of Sao Tome, there are high and / or very high risks of pepper production due to water stress. In the northern part of the island of Sao Tome (mainly in the district of Lobata), there is a moderate risk due to estimates of productivity potential.

The future scenario RCP4.5 indicates a high and very high risk in practically the whole island of Sao Tome, with higher values in the south central region of the island. The risk of pepper production is mainly due to water stress, which can be caused both by water deficiency (annual accumulation of less than 600 mm) and water excess (annual accumulation of more than 1250 mm). However, in the mountainous region of the island (border of the districts of Lembá, Caué and Mé Zóchi), the greater stress occurs due to thermal stress (region with low temperatures, that can harm pepper production).

The risk tends to be higher in the RCP4.5 scenario when compared to the RCP8.5 scenario. However, the risk in the RCP8.5 scenario remains very high in the mountainous region of Sao Tome due to thermal stress. There is also a high risk indication in the north central region of the island due to low productivity potential. This risk still occurs in the southern region of the island, but in a moderate way. At the southern end of the Caué district, there is moderate risk due to water stress.

In relation to Príncipe island, in the reference period, the risk of pepper production for the whole island is very high, due to water stress of the crop, caused by excess precipitation in the region. The same occurs in the RCP4.5 and RCP8.5 scenarios, although in the RCP8.5 scenario a small part of the west coast region, formerly classified as a very high risk region, is classified as high risk.

4.2.2. Hydroelectric power

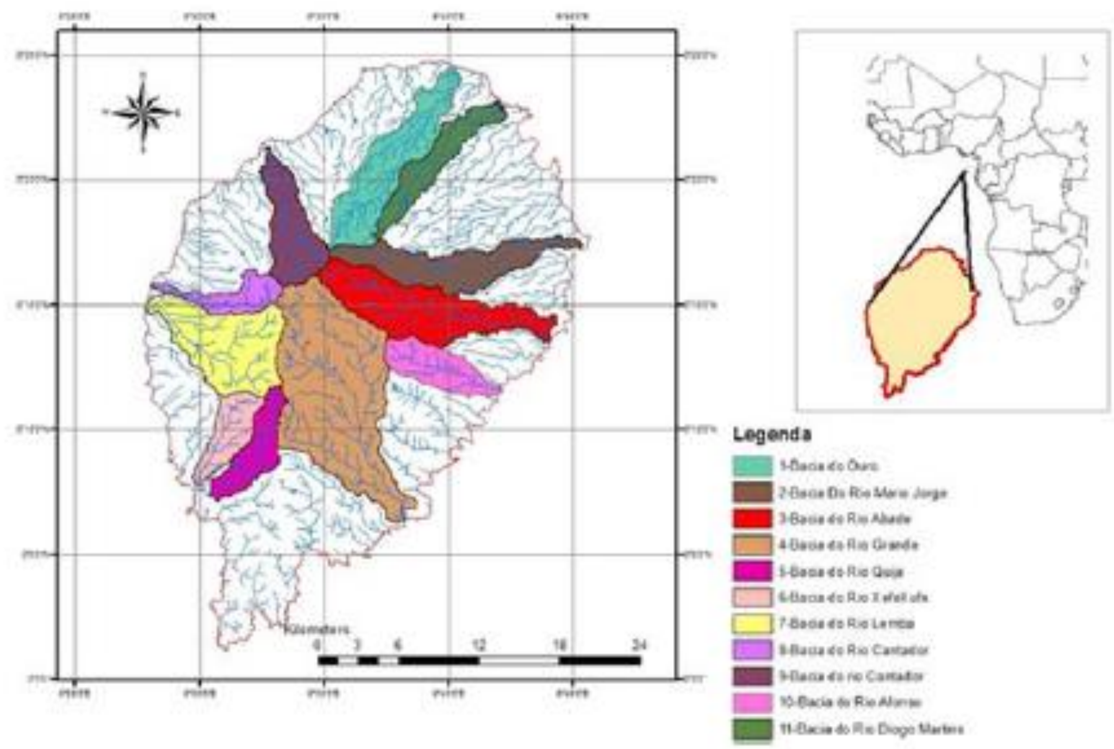
The Sao Tome island is 46 km long and 31 km wide and the highest elevations are in the eastern center. The highest point is in the western part of Sao Tome Island with an altitude of 2024 m. In the upper altitudes where the main rivers of the country start. The rivers of Ouro, Manuel Jorge, Abade and Yô Grande flow on the western coast of the island of Sao Tome. They are embedded relief rivers that run on basaltic rocks. The river basins of Sao Tome and Principe have high slopes and small extensions, consequently the concentration time is low which causes floods in a matter of hours. According to Hydroconseil (2011), there are between 10 and 30 floods per year, each lasting only a few hours. Regarding sediment transport, estimates made by

Guidroproekt (1981) concluded that Sao Tome and Principe rivers transport between 1,500 and 2,000 tons / year / km^2.

According to Oliveira (2009), the hydrography of the country is composed of a radial drainage model where the main rivers pass, in the deep valleys, covered with dense tropical vegetation and with lowland coastal lands that, in many cases, are flooded during the floods. The materials contained in the beds of these water bodies range from large blocks (0.5 to 1 m thick) to sands ; and there are terraces of roofs made of clay materials. According to the same author, the country has approximately 50 river basins and 223 water courses.

The rivers' hydrological regime is a function of the precipitation regime. There is thus a difference between the flows per unit area of the wetter regions that are located to the southwest (cases of the Quija and Xufe-xufe rivers, with around 150 l / s / km^2 per year) and zones with lower precipitations located in the northeast region (Ouro river with around 30 l / s / km^2 per year). For the Yô Grande river, located in an intermediate climatic position, the flow is about 100 l / s / km^2 per year. In Príncipe island, rainfall and, consequently, runoff variation is less significant, with an annual average flow of about 60 l / s / km^2 (Hidrorumo Projecto e Gestão, 1996).

Figure 42 - Sao Tome and Principe's main river basins



Source: Adapted from AFONSO, 2016.

Of all water resources in the country, about 4.93% is used in agriculture, 2.98% in hydroelectric power generation and 0.45% in population water supply. The remaining 91.64% are not used for any purpose (RDSTP, 2011).

Among the 50 hydrographic basins in the country, the Yô Grande river basin and the Ouro river basin were chosen to study the impacts of climate change on hydroelectric power generation and water availability. Knowledge of the possible impacts of climate change on hydropower potential and water availability are fundamental for socioeconomic development and improvement of the country's quality of life.

4.2.2.1. Yô Grande River Basin

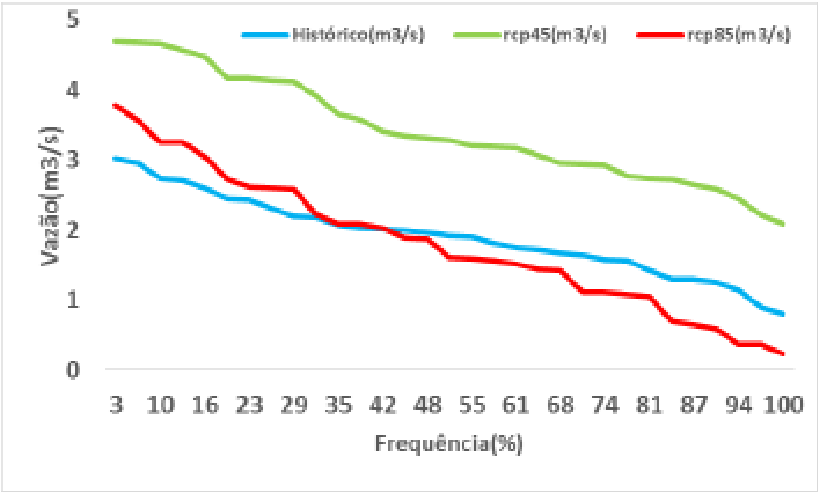
The Yô Grande river basin is the largest in the archipelago, located in the south-eastern part of Sao Tome Island, and has an area of 105.7 km^2, which corresponds to approximately 13% of the territory of Sao Tome Island. The Great Yô River is located in the less populous region of the country. The river rises at a height of 1,400 m south of the peak of Calvary. Its main tributaries are the Ubugu, Miranda, Guedes, João Nunes, Ana Chaves, Campos, Musso and Rita (Hydroconseil, 2011) rivers.

Of the 105.7 km^2 of the watershed, 78 km^2 are forests, 25.47 km^2 are shade forests for coffee and cocoa, 1.46 km^2 of arable crops, 0.42 km^2 of palm trees, 0.32 km^2 of plantation of coconut trees, and 0.11 km^2 of mangroves. According to the thematic map of soil types (not shown), three types of soils are found in the Yô Grande River basin. Humus ferralitic soils are present in approximately 85% of the basin. At the source of the basin, the predominant type of soil is the humid brown land and in its mouth the ferralitic soils predominate. There is little hydrometeorological information in the basin. According to the Hydroconseil report (2011), annual rainfall in the basin ranges from 4000 to 5000 millimeters per year. However, there is no information on the presence of rain gauges in the drainage area of the basin that would allow greater verification of this information.

The behavior of hydrological processes in a river basin is influenced by climatic, morphological and hydrographic characteristics, which condition their water availability (Corte, 2015). Water availability can be assessed to estimate a specific demand, such as the deployment of a hydro-intensive industry in the region or the establishment of public policies, such as a water master plan at regional or even national levels. In the first case, its location and feasibility of the enterprise are studied. In the second case, studies of interest of the public managers are inserted.

The water availability of the hydrographic basin (Figure 43) obtained through the water balance shows that, under scenario RCP4.5, the average flow is 78% higher than the flow in the reference period. On the other hand, under the RCP8.5 scenario, the projections show a reduction of 6% of the average flow. The effect of climate change on interannual flow variability also presents variations between scenarios. Average annual flows in wetter years increase by 70% in the RCP4.5 scenario and by 106% in the RCP8.5 scenario. On the other hand, average annual flows in the drier years increase by 19% in the RCP4.5 scenario, while they decrease by 53% in the RCP8.5 scenario. This discrepancy between scenarios in the driest years requires special attention in the development of long-term water resource planning.

Figure 43 - Annual average runoff frequency curve for the Yô Grande River Basin



4.2.2.3. Yô Grande hydroelectric potential

In the Yô Grande river basin there are studies of water potential in 6 hydroelectric plants (Hidrorumo Projecto e Gestão, 1996), 4 located in the Yô Grande river and 2 in the Ana Chaves river (Table 85 and Figure 44). The Climate Change scenarios analyzed for the use of Yô Grande 1 also present divergent results. In the RCP4.5 scenario the projections indicate a 78% increase in hydroelectric potential, while for the RCP8.5 scenario, the projections indicate a small reduction of 6% of the hydroelectric potential.

Figure 44 - Hydroelectric uses in the Yô Grande River basin. Source (adapted hydrorumo Project and Management, 1996)

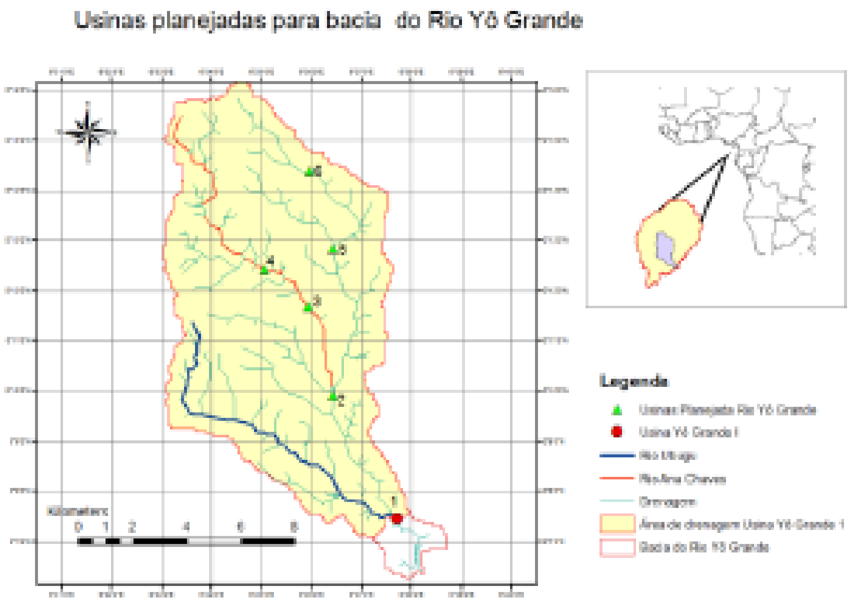


Table 85 - Characteristics of potentials in the Yô Grande River basin

Use	Previous Studies	NPA[27] (m)	Downstream Quota (m)	Gross fall (m)	Energy per year (GWh)	Nominal Power (kW)
Yô Grande 6	Guid.81	600	400	200	3.94	1000
Yô Grande 5	Guid.81	400	210	210	10.25	2000
Ana Chaves 4	Guid.81	500	300	200	6.91	1800
Ana Chaves 3	Guid.81	300	200	100	10.61	4000
Yô Grande 2	Nenhum	200	90	110	23.22	4000
Yô Grande 1	Guid.86	74	15	59	26.82	6000
Yô Grande 6	Guid.81	600	400	200	3.94	1000

Source: Hidrorumo Project and management (1996).

[27] NPA: Full Storage Level

4.2.2.4. Ouro River Basin

The Ouro River basin is located in the northwestern part of Sao Tome Island and has an area of 46.4 km^2, corresponding to approximately 5% of Sao Tome Island territory. The annual rainfall in the basin is on average 1,500 millimeters per year. The length of the Ouro river is 19.3 km and its average flow to the mouth is 1 m^3 / s (Hidrorumo project and management, 1996).

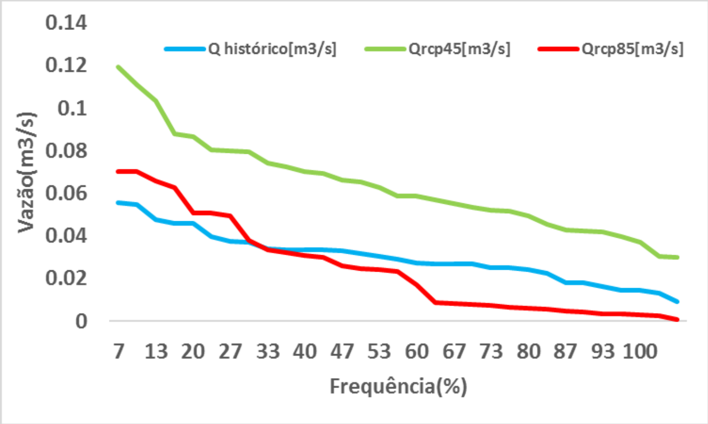
The source of the Ouro river is in the quota of 1,400 ms of altitude and to the southeast of the hill of Provas. It has great slope in its initial stretch, which gradually decreases to the level of the sea. In the upstream stretch, it receives its most important tributaries : Coimbra Water and Angolar Water.

Upstream of the basin, at its source, the soil is known as humid brown land. Still in the upper section, the soils of the ferralítico type predominate in the basin. In the middle section, the soils of brown earth are found, while in the low section, the ferruginous tropical soils are found. Coffee and cocoa crops and mid-altitude forests together account for 85% of the basin's coverage. The remaining 15% are distributed among savannas, arable crops and natural meadows.

Hydrometeorological information in the basin is scarce. No historical series of flows or meteorological stations within the basin are available to recreate the climatic behavior of the hydrological cycle in the basin. The northeast part of Sao Tome Island, where the capital is located, is densely populated and water consumption is quite high. The Ouro river is the main source of surface water for the region (Hydroconseil, 2011). According to the National Expansion Plan for National Supply (Detail, 1996), there is now an intake of 780 cmd (average daily consumption) and by the year 2040 the expansion forecast is of 2,700 cmd for the Ouro river basin. Irrigation is also present in the river basin by the Agostinho Neto company, which has a reservoir of 56,012 m3, which can benefit 639 ha of land. According to the same report, the water supply should be increased by approximately 33,000 m^3 / day by the target year of the 2040 project.

The projections of average annual flows under the effect of climatic changes presented divergent results among the scenarios (Figure 45). In the RCP4.5 scenario, there is a 110% increase in average annual outflows, while projections for the RCP8.5 scenario indicate a 17% reduction. This difference is mainly influenced by the impact in the drier years. In those years, the RCP4.5 scenario results in an increase in the average annual flow of 170%, while in the RCP8.5 scenario it is observed a decrease of 78%. In the wetter years, average annual runoff increased in both scenarios. Given the current characteristics of the demand for water resources in the basin, the divergence of scenarios, with the possibility of reducing water availability mainly in drier years, needs to be evaluated for the development of resource use planning.

Figure 45 - Frequency curve of annual average runoff for the Ouro River basin



4.2.2.5. Hydroelectric potential of the Ouro River

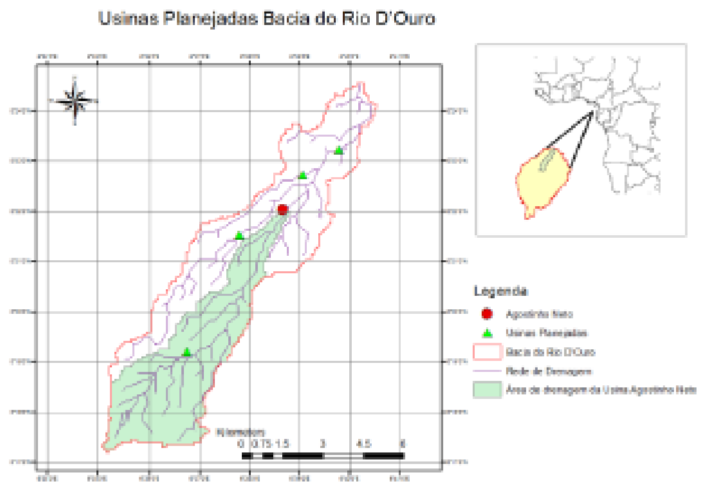
The Ouro river is the main river in the northern part of the island of Sao Tome and the only river with hydroelectric power production capacity in the region. According to the company Hidrorrumo Projecto e Gestão (1996), it is planned to build 4 hydroelectric power stations in the basin. Currently, the basin has a built structure called Agostinho Neto (Figure 46). The characteristics of the planned plants are shown in Table 86.

Table 86 - - Characteristics of the projected power plants in the Ouro river basin

Do Ouro 4	0.2	700	200	500
Do Ouro 3	0.46	500	100	500
Do Ouro 2	0.49	400	160	1000
Do Ouro 1	0.55	230	55	344
Agostinho Neto	0.7	-	55	347

Source: Hidrorrumo Project and Management (1996)

Figure 46 - Projected power stations in the Ouro river Basin



[28] NPA: Full Storage Level

Climatic changes, according to the scenarios analyzed, alter the potential of hydroelectric production in the Agostinho Neto plant (Table 86). Under the RCP4.5 scenario, projections indicate a 110% increase in hydroelectric potential, while under RCP8.5, projections indicate a 17% reduction in hydroelectric potential.

4.3 Coastal areas

In the first IPCC (1990) report, small islands did not receive a separate chapter although they were discussed in the chapter on "World Oceans and Coastal Areas" (Tsyban et al., 1990). Since 1990 two points have been emphasized : the first, that a sea level rise (Sea Level Rise - SLR) of 30 to 50 cm projected until 2050 would threaten the islands of low altitudes; The second, the costs of protection work to combat rising sea levels would be extremely high for small island nations (Tsyban et al., 1990; Bijlsma et al., 1996).

In the fifth IPCC assessment report (AR5) (2014), it is stressed that increases in the mean sea level projected towards the end of the 21st century in the moderate scenario RCP4.5 range from 0.36 to 0.71 m [average of 0.53 m] and in the more severe scenario, RCP8.5, range between 0.52 m and 0.98 m [mean 0.74 m] - see Nurse et al. (2014); Wong et al. (2014). This increase, associated with extreme events reaching the coastal zone, for example, storms and rough seas, presents severe risks of flooding and erosion at sea for low altitude areas (Nurse et al., 2014; Wong et al., 2014), effects that may lead to the reduction of the territory and cause damage to the coastal activities that are essential for the population of Sao Tome and Principe.

According to the National Strategy and Plan of Action for Biodiversity 2015-2020 (RDSTP, 2017), Sao Tome and Principe has a coastal zone of about 260 km in length and an Exclusive Economic Zone (EEZ) in the Atlantic Ocean. The coastal zone and the marine environment are an integrated resource and an essential component of the environment, which offers valuable opportunities for achieving sustainable development in Sao Tome and Principe.

At STP's CNI, several vulnerable sectors were located in coastal areas. The sectors of hotel infrastructure and beaches and housing were indicated as those of greater vulnerability. The retreat of the coast in two beaches at about 5.2 meters per year is greatly accelerated by coastal erosion (Santana, 2010), leaving the population unprotected (S. Pedro beach, for example).

In addition, the NAPA report (2006) highlighted some relevant aspects of vulnerability in the country, such as: loss of materials and fishing equipment during fishing by artisanal fishermen; loss of life due to disappearance at sea; partial or complete destruction of vessels at berths or beaches; destruction of homes where fishermen's families live as a result of the advancement of sea water; increase in the level of poverty in women because husbands lose fishing materials, equipment or their own life at sea, assuming them to manage the household with scarce resources; increase in the number of illiterates and / or work of minors (school-age children) who give up studying to have to fish and strengthen the family's livelihood.

In the Vulnerability and Adaptation chapter, previous works were mapped on the basis of possible effects of extreme climatic events on the coastal region of Sao Tome and Principe islands. In this chapter, effects on ecosystems and human activities were limited to the Flood-Resistant Zone, based on the definition of low-lying zones. From the Digital Terrain Models available for Sao Tome and Principe, slope maps were generated with classes that supported the delimitation of Low Altitude Zones (and the delimitation of areas susceptible to landslides or landslides in areas with slopes between 30 (Table 1), and in the literature (Table 1). The results obtained in this work are summarized in Table 1. Santos and Vieira, 2009; Marcelino et al., 2009).

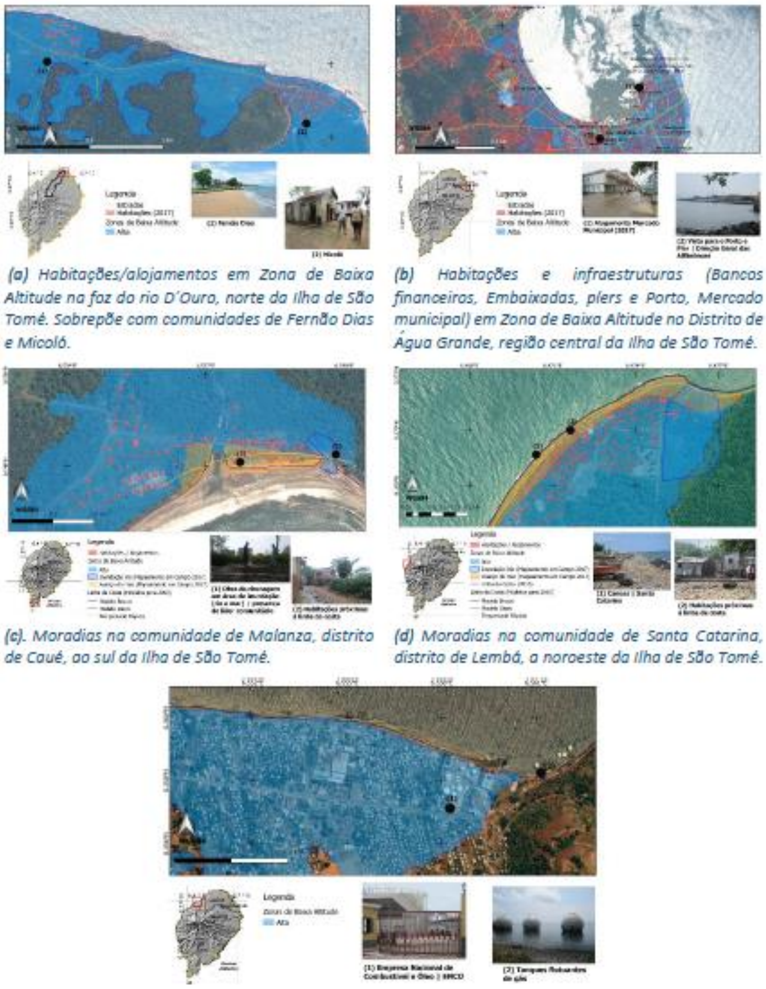
The low-lying coastal zones were delimited from the 10-meter Digital Terrain Model (MDT) for the island of Sao Tome, with the TerraSAR-X stereographic image.

About one third of dwellings (13,692 dwellings) are located in areas with altitudes lower than 10 meters and low slopes (<10 °), considered to be highly susceptible to the coastal dynamics, with the central region (districts of Água Grande and Me-Zóchi) those with the highest proportion of communities in those areas. Furthermore, in the district of Lembá, the communities of Neves and Santa Catarina are very exposed to the effects of climatic extremes. In the 1st and 2nd National Communications of Climate Change the community of Santa Catarina is mentioned and, according to projections of coastline variation for 2050, dwellings up to 30 m from the coast line will be reached.

However, in a field survey in 2017, reports were gathered that sea water advanced up to 70 m, reaching homes within the road that passes through the community of Santa Catarina. There are currently estimated 603 dwellings in a low altitude zone, totaling approximately 2,412 people affected (Figure 47).

In the Neves community, there are nationally important infrastructures such as the National Fuel and Oil Company - ENCO - and the gas storage tanks, located on the seafront and exposed to the effects of sea level rise. Approximately 1,562 dwellings are highly susceptible to tidal effects and 204 dwellings in areas considered of medium susceptibility, totaling approximately 7,000 affected inhabitants.

Figure 47 -: Flooded areas, projected 2050 shoreline advance projections and participatory mapping carried out in 2017 in the coastal community of São Tomé island.



(a) Habitações/alojamentos em Zona de Baixa Altitude na foz do rio D'Ouro, norte da Ilha de São Tomé. Sobrepõe com comunidades de Fernão Dias e Micoló.

(b) Habitações e infraestruturas (Bancos financeiros, Embaixadas, piers e Porto, Mercado municipal) em Zona de Baixa Altitude no Distrito de Água Grande, região central da Ilha de São Tomé.

(c). Moradias na comunidade de Malanza, distrito de Caué, ao sul da Ilha de São Tomé.

(d) Moradias na comunidade de Santa Catarina, distrito de Lembá, a noroeste da Ilha de São Tomé.

e) Housing and energy supply infrastructure in the community of Neves, Lembá district, northwest of Sao Tome Island.

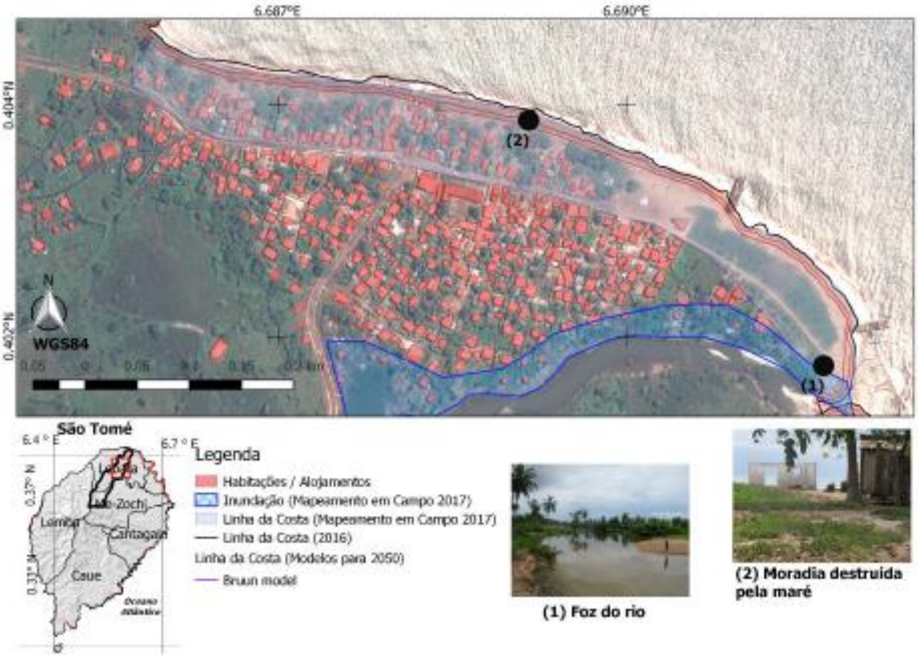
Two coastal areas were highlighted in this evaluation: the range that covers the mouth of the Ouro river and the range that comprises the mouth of the Yô Grande river, which are part of the basins studied from the hydrological point of view.

4.3.1 Sea and coast line elevation

Based on previous studies (Giardino et al., 2011, 2014) and based on mapping carried out in 2017, the coast line affected by the effects of tides and by sea level rise could vary from 10 m (Bruun model (Brunn, 1962) from the current coastline) to 70 m (mapping with community leaders from Micoló) (Figure 48), affecting almost 1,200 inhabitants.

The cumulative effects of tidal variation in periods of storms and floods can cause serious impacts on the community within a 30-meter range near the Micoló River.

Figure 48 - Projections of the shoreline advance to circa 2050 and participatory mapping conducted 2017 in the coastal community of Micoló, north of the island of São Tomé.



Residents reported that in the year 2016, the tide hit the road level of community access (advancing more than 70 m from the coast line). According to reports from community leaders, there has been community training for storm warnings and travel strategies for areas of safe expansion, as well as training in the use of GPS and radio communication for local committees (Figure 48).

In the case of the Yô Grande community, based on previous studies (Giardino et al., 2011, 2014) and mapping carried out in 2017, the coastline affected by tidal effects and sea level rise may vary between 10 -15 m (Dean model and Bruun model from the current coastline) and 70 m (mapping with the Yô Grande community, affecting almost 200 inhabitants.

Residents reported cumulative effects between tidal variation and flooding in storm periods, especially in housing near the Yô Grande river. Between March and April 2017 the school wall of the Yô Grande community was rebuilt when it was hit by strong tide in 2016.

Recommendations such as those made to the Micoló community reinforce efforts to reduce housing construction very close to the coastline in order to reduce possible impacts on the estimates of 0.36 m by 2050 and 0.71 m by 2100 (IPCC, 2014), mainly because the coastal area that covers the Yô Grande community is located in a low altitude area (elevation less than 10 meters and slopes lower than 10 °).

Figure 49 -. Projections of the 2050 shoreline advance and participatory mapping conducted in 2017 in the coastal community of Yô Grande, southeast of São Tomé island.

4.3.2. Projections of impacts of climatic extremes in the coastal zone

Climate extremes were calculated according to the ETCCDI recommendation (Alexander et al., 2005) and can be found in the climate extremes section of the chapter on Projections of Climate Change Communication. Maps of susceptibility to landslides and low altitude zones were produced and overlapped with the indexes for the reference period (Figure 50) and for the future (2041-2070) considering the RCP4.5 scenario (Figure 51). It was observed that in relation to the annual precipitation (PRCPTOT), the regions most susceptible to overturning occur in Sao Tome in the higher altitude regions. However, there are also high and intermediate values on the coast, mainly in the northwest and south of the island (with a total of 2,100 mm / year). In Príncipe island, in spite of the highest rainfall total, the areas subject to overthrows are restricted to the south of the island, with high and intermediate intensity, where the Obo Natural Park is located. In Figure 53, the projections in the RCP4.5 scenario indicate an increase in precipitation in both islands, mainly in the southwest of Sao Tome Island. In this scenario, despite the increase of annual precipitation, projections indicate that the areas of greater susceptibility are located in areas of high altitudes (above 900 m), where there are more dispersed dwellings in the territory, besides overlapping with the limits of the Obo Natural Park.

Figure 50 - Hazard map, Low Altitude Zones and landslide susceptibility, overlapping annual rainfall (PRCPTOT in mm / yr) - annual average for present climate, period 1971-2000.

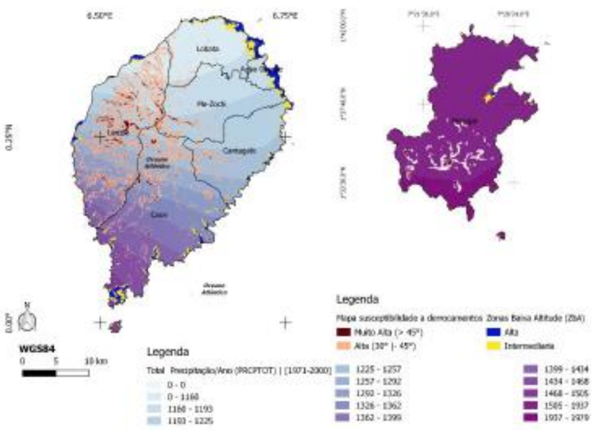
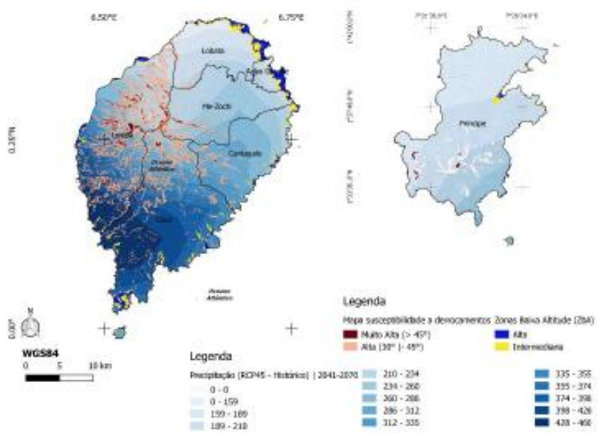


Figure 51 -. Hazard map, Low Altitude Zones and landslide susceptibility, superimposed on the field of change in total annual precipitation (difference between future period (2041-2070) in scenario RCP4.5 and reference period).



In Figure 52, four climate extremes indicators are presented for the reference period and for the future (2041-2070), considering scenarios RCP4.5 and RCP8.5. Similar to Figure 52, hazard maps in low altitude and susceptible to overturn areas are superimposed on each of the extreme weather indicators.

In Figure 52 (i) is the index RX5day that presents the highest annual rainfall accumulated in 5 consecutive days. Projections indicate an increase of this index across the island and for both scenarios. This pattern is even more evident in the RCP4.5 scenario, with higher RX5day values. The southern region of Sao Tome Island (Caué - in the communities of Malanza and Porto Alegre) and southwest (Obo Park region) may be more affected by increase in the volume of consecutive precipitations (up to 194 mm) considering the RCP4.5 and RCP8.5 projection. In these regions, there are also predominant projections of areas susceptible to landslides (areas with slopes higher than 30 °), affecting mainly rural communities (Estrela, Erminda, Vale Carmo).

Figure 52 (ii) shows the R95p index that represents the annual rainfall accumulated on days of heavy rains. The projections indicate an increase in extreme precipitation in the RCP4.5 scenario, with this increase being highest in the south-west of the island (up to 400 mm / year in the southernmost part of Sao Tome Island and 500 mm / year in island of Príncipe). In the RCP8.5 scenario, the projections indicate an increase in the southwest of the island, but a small decrease in heavy rains in the north of the island.

The consecutive dry days index (CDD) is shown in figure 52 (iii). The projections of this index show that in Sao Tome the values are higher when compared with Príncipe, especially in the central part of the island. Projections show increased CDD throughout the study area, although this increase is even more intense in the RCP8.5 scenario, which may lead to problems for the fishing and subsistence sectors.

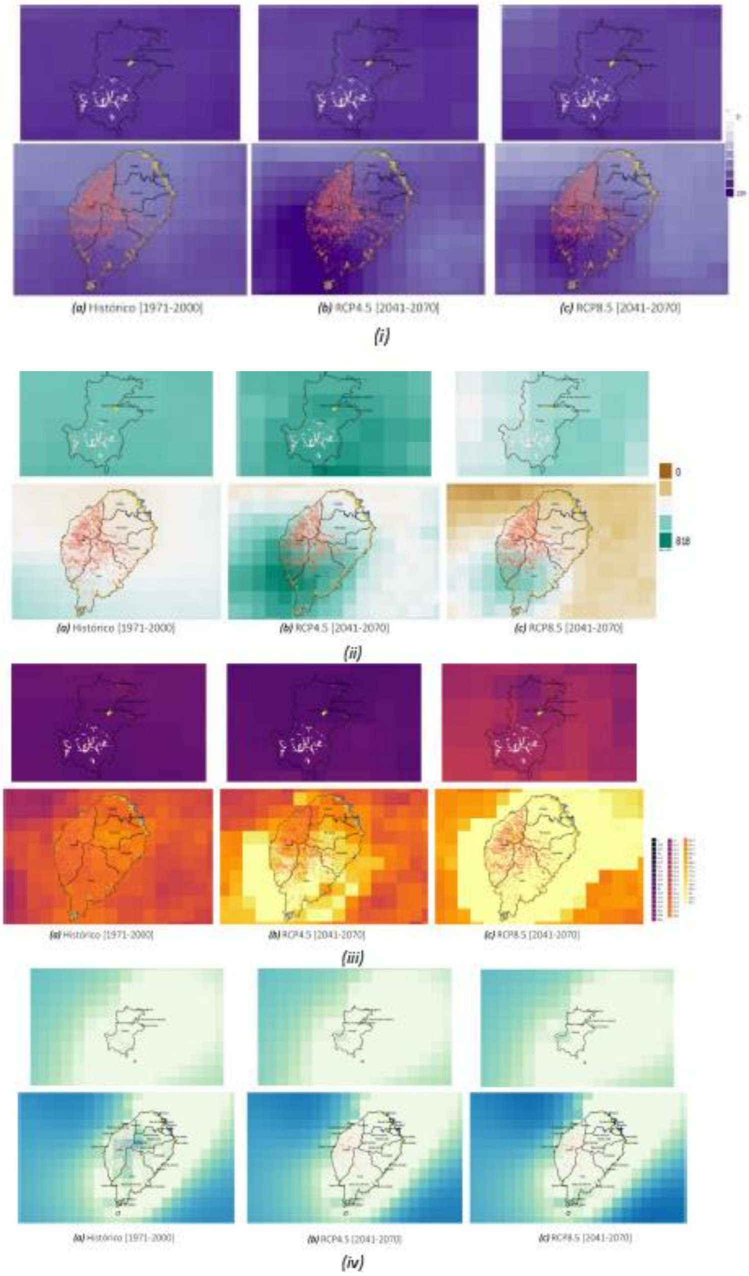
Wind speed indexes (mean, maximum and annual minimum values) were created for this work. The mean wind speed maps are shown in figure 52 (iv). According to the results of such indexes of climatic extremes of wind, there is a tendency of reduction of maximum, minimum and average values of wind in the future, in both scenarios. The daily maximum winds also tend to decrease, resulting in a weakening of wind in the future climate.

Despite this trend projected by the model in both scenarios, CONPREC reports (STP, 2016), there are accounts of strong wind events that often cause waves, causing damage to many fishermen who lose their boats at berths and many families of fishermen lose their homes located by the sea.

Additional analysis of impacts of winds in the coastal zone need to be elaborated, however there are indications of attention on possible impacts in the Neves community, where the National Fuel and Oil Company (ENCO) is installed, and supplies energy to Sao Tome and Principe.

Hazard maps in coastal zones [29]

Figure 52 - Hazard maps in coastal zones



29 Low Altitude and Slipability Zones, superimposed on weather extremes indicators for reference period (left column) and future period (2041-2070) in scenario RCP4.5 (center column) and RCP8.5 (column of right): (i) Highest total annual rainfall over 5 consecutive days (RX5day in mm / year); (ii) Heavy rain (R95P in mm / year); Consecutive dry days (CDD days / year) and (iv) Wind speed (annual average in meters per second).

4.3. Adaptation measures

The adaptation measures proposed in this National Communication are intended to complement the adaptation measures recommended in the two previous national communications, the NAPA and some adaptation projects, through the valorisation of previous efforts, indicating the scientific basis for planning and decision-making. These scientific analysis of vulnerabilities and impacts in the face of climate change were carried out in four of the most vulnerable sectors: energy, agriculture, water resources and coastal zones.

The proposed adaptation measures were developed in line with projections of sectoral impacts and vulnerability to climate change projected for the period 2041-2070.

A. Adaptation measures in the agriculture sector:

Agriculture is a very important economic sector for the country, which contributes about 22.4% to GDP. However, this sector is very sensitive to climate change, as seen in the analysis of the vulnerability scenarios (RCP4.5 and RCP8.5), both thermal stress and water stress.

Thus, for this sector the following adaptation measures are proposed:

1. To study and develop agricultural pesticides that are used in the fight against agricultural diseases, which do not present harmful effects on the environment, soil, biota, especially in areas where favorable conditions for disease occurrence are indicated (for example, southern regions of Sao Tome and Principe Island);
2. To study and develop cultural practices to reduce water stress and / or thermal stress;
3. Introduce crop varieties resistant to water stress and / or thermal stress indicated by climate change projections;
4. Introduce improved seeds adapted to climate change, based on the needs of each crop, its degree of resistance to thermal or water stress, diseases etc;
5. Implement a distribution program to the culture seed communities that are more resistant to disease, water stress or thermal stress;
6. Study and implement an agricultural irrigation system for crops in regions where major reductions in rainfall are projected;
7. To study other more productive agricultural crops for food security;
8. To study other agricultural crops more productive for commodities (palm oil and coffee);
9. Create and maintain mechanisms to ensure actions related to sustainable development in the areas of food improvement, food management, food stocks in case of disasters;
10. Develop and adopt appropriate cultivation techniques in sloping areas and other risk areas.

B. Adaptation measures in the water sector:

Although STP has a vast hydrographic network, water resources are quite sensitive to climate change according to vulnerability analysis carried out under the TNC.

However, the lack of hydro-meteorological data harm the study of existing river basins, since observational data provide information on the processes and dynamics of the hydrological response of the basin and allow to address the uncertainties in numerical modeling.

Thus, the following adaptation measures are proposed for the Water Resources sector:

1. Deepen knowledge and create a database for river basin studies;
2. Study the current and future availability and demand of water resources in STP, incorporating different scenarios of climate change;
3. Make an overall assessment of the hydrological potential available, including underground water resources;
4. Adopt legislative measures to contain the non-rational use of water resources, regulate their use and establish measures and precautions for their conservation;
5. Develop measures to discourage mismanagement and waste of water;
6. Establish measures to avoid all forms of contamination and chemical and biological water pollution;
7. Promote projects of tree plantings for the protection of Hydrographic Basins..

C. Adaptation measures in the coastal zone sector:

To cope with the adverse effects of climate change, the country has developed a series of initiatives, including the Adaptation to Climate Change Project in the Coastal Areas (PAMCZC, 2016, 2017), which has carried out actions such as revegetation of coastal borders, communities structures for adaptation, structural works (retaining walls, drainage channels), and equipment installation (radio communication, fluviometric measurement stations). PAMCZC, among other objectives, seeks to minimize risks to communities from extreme events due to climate change, and to increase their ability to adapt to the adverse impacts of climate change (PMCZC, 2017).

Plan disaster risk reduction actions associated with coastal flooding, coastal erosion, tides, hangovers, storms, combined tidal effects and river flooding ; landslides / landslides induced by occupation in sloping areas due to the relocation of people living in the coastal zone. Strengthen the system of prevention, rescue and follow-up, expanding actions already carried out within the PAMCZC framework.

As adaptation measures in the coastal zone sector, TNC proposes to:

1. The formulation of contingency plans considering areas susceptible to flooding by sea level rise and river flow, considering overcrowding areas (monitoring, warning and communication) to reduce damages;
2. Strengthening of the articulation between the different sectors of government and civil society that are in the coastal territory, in order to develop studies and actions of monitoring, risk management and adaptation that have an ecosystemic and holistic vision on that territory;
3. The implementation, validation and operation of the regional numerical model of ocean circulation, to estimate ocean temperatures and currents;
4. The implementation, validation and operation of the regional numerical model of waves, to estimate the height and direction of the waves;
5. Definition of construction patterns in coastal zones, such as height, elevation and resistance of materials;
6. The implementation of an alert system for deep sea fishing navigation;
7. The establishment of mechanisms to guarantee fish production, especially in the fishing communities of Príncipe, south of Sao Tome Island (district of Caué).

4.4. Measures to improve the data problem

In view of the problems associated with the lack of reliable data for the preparation of national communications and in addition to the NAPA measures and other adaptation projects, TNC proposes to improve data governance in order to continue and reinforce some of the actions proposed in the Second National Communication (STP 2012). In this sense, the following adaptation measures are proposed:

4.4.1. Database Organization

Throughout various studies carried out within TNC, it was found that the lack of reliable and coherent data with long duration series is a fragility in the analysis of the sectors' conditions.

This is how analysis of climatic extremes and climatic trends require long duration series of quality meteorological data. These data should have greater spatial density due to the rugged topography of the islands and the different land uses.

Likewise, the lack of hydrometeorological data observed limits the study of river basins. Observational data provide information on the processes and dynamics of the hydrological response of basins and allow to address uncertainties in numerical modeling. It is also necessary to obtain representative flow series (net discharges) in the basins, in addition to river level. Thus, in order for the country to have this data for a better analysis of vulnerability and adaptation, the following actions are proposed:

1. Implementation of permanent mechanisms for collecting and processing data at the national level, with direct involvement of the competent authorities, in particular in the Ministries of Environment, Finance and International Cooperation.

2. Development of a scientific methodology through a coherent approach to data collection and processing, trends in the evolution of interconnections between the environment and society.
3. Creation of a national data platform.
4. Creation of a database on the productivity of each crop, areas of production, disease and pest registration associated with the effects of extreme climatic events on agricultural crops.
5. The elaboration of an agricultural mapping and census for the diverse cultures.
6. Carry out field trials on optimum conditions for the development of STP crops, as well as favorable conditions for the spread of diseases and pests.
7. Carry out mapping of the physical water properties of soils to better identify the water storage capacity in the soils.
8. Development and validation of productivity models for the main island cultures ;
9. Carry out an agricultural census to obtain more information from farmers and thus support mitigation and adaptation measures ;
10. Provide institutions responsible for the production of hardware and software information capable of supporting storage, processing and energy efficiency ;

4.4.2. Socio-environmental monitoring

The intersectoral monitoring of long-term phenomena to accompany the permanent adaptation actions, in addition to the validity of projects. It is proposed that all information related to climate change in the country should be sent to the Directorate General for the Environment (DGA). It is also suggested the creation of a National Monitoring System - responsible for making the intersectoral articulation of the problem - that will include issues related to the monitoring, reporting and verification of adaptation actions in the face of climate change.

Some social dynamics have implications for the actions of the various institutions that establish the commitment to carry out intersectoral monitoring. Given this, there are necessary actions to periodically update information. Among these actions are:

1. To create networks for the collection, treatment, sharing and dissemination of data and information produced by INE, in order to assist analysis of population profile and vulnerability by sectors disaggregated by community boundaries, or by regular sampling;
2. Establish inter-sectoral risk management plans as a continuous adaptation action;
3. Systematically monitor and update the mapping of risk areas - especially in the coastal zone (risks associated with flooding due to proximity to rivers, sea level rise, sliding in urban and rural areas), and to update mapping on a larger scale (1: 25,000, 1: 10,000), depending on the context and needs of the area - for example, where disaster risk evacuation plans are being developed;
4. Map and monitor the main vulnerabilities found in these territories, identifying the socioeconomic profile of the population, as well as their perceptions regarding risk, based on studies on the perception of risks;

5. Monitor, control and inspect areas for housing construction;
6. Create partnerships with the media to communicate monitoring actions.

4.4.3. Training and research

It proposes capacity-building activities for the implementation of climate change actions for adaptation purposes. The training and capacity building actions are:

1. Train, educate and sensitize the various actors, governments and civil society in the process of adaptation to climate change.
2. To train technicians to maintain stations, collect, arrange and analyze and use data from climate models and on the theme of climatic, hydrological and agricultural modeling.
3. Training in computer systems.
4. Training in Geographic Information System (GIS).
5. Specialization in the areas of climate, hydrology, oceanography, ichthyology, knowledge of the risks of climate change, data management and management, GIS (Forests, Biodiversity and Agriculture).

CHAPTER 5: MITIGATION

5.1. Introduction

The results of the three GHG inventories show that Sao Tome and Principe is a carbon sequestration (CO_2) country thanks to the LULUCF sector, although data on sequestration tends to decrease, taking into account, on the one hand, the revision of the calculations and, on the other hand, the increase in emissions from the main emitting sectors and the reduction of forest area by deforestation.

The sectors that emit GHG are energy and transport, agriculture, waste and buildings. The energy and transport sector contribute to the largest share of the country's emissions.

To achieve the goal of reducing GHG emissions, it is essential to implement policies and adopt measures for the transfer of technology and mobilize the necessary financial resources.

5.2. Energy and Transport Sector

The energy sector, which also includes transport, is the one that contributes to most of the emissions. For this reason, mitigation measures should be geared towards integrating renewable energy sources into clean energy systems that contribute to the reduction of greenhouse gas emissions.

5.2.1. Data Sources

Based on data from NDC of Sao Tome and Principe (2015), it was possible to execute the GHG balance-based model that contains the main assumptions considered for calculations and analysis of STP mitigation measures used by the GACMO Model and presented in Table 87.

Table 87 - Data used for mitigation calculations

Year of last GHG balance	**2012**
Population	178,739 inhabitants in 2012 (INE)
Reference interest rate (discount rate)	14 % (BCSTP)
Population growth	3% for the three periods (2012-2020;

	2020-2025; 2025-2030)
GDP in 2012	263.6 Million USD
GDP growth	4.5% for the three periods (2012-2020; 2020-2025; 2025-2030)

5.2.2. Methodology

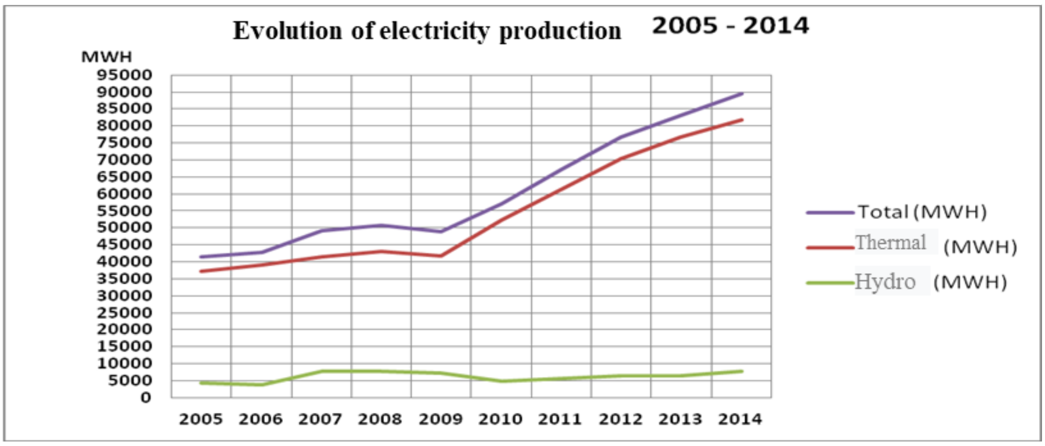
The GACMO MODEL software (V.01 / 04/2017) was developed using the Bottom-up method as an Excel-based tool for energy policy analysis and mitigation of GHGs within technological mitigation options and barriers by sector, taking as reference the year 2012 and for the implementation, the period 2020-2030.

The methodology used to make projections of reference and mitigation scenarios is proposed by MODEL (V.01 / 04/2017), where data from the last inventory of the main gases are used, as well as the main assumptions, according to Table 87.

5.3. Analysis, scenarios and mitigation measures

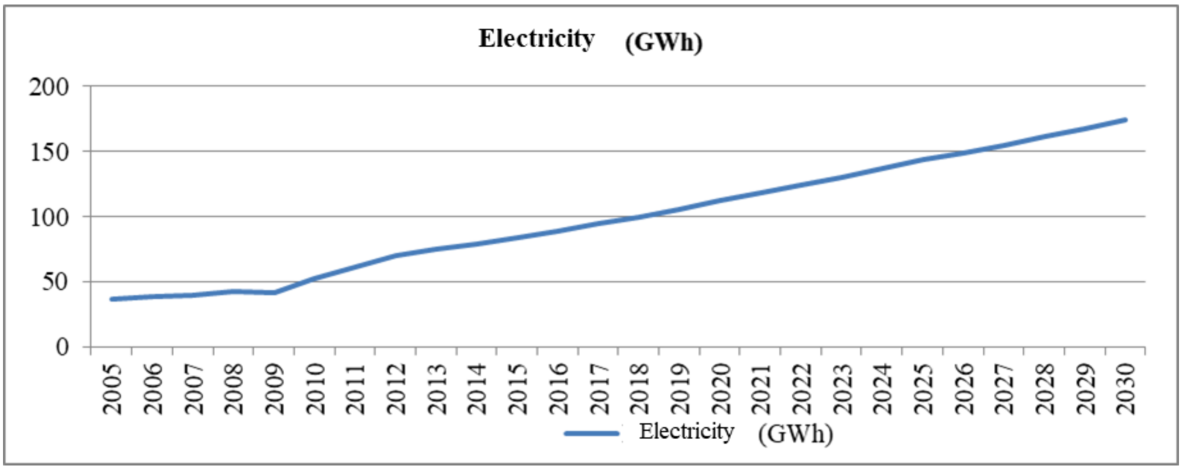
Electricity production from 2005 to 2009 grew moderately. In the following years this tendency increased significantly, with the installation of more thermal power stations. Consequently, with the increase in installed capacity, as previously mentioned, fuel consumption has also increased. On the other hand, the generation of hydroelectricity did not improve, maintaining an almost stable variation of 4,248 MWh in 2005 and 6,386 MWh in 2012, as shown in figure 53.

Figure 53 - Evolution of electricity demand until 2014



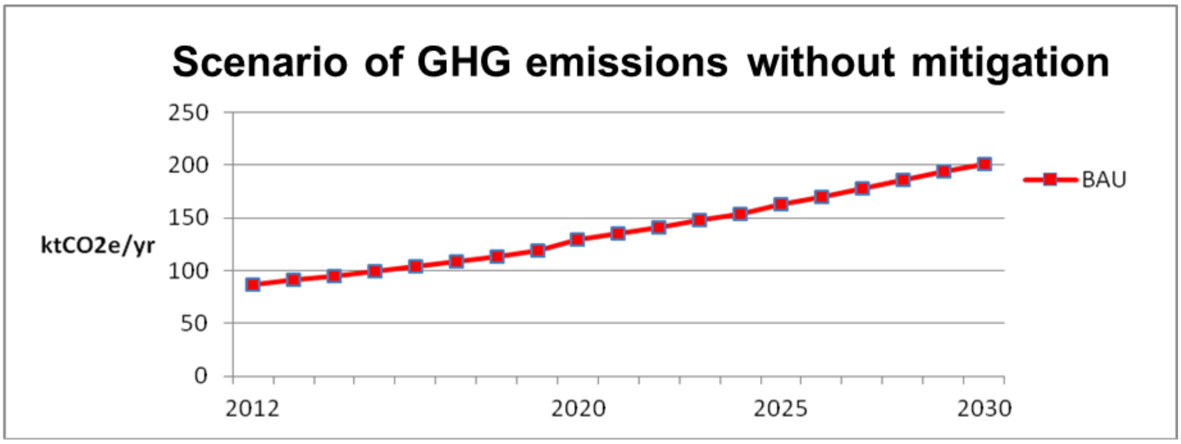
Based on this evolution and according to the assumptions considered and used in the GACMO Model (V.01 / 04/2017), the reference scenario for the electricity demand up to 2030 was projected, as shown in the following figure.

Figure 54 - Projected electricity demand by 2030 - Baseline scenario.



The Reference Scenario is based on projected emissions in the absence of additional explicit policies on climate change (Business As Usual - BAU), starting in 2012 for the energy sector, specifically the electricity and road transport subsector, and is the following: GHG emissions in the year 2020 will be around 119 kt CO_2 eq and in 2030, the 201 kt CO_2 eq emissions, as shown in figure 55 below.

Figure 55 - Reference scenario without mitigation



5.3.1. Mitigation measures

Considering the electricity demand projected for the period 2020-2030 and considering the year 2012 (70 GWh), it was projected that demand in the year 2020 would be 112 GWh, in 2025 it would be 143 GWh and in 2030 would be 174 GWh.

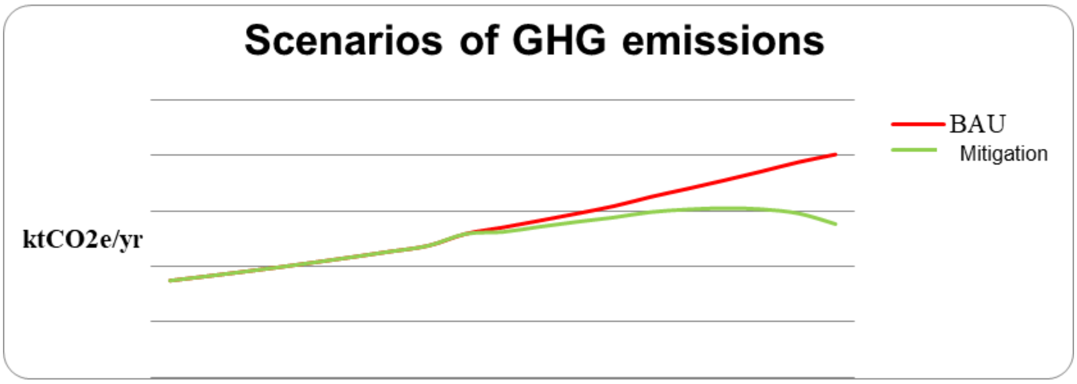
Table 88 presents the mitigation measures with respective contribution to GHG reduction, compared to the reference scenario in the period 2012-2030.

Table 88 - Mitigation measures based on baseline scenario, period 2012-2030.

1	Isolated mini-hydro plant (2 MW)	6,5
2	Power plants connected to the main network (14 MW)	27,7
3	Mini hydro power plant connected to the main network (2 MW)	4,0
4	Solar PVs (12 MW)	9,9
5	Onshore wind farm	3,8
6	Efficient LED home lighting (5 lamps / 20,000 poorest homes for 10 years, 100,000 units)	6,0
7	Efficient street lights (2,000 lights in total over 10 years)	0,8
8	More efficient network (1 GWh loss reduction)	1,5
9	Replacement 500 Gasoline Cabs / More Efficient Cars	0,2
10	Replacement of 500 diesel taxis / More efficient cars	0,3
	Total	63,0

Figure 56 shows the Baseline Scenario and the Mitigation Scenario for the 10 measures presented in Table 88, calculated by the GACMO Model.

Figure 56 - GHG emission scenarios.



As shown in figure 56, the projection of GHG emissions for the energy sector in 2030, according to the baseline scenario, would be around 201 kt CO_2 eq.

With the implementation of the mitigation options identified, there would be an emission reduction with respect to the reference scenario, of about 63 kt CO_2 eq., which corresponds to a reduction of around 31% of the GHG emissions of this sector.

5.3.2. Waste sector

The waste sector is an important emission sector where the main gases emitted are : CH_4 and CO_2.

The development of mitigation options for the waste sector has been developed on the basis of existing national data on mitigation options, the information gathered at the sector level, the data and methodology provided by the IPCC, the Clean Development Mechanism (CDM) at international level.

5.3.2.1. Data Sources

The development of the three mitigation options for the waste sector contained in the present study was prepared based on the following data :

Table 89 - Data used to develop the three mitigation options

Waste Discharge Rate	0,4 Kg/ inhab/ day (PGRSU 2011 -2016)
Methane generation rate per waste unit	0,06 Gg (IPCC 2006)
Methane Global Warming Potential	21 (IPCC, 2006)
Fraction of organic content in waste	51 % (PGRSU, 2011-2016)
Fraction of degradable organic content emitted to landfill	77 % (GACMO)
Fraction of waste deposited in the trash	0,6 (IPCC, 2006)
Fraction of waste deposited and processed at the Composting Center taking into account the collection system	30 to 90 % from 2012 to 2030
Fraction of methane in the composting gas	50 %. (GACMO)
Methane Correction Factor	0,4 (IPCC, 2006)
Waste processing capacity of the Água Grande District Composting Center	621 Ton/ year
Total waste processing capacity of the Água Grande District Composting Center	621 Ton/ year
Biodigester Capacity	94 Kg/ day (Ecovision)

5.3.2.2. Methodology

The calculation of emissions of the reference scenario was based on the factors presented in Table 90.

Table 90 - Factors for reference scenario emission formulation

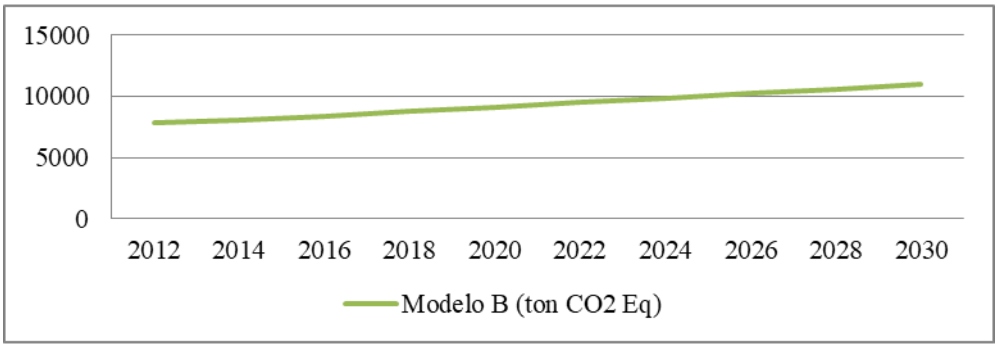
H1	Waste Discharge Rate	0,4	Kg/ inhab/ day	PGRSU
H2	Fraction of waste deposited in the trash	0,6	-	IPCC
H3	Methane Generation Rate per waste	0,06	-	IPCC

	unit			
H4	Methane correction factor	0,4	-	IPCC

5.3.2.3. Reference Scenario

Based on the calculations used to quantify emissions in the waste sector it was concluded that methane emissions for the period 2012 to 2030 ranged from 7,891.40 to 10,984.32 Ton CO_2 Eq, as shown in Figure 57 below.

Figure 57 - Baseline scenario emissions (in t CO2 eq.)



5.3.2.4. GHG mitigation options

For the mitigation options for the waste sector, the following scenarios were established: Landfill Sanitary with methane gas capture and flaring system, Biodigestor with methane gas capture and flaring system and Organic recovery center - aerobic composting.

5.3.2.4.1. Sanitary landfill with methane gas capture and flaring system

The mitigation scenario with the installation of a sanitary landfill with methane gas capture and flaring system aims at mitigating methane emissions from anaerobic waste degradation through the capture and destruction or possible use of methane gas produced in the closed system by anaerobic process that occurs in the sanitary landfill.

The waste process capacity of the landfill was established considering the small landfill (maximum capacity of 15 tons), defined from the cost of pre-implantation, implantation, operation, closure and collection capacity. The least squares regression was applied to extrapolate the total cost values corresponding to the capacity values (10 to 50 tons / day) shown in Table 91.

Table 91 - Estimated Landfill Investment (in millions USD)

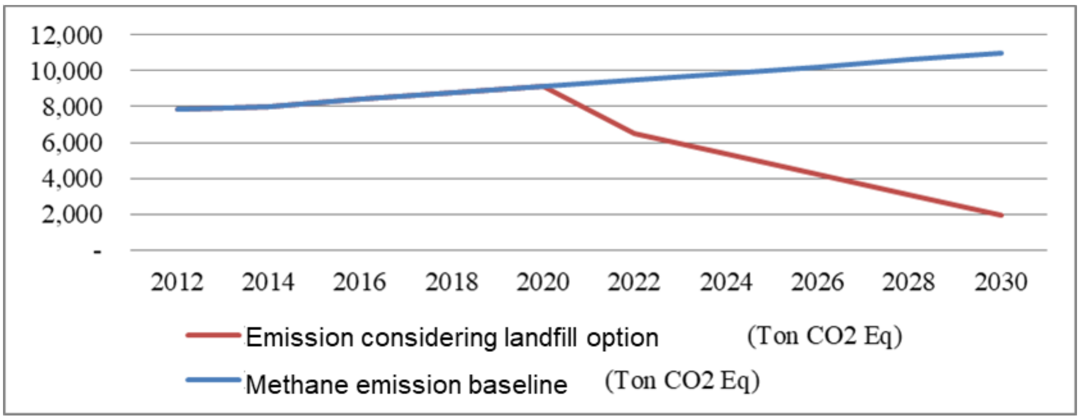
	10	15	20	30	40	50
Pre Deployment	0,13	0,13	0,14	0,14	0,15	0,15
Implantation	0,57	0,58	0,59	0,62	0,65	0,67
Operation	10,21	10,55	10,89	11,57	12,25	12,93
Closing	0,11	0,12	0,12	0,13	0,14	0,15
Post closure	0,73	0,76	0,78	0,84	0,89	0,94
Total USD (Millions)	11,76	12,14	12,53	13,31	14,08	14,85

Source: Adapted from Table 88, Estimate of investment in landfills to meet targets established by the National Solid Waste Policy between 2015 and 2019.

The fraction of waste deposited in the landfill varies from 0% in the reference year (2012) to 30% in 2030. Given the current inefficiency in the collection system, it was defined that only a small fraction of waste would be deposited in the landfill with a progressive increase until 2030.

The mitigation option considering the landfill with gas capture and flaring system will be implemented from the year 2020. This emission will be lower than the reference scenario as shown in figure 58.

Figure 58 - Methane emissions from baseline scenario and "landfill" mitigation option (in t CO_2eq.)



As shown in figure 58, in 2030 the methane emission is reduced with respect to the reference scenario by about 9,030.14 Ton CO_2 Eq., which corresponds to a reduction of about 82% by 2030.

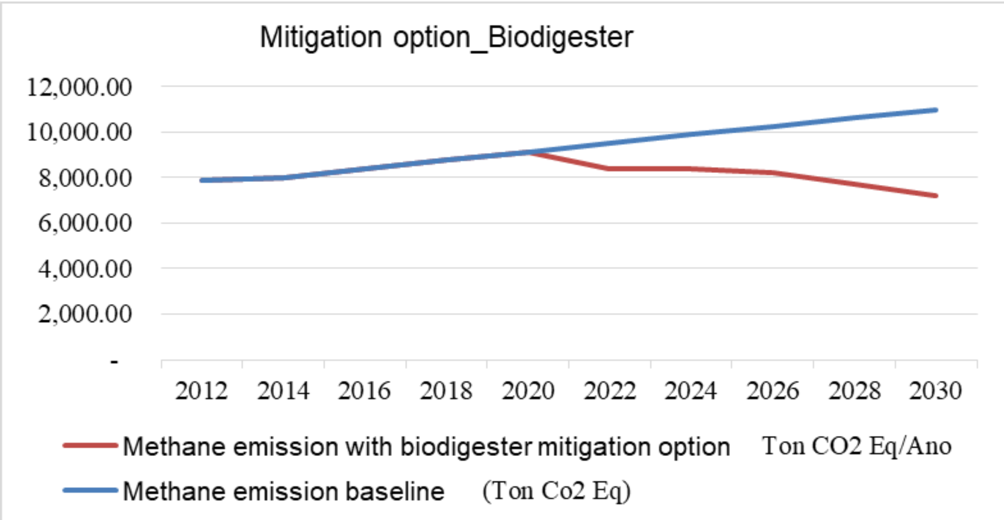
5.3.2.4.2. Biodigestor scenario with methane gas capture and burning system - Bioenergy Project

The biodigester to be built will be able to process about 220 kg of waste daily. Considering the expected characteristics of these wastes, a production of $7m^3$ of biogas per day is estimated, enough to increase the number of families benefited.

Biogas production will naturally be dependent on the feed stream and the operating temperature. However, considering that 94 kg of waste will be fed daily, a daily biogas production of 6 m3 is expected. This amount of gas will be used by 4 families (10 people).

The fraction of residue deposited in the biodigester would vary from 40% in the reference year (2020) to 100% in 2030, taking into account the current inefficiency in the collection system and the amount of waste available daily for the process. An incremental increase of the waste fraction entering the biodigester was assumed annually considering that there is an improvement in the collection system every year and an increase in the amount of waste available for the process. Methane emission considering the "Biodigestor with methane gas capture and burning" option is lower than the reference scenario as shown in figure 59.

Figure 59 - Methane emissions from baseline scenario and "Biodigester" mitigation option (in t CO_2 eq.)



As can be seen from figure 59, in 2030 methane emission with respect to the reference scenario is reduced by about 3,804.29 Ton CO_2 Eq., which corresponds to a reduction of about 35% by 2030.

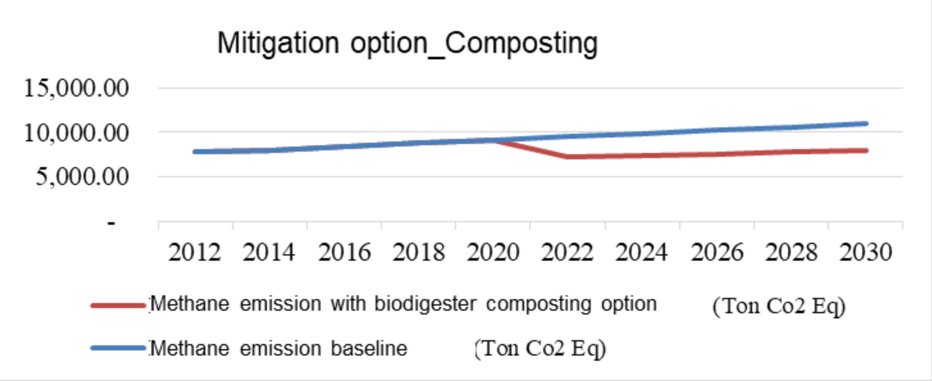
5.3.2.4.3. Scenario with Organic Valuation Center - aerobic composting

The fraction of the organic content deposited in the composting center presents an increasing variation over the years until reaching a maximum of 90% in the year 2030. There is a lack of fraction of the organic waste content in the reference year (2012), because it was taken into account that in that year the country did not have a composting center.

Methane emission ethane considering the reference scenario in the year 2030 is 10,984.32 t CO_2 Eq. Methane emission considering the mitigation option "Aerobic Composting" in the year 2030 is 7,975.48 t CO_2 Eq.

Methane emission considering the option "Organic recovery center - Aerobic composting" is lower than the reference scenario as shown in figure 60.

Figure 60 - Methane emissions from baseline scenario and "Aerobic compost" mitigation option (in t CO_2 eq.)



As shown in figure 60, a reduction in methane emission was achieved with respect to the baseline scenario at about 3,008.84 t CO_2 Eq, which corresponds to a reduction of about 27% by 2030.

5.3.3. Buildings sector

Although buildings are not a large GHG emitting sector, it is important to adopt mitigation measures for this sector due to the large use of biomass burning in the form of firewood and coal within the subsectors of the building sector, as a way to protect the environment.

5.3.3.1. Data source

For the purposes of calculation of GHG emissions from biomass burning for the building sector, it was based on assumptions obtained from different institutional and other sources, as well as from estimates based on daily knowledge and calculations based on data collected.

5.3.3.2. Methodology

In order to develop measures and actions for the mitigation of greenhouse gases for the buildings sector, it was based on calculations using Microsoft Excel 2010.

These calculations were submitted to an extrapolation of the values obtained from the emissions, using the country's SNA report and the 2nd and 3rd GHGI corresponding to the years 2005 and 2012, respectively.

The extrapolations were made taking into account the year 2012 as the year of departure (reference year) until the horizon of 2030, taking as reference the perceived trends of the GHG emissions contained in the GHGI of 2005 and 2012.

5.3.3.3 Reference Scenario

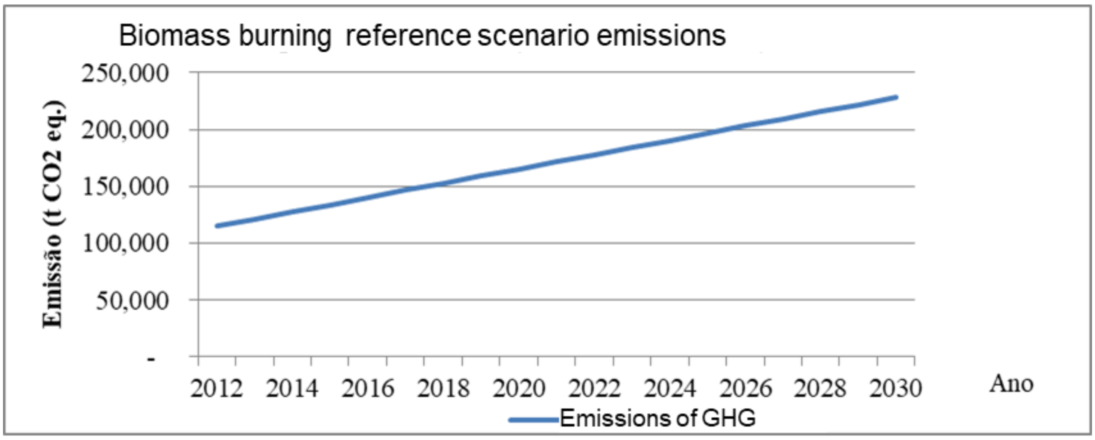
According to the GHGI Report of the energy sector referring to biomass burning (firewood and coal) there was between 2005 and 2012, a 38% increase in CO_2 emissions (total residential, commercial and public biomass), presenting 71,037 and 115,030 t CO_2 respectively.

For these two years, the variation of CO_2 emissions was approximately 44,000 t CO_2, which implies an annual variation of 6,285 t CO_2.

Based on the premise that this growth rate will continue until 2030, without implementing any type of measures, there will, therefore, be an estimated emission of about 228,155 t CO_2 inherent in the direct burning of firewood and coal in housing, public institutions and catering services.

Figure 61 shows the projection of the evolution of biomass burning emissions in the reference scenario.

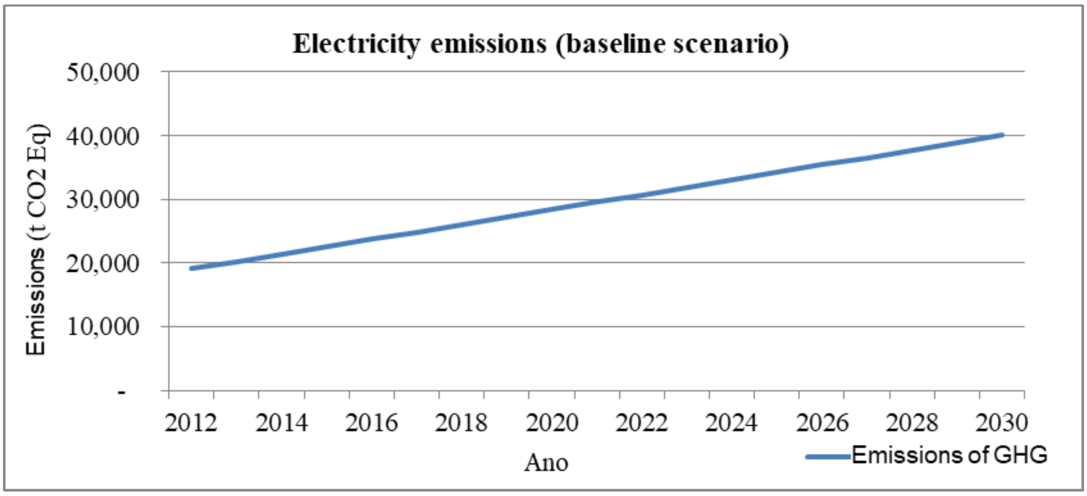
Figure 61 - Biomass burning reference scenario emissions.



Regarding electricity, according to the latest national inventory, emissions increased by 43% from 2005 to 2012, from 10,923 to 19,081 t CO_2 Eq respectively in the residential sector, with an annual variation of 1,166 t CO_2 Eq.

If this increasing trend continues until 2030, there will be an increase of emission in the order of 40,063 t CO_2 Eq, as can be seen in figure 62.

Figure 62 - GHG emission from residential electricity reference scenario

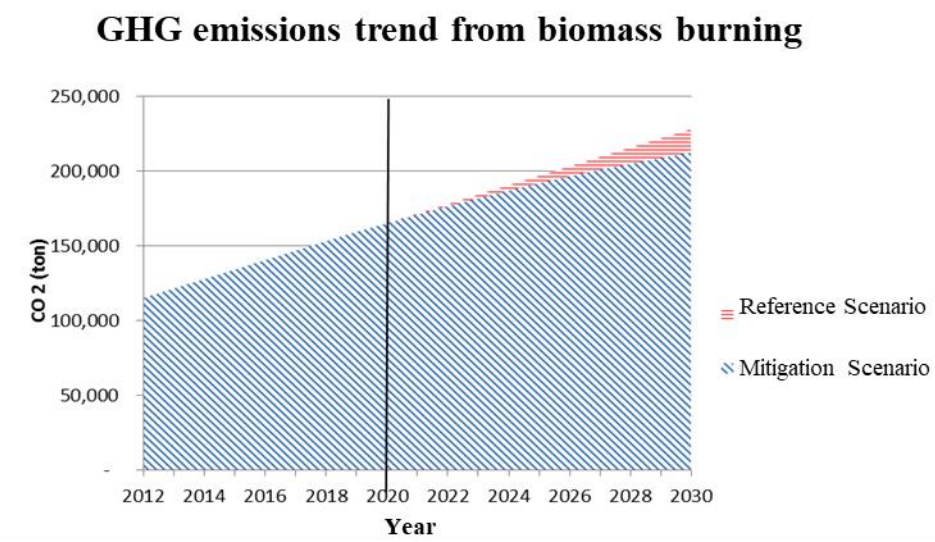


5.3.3.4. Mitigation options

5.3.3.4.1. Replacement of three-stone stoves (traditional kitchen)

As a proposal for emissions mitigation for biomass burning, the replacement of 39,600 "three stone (traditional kitchen)" stoves were established in homes, public institutions and catering services which correspond to the total of stoves that would exist in the country by 2030. With this intervention, emissions reduction is expected to be around 7% by the year 2030, starting in 2020, as shown in figure 63.

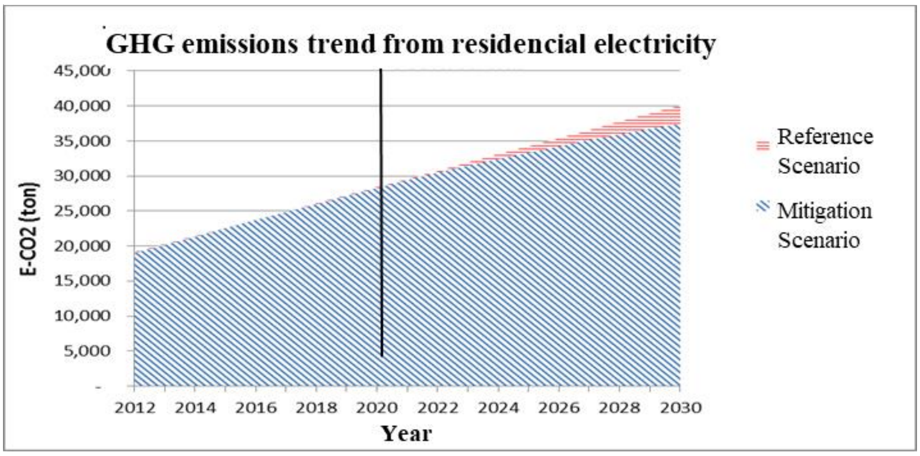
Figure 63 - GHG Mitigation Scenario (use of improved stoves)



5.3.3.4.2. Replacing light bulbs

As a measure for mitigation of GHG emissions related to residential electricity, it is suggested to replace incandescent lamps with LFC, starting in 2020 until 2030. This intervention will result in a 75% reduction in energy consumption. Thus, with this measure, the emission reduction forecast is approximately 6% by 2030, as illustrated in figure 64.

Figure 64 - GHG Mitigation Scenario (Light Bulb Replacement)



This mitigation measure of GHG emissions from proposed residential electricity presents a mitigation potential of 2,566.08 t CO_2 Eq.

5.4. Mitigation measures identified, according to priority.

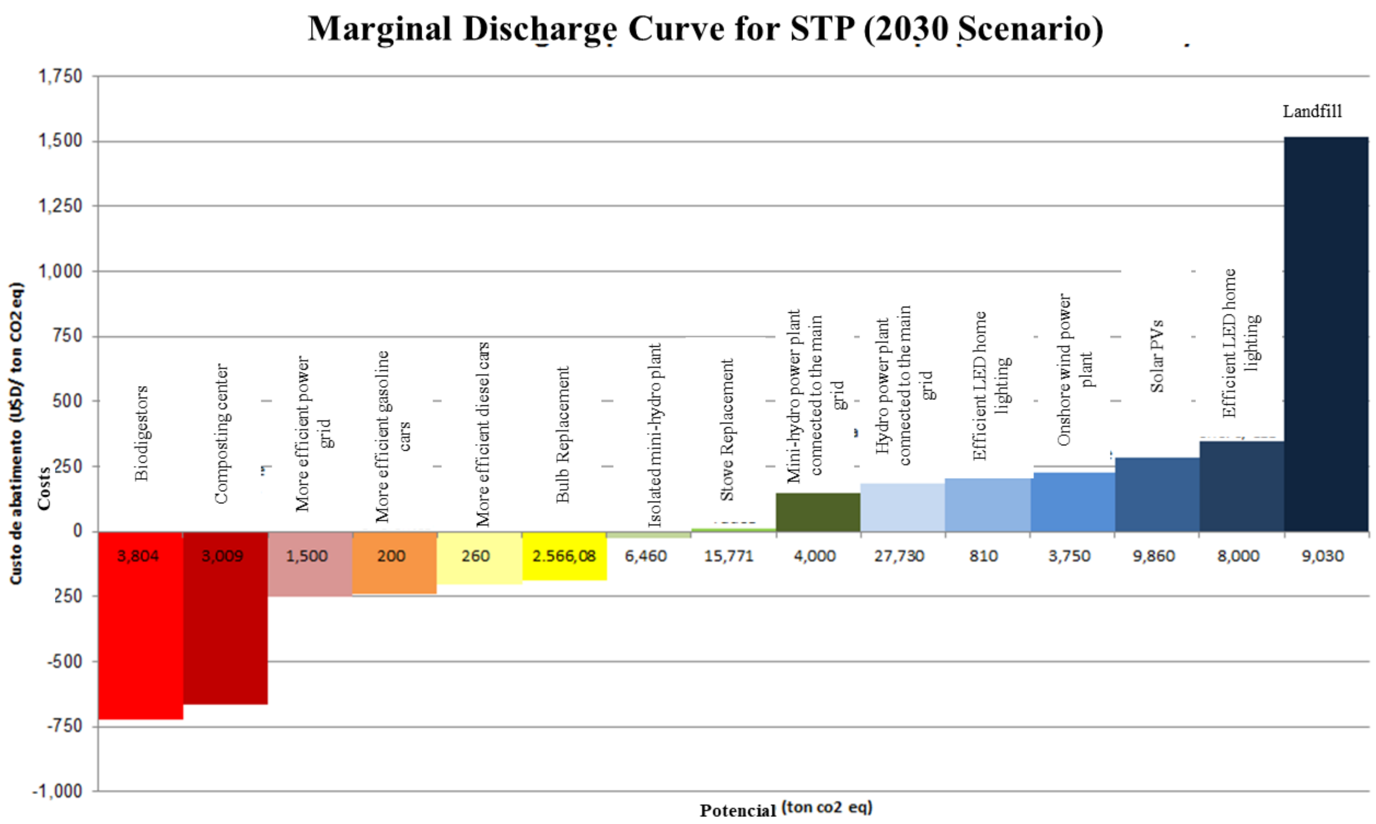
Table 92 presents the 15 mitigation measures identified in the scope of this national communication, in order of priority, through the use of certain criteria such as : the socio-economic and sustainable development impact for the country ; environmental benefits they can bring, as well as their feasibility according to the country's realities.

Table 92 - Summary of mitigation measures identified by priority.

1	Main network connected power plants (14 MW)	27 730
2	Solar PVs (12 MW)	9 860
3	Mini-hydro power plant connected to the main grid (2 MW)	4 000
4	Isolated mini-hydro plant (2 MW)	6 460
5	Efficient LED home lighting	8 000
6	Biodigestors	14 768
7	Efficient LED street lights	810
8	Bulb Replacement	2 566
9	More efficient power grid	1 500
10	Composting center	19 892
11	More efficient gasoline cars	200
12	More efficient diesel cars	260
13	Stove Replacement	15 771
14	Onshore wind power plant (3MW)	3 750
15	Landfill	54 181

Figure 65 below presents the costs and mitigation potential for all 15 proposed mitigation measures.

Figure 65 - Marginal Discharge Curve for the 15 Proposed Mitigation Measures



5.5. Barriers to Mitigation Measures implementation

Due to characteristics of the country, the implementation of the measures proposed for mitigation of greenhouse gases may be subject to certain barriers, among which are :

- Political Barriers:

Poor ownership of measures by national authorities. Many initiatives to promote sustainable development in certain socio-economic sectors of the country are only implemented when financial resources are available, usually from international development partners.

- Economical and / or Financial Barriers:

The country's economic fragility and its heavy reliance on foreign aid can greatly influence the failure to implement measures proposed for GHG mitigation.

- Technical and Technological Barriers:

Weak development and low technological capacity, modern, efficient and adequate to the domestic market, limited trained human resources, as well as lack of adequate technical updating of national consultants on specific matters.

- Cultural Barriers:

Resistance in accepting a new technology more efficient by society. Behavioral persistence, population education and outdated popular opinion.

- Market Barriers:

Small and limited market.

- Legislation Barriers:

Lack of appropriate laws and regulations.

- Institutional Barriers:

Competence conflicts, multiple institutional dependence and lack of information.

4TH PART:

MEASURES THAT FACILITATE BETTER ADAPTATION TO CLIMATE CHANGE

CHAPTER 6: OTHER RELEVANT INFORMATION TO ACHIEVE THE OBJECTIVE OF THE CONVENTION ON CLIMATE CHANGE

6.1. Introduction

To achieve a sustainable, resilient and low carbon development, the expected adaptation and mitigation measures must necessarily be supported by a technology transfer strategy appropriate to national circumstances.

6.2. Technology Transfers

In the TNC framework, an assessment of the needs for technology transfer was made, which allowed the development of a set of adaptation and mitigation measures that should be based on an efficient technology transfer strategy, in accordance with national circumstances.

The assessment of technological needs as a component of the technology transfer process is one way in which the assessment and response to the development of climate needs and opportunities are integrated together.

It is a complex and continuous process of learning that leads the beneficiary to fully assimilate the new technology and be able to use it, reproduce it and eventually be in a position to resell it. It encompasses the assessment of the national needs of the two types of technologies : greenhouse gas mitigation technologies and adaptation technologies.

Regarding the study on transfer of technologies in the scope of TNC, the traditional sectors with the highest level of GHG emissions were considered, namely : Energy and Transport, Agriculture and Forestry.

The following table summarizes the assessment of technology transfer needs.

Table 93 - Summary of technology transfer needs assessment

Power Requirement	Renewable energy Energy efficiency (equipment and constructions) Efficient lighting High energy performance building material Efficient home appliances Cogeneration	Hydroelectric power plants; Photovoltaic solar plant; Solar thermal powerplant; Technology for capturing onshore wind energy and small towers; Plant for use of biomass gas; Techniques to improve the efficiency of the national grid through small grid-connected hydropower, PV-diesel hybrid systems (up to 2 MW); Standards EE technologies for appliances with potential to reduce peak load demand by at least 1MW; Animal waste collection for energy production - Biodigestors; Enhanced High Efficiency Cookers; Rational and sustainable management of traditional energies; Efficient Charcoal Production Techniques;

Solar and wind technology;

Techniques for the development of biogas from waste;

Micro hydroelectric plants;

Innovative technologies for low energy cooling and air conditioning systems;

Biofuel production;

Innovative technologies for building high energy performance buildings.

Transport	Fuel Economy Vehicles Hybrid or gas vehicles. Improvement of road infrastructure for urban decongestion. Development of public transport.	High efficiency motors; Transport infrastructure improvement; Public transportation.

	Agricultural Area Development Technologies;
	Off-season crop technologies;
	Clone technologies for the most widely practiced crops;
Farmland Management	Planting techniques involving land topography changes.
	Technology to monitor and evaluate savannization index in Lobata District;
	Enrichment of savanna tree composition through monitored planting;
Irrigation system integrated in agricultural production	Increased tree density in different microclimates in shade forest by planting trees;
	Mangrove Rehabilitation Technology;
	Use of improved stoves;
	Conduct forest inventory with appropriate cost-effective technologies through image processing;
Greenhouse production	Develop the thematic cartography of forest ecosystems;
	Use of bioindicators for monitoring and prediction of ecosystem degradation;
Terracing	Adopt agricultural practices such as no-tillage and agroecology to increase soil carbon stock and reduce GHG emissions;
	Restoring degraded areas that contribute to the carbon content of the soil, avoiding deforestation, eg planting riparian forests or legal reserves to contribute to the increase of the biological carbon reserve.;

	Improve nitrogen fertilizer application techniques, avoiding excessive nitrous oxide emissions;
	Promote agro-forestry on the slopes;
	Introduce technologies for restoration of degraded soils by mapping them;
	Agricultural practices to conserve soil moisture and nutrients, reduced runoff loss;
	Appropriate agricultural and livestock technologies.

Sustainable management of natural resources	Logging monitoring using high resolution satellite imagery; Technology for enhancement and enrichment of secondary forests; Technology for sustainable management of natural resources and land use planning;
Biodiversity Conservation	Biodiversity Conservation Technologies;
Reforestation	Innovative technologies for planting, management and management of forest ecosystems; Reforestation in arid and semi-arid zones.

The inclusion of these priority sectors made it possible, according to the NDC, to highlight some measures, the implementation of which would help to prepare rapid responses to the adverse effects and risks of natural disasters in all socio-economic sectors.

6.3. Systematic Research and Observation

6.3.1. Research linked to climate change

Sao Tome and Principe does not have a national policy on research on climate change. However, the National Institute of Meteorology (INM), which is the institution responsible for systematic observation in the climate field at national level, ensures the essential observations and research on climate and climate change in the country. In addition to INM, there are other institutions that are involved in the research and systematic observation process, such as the Directorate General of Natural Resources and Energy, responsible for the national hydrological network and CIAT which is responsible for agronomic research.

On the other hand, there are some research activities on climate change that are being developed in the context of some projects, namely :

- West Africa Coastal Areas Resilience Investment Project (WACA / PAMCZC), with specialized studies in geomorphology and sediment transport.
- Rural Communities' Capacity-Building Project to Adapt to the Effects of Climate Change in STPs in the districts of Cauê, Mé-Zóchi, Príncipe, Lembá, Cantagalo and Lobata, which through CIAT develops research on the adaptation of resilient agricultural species to Climate changes.
- Projet African monitoring of environment for sustainable development / Environmental Monitoring Project for Sustainable Development in Africa (AMESD) developed by ITRA and AGRHYMET.

6.4. Systematic observation in Sao Tome and Principe

Climate change brings with it new issues that require relevant and long-term forecasting studies. The development of appropriate models for the proper conditions is based on a good apprehension of atmospheric, climatological, hydrometric and oceanographic phenomena and the availability of short, medium or long-term quality data. In this sense, it is essential for the country to have a quality observation network.

The present analysis concerns the climatological and hydrological networks, taking into account that the country does not yet have an oceanographic network.

6.4.1. Weather network

The national meteorological network of Sao Tome and Principe managed by INM was composed in the past of 2 synoptic stations, 18 climatological stations, 8 agro - meteorological stations and 40 mountain stations. Difficulties made the network reduced to 2 synoptic, 3 climatological and 1 agro-climatological stations at the beginning of the year 2000

A grant from BADEA to the Ministry of Public Works, Infrastructures and Natural Resources, in 2000, allowed INM to install two (2) aeronautical meteorological stations at the headwaters of lanes 11 and 21 of Sao Tome International Airport and the provision of the Forecast Center.

With the support of Portuguese cooperation, the SICLIMAD - STP project was implemented through which three automatic weather stations were installed with the capacity to transmit real - time weather information recorded.

The abovementioned synoptic stations are registered under Nos. 61931 and 61934, contribute to the WMO global weather monitoring program by means of observations and hourly data records which are transmitted 24 hours a day to the regional Brazzaville. The meteorological variables recorded in these stations are basically the following : temperature, atmospheric pressure, relative humidity, wind direction and speed, cloudiness, amount and intensity of precipitation, sunshine duration, as well as global radiation.

As part of Sao Tome and Principe's contribution to the global meteorological network, in addition to the information provided hourly during the 24 hours a day of the synoptic stations, a monthly message containing climatological information called CLIMAT is produced and sent to the referred regional center responsible for its worldwide dissemination.

In addition to the aforementioned contribution of stations 61931 and 61934, a weather station was installed in the Ilhéu das Rolas, which registers local data and transmits them via satellite for the coordination of the African Monsoon Study Project (AMMA).

In the last 10 years, there has been some effort by the state to improve the national weather network. For this purpose, under the Public Investment Program of the Government of the RDSTP for 2010, INM was contemplated with the acquisition of two classic climatological stations that were already installed and in the same Program for 2011, despite the context of the economic crisis, there were two more classic climatological stations acquired.

These acquisitions demonstrate the importance that the country's authorities attribute to climate issues and their changes.

Under the Adaptation Project for Africa, financed by the Government of Japan and implemented by UNDP, eight climatological stations were installed, four of which were automatic and four were classic, in addition to 20 mountain stations.

Two of the agro-meteorological stations that make up the national meteorological network are under the Center for Agronomic and Technological Research (CIAT) jurisdiction.

Meteorological Services had formerly a situation characterized by a vast network of weather stations and several mountain stations. They were installed in various agricultural enterprises and their dependencies, due to the need to carry out climatic studies, as well as the possibility of the owners of large plantations to obtain information about the weather and climate, especially regarding pluviometry, to ensure the cultivation in these plantations.

With the assistance of international partners, the Government of the Democratic Republic of Sao Tome and Principe equipped the National Meteorological Institute with various equipment. Equipment was installed that allowed the establishment of a network that guarantees the development of the activities of collection, processing, dissemination and archiving of meteorological data of the Country.

Today, unlike the existing classic stations, the 28 automatic hydrometeorological stations installed under the SAP project and the 3 previously installed stations, transmit data every 15 minutes to the different control centers, installed in the INM, DGRNE and the INM in Príncipe. In addition to the rapid visualization of the information, this data is stored on the servers installed in said institutions, thus allowing them to be quickly accessed and treated.

These data, in the form of graphs, were then treated by INM technicians and later used for the preparation of monthly, annual, publications and other purposes.

Data collected at the stations were :

a) Maximum temperature (° C)
b) Minimum temperature (° C)
c) Soil Temperature at 5, 10, 20, 50 and 100 cm depth (ºC)
d) Relative humidity (%)
e) Evaporation (mm)
f) Precipitation (mm)
g) Wind Direction (Cardinal Points)
h) Wind Intensity (m / s)
i) Atmospheric Pressure (HPA)

j) Insolation (%)
k) Dew Point (° C)

Aeronautical data are collected and used for the elaboration of aeronautical messages (METAR, MET REPORT, TAF AND SPECI). These data are coded by meteorologists and weather observers following ICAO and WMO recommendations. They are used for the preparation of daily forecasts.

Climatological and pluviometric data are manually handled in the climatology section. The automation of the meteorological network has also contributed to the extinction of Station Managers beyond the national budget deficit several decades ago.

6.4.2. Hydrological Network

In STP the hydrological observations are under the responsibility of the General Directorate of Natural Resources and Energy. After many years of being inoperative, some hydrological stations were installed and hydrological data observations and records resumed.

Currently, DGRNE has 12 automatic hydrological stations installed within the scope of the SAP project, which transmit data every 15 minutes to the Control Center installed in that institution.

However, efforts should continue to be made to strengthen the country's capacity in this sector in terms of strengthening coverage.

6.5. Education, training and awareness

Climate change is currently a reality that can not be ignored. There are changes in traditional climate systems around the world, and we need to be aware of these changes that have implications for the socio-economic and even cultural life of populations. It should be noted that the CNMC is in the process of developing its National Communication Strategy for Climate Change, which will be an important document in the education, training and awareness-raising of all actors, including civil society.

6.5.1. Capacity-Building for Actors

However, for many populations, especially in STP, this reality seems to go beyond the daily lives of people experiencing the consequences of the phenomenon without realizing its origin, nor reacting accordingly. Often such behavior is due to ignorance of this reality, or the deviation of attention to other concerns. For this reason, it is necessary to promote training and awareness of the population on the issues of climate change, not only from the point of view of the big global issues, but also from the day-to-day life of their lives.

For this reason, it is necessary to implement education programs at various levels of formal and non-formal education systems and specific programs targeting rural communities, where sometimes reality is more present, due to the permanent contact with nature.

Regarding the formal education system, integration of the climatic change theme into the school curricula of primary and secondary education is planned.

Considering the existence of a discipline called Environmental Education in secondary education, integration will be done through this discipline that is already the subject of a pilot experiment.

At the Higher Education level there are also initiatives aimed at integrating this theme in the pedagogical training of teachers.

6.5.2. Professional Training at Sector Level

Vocational and job-specific training is essential for internalizing the effective fight against climate change. The objective is to enable professional actors to improve their service offerings in order to respond effectively to the issue of climate change and the support and monitoring of stakeholders at the grassroots level.

The main targets to be achieved are : public administration cadres, private actors, local authorities, civil society and the media. The main areas of training will relate to : (i) integrating the climate change dimension into development policies, strategies, plans, programs and projects ; (ii) take climate change into account in the budget, programming and monitoring and evaluation processes ; and (iii) training in knowledge management and research methodologies for climate change. Training should also contribute to the control of the management mechanisms of the conventions to which Sao Tome and Principe is a party.

Agriculture is a vital sector where climate change implies the adoption of new behaviors, new technologies and new practices to adapt to the current situation. The fisheries sector is also vital in the case of STP, where about 25% of the population lives on the fishing activity and shows a change in the behavior of stocks of fishery resources, with a clear tendency in its decrease.

6.5.3. Awareness activities

At the sensitization level, the country has developed awareness activities throughout, mainly in rural and coastal areas, through the Technical Services of the Ministries of Environment and Agriculture, civil society organizations implemented through development projects in several districts and Autonomous Region of the Príncipe.

Also noteworthy are the awareness actions made through the media, especially National Radio (RNSTP), National Television (TVS), Local Radios (Community Radio and Príncipe Regional) that develop programs for the general public on climate change.

CHAPTER 7: CONSTRAINTS, GAPS AND NECESSITIES OF INSTITUTIONAL, TECHNICAL AND FINANCIAL CAPACITIES RELATED TO THE THIRD NATIONAL COMMUNICATION (TNC) OF SAO TOME AND PRINCIPE

As part of the UNFCCC, the RDSTP must honor its specific commitments under this Convention. The TNC drafting process took into account the lessons and experiences gained during the SNA elaboration. However, some gaps persist and need to be addressed in view of the importance of National Communications in terms of information and decision-making at both national and international level.

The UNFCCC recognizes that due to lack of financial and human resources and institutional and technological capabilities, Small Island Developing States (SIDS) as STPs face the challenge of mainstreaming climate change concerns into national policies.

7.1. Gaps and Constraints

7.1.1. Gaps and constraints in the preparation of the GHG inventory

In terms of GHG inventories, there has been significant progress in terms of the level of expertise of the experts involved. However, difficulties and gaps remain that relate to activity data and emission factors. They are compiled in Table 94.

Table 94 - Gaps and constraints in preparing the GHGI

Emissions Analysis by Gas Type and Subsector;	Lack of full and regular forest inventory specific data and statistics;
Uncertainty analysis;	Lack of disaggregated activity data across sectors;
Level 1 reference approach providing only aggregate emission estimates by fuel type;	Lack of STP-adapted emission factors and conversion factors;
IPCC Technical Guidelines for Establishing National GHG	High degree of uncertainty;

Inventories;	
IPCC Technical Guidelines for Establishing National GHG Inventories;	Predetermined biomass expansion factors to estimate forest biomass;
Development of quality assurance and quality control procedures;	Low availability and reliability of data used;
Estimation of emissions and removals of each direct and indirect GHGs and groups;	Low availability and reliability of activity data; Inadequate format for storing and archiving data for data subjects;
Identification of key sectors and sources;	Insufficient financial resources to deepen data collection. The method for identifying land occupation areas does not provide detailed information on area variations between categories and is spatially explicit only at the national or regional level.;
IPCC Guidelines for National GHG Inventories;	Data used for uncertainty assessment are annual, but correction factors and emission factors are standard IPCC data.;
UNFCCC / UNFCCC Software Version 1.3.2 for the compilation of UNFCCC NAIIS GHG Emission Estimates (Inventory Software Not Annex I);	Uncertainty estimates include only waste produced in the city;
UNFCCC User's Manual;	Uncertainty about data collected from institutions not available;
Simplified Manual for Greenhouse Gas Inventory: IPCC Guidelines for National Greenhouse Gas Inventories;	Lack of specific data on urban forestry;
Method 1 to identify total areas for each land use category;	Lack of adequate national statistics for activity data;

Level 1 sectoral method based on end use data, combustion types and specific energy sector technology;	Lack of performance statistics in some categories, especially informal;
Establishment of QA / QC procedures, reviews and audits. Emissions Recalculations;	Standard method for calculating methane emissions in the solid waste subsector;
IPCC Emission Usage and Standard Correction Factors for Estimating Emissions.	Insufficient Activity Data Statistics.

7.1.2. Gaps and Constraints Related to Vulnerability and Adaptation Studies

The analysis of vulnerability and adaptation study reports conducted as part of TNC indicates the need to improve understanding of issues related to vulnerability assessment and mastery of tools and methodologies. The gaps and constraints are summarized in Table 95.

Table 95 - Gaps and constraints related to Vulnerability and Adaptation Studies

Sectors	Analysis Types	Restrictions	Gaps
Energy	Methods for developing climate scenarios; Methods to analyze energy sector vulnerability to future climate change; Establishment of socioeconomic and environmental scenarios; Identification of socioeconomic and environmental impacts.	Low availability of updated data.	High degree of data-related uncertainty.
Coastal Zone	Study Methodology; Basic scenarios: temperature and precipitation; studied sea level	Poor data availability.	Very high degree of methodology-related

	projections; Establishment of socioeconomic scenarios; Establishment of environmental scenarios; Primordial factors and continuous impacts.		uncertainty.
Agriculture	Basic scenarios: temperature and precipitationEstabelecimento de cenários socioeconómicos; Establishment of environmental scenariosFatores primordiais e impactos contínuos	Poor data availability; Not too long study series	High degree of data-related uncertainty; Non-exhaustive nature of the sector study
Water resources	Data quality analysis; Scenario building; Choice of climate change vulnerability and adaptation assessment model; Impact and vulnerability in Sao Tome and Principe	Lack of data for some subsectors and poor data availability for others.	High degree of data-related uncertainty; Non-exhaustive nature of the sector study

7.1.3. Gaps and Restrictions Related to Mitigation Studies

From the analysis of the results of the mitigation studies, numerous constraints were observed and summarized in Table 96.

Table 96 - Gaps and Constraints Related to Mitigation Studies

Energy	GACMO Model (V.01/04/2017))	GACMO Model not only builds a database, but also does power planning; Ability to integrate economic and environmental parameters for future analysis of the impacts of energy use on the environment.	Requires the collection and processing of information on socioeconomic data, energy data and energy and environmental projects ; Requires a large amount of disaggregated data that is not fully available at the time of the study ; Unavailability of data from the structures responsible for its collection; Numerous inconsistencies in data analysis; Significant margin of error; Too short to complete the study and explore other aspects; Insufficient financial resources to undertake rural stakeholder data collection; Insufficient training of specialists to carry out studies; Insufficient technical capacity at institution level conducting studies.
Waste	Excel	-	Lack of skills related to using appropriate software for available data types, forcing experts to build scenarios with Excel; Most data come from estimates, not actual field measurements.; Unreliable and inconsistent and sometimes hard to access data; Significant margin of error; Insufficient financial resources to undertake rural stakeholder data collection;
Buildings	Excel	-	Lack of skills related to using appropriate software for available data types, forcing experts to build scenarios with Excel; Most data come from estimates, not actual field measurements;

			Significant margin of error.

7.1.4. Gaps and restrictions related to research on Climate Change

There are a number of constraints and gaps identified in the research sector on the issue of climate change. They can be summarized as follows:

- Insufficient consideration of climate change issues in medium- and long-term development projects;
- The lack of material and financial resources for the implementation of research programs;
- Weak collaboration between different institutions and researchers, leading to a mismatch between institutional needs and research results;
- Poor dissemination of research results.

7.2. Gaps / Constraints and the need for capacity building to prepare inventories

7.2.1. Gaps / constraints and need for institutional capacity

The tables below provide information on gaps, constraints and needs of institutional, technical, human and technological capabilities.

Table 97 - Gaps, Constraints, and Institutional Capacity Needs

Institutional Aspects	Institutional arrangements for drafting deficient national communications. No protocols for data delivery that are used to prepare Greenhouse Gas Inventories (GHG). Poor provision of information and dissemination of data at institutional level for the National Communications preparation process and dissemination of results at national level.	Legislate and institutionalize the MRV System for GHG Inventories, so that there is greater and better articulation between institutions in the process of preparing National Communications, including the issues of mitigation and adaptation actions. Create standards, partnerships, make protocols and memoranda between the coordinating entity of the NC and other entities responsible for the production and supply of data. Implement permanent data collection and

	Lack of integration of climate change into policies, strategies and plans governing sectoral and national development. Poor public awareness and dissemination of information through public education programs to educate people on key climate change issues. Loss of institutional / sectoral memory with change in Human Resources composition.	processing systems at national level, with the direct involvement of the competent authorities, including the Ministry of Environment and Climate Change, the Ministry of Planning and Development, among others. One of these institutions shall be responsible for the activity. Update / compilation of sectoral inventories in the field of Forests, Agriculture, Liquid Waste and Livestock).

7.2.2. Gaps / Constraints and need for technical capabilities

Table 98 - Gaps / Constraints and Need for Technical Capabilities

	Gaps and Constraints	Necessities
Aspects of Technical Capabilities	Poor availability of skilled and skilled human resources on GHG inventory and climate change issues. Lack of transparency in providing information from relevant institutions. Although there are no mechanisms that require us to provide information that is publicly disclosed, entities are often unavailable to share data and information and when they share it is not done in a timely manner. Sectoral inventories (Forests, Agriculture, Livestock etc) outdated or non-existent.	Continuously / permanently strengthen the capacities of national climate change experts at the level of the Ministries of Environment, Economy and other relevant Ministries (Ministry of Health, Ministry of Agriculture. Train national technicians on the IPCC 2006 Guides in the Portuguese language of national technicians involved in the preparation of inventories. Develop the necessary technical skills through training and long-term technical education. This should include postgraduate training and specialization.

7.2.3. Gaps / Constraints and need for technological capabilities

Table 99 - Gaps / Constraints and Need for Technology Capabilities

	Gaps and Constraints	Necessities
Aspects of Technology Capabilities	Unavailability of work tools, ie support manuals and emission calculation software, hardware in Portuguese language and which serve as basis for the elaboration of GHGI, National Communications and BURs. Lack of a web-based platform in terms of data available from all relevant institutions and companies. Weak technological capacity in national climate change institutions. They do not have a harmonized Geographic Information System (GIS). The absence of a satellite forest monitoring system creates enormous difficulties in providing accurate information for the elaboration of a national reference emission level and / or a national reference level for forests, either in pursuing the deforestation parameters and forest degradation themselves, as well as in the occupation and use of land. Limited geographic, geospatial, satellite, cartographic and other relevant information related to the consolidation of the forest sector database.	Create a central database for compiling and accessing existing climate scenarios, carbon emission and removal sources, socio-economic projections, vulnerability data and adaptation option information, collected and developed at national, local and sectoral level based on a online platform (web). Provide the institutions responsible for producing information with hardware and software capable of supporting storage, processing and energy efficiency capacity and provide good quality internet institutions. Harmonize existing databases. Training of national technicians in forest geomatics and environmental statistics to analyze and quantify emissions from deforestation and forest degradation. Acquisition of low cost LANDSAT, SPOT or RADAR satellite imagery or through South-South cooperation. Good quality internet. Hardware and Software Acquisition, etc. Hardware and software must be purchased based on specifications capable of supporting storage and processing capacity.

8. CONCLUSION

The Third National Communication followed the methodological guidelines recommended by the IPCC and the Secretariat of the United Nations Framework Convention on Climate Change and contains updated information on the Second National Communication (2005) and the First National Communication (1998). The institutional framework of the GHGI has improved significantly compared to that of the SNC in order to perpetuate the regular production of the inventories by the structures that have the competences in the matter as it has always been recommended.

STP is part of the set of island developing countries whose economy is mainly based on agriculture and having only a single export product, cocoa. Its economy is very fragile due to its geographical context (small islands), its reduced population and its isolation in the subregional economy marked by the existence of other linguistic contexts, namely Francophone and Anglophone.

The country is not an emitter of GHG, thanks to its low development and to its forests that retain a certain capacity of carbon of sequestration. However, the aggregated trends of emissions of the three direct gases (CO_2, CH_4, N_2O) for the 2005-2012 period shows a tendency to increase emissions, although at a slow rate, going from 10,361.71 Gg CO_2eq to 20,758.12 Gg CO_2eq. The results show that the key source categories result mainly from CO_2 emissions from the energy and transport sector, agriculture and waste. In the energy sector, the CO_2 emission is attributable to the combustion of fossil fuels in Transport, the CO_2-eq of CH_4 are attributable to Trade and Institution / Residential. For the agricultural sector, they result from N_2O emissions attributable to agricultural soils, CO_2 from soils, CO_2 absorbed by changes in forest patrimony and other stocks of woody biomass, CH_4 attributable to enteric fermentation.

The sectors most vulnerable to climate change in STP are energy, water resources, agriculture and coastal zones as studies show a high sensitivity of these sectors to climate variation, mainly to the increase in seawater mean level that can contribute to the loss of land territory.

Thus, to address these situations, adaptation measures have been proposed, according to the different scenarios in the short, medium and long term. However, efforts must be made by the country to ensure sustainable development with a more conscious use of carbon by adopting alternative energy supply measures in the energy sector, while reinforcing measures to reinforce the sequestration of our forests.

Finally, TNC provides an opportunity for the STP Government to reaffirm its commitment to continue the policy of integrating climate change into national policies and to create the best conditions for technology transfer, research and systematic observation, education and public awareness on the issue of climate change and possible solutions, given the funding and available resources.

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ANNEXES

ANNEX I: LIST OF TNC BODY MEMBERS

TNC Coordination	João Vicente, *Director of the National Institute of Meteorology* Adérito Santana, *Third National Communication Project Coordinator*
Follow-up and Evaluation	João Vicente Lima, *Member of the National Committee on Climate Change (CNMC)* Arlindo Carvalho, *CNMC Member* Madival das Neves, *CNMC Member* Manuel Penhor, *CNMC Member* Zózimo Nascimento, *CNMC Member* Elisa Afonso de Barros, *CNMC Member* Loi Heng, *CNMC Member* Lassalete Boa Morte, *CNMC Member*

	Aurélio Rita, *CNMC Member* Lourenço Monteiro, *CNMC Member* Meyer António, *CNMC Member* João Zuza, *CNMC Member*
	Amadeu Maia, *CNMC Member*
	Diallo P. Dos Santos, *CNMC Member*
	Heliodoro Quaresma, *CNMC Member*
	Dulce Vera Cruz, *CNMC Member*
	Jorge Boa Morte, *CNMC Member*
	Manuel Jorge de Carvalho, *CNMC Member*
	Abdul Afonso de Barros, *CNMC Member*
TNC Compilation Team	Victor Bonfim, *Director of the Conservation, Sanitation and Nature Quality Directorate* Lourenço Monteiro de Jesus, *General-Director of Environment*

National Circumstances	Abnilde De Ceita Lima, *Technician of the Directorate-General of the Environment* Victor Bonfim, *Director of the Conservation, Sanitation and Nature Quality Directorate* Abnide Lima, *Technician of the Directorate-General of the Environment* Joaquim Amaro, *Technician of the Directorate-General of the Environment*	
GREENHOUSE GAS INVENTORY		
Team Leader	Artur Jorge de Lima Trindade, *General Regulatory Authority Technician*	
Sectors	Energy	António da Trindade Afonso dos Ramos, *National Transport Institute Technician* Belizardo da Conceição Afonso Neto, *Director of the General Directorate of Natural Resources and Energy* Fausto Menezes dos Santos Vera Cruz, *National Oil Agency Technician* Gabriel Lima Maquengo, *Water and Electricity Company Technician* Leonel Bonfim Wagner da Conceição Neto, *National Airport and Air Safety Company Technician*

	Waste and Industrial Processes	Abenilde Pires dos Santos, *Director-General of Industries* Adérito Bonfim, *Technician of the Directorate-General of Industries* Antónia Neto, *Technician of the Center for Agricultural and Technological Research* Sulisa Quaresma, *Technician of the Directorate General of the Environment* Wildmark Trovoada, *Outside consultant.*
	Agriculture and Livestock Land Use, Land Use Change and Forests - LULUCF	Álvaro Vila Nova, *Livestock Directorate Technician* Carlos Manuel Das Neves Baia Dê, *Livestock Directorate Technician* Dinazalda Pires da Costa, *Livestock Directorate Technician* Páscoa D'Apresentação Costa, *Forest Management Technician* Adilson da Mata, *Forest Management Technician* Meyer António, *Forest Management Technician*

		Olavio Anibal, *Fisheries Director* Sabino Carvalho, *Forest Management Technician*
VULNERABILITY AND ADAPTATION		
Team Leader	Aderito Santana, *National Institute of Meteorology, National Coordinator of TNC Project* Chou Sin Chan, *National Institute for Space Research, Brazil*	
Sectors	**Climate**	Chou Sin Chan, *National Institute for Space Research, Brazil* André Lyra, *National Institute for Space Research, Brazil* Claudine Dereczynski, *Federal University of Rio de Janeiro, Brazil* Gustavo Sueiro, *National Institute for Space Research, Brazil* Isabel Pilotto, *National Institute for Space Research, Brazil* Jorge Luís Gomes, *National Institute for Space Research, Brazil* Luís Felipe Alves de Carvalho, *National Institute for Space Research, Brazil*

		Minella Martins, *National Institute for Space Research, Brazil* Nicole Resende, *National Institute for Space Research, Brazil* Priscila Tavares, *National Institute for Space Research, Brazil* José Luiz Onofre, *National Institute of Meteorology, São Tomé and Príncipe* Manuel Penhor, *Researcher at the University of São Tomé and Príncipe* Idalécio Major, *National Institute of Meteorology, São Tomé and Príncipe* João Vicente Domingos Vaz Lima, *Director National Institute of Meteorology, São Tomé and Príncipe* Adérito Santana, *National Institute of Meteorology, São Tomé and Príncipe* Minella Martins, *National Institute for Space Research, Brazil*
	Agriculture	Armando Dias Monteiro, *Technician of the Ministry of Agriculture and Rural Development* Ludmila Gomes, *Technician of the Ministry of Agriculture and Rural Development, São Tomé*

	Water resources	Daniel Andrés Rodriguez, *Federal University of Rio de Janeiro, Brazil* José Bastos, *Director of Directorate-General of Natural Resources and Energy, São Tomé and Príncipe* Justina Lima, *Directorate-General for Natural Resources and Energy Technician, São Tomé and Príncipe* Chicher Pires Diogo, *Directorate-General for Natural Resources and Energy Technician, São Tomé and Príncipe* Kiloange Lima, *Directorate-General for Natural Resources and Energy Technician, São Tomé and Príncipe* Alessandro Marques Martins, *Federal University of Itajubá, Brazil*
	Coastal Zone	Allan Yu Iwama, *IBICT Researcher and collaborator of the National Center for Natural Disaster Monitoring and Warning, Brazil* Abenilde Pires dos Santos, *Technician of the Industry Directorate, São Tomé and Príncipe* Abnilde de Ceita Lima, *Technician of the Directorate-General of the Environment, São Tomé and Príncipe*

	Adaptation	Victor Marchezini, *National Center for Natural Disaster Monitoring and Warning, Brazil* Victor Bonfim, *Director of the Conservation, Sanitation and Environmental Quality Directorate, São Tomé and Príncipe* Sulisa de Jesus Quaresma, *Directorate-General of the Environment Technician*
	MITIGATION	
Team Leader	Armando Dias Monteiro, *Technician of the Ministry of Agriculture and Rural Development*	
Sectors	**Buildings**	Armando Dias Monteiro, *Technician of the Ministry of Agriculture and Rural Development* Álvaro Vila Nova Sabino Carvalho, *General Forest Directorate Technician*
	Energy	Artur Trindade, *AGER Technician, São Tomé and Príncipe* Gabriel Lima Maquengo, *Water and Electricity Company Technician* Leonel Bonfim Wagner da Conceição Neto, *National Airport and Air Safety Company Technician*

	Waste	Darnel Baía, *Directorate-General of the Environment Technician* Abnilde De Ceita Lima, *Directorate-General of the Environment Technician* Kassi Costa, *Directorate-General of the Environment Technician*
OTHER INFORMATION		
Technology transfer	Abenilde Pires dos Santos, *Industry Director Technician* Madival das Neves, *Director of Geographic and Cadastral Services* Kassi Costa, *Directorate-General of the Environment Technician*	
Systematic Research and Observation	Cosme Dias, *Technician of the National Institute of Meteorology*	
Constraints, Gaps, and Needs for Institutional, Technical, and Financial Capabilities	Sulisa Quaresma, *Directorate-General of the Environment Technician*	