REPUBLIC OF EQUATORIAL GUINEA

MINISTRY OF AGRICULTURE, LIVESTOCK, FOREST AND ENVIRONMENT

FIRST NATIONAL COMMUNICATION TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE

MALABO, 2019

REPUBLIC OF EQUATORIAL GUINEA

Ministry of Agriculture, Livestock, Forest and Environment

General Directorate of Environment

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Edited by:

Santiago Francisco ENGONGA OSONO

Pedro MALAVO NSENE

Guillermo Pastor ORBE ARENCIBIA

Malabo, 2019

The research presented in this document was funded by the Project “First National Communication of Equatorial Guinea to the United Nations Framework Convention on Climate Change” with funds from the GEF/UNEP and the Government of the Republic of Equatorial Guinea.

Cite as:
FNC Equatorial Guinea (2019): First National Communication to the United Nations Framework Convention on Climate Change. Republic of Equatorial Guinea, Ministry of Agriculture, Livestock, Forests and Environment (MAGBMA), Malabo, Equatorial Guinea, First Edition 2019.

First edition, 2019
Scientific review:
Ms. C Santiago Francisco Engonga Osono
Lic. Pedro Malavo Nsene
Dr. C Guillermo Orbe Arencibia
Lic Gabriel Ngua Ayecaba
Dr. C Maximiliano Fero Meñe
Dr. C. Aldo S. Moya Álvarez
Dr. C. José Manuel Esara Echube
Ms. C. Sinaí Barcia Sardiña
National and International Consultants:
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Lic. Rubén Darío Nsó Edó Abegue
Ing. Manuel Ntutumu Nanguande
Dr. Diosdado Obiang Mbomio Nfono
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Dr. C. Osmar de Jesús Pérez Lozada
Ms. C. Severo Meñé Nsue Mikue
Dr. C. Demetrio Bocuma Meñé

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Reed Power (USA), Seafront, Bata, Equatorial Guinea- 2013.

Acronyms

AG	Agricultural Groups
CSA	Climate Smart Agriculture
ASECNA	Agency for the Safety of Aerial Navigation in Africa and Madagascar (in French)
WB	World Bank
GCC	Global Climate Change
FF	Fossil Fuels
ICTA	International Center for Tropical Agriculture
WFS	World Food Summit
UNFCCC	United Nations Framework Convention on Climate Change
COP	Conference of Parties of the UNFCCC
RCP	Representative Concentration Pathway
BD	Biological Diversity
CS	Climate Scenarios
ECA	Agricultural Training School (in Spanish)
GE	Greenhouse Effect
RE	Renewable Energies
FAO	Food and Agriculture Organization of the United Nations
EMP	Extreme Metheorological Phenomena
GEF	World Environmental Fund
GHG	Green House Gases
SFM	Sustainable Forest Management
CI	Climate Indicators
INCOMA	National Institute for Conservation of the Environment (in Spanish)
INDEFOR-AP	National Institute for Forest Development and Protected Areas (in Spanish)
INEGE	National Institute for Statistics in Equatorial Guinea (in Spanish)
INPAGE	National Institute for Agricultural Promotion of Equatorial Guinea (in Spanish)
IPCC	Intergovernmental Panel on Climate Change
MAGBMA	Ministry of Agriculture, Livestock, Forest and Environment
IOM	International Organization for Migration
WMO	World Meteorological Organization
NOCC-GE	National Office of Climate Change-Equatorial Guinea
OUN	Organization of the United Nations
WFP	World Food Program
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
DVR	Danger, Vulnerability and Risk
REDD +	Reduction of Emissions from Desertification and Deforestation
RGE	Reinforcement of the Greenhouse Effect
NAS	National Agricultural Sector
UNGE	National University of Equatorial Guinea (in Spanish)
USAID	United States Agency for International Development (in English)
EEZ	Exclusive Economic Zone

Dedication

TO THE MEMORY OF MR. NICANOR ONA NZE ANGUAN, NATIONAL FOCAL POINT OF CLIMATE CHANGE OF EQUATORIAL GUINEA TO THE UNITED NATIONS FRAMEWORK CONVENTION ON CLIMATE CHANGE (UNFCCC), WHO PASSED AWAY DURING THE COP 22 ON NOVERMBER 18, 2016, IN MOROCCO.

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Chapter 1

Chapter 1. Introduction

1.1 Climate Change

Man's concern for whether[1] and Climate[2] is lost in its origins, mainly conditioned by the exposure and dependence it had on the fluctuations of nature. These changes could be sudden and extreme, while others were slow and imperceptible, but something was certain; the weather was variable. Moreover, this manifest variability[3] was not only temporary, it was also spatial, which provides a global tapestry of climatic states, determined by complex interactions between astronomical, meteorological and geographical influences known as climatic factors.

Variability is one of the essential characteristics of climate behavior, according to Martin Vide (2003). It is the results of complex processes of interaction between the atmosphere, the earth's surface, the oceans, the cryosphere (covered with ice) and the biosphere (flora and fauna) which together form the Climate System. The relations between them are very close, with varied and complex transfers of energy and matter, which makes the changes in one strongly affect the rest. The temporal scales (response speed) vary greatly between them causing internal mismatches that are a source of variability.

A "long" temporal succession of meteorological data related to a locality, includes all the observed weather conditions (up to the extreme ones) forming all, what is known as a climatic series. The examination of the different climatic series of each of the meteorological variables determines the local climate. When differences are observed between the statistics of the elements of the climate, calculated for different very long periods of time, it is in the presence of "Climate Change".

The detailed analysis of geological data; the fossil evidence found; historical information and the instrumental records examined show that the weather has changed in the past. In all the previous cases, the causes were natural, caused by the natural variability of the climate itself; changes in the Milankovitch Cycle (eccentricity, inclination and precession of the Earth's orbit); volcanic eruptions among others. You can refer to very hot periods such as the so-called Medieval Optimus (1100-1250) in which the Arctic ice declined; the Vikings colonized Greenland; tree species grew up in the highlands of the Alps and the grape vines were grown in much of Europe and southern England. However, there are others that are very cold, such as the one between 1300-1850 when temperatures dropped significantly, mainly in Europe. This period is known as the "Little Ice Age" and caused an extended and prolonged famine that killed between 10-20% of the European

[1] **Weather** (Atmospheric): According to the World Meteorological Organization (WMO) it represents the physical state of the atmosphere in a given territory, characterized by the combination of meteorological elements at a given time.
[2] **Climate**: According to the WMO it is the fluctuating set of atmosphere conditions characterized by the states and the evolution of the weather in a certain portion of the space.
[3] **Climate variability**: They indicate the deviations of the climatic statistics in periods of months, seasons or years, with respect to long-term statistics referred to the same period (month, season or year) and is measured by those deviations known as anomalies.

population. There was widespread growth of glaciers; the ice extended to Scotland and the River Thames and the canals of the Netherlands froze.

Throughout Earth's history, the weather has changed naturally; glaciers move forward or backward and natural systems adapt based on such changes. The periodic glaciations of the last 2, 5 million years were caused by changes in the axis of rotation of the earth that caused significant variations in the solar radiation received.

The changes that were observed since 1850 began to concern the scientific community, the population and governments. Given these circumstances, in June 1972, the Conference on the human environment was organized in the city of Stockholm, Sweden; in 1988 the resolution entitled "Climate protection for present and future generations" was approved at the UN General Assembly. This resolution led to the creation of the Intergovernmental Panel on Climate Change, known as IPCC, that same year, sponsored by the World Meteorological Organization (WMO) and the United National Environmental Program (UNEP) and subsequently ratified by the UN General Assembly through Resolution 43/53.

For IPCC experts, the term Climate Change[4] refers to any change in climate over time, either due to natural variability or as a consequence of human activity. These international experts periodically evaluate (every five years) the global climate and prepare the most comprehensive and up-to-date reports on global climate change which are a reference standard for academic media, governments and industries worldwide.

The IPCC (2013) ratifies the statements made in other previous reports of the experts: the observed Climate Change is caused by human activities, it does not have a natural character. Secondly, it is happening very fast, at a speed that natural human ecosystems do not have time to adapt and, on the other, on a global scale. Human activities occur today on a scale that interfere with natural systems, such as the global climate. According to the IPCC (1997), human activities (mainly, the burning of fossil fuels and changes in land use and land cover) are increasing the concentration in the atmosphere of greenhouse gases, which they alter radioactive balances and tend to heat the earth's atmosphere.

Scientific studies show that human health, ecological systems and socio-economic sectors (for example, hydrology and water resources, food and fiber production, coastal systems or human settlements), all of which are vital for sustainable development, are sensitive to climate changes and in particular to the magnitude and speed of climate change, according to the IPCC (1997).

[4] **Climate change**: Fort he United Nations Framework Convention on Climate Change (UNFCCC) it refers to a change of climate directly or indirectly due to human activity that alters the composition of the global atmosphere and adds to the natural variability of weather that is observed in comparable periods of time.

1.1.1 Causes of Climate Change

The Industrial Revolution that emerged in England at the end of the 18th century and the beginning of the 19th century marks the beginning of temporary times, indicating a turning point in human history, according to Chaves (2004). It was a process whose impacts were not only technological, but also cultural and socio-economic.

It can be affirmed that iron and steel began to be used on an unprecedented scale in the period mentioned above; new energy sources such as coal, gas and oil and new driving forces such as the steam engine. New spinning machines (*spinning Jenny*) or knitting machines (the mechanical loom) were invented with a huge increase in production with a minimum of human energy expenditure. New forms of organization and division of labor (*factory system*) and greater specialization of labor. Transportation improvements (trains and steamboats) and a growing interaction between science and technological application on an industrial scale.

The technological inventions allowed a greater extraction of raw materials, with a substantial increase in the production and commercialization of the products. For the first time in human history, man had the ability to change the face of the planet, the nature of its atmosphere and the quality of its waters. In a visionary way, in the first half of the XIX century Arrenhius[5] (1895) warned about the likelihood that burning coal and oil could cause warming of the earth's atmosphere. He considered that if the CO2 value of the time was doubled, temperatures could rise between 4 and 6°C. This criterion was little valued, as it disagreed with those existing at the time, and even later in which most of the sciences considered that the terrestrial climate tended to cool down.

The evidence on climate change was accumulating and at the beginning of the second half of the twentieth century a part of the scientific community begins to publish this evidence. Immediately the world press disseminates the work done, attracting the attention of scientists, politicians and readers in general. The interest generated in the possible changes in the earth's climate, associated with human activities, encourages the scientific exchange of experts in the field. And although the criteria were not unanimous in terms of the causes, the general consensus was that the earth's climate was changing.

In 1979, the first World Climate Conference was held in the city of Geneva, Switzerland, in which governments were urged to anticipate and prevent the potential dangers of climate change. At this conference a Global Climate Program was established by WMO and UNDP, UNFCCC (2006). Subsequently, several successive actions have been performed. In 1983, the United Nations Commission on Environment and Development (UNCED) was created; in October 1985, the United Nations organized the Villach Conference, Austria, on the gases responsible for the greenhouse effect; in 1988, the Intergovernmental Panel on Climate Change (IPCC) was established. In the same year, a Conference is organized in Toronto, Canada (World Conference on the Changing Atmosphere, Implications for World Security). Representatives from 46 countries promoted the development of

[5] **Svante August Arrenhius** (1859-1927): Científico sueco, Premio Nobel de Química 1903 por su contribución al desarrollo de la disolución electrolítica. Fue el primero en anunciar que el uso de combustibles fósiles provocaría un calentamiento del clima global.

comprehensive and global framework convention to protect the atmosphere. For the first time in this conference, the phenomenon was specially referred to as "climate change" and the possibility that is main causes are human activities.

On the proposal of Malta, the United Nations General Assembly treated climate change for the first time as a common concern of humanity. WMO and UNDP contributed to the establishment of the IPCC to assess the magnitude and chronology of the changes. In November 1990, the Second Climate Conference was organized and in the same year, the IPCC published the First Assessment Report on the State of the World Climate in Sundsvall, Sweden, which had a considerable impact among policy makers and public opinion. It was the first major scientific report on climate change of the XIX century. Which laid the foundation for the adoption in 1992 of the United Nations Framework Convention on Climate Change (UNFCCC), whose declaration entered into force on March 21, 1994.

Among the first research that refer to what is now called the Greenhouse Effect, we can mention the works carried out by Fourier (1824)[6]. This leading French scientist was the first to argue that the average temperature of the earth remained warm because the atmosphere retains heat as if it were under a glass. This phenomenon was eventually called "greenhouse effect".

Later, in 1854 John Tyndall[7] discovers that CO2, CH4 and water vapor blocked infrared radiation, despite being in small quantities in the atmosphere. This described property was what allowed to explain the greenhouse effect detailed above by Fourier (1824). Since then, after the work of Tyndall these gases are known as: Greenhouse Gases (GHG)[8].

The earth, upon receiving solar radiation, reflects a part of it in space when it hits the clouds, but most of it crosses the atmosphere and reaches the earth's surface. The energy received from the sun (mostly shortwave) that reaches the surface heats it and causes it to emit thermal waves known as long waves (infrared radiation) into space. However, not all energy released by earth is returned to space; part of it is trapped in the atmosphere due to the existence of GHGs. This phenomenon by which certain gases that are components of the atmosphere retain part of the energy that the earth's surface emits after being heated by solar radiation is called "Greenhouse Effect". It is a natural atmospheric phenomenon, beneficial for life on the planet; if the average temperature of the earth does not exist, it would be -18°C and not 15°C as it is today.

To maintain that value in a stable range, there must be a balance between the reception of solar radiation and infrared radiation returned re-turned to space. This balance between incoming and outgoing radiation (solar reflected plus outgoing infrared) is called "earth's energy balance". Any alteration of this radiation balance, whether due to natural or anthropogenic (man-made) causes, is a "radioactive forcing" and involves a change in weather and associated weather. When the forcing

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[6] **Jean-Baptiste Joseph Fourier** (1768-1830): Outstanding French mathematician and physicist known for his work on the decomposition of periodic functions in convergent trigonometric series called "Fourier Series" in his honor. He was first to give a scientific explanation to the "greenhouse effect".

[7] **John Tyndall** (1820-1893): Irish physicist, known for his study of colloids. He studied the so-called "Tyndall effect", which was named in honor of his name.

[8] **Greenhouse Gases** (GHG): According to the UNFCCC (1992) the GHGs (both natural and anthropogenic) are as follows: Water vapor (H_2O); Carbon Dioxide (CO_2); Methane (CH_4); Nitrous Oxide (N_2O); Ozone (O_3) and Chlorofluorocarbons (CFC).

implies an increase in temperature, regardless of the causes (natural or anthropic) it is said to be in the presence of a "positive radioactive forcing". If on the contrary the temperatures decrease, then it is a "negative radioactive forcing".

The industrial revolution was undoubtedly a milestone in the technological, social and economic development of humanity. From an environmental point of view, it laid the foundations for the use and exploitation of fossil fuels and natural resources to the point of being able to deplete their existence today. On the other hand, the industrial and agricultural expansion, the population increase and the foundation and development of the cities, with their consequent infrastructure needs, produced profound transformations in the balance of materials and energy, degraded the air, water and soil by pollution. Agricultural, industrial and domestic wastes increased. Since then, anthropic landscapes predominate, that is landscapes or modified or created by human on a natural basis.

All these activities and others increased the presence of GHGs in the atmosphere. According to the IPCC (2013), in the last 800 000 years, atmospheric concentrations of carbon dioxide (CO2); methane (CH4) and nitrous oxide (N2O) have risen to unprecedented levels. CO2 concentrations have increase by 40% since the pre-industrial era due, first, to emissions from fossil fuels and, secondly, to net emissions from land use change. The oceans have absorbed about 30% of the anthropogenic CO2 emitted, causing its acidification. The observed increase in GHGs has caused the "Reinforcement of the Greenhouse Effect", responsible for global climate change, which is currently considered the main environmental problem facing humanity in the present century.

At present there is no doubt about the causes of global climate change. As time has passed, the causes of climate change have been proved at a more reliable level. According to the IPCC (2013), it is "highly probable" (between a 95-100% probability) that human influence has been the dominant cause of warming observed since the mid-twentieth century. The aforementioned report states: *"the human influence has been detected in the warming of the atmosphere and the ocean, in alterations in the global water cycle, in reductions in the amount of snow and ice, in the global average elevation of the level of sea water and changes in some extreme weather events. This evidence of human influence is greater since the Fourth Assessment Report was prepared".*

1.1.2 Changes observed in the global climate system.

In the global scientific community, the consensus regarding climate change and its causes has progressed a lot. At present, the observations of the climate system are based on direct measurements and remote sensing from satellites and other platforms. On the other hand, paleoclimatic reconstructions provide records that go back centuries or millions of years. Both lines of research provide an overview of the variability and long-term changes in the atmosphere, the oceans, the cryosphere and the earth's own surface.

For the IPCC experts (2013), the warming of the Climate System is unequivocal and, since the 1950s, many of the changes observed have been unprecedented in the last decades to millennia. The atmosphere and ocean have warmed, snow and ice volumes have decreased, sea levels have risen and GHG concentrations have increased. According to WMO (2014), the year 2013, together with 2007, is the sixth warmest year since the world records began in 1850. While the climate varies

naturally from year to year, there is no doubt that there exists a tendency to global warming throughout the world. Thirteen of the warmest fourteen years of which there is a record are in the XIX century, and each of the last three decades has been warmer than the preceding one, with 2001-2010 being the warmest recorded decade.

The IPCC (2013) has grouped the main evidence of climate change observed in the climate system into some of its components for better analysis. Here are some of the most important identified:

In the atmosphere

Each of the last three decades has been successively warmer on earth's surface than any previous decade since 1850. In the northern hemisphere, the 1983-2012 period is likely to have been the warmest 30-year period of the last 1,400 years (average confidence level). Other relevant summary data are:

- The data of the surface temperature of the earth and the oceans, combined and averaged globally and calculated from a linear trend, show a warming of 0,85 (0,65 to 1,06) °C, during the period 1880-2012;
- On average, over the continental areas of mid-altitudes in the northern hemisphere, rainfall has increased since 1901 (average confidence level before 1951, and high thereafter);
- Since 1950, approximately, changes in numerous extreme meteorological and weather events have been observed.

In the oceans

It is almost certain that the upper layer of the ocean (0-700 m) was heated between 1971 and 2010 and is likely to have been heated between the 1870s and 1971. Other relevant summary data are:

- More than 60% of the net increase in energy in the climate system has been stored in the upper layer of the ocean (0-700m) during the relatively well sampled period of 40 years, between 1971 and 2010, and approximately 30% has been stored in the ocean below 700m;
- It is very likely that regions with high salinity where evaporation predominates, have become more saline, and that regions with low salinity, where rainfall predominates, have been desalinated since the 1950s;

In the Cryosphere

Over the past two decades, the ice sheets of Greenland and Antarctica have been losing mass, glaciers have continued to shrink almost all over the world, and Artic ice and snow in spring in the northern hemisphere have continued to shrink in extension (high confidence level). Other relevant summary data are:

- It is very likely that, on average, the rate of ice loss from the Greenland ice sheet has increased considerably, from 34 (6 to 74) Gt/year^{-1}, during the period 1992-2001, to 215 (157 to 274) Gt/ year^{-1}, during the period 2002-2011;
- It is very likely that the average annual area of Artic sea ice has decreased during the period 1979-2012 in a range of 3,5% and 4,1% per decade (which corresponds to a range of between 0,45 and 0,51 million km^2 per decade), and it is very likely that the summer minimum of sea ice (permanent sea ice) has decreased in a range of 9,4% to 13,6% per decade (which corresponds to a range between 0,73 and 1,07 million km^2 per decade);

- There is a very high level of confidence that, since the mid-twentieth century, the extent of the snow cover of the northern hemisphere has decreased;
- There is a high level of confidence that permafrost temperatures have increased in most regions since the early 1980s. The warming observed was up to 3°C in parts of northern Alaska (from the beginning of the 1980s in the mid-2000s) and up to 2°C in northern parts of European Russia (from 1971 to 2010).

At sea level

Since the mid-nineteenth century, the pace of sea level rise has been higher than the average of the previous two millennia (high confidence level). During the period 1901-2010, the average global sea level rose 0,19 m (0,17 to 0,21 m). Other relevant summary data are:

- It is very likely that the average global average sea level rise was 1,7 (1,5 to 1,9) mm/ $year^{-1}$ between 1901 and 2010, 2,0 (1,7 to 2,3) mm/ $year^{-1}$ between 1971 and 2010, and 3,2 (2,8 to 3,6) mm/ $year^{-1}$ between 1993 and 2010;
- Since the beginning of the 1970s, the combination of the loss of mass of the glaciers and the thermal expansion of the ocean caused by the warming account for approximately 75% of the observed elevation of the global average sea level (high confidence level).

1.2 Equatorial Guinea in the context of climate change

The changes observed in the climate of Equatorial Guinea are consistent with the changes that have taken place globally. Several documents have been produced by the Republic of Equatorial Guinea, to address the effects of Climate Change, both in adaptation and in mitigation, among them are:

- The National Adaptation Action Plan 2013 (PANA), it makes a detailed analysis of the observed evidence of climate change and national circumstances to face these changes. It states that: "the country of highly vulnerable to climate change, given the magnitude of the expected impacts and the country's low capacity to adapt in terms of high poverty rates, inequality in the distribution of resources and the lack of a firm sustainable implementation of its development plan";
- The National Contributions Planned and Determined at the National Level 2015 (INDC), show the strategy of emission reduction in the five sectors identified: 1.) Energy; 2.) Agriculture and change of uses; 3.) Transportation; 4.) Forestry sector and 5.) Waste;
- Study of the Cause of Deforestation and Degradation (2018), talks about the most degraded areas of the country, as well as the most deforested. It describes the causes of deforestation and forest degradation in Equatorial Guinea;
- National REDD+ Strategy (2018), proposes the measures that the country would adopt to reduce the effects of drivers or causes of deforestation and forest degradation, in order to reduce greenhouse gas emissions;
- National Investment Plan REDD+ (2019) (PNI-REDD+), gathers the main activities in which the country wishes to invest in the implementation of the REDD+ mechanism, a document produced with the technical support of FAO and under the financing of the Central African Forest Initiative (CAFI);

- The Country Program (2019), the country is preparing the country program with the Green Climate Fund, which is the document that includes the country's main financing priorities.

Equatorial Guinea's first steps in environmental issues are mostly related to biodiversity conservation and environmental pollution. In this regard, the country's first international participation was in the Convection for the Conservation of the Atlantic Tunas in Rio de Janeiro between May 2 and 14, 1966. However, with respect to climate change is in the Framework Convention of the United Nations on Climate Change (UNFCCC) in May 1992 in the city of New York where Equatorial Guinea is introduced in the subject referred to. As of this meeting, the country has signed and/or ratified all international agreements on climate change and sustainable development promoted by the UN; from the Kyoto Protocol (adopted in 1997 and in force in 2005), to the United Nations Conference on Sustainable Developments (Rio +20) in 2012.

The country has been a member of the UNFCCC and has participated in the IPCC meetings since 1990. This active international participation of the country in issues related to environmental protection and climate change contrasts with the fragile implementation of international treaties signed internally. The regulatory and institutional framework in the aforementioned issues is still weak, which conspires against the implementation of the signed agreements and the commitments made by the government.

An important step was achieved with the implementation of Law No.7/2003 which is considered the Environmental Regulatory Law in Equatorial Guinea. Regardless of the fact that the Country's Constitution explicitly protects nature (article 6), the legal framework of the country in environmental matters is currently conforming to the enforcement of other laws, among which the Mining Law stands out (Law No.9/2006) and Hydrocarbons (No8/2006) among others.

Regardless of what has been achieved and the progress in environmental conservation and fight against climate change, much remains to be done. In the regulatory framework, there are still legal loopholes that allow activities that favor the increase of GHGs or go against the policies of adaptation to the impacts of climate change. On the other hand, inspection and supervision activities to monitor the implementation of existing laws themselves are now inoperative, which must be overcome as quickly as possible.

The Republic of Equatorial Guinea has a firm commitment to contribute to the fight against Climate Change, which has become apparent with the signature on April 22, 2016 and the Ratification on July 16, 2018 of the Paris Agreement, demonstrating the political will of the Government in this regard. On the other hand, there is currently a national strategy to develop resilience to it and contribute with its modest efforts to reduce GHG emissions, taking into account the common responsibility that all nations have in their fight against the main environmental problem facing humanity: climate change.

1.3 Development Strategy

The economic growth achieved by Equatorial Guinea in recent years is impressive, according to Holmes (2009). Its historical mercantile base bas been on the exploitation of raw materials. At present it is based on the oil exploitation that began in the early 1990s. The extraction between 1995 and 2005 increased from 6000 to 360 000 barrels per day, multiplying production by 60 in just 10 years, according to Horizon 2020 (2007). The increase in oil and gas exports in a country with small population resulted in Equatorial Guinea being the first high-income country in sub-Saharan Africa, according to PANA (2013).

Equatorial Guinea, despite having a high Gross Domestic Product (GDP) per capita, human development and poverty reduction remains the biggest challenge facing Equatorial Guinea, African Development Bank (AfDB) (2012). This report plans that 77% of the country's population lives in poverty; 57% do not have access to drinking water and 16% of children under five suffer from chronic malnutrition. Government efforts to raise the welfare, health and education of the people are a priority. If the results obtained in this regard are compared with the period before 1979, the progress is significant. Between 2000 and 2012, the value of the Human Development Index (HDI) of the country increased from 0,498 to 0,554, an increase of 11% placing the country in 136th place out of 187 countries, according to UNDP (2013). According to the UNDP Report (2018), Equatorial Guinea is in the 141st place with an index of 0,591 which shows a setback associated to the economic crisis experienced by the fall in oil prices mainly.

Gender equality is a permanent goal in Equatorial Guinea. Only 46% of married women between 15-49 years are active, compared with 92% of mean of the same age, PEDSGE (2011). To this situation must be added according to the previous report that 66% of working women earn less than their husbands and 63% of them claim to have been victims of physical violence at some time in their lives. Of these, 32% have been victims of sexual violence.

Most of the food consumed by the mostly urban population is imported, so food security and sovereignty are very vulnerable despite the country's great potential for agriculture and fisheries. In the local populations, the main source of food is the forest, which puts great pressure on it. In these areas of the country, the majority of the population (mainly young) has emigrated to the cities seeking to improve their quality of life contributing to a rapid and uncontrolled urbanization on the one hand and on the other causing a lack of labor in the fields where in general, ancestral practices and uses are still used. These practices generally emphasize the vulnerability of these sectors to the risks and impacts of climate change.

The health situation in the country, despite the efforts of the government must continue to improve to reach levels that meet the demands of the population. According to Horizon 2020 (2007), the system of health and prevention in Equatorial Guinea is currently deficient. Health coverage does not cover the entire country and high infant mortality prevails.

AIDS is the leading cause of death in the country with 22,4% of the total deaths, followed by malaria with 14,6 % of total deaths, INEGE (2018). This same source shows that of the total deaths recorded in hospitals, 65% are in-hospital, that is, death occurs after 24 or 48 hours (depending on the hospital) since the patient is admitted.

The pathologies that are most recorded by out-of-hospital death compared to in hospital deaths are maternal death (of every 17 deaths that occur in the hospital for this cause, 15 are before 24 or 48 hours of being admitted to the woman), in second instead, there are trauma deaths.

The situation described above is partly conditioned by the need to increase funds to fight poverty. According to the AfDB (2012), the investment allocated to education and health in 2008 represents only 11 and 6% respectively of the total annual expenditure which represents (0,2 and 0,1 of the GDP), hence its recommendation when compared with neighboring countries.

Currently, the Economic and Social Development Strategy and Plan is being reoriented, in order to align the country's Development Goals with the United Nations Sustainable Development Goals (SDGs) and the 2063 Agenda of the African Union, reason whereby the Government organized the Third Economic and Social Conference, under the slogan "Consolidating Social Equity and Economic

Diversification". At that conference, the road map will be established until 2035 of its economic and social development plan.

In general, from a social-economic point of view, a strategic projection of dynamic development is observed, which is constantly updated and improved, adapting to the new times. However, in the interest of converting natural resources into economic resources, the inclusion of climate change in the country's development plans has lagged.

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Chapter 2

Chapter 2. National circumstances

2.1 Background

In Equatorial Guinea, the research carried out regarding climate change and its impacts on the environment are not abundant. The first works concerning Weather and Climate date back to the Spanish colonial era and an important part of these were carried out by Catholic priests moved in the country.

After the independence granted by Spain on October 12, 1968, democratic elections were held and for the first time in its history the people of Equatorial Guinea elect their rulers. Bad government management, internal political conflicts and lack of freedom significantly reduced intellectual work and therefore the development of scientific research. This dark period of Equatoguinean history was overcome by a military uprising on August 3, 1979, by the then Delegate Minister of Defense, Lieutenant Colonel Teodoro OBIANG MBASOGO. The new government promoted and developed intellectual training, mainly in countries with a socialist regime such as Russia, Cuba and China among others. Currently, most of the professionals in the country have their initial training in these countries, although they have subsequently been professionally exceeded in other countries such as Spain, France and the United States, and even some in the region such as Cameroon and Nigeria.

In the field of environmental protection, the country's constitution from 1982 (known as "La Carta Magna de Akonibe" and recently modified) and the Environmental Regulatory Law (No7/2003 and its amendment proposal) lay the foundations for conservation and environmental management in Equatorial Guinea. In this area of knowledge research, the establishment of the Department of Environmental Sciences (FMA) at the National University of Equatorial Guinea (UNGE) has led in recent years to carry out some work related to climate, climate change and its impacts, as well as environmental pollution and its effects on the environment and human health.

One of the main concerns of the Government in the implementation of a coherent Environmental Policy is the creation of a Ministerial Department responsible for the Environment, which is currently called: Ministry of Agriculture, Livestock, Forests and Environment, to whose front is a Minister, a Vice-Minister, a Delegate Minister, two Secretaries of State, a General Secretariat and six General Directorates.

For the management of the Environment, the Ministry has a Secretary of State, in charge of Forests and Environment, under which the General Directorate of Environment is located, which in turn has a functional organization chart for the execution of different activities under its scope of action. The Directorate General for the Environment, for its part, is composed of different services, such as the National Office of Climate Change (ONCC), which is the body responsible for working closely with the United Nations Framework Convention on Climate Change, headed by a National Coordinator and where the National REDD+ Coordination is integrated. At the General Directorate, all the conventions related to climate change signed by the country are also found there, as well as for the conservation of biological diversity and the environment.

At the international level, the country has signed and/or ratified practically all international agreements aimed at protecting the environment and fighting climate change. An example of this, the country signed the Paris Agreement (2015) and ratified it in July 2017 demonstrating the political will to contribute with the rest of the international community to fight climate change.

2.2 Geographic characterization of Equatorial Guinea

The Republic of Equatorial Guinea is located near the equator, in the Gulf of Guinea, Figure 2.1. The country is composed of two regions, one continental and one insular consisting of two fundamental islands, Bioko and Annobon and smaller islanders such as Corisco, Elobey Grande, Elobey Chico and Mbañe. It has total surface area of 28,051.46 km^2 distributed as shown in Table 2.1. The continental part limits to the north with the Ntem River and Cameroon, to the south and east with Gabon and to the west with the Atlantic Ocean. It shares the maritime borders with Nigeria, Sao Tome and Principe, Gabon and Cameroon.

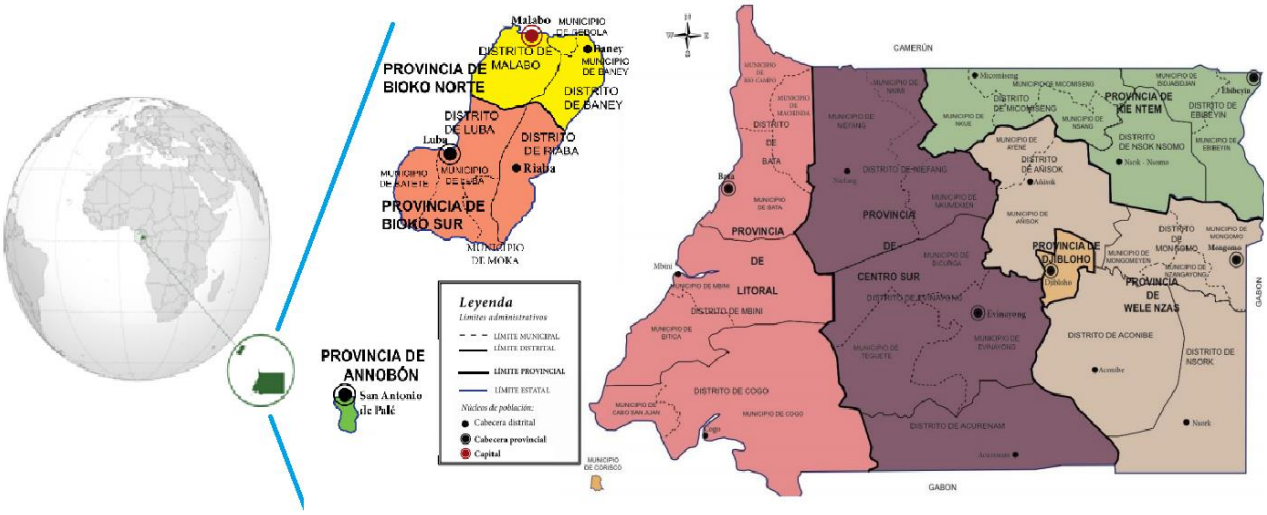

Figure 2.1. Geographic location of Equatorial Guinea (left) and administrative political division (right). Source: Google and INEGE 2018, respectively.

The country has 314, 000 km² of territorial waters (Exclusive Economic Zone-EEZ) and more than 644 km of sea coasts which are very rugged, with some bays and capes, such as the Bay of Luba and Cape San Juan as the most important ones.

From an administrative political point of view, Equatorial Guinea is divided into 8 provinces (Bioko Norte, Bioko Sur, Litoral, Centro Sur, Djibloho, Kie Ntem, Wele Nzas and Annobon), **Figure 2.1**. These in turn are subdivided into 19 districts and 37 municipalities, 65 urban districts, as well as Neighborhood Communities and Village Councils. Its capital is Malabo which is located on the island of Bioko; other cities are; Bata, Djibiloho, Ebebiying, Evinayong and Mongomo.

The relief of Equatorial Guinea is very varied, there are 4 fundamental mountain systems that represent 20% of the total area of the country. The island of Bioko is formed by two volcanic massifs, whose summits reach 2000 m and even exceed 3000 m (Atlas de Guinea, 2000). The maximum height

is the Basile Peak with 3011 m above the average sea level and the other two important mountainous systems, the Pico de Moka and the Gran Caldera de Luba, both with more than 2000 m high.

Table 2.1. Territorial extension of Equatorial Guinea.

Regions	km²	Latitude	Longitude E
CONTINENTAL REGION	26000	0°55´ - 2°21´	9°20´ - 11°25´
BIOKO	2017	3°48´ - 3°12´	8°25´ - 8°65´
ANNOBON	17	-1°24´ - -1°28	5°36´ - 5°38´
CORISCO	15	0°55´	9°20´
ELOBEY GRANDE	2.27	1°	9°30´
ELOBEY CHICO	0.19	1°	9°30´
TOTAL	28051,46		

The soils in Equatorial Guinea almost entirely in the continental part, develop on rocks poor in fertilizing elements and deeply altered in several meters of thickness. In the insular region the different types of soil identified fall into the category of andosols, of volcanic origin and very fertile. There are other types of soils, but they only cover less than 10% of the total area and are associated with formations of marine origin throughout the continental coastline.

Surface and groundwater resources are abundant. The country is equipped with water sources thanks to its rivers and lakes that run along the mainland and the islands. There are many waterways that have a torrent character because of the low distances between the peaks and the sea, mainly on the island of Bioko.

Being a country belonging to the Congo Basin, the second largest forest mass in the world after the Amazon, the flora and fauna are extraordinarily rich in biodiversity at the level of Central Africa, especially in the continental region. 62,5% of its total area is covered by a dense tropical forest. The islands of Bioko and Annobon, given their insularity, have a great variety of endemic species (plants and animals), many of them in danger of extinction.

2.3 Climatic characteristics

According to the Köppen, the climate of Equatorial Guinea is “tropical rainforest”, with features of “tropical savanna” at its easternmost tip. Due to its geographical position, which determines the reception of high radiation values, the climate of Equatorial Guinea is warm throughout the year with generally high temperatures. These characteristics are conditioned in the first place by its location in the low-pressure belt that surrounds the Earth through the equatorial zone, where vertical air movement predominates and where surface winds are light and variable. Second, by the behavior of the so-called “African monsoon” (winds that are reversed with the season) which determines the position of the “Intertropical Convergence Zone” (ICZ) and the consequent weather conditions that it has associated. Finally, the insular nature of a portion of the country, the existence of coast and the relief, significantly modify the climate of the territory.

The mountainous areas, both in the continental and insular regions, constitute the physical-geographical condition that changes the local climate in a more contrasting way. This vertical zone that introduces the relief causes a gradual decrease in air temperature, significant variations in the total annual rainfall, presence of local wind systems and a marked reduction in sunstroke due to the increase in cloud cover. The coastal areas of the country have as climatic regularities the stability of the thermal regime and small daily thermal oscillation, high potential of solar radiation, great constancy of the direction of the prevailing winds and high environmental humidity.

Thermal regime

The air temperature in Equatorial Guinea remains high throughout the year with average values ranging between 22,7°C and 25,4°C. As can be seen in Figure 2.2, there is an absolute annual maximum in the month of February and a minimum in the month of August. As a characteristic of the equatorial zone, the average daily thermal oscillation (8 °C) is superior to the annual thermal oscillation (2,2 °C).

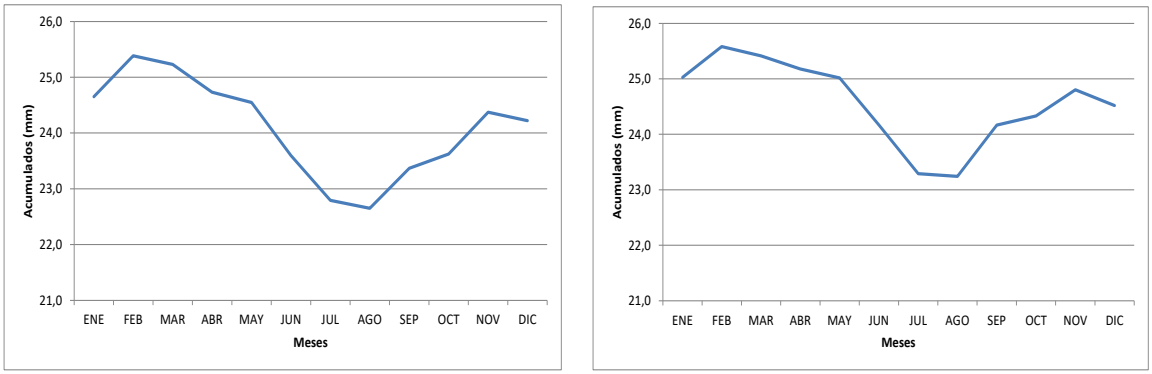

Figure 2.2. Annual variation of the temperature in the insular region (left) and the continental (right) of the country. Reference period 1971-2000. Extracted from: *Climatic Research Unit School of Environmental Sciences University of East Anglia.*

The average temperature in Malabo (Bioko) is 26,4 °C, lower in the highest areas of the Basile Peak and in the southern part of the island (Caldera de Luba) due to the high annual average rainfall (above 10 000 mm annual, according to the Atlas of Equatorial Guinea (2000)). The less warm months are August and September with an average temperature of 25,4 °C and the warmest February and March with 27,5°C and 27,6°C respectively. The highest maximum is 37,3 °C reported on 25/Sep/2003 and the lowest minimum of 11,0 °C reported on 1/15/2001, ASEGNA. The highest average maximum temperatures occur in February and March with 32,1 °C and the lowest in August and September with 28,5 °C and 28, 8 °C respectively. The lowest average minimum values occur in the months of December and January (21,8 and 21,7 °C respectively) and the highest in March and April (23,2°C and 23,1°C respectively).

In Bata (Rio Muni) the average annual temperature is slightly lower, with an average annual value of 26,2 °C, lower in the highlands. The warmest month is February (28,1 °C), while the least warm is July

with 26 °C. The highest average maximum temperature values occur in March with 32,3 °C and the lowest in July with 29,6°C. On the other hand, the highest minimum temperatures occur in February with 24,1 °C and the lowest in July with 22,4 °C.

Precipitation regime

One of the features that most clearly characterizes the climate of Equatorial Guinea is the marked seasonal nature of rainfall. In the insular part two periods are defined, one rainy that goes from March to October where on average 1961 mm accumulates that represents 85% of the annual total and a dry or dry period from November to February with 341 mm that represents the remaining 15%. In the continental part, however, the existence of two periods with abundant rainfall where 74% of the annual total falls alternates with periods of less rainfall, Figure 2.3.

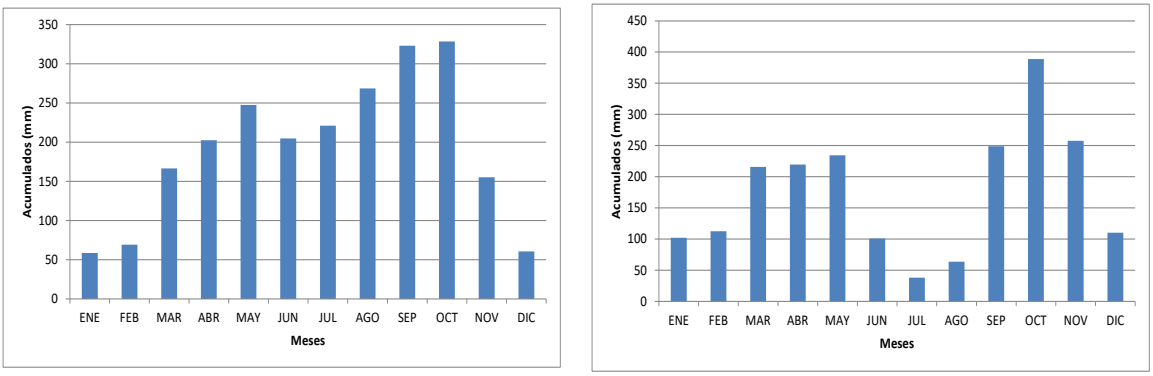

Figure 2.3. Annual variation of the accumulated rainfall in the insular region (left) and continental (right) of the country. Reference period 1971-2000. *Extracted from*: *Climatic Research Unit School of Enviromental Sciences University of East Anglia.*

As for the winds, calm (0 m/s) predominates, as is characteristic in equatorial areas, Figure 2.4.

The prevailing winds are from SW to W with average speed values of around 5km/h. In the city of Bata, the frequency of calm is lower (15,1 %) and the prevailing winds are from the south (30%) and from the west (27%).

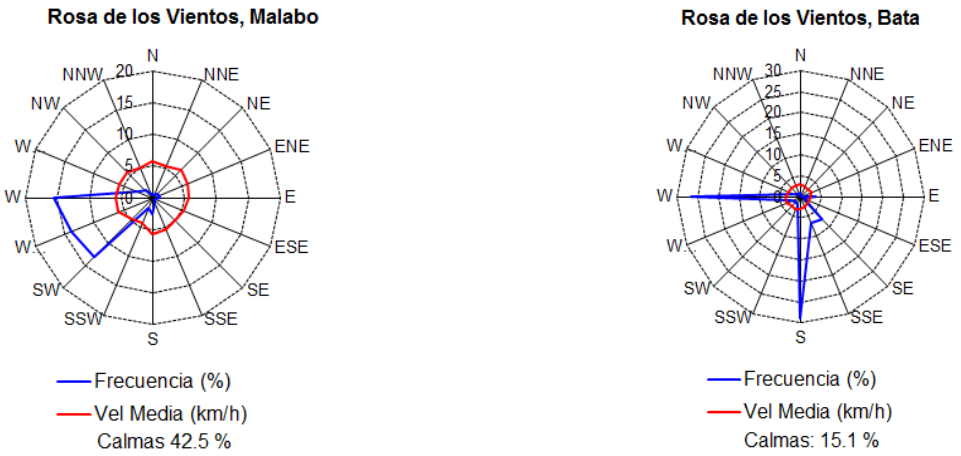

Figure 2.4. Wind rose from the cities of Malabo and Bata, 1999-2010 period. Source: ASEGNA.

With respect to the "dangerous meteorological phenomena", although there are no official records, an increase is observed in recent years mostly related to the "Several Local Storms" (SLS), almost always accompanied by thunderstorm and turbidity related to the Intertropical Convergence Zone (ICZ) or strong deep convection. "Heavy rains" (≥100 mm in 24 hours) also occur in the country, mainly in areas of the southern and mountainous part of the island, which are scarcer towards coastal areas.

2.4 Population, education and human health

2.4.1 Population.

The population of the Republic of Equatorial Guinea is 1,225,377 people, **Table 2.2.** In the Continental Region there are 885,015 inhabitants representing 72,2% of the total population, and the Insular Region with 340,362 inhabitants representing 27.8%. The population density of 45 inhabitants/km², according to the statistical yearbook of INEGE (2018).

Table 2.2. Distribution of the population of Equatorial Guinea by provinces: Source INEGE (2018).

Administrative unit	Total population	Area (km2)	Density Hab./km2	Number of districts
Insular region	340.362	2.034,0	167	5
ANNOBON	5.314	17,0	316	1
BIOKO NORTE	300.374	776,0	387	2
BIOKO SUR	34.674	1.241,0	28	2
Continental region	885.015	26.017,5	34	14
LITORAL	367.348	6.665,7	55	3
CENTRO SUR	141.986	9.930,8	14	3
KIE NTEM	183.664	3.942,9	47	3
WELE NZAS	192.017	5.025,6	38	4
DJIBLOHO	sd	452,5	sd	1
TOTAL	**1.225.377**	**28.051,5**	**45**	**19**

The languages spoken in the country are Spanish, as the official language and French and Portuguese as co-official languages. There are several vernacular languages among which are: Fang, Bubi, Ndowe, Bisio, Fadambo and "Pidgin English" or Fernandino. Most of the population practice the Christian religion.

In general, there is a greater male population in the country, except on the island of Annobon where women predominate, **Table 2.3.**

Table 2.3. Distribution of the population of Equatorial Guinea by sex: Source: INEGE (2018).

Province	Total	Male	%	Female	%
ANNOBÓN	5.314	2.599	48,9	2.715	51,1
BIOKO NORTE	300.374	158.898	52,9	141.476	47,1
BIOKO SUR	34.674	18.204	52,5	16.470	47,5
CENTRO SUR	141.986	72.697	51,2	69.289	48,8
KIE NTEM	183.664	92.016	50,1	91.648	49,9
LITORAL	367.348	192.123	52,3	175.225	47,7
WELE NZÁS	192.017	103.113	53,7	88.904	46,3
EQUATORIAL GUINEA	1.225.377	639.649	52,2	585.728	47,8

The population of Equatorial Guinea is mainly young, with a high number of children who are in ages between 0-14 years, representing 47,3% of the general population. The gross birth rate is 43,2% and the average number of children of the Equatoguinean woman is 5,1 children at the end of her reproductive life (5,4 in urban areas and 6,0 rural areas), PEDSGE (2011). According to this report, 32% of the households are under the responsibility of a woman and 40% of the population of households is under 15 years old.

Immigration has contributed in part to the population increase and represents 12,4% of the total population residing in the country. The Province of Wele Nzas is the one with the highest proportion of foreign population with 16,5%; Bioko Norte, in second place 12,7 %. Bioko Sur and Annobon are the ones with the lowest proportion of the foreign population with 6,1% and 1,7%, respectively, INEGE (2018).

In the Population Census analysis (2015) it is estimated that 70,6% of the total population of the country is predominantly urban, due to the greater concentration of people in the cities of Malabo and Bata, **Table 2.3.** The province with the highest population in urban area is Bioko Norte with 90,8% and the lowest is that of Centro Sur with 41,2%. In general, except in the provinces of Littoral and Bioko Norte, the rest predominates the rural population.

Table 2.3. Resident population by zones

Geographic area	Urban zone		Rural zone		Population density
	N^0	%	N^0	%	
Insular region	**292 233**	**86.0**	**47 461**	**14**	**173**
Bioko Norte	272 249	90.8	27 585	9.2	452
Bioko Sur	14 751	42.6	19 876	57.4	27
Annobón	5 233	100	0	0	258
Continetnal region	**571 080**	**64.7**	**311 668**	**35 32**	**35**
Litoral	344 527	94.1	21 602	5.9	53
Centro Sur	58 462	41.2	83 440	58.8	18
Wele Nzas	90 907	47.5	100 149	52.5	29
Kie Ntem	77 182	42.1	106 149	57.9	52
Equatorial Guinea	**863 313**	**70.6**	**359 129**	**29.4**	**45**

In human settlements, 66% of households have access to electricity (93% in urban areas and 43% in rural areas). About the availability of drinking water, 56% have some type of access to this resource (82% in urban areas and 33% in rural areas). Most households do not have toilets or latrines, especially in rural areas, PEDSGE (2012).

2.4.2 Education

Since 1995, the country has had a general education law that regulates all the activity of the public education sector and opens avenues for initiatives aimed at the development of education. For this purpose, both public and private education coexist, which is also for its creation and operation regulated by government decree.

The education system of Equatorial Guinea has a four-level structure: preschool, primary, secondary and high school (tertiary). In the last five years the system has changed its structure. The most important changes are in the establishment of two years of preschool, the transition from an elementary school from five to one of six grades, the reorganization of the secondary school in a basic secondary school, the baccalaureate and the elimination of the pre-university year.

84,6% of children between the ages of 5-14 attend a school setting, whether primary, secondary or higher. 88,7% of the population of 5 years and more can read and write the Spanish language. In the early school ages (5-9 years), there is a balance of schooling by sex with a slight difference, in favor of girls, being 98% for boys and 98, 9 for girls. Form there, schooling takes a decreasing behavior, with girls being the most disadvantaged. In this regard, PEDSGE (2011) states that: "8% of women aged 15-49 in Equatorial Guinea did not receive formal education compared to 4% of mean of equal age".

Table 2.4. Distribution of Primary Schools by Provinces INEGE (2018).

Provinces	2014 - 2015			2015 - 2016		
	Public	Private	Total	Public	Private	Total
Annobón	1	1	2	1	1	2
Bioko Norte	37	91	128	36	112	148
Bioko Sur	22	4	26	24	4	28
Centro Sur	110	14	124	109	13	122
Kie Ntem	132	13	145	141	17	158
Litoral	118	110	228	121	141	262
Wele Nzás	136	13	149	140	16	156
Equatorial Guinea	**556**	**246**	**802**	**572**	**304**	**876**

The number of primary schools nationwide grew 9,2% from the 2014-2015 academic year to 2015-2016; that is, an increase of 74 primary schools, of which 58 were private and 16 public, **Table 2.4.** Most of the schools were created in the provinces of Bioko Norte (20) and Littoral (34).

In the 2015-2016 school year there was an increase of 29 secondary schools compared to the previous year, which represents an increase of 21,2%. The provinces with the highest increase in secondary schools were Littoral and Bioko Norte, with 18 and 7 schools respectively. The number of public secondary schools grew in 6 units and that of private schools in 23, INEGE (2018).

Table 2.5. Distribution of secondary schools by provinces. INEGE (2018).

Provinces	2014 - 2015			2015 - 2016		
	Public	Private	Total	Public	Private	Total
Annobón	1	0	1	1	0	1
Bioko Norte	7	41	48	6	59	55
Bioko Sur	2	1	3	2	2	4
Centro Sur	5	3	8	6	4	10
Kie Ntem	7	6	13	7	6	13
Litoral	4	44	48	9	57	66
Wele Nzas	11	5	16	12	5	17
Equatorial Guinea	**37**	**100**	**137**	**43**	**123**	**166**

Higher education in Equatorial Guinea was carried out abroad through the granting of scholarships from friendly countries, which, although it helped the country, led to uprooting and brain drain. As of January 6, 1995, the National University of Equatorial Guinea (UNGE) is created by Law 12/1995.

UNGE is the "Alma Mater Studiorum" of institutions of higher education in Equatorial Guinea. In the 2017-2018 school year at the National University of Equatorial Guinea (UNGE) 7,707 students were enrolled. The faculties (departments) with the highest percentage of enrollment during the school year in question were the faculties of Law, Political Science, Communication and Philosophy, with 30%; Pedagogy and Education Sciences, Management and Administration, with 12% and Engineering and Agricultural Technologies and Fisheries, with 12%, Figure 2.5. In all faculties, except Health Science, there are more men than women, INEGE (2018).

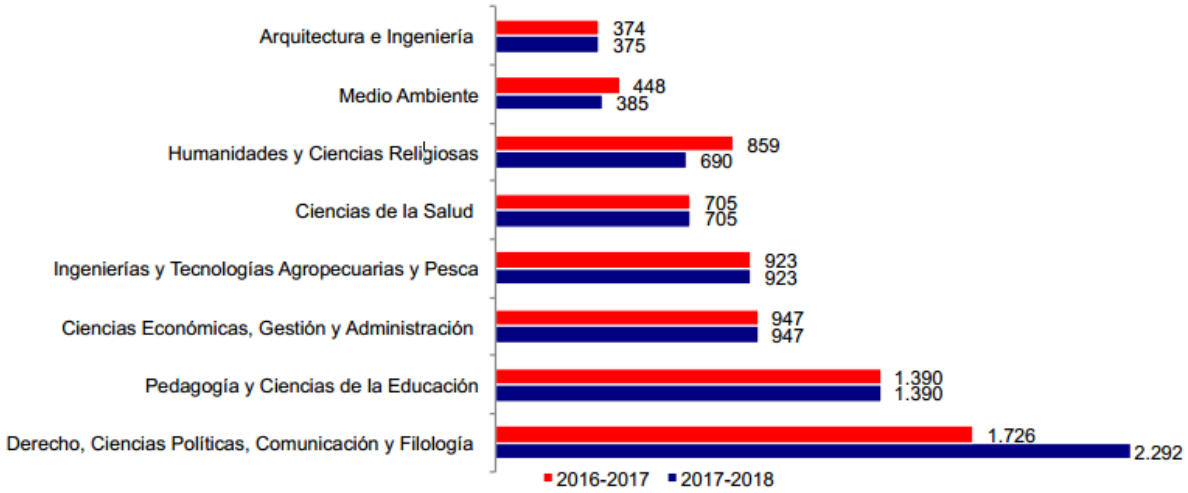

Figure 2.5. Enrollment at the National University of Equatorial Guinea (UNGE). Source: INEGE (2018)

Regarding vocational and technical education, there are only a few specialties, which do not meet the needs of the professional sector in the country. That is why the training of active workers, in many cases is the responsibility of their companies or personal interests mostly outside the country.

The Rio + 20 Report (2012), made an analysis of the state of the Education System in Equatorial Guinea at the time, posing as the main problems of the sector: insufficient number of schools; the absence of adequate infrastructure, as well as the poor qualification of teaching staff.

Regarding the development of high-performance sports, there are no centers in the country that develop the sports talent of people with these attitudes. In general, national athletes who reach international levels develop their talent abroad.

In the case of special education for children with mental retardation, behavioral problems, deaf and hard hearing, blind and visually impaired, there is currently no teaching system designed to overcome the difficulties of these people. Important steps are being taken in the care of children with these disabilities, for example, with the Equatorial Guinea Child Support Committee (CANIGE) sponsored by the First Lady of the Republic, NGOs and the Ministry of Education.

2.4.3 Health

Public health and the health situation in the country, regardless of the progress made and the plans and projects under execution, need to make much more progress, faster and across the country. According to PEDSGE (2011), infant and juvenile mortality is high nationwide. 65 per thousand live births die before reaching their first anniversary (33 between 0-1 month and 32 between 1-12 months). Of every 1000 children of a year, 51 do not reach the fifth anniversary. In general, the risk of death between birth and the fifth anniversary is 113 per 1000 live births, while neonatal mortality is 33 per 1000 live births and infant mortality is 65 per 1000 live births. If this situation is analyzed in the last ten years, it shows significant variation from one area to another, with respect to the educational level of the mother.

The public health system categorizes hospitals according to geographical distribution, classifying them into regional, provincial and district hospitals, located in the capitals of each region (Malabo and Bata), five provincial hospitals in the principal provinces except for the cities of Bata and Malabo and eleven district hospitals located in the principal districts except the districts that are principal provinces, according to INEGE (2018). Therefore, the data and assessments expressed here do not include data from the private sector of health services.

In 2016, the main causes of morbidity were infectious diseases mainly related to hygiene, this group concentrated 70,8% of medical consultations, including malaria, which caused 30,9% of visits to the doctor; followed by acute respiratory infections, with 17,3%; thirdly, salmonellosis, with 14,2% and acute diarrheal diseases with 8,4%. It should be noted that HIV/AIDS only registered 2% of medical consultations in 2016, although it was the biggest cause of death in the same year, INEGE (2018).

With respect to Sexually Transmitted Diseases (STDs), in 2016 a total of 14,494 cases were attended in consultation. Of these, 7,430 in the Insular Region and 7,064 in the Continental Region, with HIV/AIDS standing out with 5,322 cases, (36,7%) of the total; followed by Syphilis with 2,875 cases (19,8%) and Hepatitis B with 2,090 cases (14,4%).

At present, the government continues to increase the actions to improve the health of the Equatoguinean population, implementing several health programs, in some cases with international collaboration, among which are:

- National Program to Combact Malaria and HIV-AIDS;
- National Tuberculosis and Leprosy Program;
- National Reproductive Health Program;
- National Health Education and Social Mobilization Program;
- Trypanosomiasis Program;
- Mental Illness Program;
- Primary Health Care Strategy (PHC);
- Poliomyelitis Eradication Plan;

The health strategy in Equatorial Guinea advances and is strengthened. An example of this has been the sanitary measures implemented at borders to prevent the entry of diseases such as Ebola present in the region.

2.4.4. Human Development Index

Since 1990, the United Nations Development Program (UNDP) develops an index composed of three elements or indicators that involve health, education and wealth. Aspects considered are life

expectance at birth, adult literacy rate and the combined gross enrollment rate in primary, secondary and higher education, as well as years of compulsory education, as well as GDP per capita in US dollars. UNDP divides countries into four broad categories of human development: very high; high; medium and low.

The objective of this index is to have a way of measuring the "quality of life" of human beings in the environment that is developed, and on the other hand to have a variable for the classification of a country or region in question. In summary, the HDI is a synthesized measure of the value of human development; it measures the average progress achieved by a country in three strategic dimensions of human development: enjoy a long and healthy life, access to education and decent living standards.

According to the UNDP Report published on September 14, 2018 (http://hdr.undp.org/sites/default/files/2018_human_development_statistical_update.pdf), Equatorial Guinea ranks 141 of a list of 186 countries with a 0,591 index which places the country in a group of countries of a Medium Human Development. The trend manifested in that year was 0,001 lower compared to the previous year, from which it follows that the situation continues to fall, mainly associated with the recession in which the country is compared to 2017 with its best valuation.

2.5 Political Structure. Environmental Management Legal and Institutional Framework

2.5.1 Political-administrative Structure. Territorial organization.

Equatorial Guinea is a presidential republic, in which the State exercises its functions through the President of the Republic, the Council of Ministers, the Prime Minister, the House of Representatives of the People, the Judiciary and other organs created pursuant to the constitution.

Among the powers of the President of the Republic are to convene and preside over the Council of Ministers, appoint the Prime Minister and the members of the Government, approve the laws issued by the House of People's Representatives, dissolve the Parliament, etc. He is the head of all National Armed Forces, State Security Forces and Public Order Forces and when circumstances demand it, he may declare by decree the state of alarm, the state of emergency or that of siege, informing the Chamber of the Representatives of the People.

Since August 3, 1979, the Presidency of the Republic of Equatorial Guinea is exercised by his Excellency Obiang NGUEMA MBASOGO. Since then he has won all the elections at he head of the Democratic Party of Equatorial Guinea (PDGE), founded by him in 1987.

The executive power is exercised by the Council of Ministers, which is the body that executes the general policy of the Nation determined by the President of the Republic, ensures the application of the Laws and assists the President of the Republic permanently in Political and Administrative matters. It is chaired by the President of the Republic and is made up of the Prime Minister and other members of the Government composed of: The Vice-Prime Ministers; the Ministers of State; The ministers; Delegate Ministers; the Vice-Ministers; the Secretaries of State.

Among the other Constitutional Bodies of the State are the House of People's Representatives, which represents the country's parliament. It is the highest legislative body of the Republic of Equatorial

Guinea and is made up of one hundred deputies representing the different ideas and political tendencies that exist in the country. These representatives are elected for a period of five years by universal, direct and secret suffrage.

The judiciary is independent of the legislative branch and the executive branch. It exercises the jurisdictional function of the State and determines the organization and powers of the courts necessary for the effective functioning of justice. The Supreme Court of Justice is the highest court in all orders. The President of the Supreme Court of Justice and its members are appointed by the President of the Republic for a period of five years. Regarding constitutional guarantees, the Constitutional Court is the State Body in charge of knowing the institutional resources of the laws, the appeals for protection against the provisions and acts that violate the rights and freedoms recognized in the Basic Law. It is composed of a president and four members appointed by the President of the Republic. Two of them are nominated at the proposal of the House of People's Representatives. The term of office of the members of the Constitutional Court is seven years.

2.5.2 Legal Framework

Since 1982, with the elaboration of the Fundamental Law of the Country ("Carta Magna de Aconibe"), in its article 6 it establishes that the state will ensure the conservation of nature, cultural heritage and the artistic and historical wealth of the nation, so that the development and conservation of the environment be profiled as two inseparables components. That is, socioeconomic development is promoted and nature conservation by the state is foreseen.

Since that date the legal system in environmental matters has continued to strengthen. In 1988, Law No.8 regulating Wildlife, Hunting and Protected Areas was approved, which addresses for the first-time issues of protection of threatened natural species. It included a framework for the regulation of hunting activities, including means of protection and promotion of nature. It is followed by the years 1991, 1992, 1993, and 1994, two decree laws and a ministerial order, which deal with the reduction of large-scale timber extraction on Bioko Island, the wood harvest regulations rules in the continental region and the management of the National Forest Development Fund (FONDEFO). In 1997, Law No.1 on Use and Forest Management is established, which regulates the conservation and exploitation of forest resources.

In more recent dates, Law No 7/2003 was approved, which establishes the regulatory framework for the environment in the Republic of Equatorial Guinea. This Law establishes the basic norms of the management, conservation and recovery of the environment in the country, promoting the sustainable use of natural resources. Subsequently, the Decree No173/2005, which regulates the environmental protection provisions and regulations and the sustainable use of natural resources, was enacted.

In 2005, the Law No8 on Urban Planning was also approved, which provides for the execution and execution of urban master plans, including environmental protection and water supply measures. In 2006, Law No8 on hydrocarbons, for its part, mandates the adoption of environmental safeguard measures in the sector. Finally, in 2007, Law No3 Regulating Water and Coasts was enacted and approved. The purpose of this law is to regulate the management and use of surface and underground continental waters, hydrological planning, the maritime and terrestrial public water domain, the public use of the sea and its shore and the adequate quality level of water and riverbanks.

These laws, among many others, are a sign of the State's interest in regulating environmental management and incorporating the environmental dimension into the country economic and social development policies and plans.

2.5.3 Institutional framework

The institutional organization of Equatorial Guinea was established in the Fundamental Law (Carta Magana de Akonibe) signed on August 15, 1982. This meant political normalization by establishing constitutional guarantees, as well as the political re-institutionalization of ministerial departments. Progressively the institutional framework of the environment was developed, through the creation of several institutions of the Central State Administration.

By means of Decree No. 39/2003, the Ministry of Fisheries and Environment was created as a body of the central administration of the State in charge of the environment. Subsequently, in several reshufflings carried out by the Government, the environmental sector has shared ministerial portfolio with other departments. At present, the Ministry of Agriculture, Livestock, Forest and Environment (MAGBMA) is the ministry of the sector by Presidential Decree No. 79/2018 dated May 3, 2018.

As it is to understand the protection of the environment is a task of all, reason why other ministerial institutions are directly involved in its protection from their scope of action. Amon they are: Ministry of Health and Social Welfare; Mines, Industry and Energy; Infrastructure and Urban Planning; Economy and Commerce; Education and Science; Information and Tourism; Foreign Affairs, Cooperation and Francophonie; Transportation and Telecommunications; the Ministry of Interior and Local Corporations; and Finance and Budget. Non-governmental organizations (NGOs) work in this direction, such as: Friends of Nature and Development of Equatorial Guinea (ANDEGE), Association of Local Development (ADELO), AMIFLORA and Bicam Afam, among others.

2.6. The economy of Equatorial Guinea

Since the early 1990s, the economic results of Equatorial Guinea have been exceptional thanks to the discovery and exploitation of important oil fields, according to Equatorial Guinea 2020 (2007). So that hydrocarbons (oil and gas), became the driving force of the Equatorial Guinea economy leaving the old coffee, cocoa productions in lagging positions.

The investments made by the government and its partners, as well as the very favorable prices of fossil fuels in the world market favored an unprecedented economic growth in the country. In 1999, the nominal GDP of Equatorial Guinea grew by 74,6%, which is the highest rate recorded in the 1990s. From 2000 to 2011, the economy grew to reach an annual average of 23, 2%, in nominal terms. In the last year mentioned above, the GDP reached about USD 11,000, which placed the country among the "higher income" countries (≥ USD 7,000), Figure 2.5.

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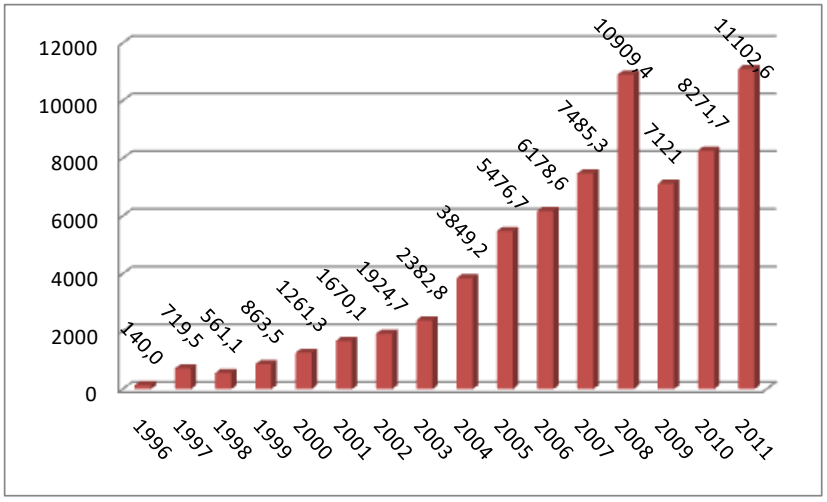

Figure 2.5. Evolution of the Per Capita Income of Equatorial Guinea in USD. 1997-2011 period. Source: DGE (2013).

Although in 1997, the relative contribution of oil production was significant with respect to the other components of the GDP, with 62%, still agriculture and timber production continued to play an important role in the national economy, with 17% and 9% respectively.

In the period between the end of the 90s and the middle of the first decade of this country, a greater portion of the public expenditure was directed to works for the upgrading of the country. The main investments were directed to infrastructures, roads, water supply network and electricity, public buildings, hospitals, social housing, etc. In 2010, public infrastructure expenses amounted to 40% of GDP, which are high compared to, for example: the productive sector (29%), the public administrative sector (18%) and much less compared to the social sector which barely reached 12%.

In an economy dependent on the hydrocarbons sector, as oil prices plummet, it drags the other sectors into a deep economic recession. The economic plans of the country must be reformulated to new horizons and new temporary spaces. The former sectors marginalized by the "Dutch disease effect" with the oil boom are those that are forced to grow to find the income the country needs. An example of this is cocoa production, which stimulates investment and the rescue of old abandoned farms, which improves their production and export, **Table 2.6.**

Table 2.6. Cocoa production and export (tons) INEGE (2018).

ACTIVITY	YEARS				
	2013	2014	2015	2016	2017
Production	677.71	668.84	587.88	745.94	726.70
Export	528.74	660.20	573.24	679.23	672.93

The agricultural sector, despite the efforts made, does not currently guarantee the country's food security. With more than 22,000 census farms, and 18, 800 has been cultivated, production remains

extensive, rudimentary and poorly diversified. Growth in farmland is an additional pressure on forests which also increases their production of goods and services.

The forestry sector, as a result of the fall in oil prices, acquires greater weight as an important source of economic resources. For this reason, the production and export of wood is increase, **Table 2.7,** which on the other hand directly affects the environment with a significant loss of forest area. According to the 2014 Biodiversity Report, the area covered by national forests has been declining dramatically for 15 years, falling from 1, 670, 000 hectares in 1997 to 740, 122 hectares in 2013.

Table 2.7. Wood Production and Export (m^3). INEGE (2018)

YEARS	PRODUCTION	EXPORTS			
		ROUNDWOOD TIMBER	PLANKS	CHAPAS	TOTAL
2013	354 799	323 829	1 990	10 976	336 796
2014	463 524	320 606	747	8 427	329 780
2015	561 261	318 806	1 216	4 678	324 700
2016	652 156	588 147	1 846	5 625	595 618
2017	528 226	659 307	7 199	5 257	671 763

Wood production in 2017 decreased by 19,0% compared to the previous year. This decrease is due to the temporary prohibition logging trees for commercial purposes. Decision that occurred after the verification of the exceeding of the maximum quota of 450,000 m3/year per company, established by Decree No.61/2007.

Equatorial Guinea has a Marine Exclusive Zone (EEZ) of more than 341,000 Km^2 ten times the total area of its territory. Hence, fishing activities must eventually meet the needs of marine products for the Equatorial Guinean population. The catch in 2017 (was 1,273 t), more than three times higher than in 2016 (386t). The prospects are encouraging for the sector in the short and medium, after the signing of a project for the construction of cold storage rooms in the capitals of the provinces, and the purchase of twenty-five fishing boats, among others.

In the hydrocarbons sector, the production and export of crude oil has fallen significantly, **Figure 2.6** while the production of its derivatives (mainly gas) has been increasing. According to INEGE (2017) the oil exploitation companies in Equatorial Guinea are: MEGI, Amerada Hess EG, MEGPL and Noble Energy.

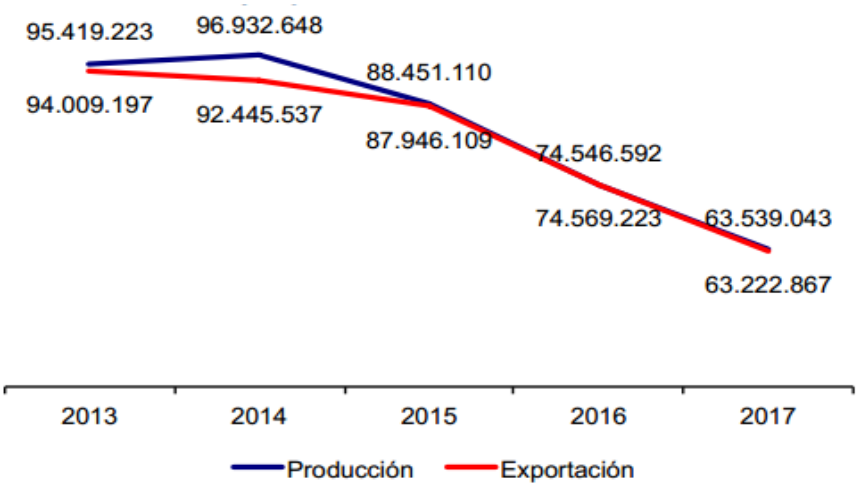

Figure 2.6. Evolution of the production ad export of crude oil (in barrels). Source: Ministry of Mines and Hydrocarbons.

In the reference period previously analyzed (2013-2017), the year with the highest production stood at 63,539,043, 14,8% less than the previous year. Of the total produced in 2017, 95,5% was exported. Regardless of the fall in production, its contribution in GDP remains very significant.

However, in the case of crude derivatives there is a significant increase in the production of these derivatives. Taking in to account the country's abundant potential gas reserves, it is possible to bet that in the near future its revenues will be a determining component in the economic development of the country, Table 2.8. The main gas company operating in the national territory is Equatorial Guinea Liquefied Natural Gas (EG-LNG) which since 2007 began its processing and export activities. Nationally, the National Gas Society of Equatorial Guinea (SONAGAS-EG) oversees the distribution of liquefied gas.

Table 2.8. Gas production (2013-2017). INEGE (2018)

YEAR	PRODUCTION			
	LNG	PROPANE	BUTANE	METHANE
2013	30 853 107	4 749 214	2 782 407	7 807 535
2014	30 409 417	4 211 056	2 629 206	7 504 993
2015	27 690 788	3 885 206	2 408 709	6 491 239
2016	28 161 594	4 414 995	2 612 765	8 520 811
2017	30 895 515	5 084 787	2 973 364	8 658 332

The increase in the production of derivatives (LNG, Propane, Butane and Methanol) has resulted in an increase in their exports, mainly since 2016, FIGURE 2.7.

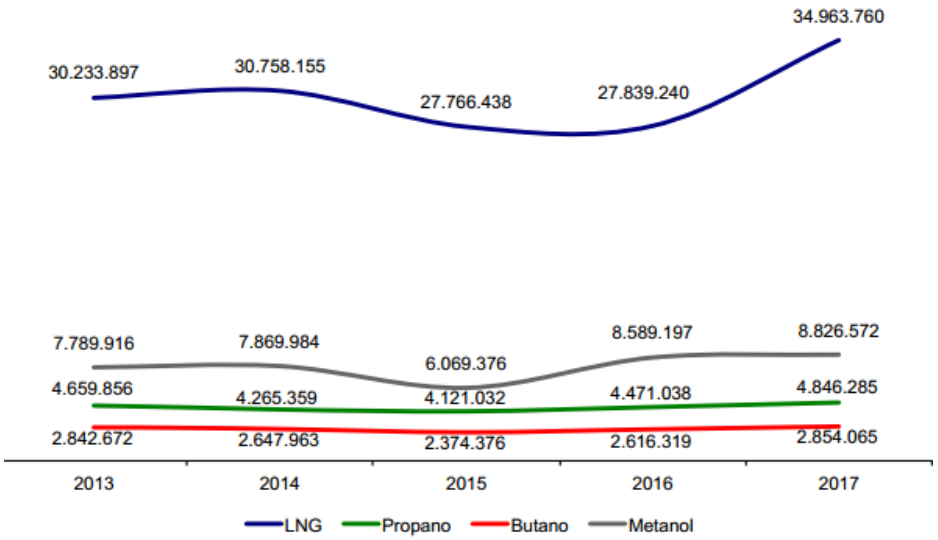

Figure 2.7. Evolution of exports of Gas and Crude derivatives. Source: Ministry of Mines and Hydrocarbons (MMH).

The construction activities developed in the country demand a large amount of materials necessary for these actions. Among these are the "aggregates": they are inert granular materials formed by fragments of rock or sand used in construction (building and infrastructure) and in many industrial applications. The best-known aggregates are: sand, gravel and fine gravel etc. All necessary materials is extracted from the country, and represents an important source of income and national labor, **Table 2.8.**

Table 2.8. Aggregates Production by Regions (m^3). INEGE (2017)

YEAR	PRODUCTION		
	INSULAR REGION	CONTINENTAL REGION	TOTAL
2013	841.880,1	1.393.369,7	2.235.249,8
2014	713.964,3	1.553.839,1	2.267.803,4
2015	490.809,2	913.911,9	1.404.721,0
2016	491.716,8	611.063,9	1.102.780,8

The productive sector of Equatorial Guinea needs, regardless of the state of the national economy that Small and Medium Enterprises (SMEs) be involved in investment in the country. These are referred to as "engine" in the creation of a strong productive environment, guaranteeing the creation of numerous jobs and a more equitable distribution of income.

2.6.1 Economy and Environment

The Fundamental Law of Equatorial Guinea, states in its article 6, "The state encourages and promotes culture, artistic creation, scientific research and technology and ensures the conservation of nature, cultural heritage and artistic and historical wealth of the Nation". "While the Environmental Regulatory Law in the Republic of Equatorial Guinea (7/2003), it establishes in its

article 5 “to favor sustainable development through a system of environmental administrative intervention that harmonizes economic development with environmental protection”.
In the declaration on the guiding principles of development, in the Industrialization Plan of Equatorial Guinea, PEGI (2012) implicitly states that sustainable development constitutes a cross-cutting objective of Government policy. The above is intended, among other things, to improve the quality of life of the inhabitants of Equatorial Guinea and future generations, in addition to promoting a dynamic economy with a high level of employment and training, the protection of flora and the environment.
The global economic situation and its impacts at the national level have forced the reformulation of the country’s economic strategy. For this, the Third National Economic Conference was held, which establishes the development pathways until 2035. One of the proposals raised at the level of the Conference is to introduce the United Nations Sustainable Development Goals (SDGs) into the national economic program. The environmental sector, the problem of climate change, the protection of biodiversity, desertification and drought, as well as the use of renewable energies will be present in the general financing of the States allocated to the ministry overseeing environmental matters.
The State provides funds directly to the environmental sector directly to the ministry in charge. These funds are dependent on the requests proposed by the ministry to the General State Treasury and by the State’s own availability. Similarly, funds are allocated to the National Institute for Environmental Conservation (INCOMA) independently to execute its projects.
From other ministries, funds and qualified staff are also allocated so that they can execute plans for the protection of the environment. It is also important to mention that the international economic situation has had an impact on the state budgets, for this reason there is still a need for greater investment in environmental protection.

2.7 Energy

In Equatorial Guinea all the electrical energy consumed is of national production and since colonial times it has been created by hydraulic or semi-hydraulic power plants and some thermal power plants. These generation plants have always evolved over time and according to the economic possibilities of the country.

The National Electric System (NES) is made up of two systems that are not physically interconnected. The Continental Region Electric System (CRES) that supplies electricity to the main cities of Rio Muni and the Insular Region Electric System (IRES) which is responsible for supplying energy to the country’s islands. It also exists in small central isolated villages or generators that supply them with electricity and are considered as Isolated Systems (IS). The SEGESA Company is responsible for the electrical distribution throughout the country.

The power generation capacity in the country (as of June 2018) reached 394,718 MW, of which 127,114 MW corresponded to the generation through renewable energy (hydroelectric power plants); 156 MW through natural gas thermoelectric plants; and 111,604 MW of installed generation power based on diesel fuel (especially in SA), Table 2.9.

Table 2.9. Total Installed Power (in MW), by type of plant (as of June 2018)

TYPES GENERATED	CONTINENTAL REGION (MW)	INSULAR REGION (MW)	TOTAL (MW)
DIESEL	76.1	35.504	111.604
NATURAL GAS	0	156.0	156
HYDROELECTRIC	123.2	3.914	127.114
SOLAR	0	0	0
TOTAL	199.3	195.418	394.718

It is important to point out that of the 111,604 MW of installed power for the diesel generation that the country has, 55,8 MW correspond to generator sets that operate in SA in the villages where the distribution of the national network does not reach.

Currently, work continues to increase generation capacity with the execution of new projects. The efforts to complete the Dsenje hydroelectric power station on the mainland with a capacity of 200 MW and the solar park on the Annobon Island of 5 MW are highlighted. In this sector of renewable energy, other projects are being carried out to bring electricity to isolated areas of the national territory as well as to remote islands.

2.7.1 Energy use

The use of energy is aimed primarily at the consumption of the industrial sector, services, government institutions (ministries, public schools, hospitals, institutes, etc.), and the residential sector.

The increase of the urban population, and the economic improvement of the first part of the present century increased the energy needs of a large part of the population by having greater access to goods, mainly household electrical equipment. Associated with this demand, the stores of nationals and foreigners offering goods and products needed by the population have increased, Table 2.10.

On the island of Bioko, the production of electricity exceeds demand. In the rest of the country, production still does not cover all electricity needs regardless of specific consumer sectors.

Table 2.10. Energy demand. 2010 – 2015. Source: INEGE 2017

YEAR	DEMAND (MW)	
	MAXIMUN	MINIMUN
2010	23,7	18,4
2011	42,1	19,5
2012	62,4	38,15
2013	70,14	55,64
2014	71,81	58,94
2015	70,29	59,38

2.8 Agriculture, land use and silviculture

2.8.1 Agriculture

The cocoa and coffee that were the main export products at the time of the colony, currently its production is testimonial. Just about 1000 t of cocoa on Bioko Island, which the State buys at subsidized prices, and a symbolic amount of coffee in the continental zone. Self-subsistence food agriculture exists, but it does not allow to cope with urban demand, now satisfied by imports. Food production focuses on the cultivation of bananas, cassava (or yuka), cocoyam (or malanga), yams, potatoes, bananas, nuts, palm oil and vegetables, making fruit and vegetables a potential for creation of agroindustry for the diversification of the economy.

Livestock development has been hindered by the abundance of epidemics and pests, the lack of equipment in the sector and the low reproduction rate of livestock. Its contribution to GDP is almost negligible. Most of the meat is imported. However, to reduce dependence from abroad, the Government, with technical assistance from FAO, has recently developed, validated and adopted a National Plan for Food Security (PNSA), which has 7 subprograms:

- ✓ Sustainable intensification of agriculture productions;
- ✓ Diversification of food sources, whose components are (livestock, veterinary services and fisheries);
- ✓ Management of natural resources and use of non-timber forest products;
- ✓ Nutrition and management of food vulnerability;
- ✓ Institutional strengthening;
- ✓ Coordination and management of the Plan.

Each of the subprograms mentioned above addresses the background and issues, the objectives, components and results, the actions to be taken and the costs.

On the other hand, the agriculture decline experienced in the last decade has increased the massive rural exodus towards urban centers and the abandonment of activities despite the efforts of the State to curb this trend subsidizing mass export crops.

2.8.2 Land use and tenure

The land use and tenure situation are marked by norms and customs that date from the colonial era. In the Continent the usufruct system is applied, like that of neighboring countries, with a patrilineal regime. Access to land is subject to the provision of heads of household (men) who grant women a part of their land to produce food crops for household consumption and another part to market.

On the Island of Bioko, the rights over the use and ownership of the land link historical-customary and legal-advice aspects. Traditionally follows a matrilineal regime. Since pre-colonial times there are lands reserved for each town (Reserve of Villages), exercising on them the members of the community an exclusive and exclusive domain. There is also the traditional way of holding small individual farms.

As of 1979, some lands became property of the State or the occupants who dedicated themselves to subsistence agriculture. Certain areas of cocoa and coffee exploitation went to foreign companies that are responsible for marketing these products.

In 2008, the Land Ownership Regime Law was passed, which is not available to most of the population. However, in its article 1 it states that the land as property is classified as:

- State patrimonial property;
- Public Property of the Municipalities;
- Property of the Population Councils;
- Family or Traditional Property;
- Private property.

The same Law classifies the land in Rustics (for agricultural use) and Urban (construction of houses and infrastructure). The Law also "guarantees" and "protects" the right to Public, Private and Traditional land for farmers who own it.

2.8.3 Silviculture

The country has a great forest wealth that is part of the rich plant and animal reserve of the Congo Basin, the second largest area of tropical forest in the world after the Amazon. The total forest area of Equatorial Guinea represents 62,5% of the territory and is covered by dense tropical rainforest that houses natural resources of fundamental importance for the development of the country and the improvement of the quality of life of its population. In the continental part 1 637 000 ha (with a volumetric density of timber species of 164,57 m^3 /ha), 104 000 ha in Bioko (density of 95,5 m^3/ha) and in Annobon 12 000 ha correspond to forested areas. In the islands of Bioko and Annobon, due to their insular nature, a great variety of endemic plan and animal species are present.

The height of its forests varies between 35-40 m high with three strata of well-defined vegetation. The first area primary formations composed of dense rainforests or medium and low altitude forests as dominant, species of great timber value, forests of swampy lands and mangroves. The second stratum is composed of a secondary formation derived from the regeneration of the forest after logging and finally the tertiary formations where heliophiles and agrological ones predominate. The total volume of timber species on Bioko Island is 95,5 m^3 /ha and in the continental region the primary forests reach 180 m^3 /ha and 193 m^3 /ha those exploited selectively.

Given this situation, since 1997 a new legislation for the forestry sector was adopted with the objective of maintaining a long-term sustainable exploitation of wood, compatible with the preservation of the environment and increasing revenues from concessions. On the other hand, since 2000 the Ministry of Agriculture and Forestry creates the forestry policy of Equatorial Guinea where the Government's priorities on the country's forestry activity are established. This policy has among its fundamental objectives, the protection and conservation of Forest Heritage, its environment and the preservation of forest ecosystems. In 2007, the Decree No. 61/2007 was enacted with the intention of promoting the development of the timber industry by prohibiting the export of logs or roundwood from Equatorial Guinea and the transformation of 100% of the wood in the country.

With the oil boom, logging decreased significantly. Subsequently with the fall in oil prices its exploitation has been reinforced. Such a situation has increased the pressure on forests, which also contributes to the overexploitation of forestry companies, illegal and indiscriminate logging by

citizens and peasants, the expansion of widening areas and the establishment of the road network and other infrastructure undertaken in development plans, constantly reducing forest cover and contributing to the degradation and deforestation of the forests of Equatorial Guinea.

Currently in the search for diversification of the economy and at the same time in the conservation of forests, the Equatorial Guinean government in collaboration with COMFAC (Forestry Commission of Central Africa) encourages the application of REDD Plus (+) mechanisms to not only protect forests but promote environmental protection and develop agriculture, education especially in rural areas and at the same time contribute to the fight against climate change.

2.9 Water resources

The climate of the Republic of Equatorial Guinea is characterized by heavy and heavy rainfall, so its surface water resources are large today. This climate singularity has led to the existence of abundant water resources, throughout the national territory, mainly of fast-flowing rivers that move west on the mainland. On the Island of Bioko, they are abundant, but of short course due to the steep orography and have a radial distribution with respect to the main heights. However, natural water reservoirs such as lakes and lagoons in the national territory are not abundant.

With regard to groundwater, these are abundant, so the country's water potential can be considered abundant, although it is currently unknown how much it rises. As for regulated waters (dams and micro-presses), they are practically non-existent in the country, causing practically all surface runoff to go to the sea.

On the other hand, there is no study of river basins in the country that allows their management efficiently and sustainability. In the mainland, the largest aquifers are associated with the rivers that are located on the northern border (Ntem River) and the south (Utamboni River). In the central part is the Wele River; all of them drain to the western part leading to the Atlantic in relatively open estuaries.

Although the water potential of Equatorial Guinea is not known exactly, the abundant rains and rivers that cross the country make it possible to ensure that this precious resource is substantial throughout the national territory at the moment. However, provisioning to the population is precarious. In urban areas, it does not exceed 60% of the population that has access to clean water, but it is not treated properly, as established by WHO standards.

2.10 Biological diversity

The Republic of Equatorial Guinea is one of the countries of the African continent with a great biological diversity, many endemic species, of high generic value and others of relict distribution, Table 2.11. The islands of Bioko and Annobon because of their insular nature have many endemic plant and animal species. Most of the country is covered by dense rainforests, with an increasing proportion of intervened forests. There are several types of vegetation derived from the rainforest and irregularly distributed throughout the territory. 1105 plant species have been recorded in Bioko that have great similarity with the region of Mount Cameroon and 350 tree species in the continental region.

Table 2.11. Biological diversity in Equatorial Guinea.

Taxonomic groups	Continental region		Bioko Island		Annobon Island	
	Species (n)	Endemics (%)	Species (n)	Endemics (%)	Species (n)	Endemics (%)
Mammals	> 100	¿	> 65	28	2	0
Birds	300-600	¿	143	1	9	22
Reptiles	> 25	¿	52	2	7	29
Amphibians	40-50	¿	33	3	0	-
Fishes	167	¿	34	¿	4	25
Higher plants	4000-5000	¿	> 1000	9	> 200	15

The presence of natural ecological corridors in the continental region and the absence of barriers with neighboring countries facilitate the migration of species. There are almost 200 species of mammals, 17 of primates, 133 of ungulates and some wild elephants. Although there are no data on the number of reptile species, the continental region has the greatest diversity of chameleons in Africa with 6 species. 314 bird species belonging to 47 families have been recorded, the ichthyofauna reaches more than 167 species of which at least 8 are unique or endemic. In the insular region, more than 60 species of terrestrial mammals have been identified, of which 28% are endemic, especially primates. 53 species of reptiles, 4 species of sea turtles and 45 species of freshwater fish have been detected. There are 38 species of land birds of which 45% are endemic at the subspecies level. The fauna on the island of Annobon is poor, but it has great biological value due to its great endemism.

In 2000, in order to improve the management of biodiversity and forestry resources, the Government adopted the National Forestry Action Program that includes the rational use of forest resources and their economic potential, the conservation of forest ecosystems, and the social functions of the forest, among others and in 2005 the National Strategic Plan for Biodiversity. The National System of Protected Areas (SNAP) was established, which increases formal protection from 18,5% to 40% of the national territory. The Forest Action Plan was developed within the framework of the project "Conservation and rational use of forest ecosystems in Equatorial Guinea" (CUREF) with the support of the European Community. The main objective of the plan is to identify priorities for action in the short, medium and long term to improve knowledge of the country's forest resources and their rational management, as well as strengthen their management capacity.

From 1985 to the present, inventories are being made that will undoubtedly expand the number of known species in the country; such is the case of ECOFA in the Continental Region and the Association Friends of Nature in the insular part, as well as the National University of Equatorial Guinea (UNGE).

2.11 State of the environment

Despite the non-existence of a National Environmental Strategy in the country, four main environmental problems have been identified: water pollution, soil, air and the human residential environment; degradation of soils and vegetation cover; loss of biological diversity and decreased availability of basic resources for the national economy, according to ENGONGA *et al*, (2011).

2.11.1 Water pollution, soil, air and the human residential environment

Practical experience in Equatorial Guinea has demonstrated the existence of several sources of pollutants that cause a marked deterioration in the quality of water, soil and environmental conditions in human settlements. The accumulation of solid and liquid waste that is thrown directly into the riverbed and the sea, fecal pollution presents mainly in urban areas and the spillage of toxic substances associated with oil activity are the main sources of pollutants.

Sanitation levels in general are insufficient, however, there are extractor companies that have environmental management programs, which involve the storage and export of pollutants.

2.11.2 Soil degradation and vegetation cover

Soils and vegetation cover face a serious situation in the country in recent years. This fact is linked to the accelerated development that the country has been experiencing since the early 1990s. The extraction of sand and other aggregates used for construction has affected mangroves, flooded lands and the coastline, mainly on the island of Bioko. Mangrove areas have also been intervened for the construction of infrastructure and although to a lesser extent for national tourism. As a result, there has been a reduction in the mangroves that cover the shoreline.

Cocoa production and the successive intensive or extensive subsistence agriculture in some areas of the country have changed the land cover. The itinerant logging and slash and burn agriculture practiced by the population, together with the occurrence of forest fires, has caused negative impacts on the soils and vegetation cover of Equatorial Guinea. However, it should be noted that the reduction of logging has had a positive impact on plant cover.

2.11.3 Loss of biological diversity

The great variety of species of flora and fauna of the country, with a wide variety of endemic species is being strongly threatened by human activities. This contributes to insufficient environmental education and public awareness, mobile or itinerant agriculture, the informal and illegal exploitation of the forest, the construction of infrastructure and poverty. The regulation and limitation of logging together with the creation of protected areas have limited monitoring of the variation of flora and fauna. Currently, the most relevant pressures affect wildlife and coastal mainly in the insular part.

2.11.4 Decrease in the availability of basic resources for the national economy

Agricultural practices, street farming, logging, indiscriminate hunting and destruction of mangrove habitat, unregulated mining, affect the availability of basic resources for the national economy, but mainly in rural areas where they are the main source of employment and livelihood. On the other hand, this unfortunate situation increases the workload of the inhabitants of these affected areas and increases the migration of most of the active population to the cities, increasing urban poverty.

At national level, there is not only a migration to the cities, but also abroad for many of the qualified citizens of the country looking for better salary conditions (very low in the country), and opportunities for overcoming which seriously affects the availability of national human resources. Similarly, Equatorial Guinean businessmen with important wealth do not invest in the country, which lead to a national capital flight, job insecurity and financial insecurity.

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Chapter 3

Chapter 3. National Inventory of Emissions and Absorption of Greenhouse Gases. Year 2013

3.1 Introduction

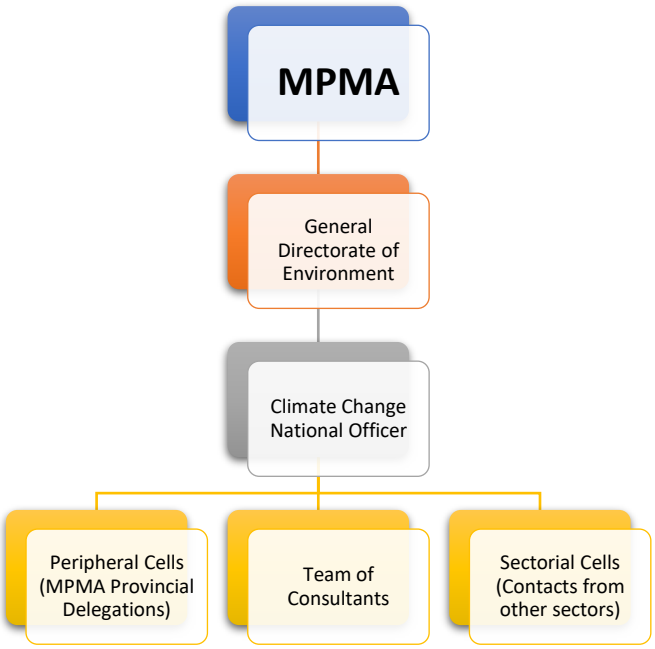
The “Inventory of Greenhouse Gas Emissions” (INGEI) includes estimates of emissions by sources and sinks for 2013 in the territory of Equatorial Guinea. It was carried out in accordance with the provisions of articles 4 and 12 of the UNFCCC and in the guidelines for the preparation of national communications of non-Annex I Parties to the UNFCCC, which indicate that Parties not included in annex I of the convention, inform the conference of the Parties, through the secretariat and in accordance with the commitment stipulated in paragraph (a) of article 4, paragraph 1, of the convention, “to prepare, periodically update, publish, and facilitate the conference of the Parties, in accordance with Article 12, national inventories of anthropogenic emissions by sources and absorption by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed by the Conference of the Parties”.

3.2 National System for the Determination of GHG Emissions and Removals or Preparation and Associated Institutional Arrangements.

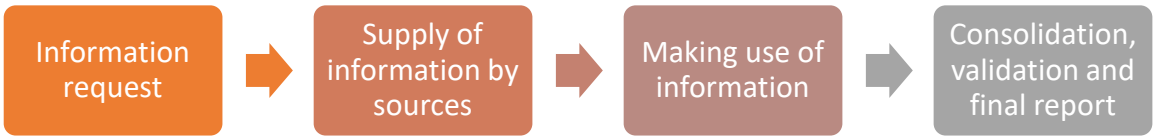
The ministry of Fisheries and Environment (MPMA) of Equatorial Guinea is responsible for the preparation of this national communication; being the technical executive arm the General Directorate of Environment. Regarding the National Inventory of Greenhouse Gases, a work Coordination structure was also established at the Climate Change Office level, in charge of preparing emissions reports and inventory in general.

The main input of NIGE, like other domains of national communication, was the work of consultants and peripheral and sectorial structures; under the coordination of the National Focal Point on Climate Change, with an organic structure that is outlined in the diagram below.

Organic structure for the NIGHG of the first national communication



The flow of necessary information (activity data) used to prepare the NIGHG in Equatorial Guinea was the one shown in the following scheme:



The Flow of necessary information (activity data) used to prepare the NIGHG in Equatorial Guinea was the one shown in the following:

Module: Energy
International Energy Agency (IEA)
General Directorate of Hydrocarbons
Aeronautical Authority of Equatorial Guinea
Industrial and Product Use Module
National Institute of Statistics of Equatorial Guinea (INEGE)
General Directorate of Mines and Quarries
General Directorate of Hydrocarbons
Equatoguinean Beverage Society
Module: Agriculture, forestry and other land uses (AFOLU)
Ministry of Agriculture and Forestry (MAB)
General Directorate of Forests and Reforestation (National Program on Family Poultry)
General Directorate of Forests and Reforestation (Interactive Forest Atlas 2013 and National Plan of Forestry Action of the year 2000_
National Institute of Statistics of Equatorial Guinea (INEGE)

Module: Waste

National University of Equatorial Guinea (Department of Environmental Sciences)

National Institute of Statistics of Equatorial Guinea

This is the country's first experience in developing a National Greenhouse Gas Inventory and it produced the following results and gaps:

- Information available at a dispersed national level and without the level of detail necessary for the estimation of all emissions.
- Clear identification of the institutions and agencies providing information.
- Need to strengthen knowledge about the importance of the generation and use of official and relevant data and information to ensure that INGEI is accurate and representative of reality in terms of national emissions.
- The need to strengthen institutional arrangements in the country to obtain this information in a sustainable and constant manner.

3.3 Methodologies and data used

For the preparation of the Inventory, the methodology of the Intergovernmental Panel on Climate Change (IPCC) contained in the Revised 1996 Guidelines for National Inventories of Greenhouse Gases (IPCC/OECD, IEA, 1997), the 2006 IPCC Guidelines for national inventories of greenhouse gases (IPCC, 2006) and the 2006 Guide on Good Practices for Land Change and Use, using the available national information and predetermined values in the aforementioned methodology. The emissions are presented in Giga grams (Gg) equivalent to 1000 tons.

The emissions in this inventory are accounted for by each GHG and, also, units of equivalent CO_2 (CO_2eq.), which are estimated by multiplying the amount of emissions of a greenhouse gas by its global warming potential value. By expressing GHG emissions in these units, we can compare them with each other and measure the contribution of each source to the national total of inventory emissions.

Due to the multisectoral and multidisciplinary nature of the work, the necessary data for the preparation of the inventory were provide by various sectors and institutions. However, the information available at the national level is still much dispersed and lacks the level of detail necessary for the estimation of all emissions.

In all cases, the default emissions factors provided by the IPCC Guidelines (1996 and 2006) have been used.

For each of the categories of sources addressed in this report, the best estimation methods that made available the data available in the country and collected for inventory realization were used.

Due to the difficulties faced in capturing the activity data required for the preparation of the inventory, all the methods used are Level 1 (simpler, where country data and default factors of the IPCC Guidelines or other methodologies are used recognized) which increases the uncertainty of the results obtained. For each other categories of sources addressed, the methodology used is explained in detail as well as the criteria from which it was addressed, both the selection of the data and the calculation of the emission factors and parameters used.

The inventory of Greenhouse Gases 2013 only included the estimation of the net emissions of Direct Greenhouse Gases: carbon dioxide (CO_2); methane (CH_4) and nitrous oxide (N_2O).

Due to the lack of the necessary information, this inventory did not estimate the emissions of Indirect Greenhouse Gases: nitrogen oxides (NOx), Sulfur dioxide (SO_2), carbon monoxide (CO) and other Direct GHGs such as: hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfur hexafluoride (SF6), which is an important inventory limitation. In the case of Volatile Organic Compounds other than Methane (COVDM), they

were only estimated in the Industrial Processes and Product Use sector in the category of Minerals Industry (asphalt production) and in the production of alcoholic beverages.

The sectors considered in this inventory are:

- Energy
- Industrial processes and product use (IPPU)
- Agriculture, forestry and other land uses (AFOLU)
- Waste

For the analysis of stationary combustion in the Enery sector, the activity data for all levels are the quantities and types of fuels burned. Most consumers (businesses, small commercial consumers and households) normally pay for solid, liquid or gaseous fuels they consume. Therefore, the masses or volumes of fuels they consume are measured or dosed. That is why the amounts of carbon dioxide can normally be calculated from the fuel consumption data and the carbon content of the fuels considering the fraction of carbon without oxidizing.

Fuel statistics compiled by a national official recognition body are usually the most appropriate and accessible activity data. In the case of Equatorial Guinea, the compilers of this inventory only had access to some of these statistics and that is why this report also used data specially provided by the country to international organizations such as:

- The international Energy Agency (IEA)
- The United Nations (UN) (http://unstats.un.org/unsd/energy/)
- United States Geological Institute (USGS) (www.minerals.usgs.gov/minerals)

These international organizations collect energy data from the national administrations of their member countries, through questionnaire systems. The data collected are, accordingly, “official” data.

The industrial sector in Equatorial Guinea has been progressively losing weight in GDP since 1995. Currently, this sector has as its main component in the country, construction and manufacturing. The manufacturer has traditionally been mainly composed of wood and carpentry, breweries, textiles and construction materials industries. However, in recent years it has had a wide expansion in the field of industry associated with petrochemical farms.

The construction sector is one of the most dynamic in the Equatorial Guinean economy. It is a sector in clear expansion. Its contribution to GDP has remained at the same levels despite the strong growth recorded in the Guinean GDP, which gives an idea of its dynamism.

In the Industrial Processes and Product Use sector of this inventory, the emissions from methanol production and the COVDM emissions from asphalt production for roads and the production of alcoholic beverages were evaluated.

Regarding the Agriculture, forestry and other land uses sector, emphasis was place on the calculation of direct emissions of N_2O (for Manure Management) and CH_4 (for Enteric Fermentation of Ruminants and Manure Management), which are two main categories of emission source. According to IPCC (1996 and 2006), the data required for Enteric Fermentation and Manure Management is the stock of livestock by type of domestic livestock. For Manure Management, the stock of cattle according to climatic zone, defined by the IPCC (1996 and 2006) must be known according to the annual average temperature, for this, this study is located within the Warm Zone, of average annual temperature greater than 25°C. The collection of information from the National Family Poultry Program (2013), implemented with the assistance of the Food and Agriculture

Organization of the United Nations (FAO), allowed for the availability of the necessary data for the calculation of emissions.

In the case of forestry emissions, the sources of activities correspond to the 1990-2013 time series. The sub-categories of forests used in this report come from the National Forest Action Plan document of the year 2000 (MAB, 2000), which derive form the national forest inventory conducted from 1990-1992. This is the reference of the area taken as the basis for this inventory, while the current surface has been evaluated through the cartographic bases on the National Institute of Forest Development and Management of the National System of Protected Areas (INDEFOR) for the Continental Region and Annobon and, by Navarro et al., (2012) for the Insular Region (Bioko). In addition, the reports of infrastructure works projects carried out in the country since 1995 (new cities, highways, model farms, high voltage networks, new airports, new national roads, hydroelectric plants, etc.) have been used.

In the National Inventory of Greenhouse Gases of Equatorial Guinea, for the category Waste, the data disaggregated at the regional level (continental region and insular region) were considered, taking the provincial headings as key inventory points to estimate the total amount of incinerated waste and/or openly incinerated, which is equivalent to the Level 1 Method of the IPCC inventory methodology for 2006. It should be stressed that, since it was the first time this type of inventory is carried out at the national level, it was not possible to consider all districts of each province, but the districts that are provincial capitals and only in the last period, analyzed.

3.4 General results obtained

3.4.1 Gross Emissions

Gross emissions do not include GHG emissions and removals derived from the Land Use Change and Forestry sector. In relation to direct GHGs, CO_2 emissions predominate significantly, followed by CH_4 and N_2O.

Table 3.1. Gross emissions by sectors (Gg). Equatorial Guinea, 2013.

Sector	GEI			
	CO_2	CH_4	N_2O	COVDM
ENERGY	1833.4	109.2	0.04	NE
INDUSTRIAL PROCESSES	656.3	2.3	0.00	29.1
AGRICULTURE	NA	0.3	0.00	NA
WASTE	0.5	0.3	0.00	NE
TOTAL NATIONAL	2490.2	112.1	0.04	29.1

NA – No applicable; NE – No estimated due to lack of activity data.

The total gross GHG emissions in this year were 2631.4 Gg, **Table 3.1.** CO_2 has the largest contributions to emissions with 94.6% of these since CH_4, and N_2O and COVDM only contribute 5.4%.

3.4.2 Net Emissions

Unlike gross emissions, the determination of net emissions includes GHG emissions and removals from the Land Use Change and Forestry sector. In Equatorial Guinea, CO_2 removals due to the growth of biomass in forests far outweigh the emissions that occur in them due to wood extraction and other causes. The effect of these net removals in that sector is also evident in the net CO_2 emissions (**Table 3.2**).

Given the great weight of CO_2 removals by forests in the country, when the analysis incorporates emissions and removals from the Land Use Change and Forestry sector, the country becomes a net sink of GHG emissions.

Table 3.2. Net GHG emissions by sector (Gg). Equatorial Guinea, 2013.

Sector	GEI				
	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	COVDM
ENERGY	1833.4		109.2	0.04	NE
INDUSTRIAL PROCESSES	656.3		2.3	0.00	29.11
AGRICULTURE	NA		0.3	0.00	NA
LAND USE CHANGES AND FORESTRY	9969.4	-18672.9			
WASTE	0.5		0.3	0.00	NE
TOTAL NATIONAL	12459.6	-18672.9	112.1	0.04	29.1
	-6213.3		112.1	0.04	29.1

NA – No applicable; NE – No estimated due to lack of activity data.

3.4.3 Inventory Report

In decision 17-CP.8 (UNFCCC, 2003), all Parties not included in Annex I are encouraged to use Tables 1 and 2 include in the guidelines for the preparation of their national communications in order to report your national GHG inventories. **Tables 3.3** shows the total net GHG Emissions and Absorption for 2013 in Equatorial Guinea.

In 2013, greenhouse gas emissions were mainly generated in the sector changes in land use and forestry and in the energy sector. To a much lesser extent it came from the industrial, agricultural and waste sector, **Table 3.3.**

Table 3.3. Total net GHG emissions and removals (Gg) for 2013 in Equatorial Guinea.

Sinks Categories and Sources	CO_2 Emissions	CO_2 Removals	CH_4	N_2O	COVDM
TOTAL NATIONAL	12459.6	-18672.9	112.1	0.052	29.1
1 - Energy	1833.5		109.2	0.043	0.018
1.A – Fuel burning activities (Reference)	4029.8				
1.A – Fuel burning activities (Sectors)	1093.7		0.070	0.031	0.000
1.A.1 – Energy industries	231.1		0.004	0.000	0.000
1.A.2 – Manufacturing and construction industries	82.8		0.003	0.001	0.000
1.A.3 - Transportation	688.6		0.054	0.029	0.000
1.A.4 – Other sectors	91.2		0.009	0.000	0.000
1.B – Fugitive Emissions	739.760		109.1	0.012	0.018
1.B.2 – Oil and Natural Gas	739.8		109.1	0.012	0.018
2 -Industrial processes and use of products	656.3		2.2	0.0	29.108
2.A – Mineral Industry	0.0		0.0	0.0	26.9
2.A.5 - Others (Asphalt production for paving)	NA		NA	NA	26.9
2.B – Chemical Industry	656.3		2.2	0.0	0.0
2.B.8 – Petrochemicals (Methanol)	656.3		2.2	NE	NE
2.H - Other	0.0		0.0	0.0	2.2

2.H.2 – Food and beverage industry	NE		NE		2.2
3 - Agriculture, Forest and Other Land Uses	9969.357	-18672.858	0.274	0.009	NE
3.A - Cattle			0.274	0.0	NE
3.A.1 – Enteric fermentation			0.259		NE
3.A.2 – Manure management			0.015	0.0	NE
3.B – Land Use	9969.4	-18672.9	0.0	0.0	NE
3.B.1 - Forestry	0.0	-18672.9	0.0	0.0	NE
3.B.6 – Other lands	9969.4	0.0	0.0	0.0	NE
3.C - NO_2 emissions from managed soils and CO_2 emissions derived from the application of lime and urea	NE		NE	0.009	0.0
3.C.4 – Direct N_2O emissions from managed soils				0.009	0.0
4 - Waste	0.480		0.342	0.0	0.0
4.C – Incineration and open waste incineration	0.480		0.156	0.0	0.0
4.C.2 – Burning of open pit wastes	0.480		0.156	0.0	0.0
4.D – Wastewater treatment and disposal	0.0		0.186	0.0	0.0
4.D.1 – Treatment and disposal of domestic wastewater	0.0		0.186	0.0	0.0
International Deposits	2.9		$0.2*10^{-4}$	$0.8*10^{-5}$	
Aviation	2.9		$0.2*10^{-4}$	$0.8*10^{-5}$	
Marine	NE				
Biomass Emissions	435.4		NE	NE	NE

NA – No applicable; NE – No estimated due to lack of activity data.

3.5 Contribution Relating to Global Warming. Aggregate Emissions in CO_2 Equvalent (CO_{2eq})

The different gases do not contribute in the same degree to the increase of the greenhouse effect. To express GHG emissions on an equivalent basis (CO_{2eq}) that reflects its contribution to possible future warming, Global Atmospheric Heating Potentials (GWP) are used.

Table 3.4 shows the contribution related to the radiative forcing of the gross emissions estimated in this inventory report for the main direct greenhouse gases. The Global Atmospheric Warming Potential values are used for the calculation of a time horizon of 100 years reported in the Second Evaluation Report of the IPCC (IPCC 1995).

Table 3.4. Gross and net aggregate GHG emissions by sector and national total in Gg CO_2eq. Equatorial Guinea, 2013.

Sector	CO_2 eq Emissions	
	Gross Emissions	Relative Contribution (%)
Energy	4139.7	85.24
Industry	703.7	14.49
Agriculture	5.8	0.12
Wastes	7.7	0.16
Total	**4856.8**	**100.0**

As can be seen in **Figure 3.1,** in gross CO_2eq, and CO_2 and CH_4 emissions have the greatest contribution to heating, while N_2O contributions are practically negligible in the country with less than 1% of emissions.

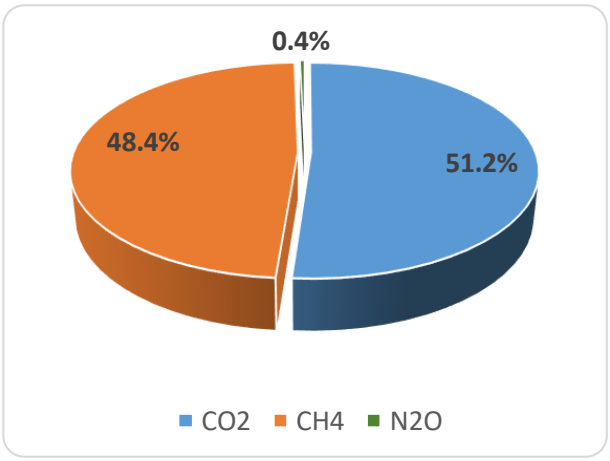


Figure 3.1. *Gross CO_2eq (Gg) emissions by GHG. Equatorial Guinea, 2013*

3.6 Per capita emissions of CO_2 and GHG

The results obtained in the calculation of annual per capita emissions of CO_2 and GHG for the year evaluated in this report are shown in **Figure 3.2.** Gross CO_2 emissions (in T of CO_2) and aggregate gross GHG emissions (in T CO_2eq) are used for this calculation, which are the indices that are used most frequently for this purpose.

GHG emissions in Equatorial Guinea are less than 0.1% of global emissions, however, it has a per capita average of CO_2 emissions of 2.5 tCO_2 (4.8 t $CO_{2\ eq}$). This situation is very worrying, because if only the emissions are valued considering the contributions at a global level, it could fall into a certain state of complacency when they are considered relevant, which is totally false. As a country, taking into account its population, the contribution is significant, so mitigation measures must be taken into account in all public policies developed in Equatorial Guinea.

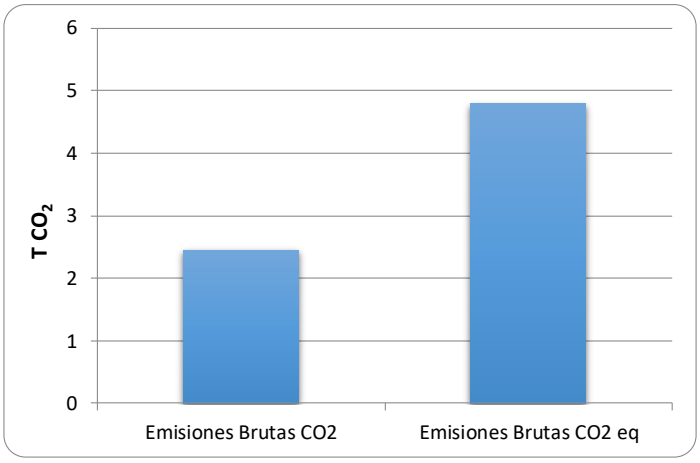


Figure 3.2. *Per capita emissions of CO_2 (t CO_2/person), and GHG (t CO_2 – eq/person). Equatorial Guinea, 2013.*

3.7 Module 1: Energy

3.7.1 Fuel Production in Equatorial Guinea in the Period 1991-2013

The Equatorial Guinean economy is based mainly on the extraction and processing of hydrocarbons, with an average percentage over the total added value greater than 85%, except as of 2009, due to the sharp drop in the price of a barrel of oil and the beginning of the decline in production from that year (until then everything had been increases), **Figure 3.3.** (BICE 2010) it is estimated that in 2011 oil and gas production constituted 88% of GDP, 100% of exports, and 90% of tax revenues (BAfD 2012).

The country articulates the hydrocarbon extraction and processing industry through two large groups of projects. On the one hand, the extraction of crude oil, condensate and gas in the Zafiro, Ceiba and Alba fields, with a total production in 2013 of about 300,000 barrels/day. On the other hand, the use of gases and derivative liquids (oil condensates among others) of the Alba field, to obtain three final products for exports: liquified natural gas (LNG), methanol and LPG (liquified petroleum gas, butane and propane), which has had a special nominal and real development in the last decade.

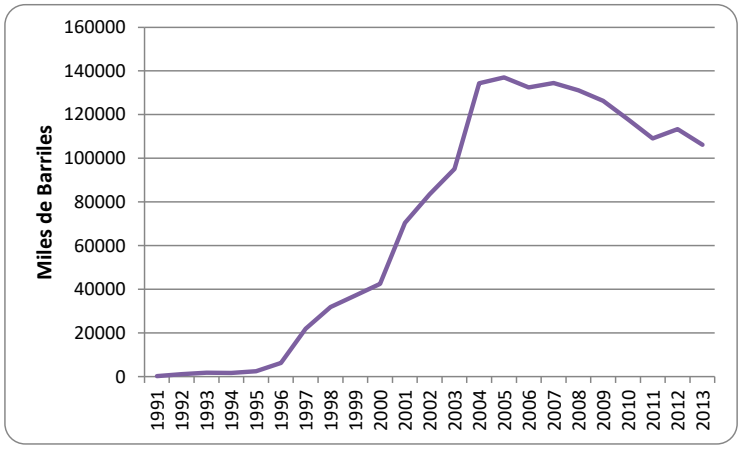


Figure 3.3. Oil production in Equatorial Guinea.

Indeed, Equatorial Guinea is one of the largest producers of crude oil per capita in the world, with almost half a barrel of oil per person per day, ahead of countries such as Saudi Arabia or Oman, BICE (2010).

3.7.2 Emissions from fuel burning

Carbon dioxide emissions come from the oxidation of carbon from fuels during combustion. Under optimal combustion conditions, the total carbon content of fuels should be converted to CO_2. However, the actual combustion processes are not perfect and the consequence of this is that small amounts of partially oxidized and non-oxidized carbon are produced.

A small fraction of the carbon is not immediately oxidized as CO_2 and is emitted in the form of gases other than CO_2 such as methane (CH_4), carbon monoxide (CO) and volatile organic compounds other than methane (COVDM).

In 2013, GHG emissions in Equatorial Guinea, according to the sectoral approach (**Figure 3.4**), show that the greatest weight (63%) is in transport sector followed by electricity generation (21%). In the same measure are those emissions from the burning of fossil fuels in manufacturing and construction industries and the residential sector with only 6%.

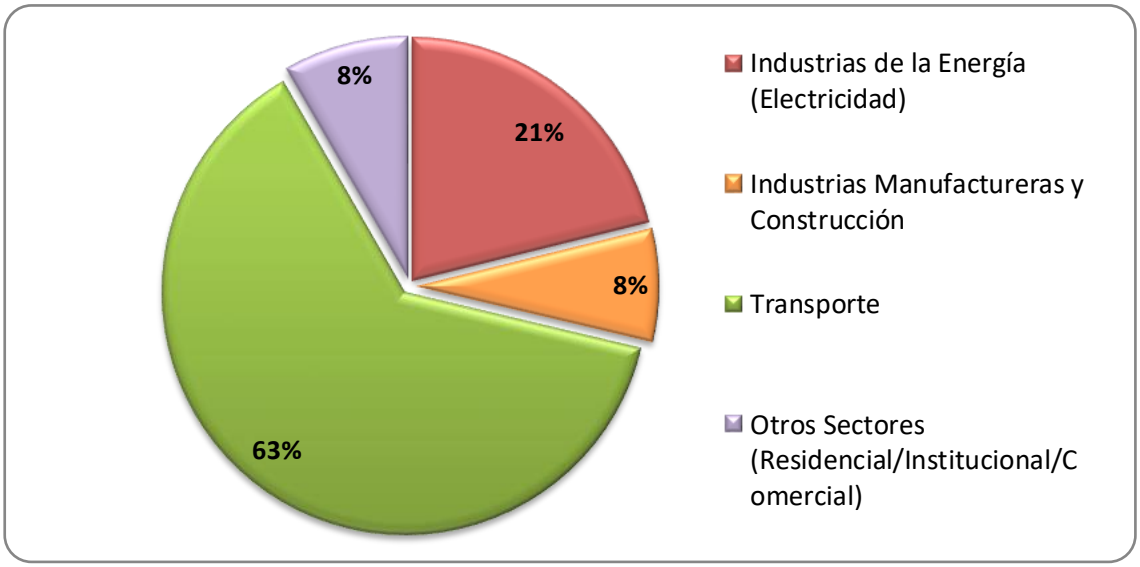


Figure 3.4. *CO_2 (Gg) emissions by categories of sources or sectorial approximation for the year 2013.*

The contribution of CO_2 emissions derived from the burning of biomass and charcoal for energy purposes was 435.4 Gg in 2013, Table 3.5. These emissions are presented for information only and are not included in the totals of this module or of the country as well as the emissions of international bunkers (fuels used in international aircraft and vessel trips). In this case, the IPCC recommends this since CO_2 emissions from biomass fuels are estimated and declared in the AFOLU sector.

Table 3.5. Contribution of the residential sector to CO_2 (Gg) emissions from the burning of biomass and charcoal for energy purposes. Equatorial Guinea, 2013.

Source category	CO_2
Residential Sector	435.4

In stationary and mobile combustion sources, emissions of different gases occur in addition to CO_2, which come, some of them, from incomplete combustion of fuels. Table 3.6 includes emissions of gases other than CO_2 derived from the burning of energy fuels for the year of the inventory.

Table 3.6. Emissions of CH_4 and N_2O derived from the burning of fuels by source categories (Gg). Equatorial Guinea, 2013

Sinks Categories and Sources	CH_4	N_2O
1.A – Fuel burning activities	0.070	0.031
1.A.1 – Energy industries	0.004	0.000
1.A.2 – Manufacturing and construction industries	0.003	0.001
1.A.3 - Transportation	0.054	0.029
1.A.4 – Other sectors	0.009	0.000

3.7.3 Emissions from mobile sources

This section presents the results of the determination of GHG emissions from mobile sources in more detail than described above. The subcategories into which this sector divides include the following sources: road

transport, marine vessels, rail engines, and aviation. The fossil fuels that burn these sources produce carbon dioxide (CO_2), in addition to small amounts of methane (CH_2) and nitrous oxide (N_2O).

Information on fuel consumption was obtained directly from the Aeronautical Authority of Equatorial Guinea.

No emissions from rail and maritime transport were calculated in the inventory due to the lack of information on fuel consumption in these subsectors.

For the calculation of aviation emissions, the simple Tier 1 method was used, which uses the aggregate fuel consumption in civil aviation, multiplied by average emission factors. These emission factors have been averaged over all flight phases, assuming that 10% of the fuel consumed is used in the Landing-Takeoff (CAD) phase of flights.

Emissions from aviation are the result of the burning of reactor fuel (kerosene and gasoline for jet engines) and gasoline for aviation. These emissions vary according to the type of fuel, the location of the exhaust gases (height), the type and efficiency of the engines, and the length of the flights. Aircraft emit CO_2, CH_4, N_2O, CO, COVDM, SO_2, and NOx. **Table 3.7** shows the GHG emissions from the transport sector in Equatorial Guinea corresponding to 2013. As can be seen, road transport by diesel and national aviation are the larges emitters in this sector.

Table 3.7. GHG emissions from the transport sector in Equatorial Guinea 2013.

SOURCE	CO_2	CH_4	N_2O
Road transport- Petrol/Gas	70.7	0.03	3.2
Road transport - Diesel	350.4	0.02	3.9
Aviation (National)	267.5	0.00	2.0
Aviation (International)	2.86*	0.00002*	2.0*
Total	**691.5**	**0.05**	**11.1**

* For information only. These emissions are not included in the Energy sector totals or in the inventory totals as recommended by the 2006 IPCC Guidelines.

Table 3.8. GHG emissions from aviation in Equatorial Guinea by zones. Year 2013.

ZONE	CO_2		CH_4		N_2O	
	National	International	National	International	National	International
Malabo	242.2	1.7	0.0017	0.00001	0.0068	0.00005
Bata	19.6	1.1	0.0001	0.00001	0.0005	0.00003
Annobon	0.2	0.0	0.0000	0.00000	0.0000	0.00000
Mongomeyen	5.5	0.0	0.0000	0.00000	0.0002	0.00000
TOTAL	**267.5**	**2.9***	**0.0019**	**0.00002***	**0.0075**	**0.000080***

* For information only. These emissions are not included in the totals of the Energy sector or in the totals of the inventory.

3.7.4 Fugitive Emissions from Petroleum and Natural Gas Activities

In this source category, all emissions of Methane (CH_4), Carbon Dioxide (CO_2) and Nitrous Oxide (N_2O) from the extraction, processing, transportation and use of oil and natural gas, as well as from non-productive combustion (burning in torches). The use of oil and gas, and products derived from fuels, to provide energy for internal use

in the processing and transportation of oil and natural gas production is excluded (they are considered fuel burning and were already include in an earlier heading).

Table 3.9. Emissions (Gg) of CO_2 and CH_4 from oil and natural gas activities in Equatorial Guinea. Year 2013

Category	Types of emissions	CO_2 Emissions	CH_4 Emissions	NO_2 Emissions	COVDM Emissions
Gas production	Fugitives	2.9	108.7	0.00	0.00
Oil production	Fugitives	$6.52 * 10^{-4}$	0.01	0.00	0.00
Oil and gas production	Venting and torches	736.8	0.5	0.01	0.018
Total		**739.8**	**109.2**	**0.01**	**0.018**

3.7.5 Summary of Energy Module Emissions

Table 3.10 shows the total GHG emissions in the Energy Module for 2013 in Equatorial Guinea. As noted, there is a predominance of CO_2 emissions from the burning of fossil fuels with more than half of the total.

Table 3.10. Total GHG emissions from energy activities (Gg). Equatorial Guinea, 2013.

Sinks Categories and Sources	CO_2	CH_4	N_2O	COVDM
1 - Energy	1833.5	109.2	0.04	0.02
1.A – Fuel burning activities	**1093.7**	**0.070**	**0.031**	**0.000**
1.A.1 – Energy industries	**231.1**	**0.004**	**0.000**	**0.000**
1.A.1 a Electricity and heat generation	231.1	0.004	0.000	0.000
1.A.2 – Manufacturing and construction industries	**82.8**	**0.003**	**0.001**	**0.000**
1.A.2.k - Construction	82.8	0.003	0.001	NE
1.A.3 - Transportation	**688.6**	**0.054**	**0.029**	**0.000**
1.A.3.a – Civil Aviation	267.5	0.002	0.007	0.000
1.A.3.b – Road transport	421.1	0.052	0.022	0.000
1.A.4 – Other sectors	**91.2**	**0.009**	**0.000**	**0.000**
1.A.4.a - Commercial/Institutional	31.5	0.004	0.000	0.000
1.A.4.b - Residential	59.7	0.005	0.000	0.000
1.B – Fugitive Emissions	**739.8**	**109.1**	**0.012**	**0.018**
1.B.2 – Oil and Natural Gas	**739.8**	**109.1**	**0.012**	**0.018**
1.B.2.a - Oil	735.8	0.469	0.012	0.018
1.B.2.b – Natural Gas	4.0	108.7	0.000	0.000

NA – No applicable; NE – No estimated due to lack of activity data.

However, when performing the anlysis from the sectoral point of view, it is observed that the highest CO_2eq emissions are reported in the oil and gas extractive industries and in the transport sector with 73% of the total emissions, **Figure 3.5.**

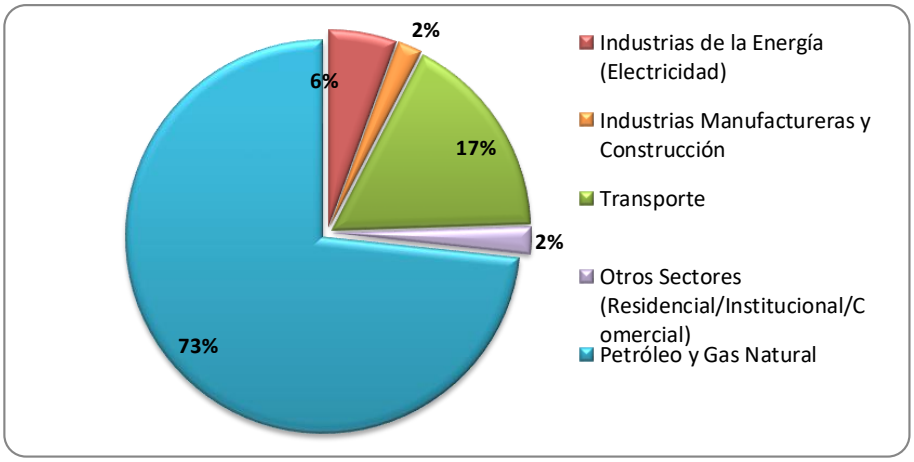


Figure 3.5. *CO_2 eq emissions from the Energy Sector in Equatorial Guinea, year 2013*

3.8 Module 2: Industrial Processes

This module deals with greenhouse gas emissions generated by industrial activities that are not related to combustion. The main sources in this section are those industrial production processes that transform materials physically or chemically and that meet their energy requirements by transferring the processes analyzed in the Energy Module.

As mentioned earlier, the industrial sector in Equatorial Guinea is very depressed in the country with very little representation in GDP. Within this, the manufacturing sector has little weight in the economy, since it only represents 0.1% of GDP. Construction is the economic activity that has shown the greatest dynamism (with a contribution to GDP of around 3%) within this sector. Petrochemical production is added to this, an activity that has also made great progress in recent years.

3.8.1 Petrochemical production. Methanol

Methanol production in Equatorial Guinea is carried out by the Atlantic Methanol Production Company (AMPCO), a consortium composed of the companies Marathon Oil, Samedan (Noble Energy) and SONAGAS, through the Methanol Plant in Punta Europa, built in 2001. The plant consumes about 125 mmcfd of gas of a quality of 1000 BTU to produce 19,000 barrels of capacity and Methanol is exported to world markets through two vessels, 300,000 tons, dedicated to the transport of methanol.

Almost all methanol is manufactured worldwide by means of steam reforming of natural gas. Steam reforming and the displacement reaction produce "synthesis gas" composed of CO_2, carbon monoxide (CO) and hydrogen (H_2). The process of producing methanol from natural gas, CO_2, CO, and H_2. There are several alternative processes to produce methanol from natural gas or other process fuels. These include the processes of conventional reforming, combined reforming and partial oxidation.

In 2013, a total of 979, 615t of methanol were produced in Equatorial Guinea, a process from which, as emissions, 656.3 Gg CO_2 and 2,3 Gg of CH_2 were derived, **Table 3.11.**

Table 3.11. CO_2 and CH_4 emissions produced from methanol production in Equatorial Guinea, year 2013.

GHG emissions from methanol production	Gg CO_2	Gg CH_4	Gg CO_2 eq.
	656.3	2.3	703.6

3.8.2 Mineral Products Industry. Asphalt Road and Road Paving

This source category covers emissions that do not come from combustion due to asphalt production in asphalt plants, except for refineries, and their applications (such as road paving and roof waterproofing operations, as well as further releases from the surfaces).

The asphalt surfaces of streets and roads are composed of compacted aggregates (natural gravel, manufactures stoned, oil refining by-products etc.), and an asphalt binder (for example, asphalt cement or fluidized asphalts). Asphalt cement is semi-solid and must be heated before mixing with aggregates in hot mixing plants. In this mixture, aggregates (sand, gravel, gravel and stone dust) are used as well as fuel oil, different types of asphalts and crude oil depending on availability and possibilities.

Asphalt mix production activity data was used in the Equatorial Guinea plants, belonging to the following companies: SETRACO, Sogeco Ecocsa, Arrab Contractors and Mangrove.

The emission of COVDM referring to the asphalt mixture produced in plants shows a negligible emission value. However, by adding to the pavement emission value, a considerable amount is already obtained expressing the COVDM emission from the paving. In 2013, these emissions were 26.9 Gg of COVDM in Equatorial Guinea, **Table 3.12.**

Table 3.12. Emissions of COVDM derived from asphalt production and asphalt paving (Gg) in Equatoiral Guinea for 2013.

Category	COVDM (Gg) Emissions
Asphalt production	1.9 x 10-3
Pavement	26.9
TOTAL	26.9

3.8.3 Other industries. Food and drinks (Beer and other alcoholic beverages)

Emissions from the manufacture of alcoholic beverages (beers, wines, etc.) are discussed in this section, **Table 3.13.** In this process, COVDM are basically issued. In this case, emission estimates are based on annual beverage production data.

Emissions of COVDM (mainly ethanol) occur in any of the four stages of alcoholic beverage production: preparation of the new raw material, fermentation, distillation and maturation. As already stated, emissions are estimated from the annual amount produced from the emissions factors recommended by the 1996 IPCC Guidelines and from EMEP/CORINAIR (1996).

For the calculations, it was possible to obtain production data of the country's own alcoholic beverages through the yearbooks published by the National Institute of Statistics of Equatorial Guinea. In the year studied, there was an emission of 2.23 Gg of COVDM in Equatorial Guinea.

Table 3.13. Emissions of COVDM derived from the production of alcoholic beverages (Gg) in Equatoiral Guinea for 2013.

Category	COVDM (Gg) Emissions
Beer	0.6 x 10-2
Other drinks	2.2
TOTAL	2.2

3.8.4 Summary of emissions in the "Industrial Processes and Product Use" module.

Table 3.14 shows the summary of GHG emissions that are not a product of combustion, by categories of the Module "Industrial Processes and use of products" for the year 2013 in Equatorial Guinea. As can be seen in the table, CO_2 emissions derived from methanol production and COVDM emissions derived from asphalt paving predominate. It is necessary to emphasize that the estimates are not complete, due to lack of activity data in some subcategories within this sector.

Table 3.14. Total GHG emissions from Industrial processes (Gg). Equatorial Guinea, 2013.

Sinks Categories and Sources	CO_2	CH_4	N_2O	COVDM
2 -Industrial processes and use of products	656.3	2.3	0.000	29.1
2.A – Mineral Industry	0.0			26.9
2.A.5 - Others (Asphalt production for paving)				26.9
2.B – Chemical industry	656.3	2.3	0.0	0.0
2.B.8 - Petrochemical	656.3	2.3	0.0	0.0
2.B.8.a - Methanol	656.3	2.3		
2.H - Other	0.0	0.0	0.0	2.2
2.H.2 – Food and beverage industry	0.0	0.0	0.0	2.2
2.H.2.b – Alcoholic drinks				2.2

3.9 Module 3: Agriculture, Forests and Other Land Uses

In Equatorial Guinea, the agriculture sector, together with forests and fisheries, was a primary economic contributor until the beginning of the 21st century (BAfD 2012), being a livelihood for 80% of the population (PNDES 2007). At present, it has significantly lost its contribution to GDP from 45% in 1994 to only 2% in 2010 (PNDES 2007). High agricultural productivity was attributed to cocoa, wood and coffee, especially during the colonial era.

Agriculture has great potential in Equatorial Guinea due to favorable weather conditions, sufficient available land and highly fertile volcanic soil (especially in the islands), together with a high unemployment rate in unskilled youth demographics. Despite this, Equatorial Guinea currently imports most of its merchandise, including large quantities of meat, cereals, rice and wheat.

The main crops that are collected include large bananas and bananas, cassava (cassava), rice, yams, corn, legumes, peanuts, vegetables, mango, pineapple, avocado, oranges, tangerines, coffee, cocoa, palm oil and wood fruits. When it comes to cash crops, cocoa and coffee are the only agricultural products that are still commercially produced, but in very small quantities. Livestock production is poorly developed due to diseases

and pests, and consists mainly of animals such as pig, goat or birds. On a very small scale, there are government programs to support the raising of cattle.

In this inventory the methodology proposed in the 2006 IPCC Guidelines has been used, which integrates the guidelines included in the *IPCC Guidelines for national inventories of greenhouse gases, revised version in 1996 for Agriculture (*Chapter 4) and for Land Uses, land use changes and forestry (Chapter 5). In this integration it is recognized that the processes underlying greenhouse gas emissions and removals, as well as the different forms of carbon stored on land, can occur in all types of land.

In this module, emissions and removals of CO_2 and non- CO_2 greenhouse gases are estimated separately for each of the six categories of land use (Forest land, Cropland, Grassland, Wetland, Settlement and Other land). The other categories of CO_2 and non-CO_2 emissions, such as emissions related to livestock, resulting from the management of land N, liming of the soil and harvested wood products, are estimated at national level since, and only had total data.

3.9.1 Agriculture: Emissions from Enteric Fermentation

Methane production due to enteric fermentation is a normal process that occurs in the digestive system of herbivorous animals. The methane produced by animals is dependent on the type and amount of food consumed, the age and weight of the animal, as well as the digestive system, this being the most important element. According to the digestive systems, the largest production of methane corresponds to ruminants. Other animals such as horses, donkeys and pigs (pseudo ruminant the first two and monogastric the last) have a lower production of this gas.

The estimation of methane and nitrous oxide emissions form categories of livestock-related sources requires the definition of subcategories, annual populations and estimates of food intake.

For this, the species included in several categories of sources were identified, they are: cattle, sheep, goats, pigs and poultry. The statistical data obtained are from two sources, some from the FAO database (FAOSTAT 2013), which are by default, and others from information from a national program on Family Poultry Farming 2013, also implemented by FAO assistance where the latter are those that have been considered for the calculation of emissions in this category, Table 3.15.

Table 3.15. Type of domestic livestock species and comparison of their existence

Type of domestic livestock	No. of heads (FAOSTAT 2013)	No. of heads (Family aviculture program 2013)
Cows	866	8000
Sheep	976	410
Goats	1016	1200
Pigs	1034	3200
Chickens	1057	7000
Ducks	1068	1000

The CH_4 emissions produced by Enteric Fermentation in Equatorial Guinea contribute 94% to the total emissions of the sector, with a total of 0.259 Gg (5.4 CO_2 eq) in 2013. Table 3.16 shows methane emissions from enteric fermentation disseminated by species. Cattle contribute the highest total emission: (95.7%) for enteric fermentation, following the order of importance of goats (2.3%).

Table 3.16. CH_4 emissions from enteric fermentation, year 2013

Species	Enteric fermentation		
	Gg CH_4	Gg CO_2 eq.	Contribution of sector (%)
Cows	0.248	5.2	95.7
Sheep	0.002	0.043	0.8
Goats	0.006	0.126	2.3
Pigs	0.003	0.067	1.2
Chickens	-	-	-
Ducks	-	-	-
Total	**0.259**	**5.4**	**100**

The greater methane emission from cattle is given by the characteristics of their digestive system. These have a multicavitative digestive system, unlike the rest of the cattle, being formed by four cavities or pre-stomachs, which are: rumen or pouch, where CH_4 forms, the reticulum, the omasum and the abomasum.

3.9.2 Agriculture: Methane emissions from manure management

From the excreta of domestic animals' methane emissions can occur, finding that the most important potential emissions come from cattle and pigs. This methane is produced by the decomposition of manure under fundamentally anaerobic conditions and the amount that is emitted into the atmosphere depends on several factors, such as: the animal population, the daily average of volatile solids excreted, the potential methane production of the manure and the manure management system, among others.

In this category of source, the term "manure" includes both excrement and urine produced by cattle. In addition, the term manure management is used as a collective name for all types of storage and treatment of manure. In this section, the Excreted Nitrogen from manure is estimated.

The manure management system considered in this report of the inventory of Equatorial Guinea is the *direct deposition in grasslands and grasslands.* This manure is considered deposited directly on grazing soils.

CH_4 emissions resulting from the management of manure from domestic livestock are insignificant in the country, Table 3.17. In the case of methane, bovines contribute 53% of the contribution to these emissions, followed by pigs (43%). The rest of the species account for only 4%.

Table 3.17. Emissions of CH_4 and N_2O from manure management, year 2013

Species	Gg CH_4	Gg CO_2 eq.	Contribution (%)
Cows	0.0080	0.168	53
Sheep	0.0001	0.002	1
Goats	0.0003	0.006	2
Pigs	0.0064	0.134	43
Chickens	0.0002	0.003	1
Ducks	0.0000	0.000	0
Total	**0.015**	**0.314**	**100**

3.9.3 Land Use: Forest Lands that Remain as Such

This category is particularly relevant for Equatorial Guinea, as it is a country belonging to the Congo Basin, the second larges forest mass in the world after the Amazon. The flora and fauna are extraordinarily rich in biodiversity at the level of Central Africa, especially in the continental region. 62.5 % of its total area is covered by a dense tropical forest (FAO 2005; MAB, 200).

The activity data in this module correspond to the time series 1990-2013. The sub-categories of forests used come from the document "National Action Plan for Forestry of the Year 200" (MAB, 2000), which derives from the national forestry inventory made from 1990-1992. This is the reference of the area taken as original for this inventory, while the current surface has been evaluated through the cartographic bases of the National Institute of Forest Development and Management of the National System of Protected Areas (INDEFOR) for the Continental Region and Annobon and by Navarro *et al.,* (2012) for the Insular Region (Bioko), as well as the reports of infrastructure works projects carried out in the country since 1995 (new cities, highways, model farms, high voltage networks, new airports, new national roads, central hydroelectric plants, etc.), **Table 3.18.**

Table 3.18. Forest categories to consider in this inventory (2013)

Domain (IPCC 2006)	IPCC 2006 and Navarro et al. (2012)	Sub-type or forest category (MAB, 2000)	Total area 1990 (MAB, 2000)	Deforested area 1990-2013	Total area 2013	Percentage of area (%)	Adjusted average biomass IPCC 2006
TROPICAL	A) CONTINENTAL REGION						
	Dense rainforest Very Wet Guinean & Congolian forest	Mature dense forests	1 492 300	11 860	1 480 440	53.21	255.2
		Mixed forest (degraded + dense relics + agroforestry)	394 900	0	394 900	14.19	262.2
		Young secondary forests (fallows and crops)	618 800	7 086	611 714	21.99	262.2
	Mangroves	Mangroves	26 000	1 300	24 700	0.89	99.1
	Meadows	Meadows and zeros domes with bushes	5 300	0	5 300	0.19	70.0
	Others	Other areas (water, urbanization, etc.)	64 400	0	64 400	2.31	0.0
	SUB-TOTAL A)		**2 601 700**	**20 246.2**	**2 581 454**	**92.78**	
	B) INSULAR REGION BIOKO						
	Dense rainforest Very humid Guinean & Congolian	Mature low altitude dense forests	54 644	150	54 494	1.96	199.2
		Mixed forests (degraded+ dense relics+ agroforestry)	18 970	1.350	17 620	0.63	199.2

		Young secondary forests (fallows and crops)	70 280	0	70 280	2.53	199.2
	Dense rainforest Very Wet Afromontane	Mature dense forests afro-montane	51 296	1.092	50 204	1.80	115.0
		Meadows and zeros domes with bushes	5 860	0	5 860	0.21	70.0
	Others	Other areas (water, urbanization, etc.)	650	0	650	0.02	0.0
	SUB-TOTAL B)		**201 700**	**2 592.5**	**199 107**	**7.16**	
	C) INSULAR REGION ANNOBON						
	Dense rainforest very wet Guinean & Congolian	Wet dense forests	1 650	0	1 650	0.06	199.2
	Prairies and other	Prairies, zeros domes with bushes and others.	50	0	50	0.00	70
	SUB-TOTALC)		**1 700**	0	**1 700**	**0.06**	
COUNTRY TOTAL			**2 805 100**	**22 838.73**	**2 782 261**	**100**	

In the insular part (Bioko), the classification of Navarro *et al.* (2012), although very complex compared to other authors, but it is the most accurate with evaluations in the field, however it was necessary to unite many categories due to similarity and poor surface representation. In the Annobon part, no new vegetation characterization has been found, the one used is that of CUREF (1999).

In the 1996 and 2006 IPCC Guidelines to estimate the average annual change in biomass, a simple method is proposed that uses the area covered by managed forests (which remain as forest use, that is, do not change use in the year of inventory), the average annual growth rate of aerial biomass in these forests and the biomass losses that occur in them. This method is known as Profit and Loss.

The results showed that the total gain of forest carbon (ΔC_G) per year is 5, 401, 423.5 TC/year), **Table 3.19.**

Table 3.19. Total forest carbon gain. Year 2013

Region	ΔC_G (T C year $^{-1}$)	CO_2/year (Gg)
Bioko	5013687.0	-18383.52
Continental	384442.9	-1409.62
Annobon	3293.5	-12.08
Total	**5401423.5**	**-19805.22**

The result of the total loss of forest carbon (ΔC_L) per year by removal is 308825.9 TC/year, equivalent to 1 132 361 T CO_2 (1 132.36 Gg of CO_2/year), **Table 3.20.**

Table 3.20. Total loss of forest carbon by removal. Year 2013

Region	ΔC_L (T C year $^{-1}$)	CO_2/year (Gg)
Bioko	12405.8	45.49
Continental	296420.1	1086.87
Total	**308825.9**	**1132.36**

The difference between the gain and the loss by removal (ΔC_B) has resulted in 5092597.6 TC/year, equivalent to 18 672 860 T CO_2/year (18 672.9 Gg of CO_2/year), Table 3.21

Table 3.21. Annual change in carbon stocks in biomass. Year 2013

Region	ΔC_B (T C year $^{-1}$)	CO_2/year (Gg)
Bioko	4717266.9	-17296.6
Continental	372037.2	-1364.1
Annobón	3293.5	-12.1
Total	**5092597.6**	**-18672.9**

3.9.4 Land Use: Forest Land converted to Other Land (deforestation)

The conversion of forests to other uses generally involves clearing the undergrowth and clearing, activities that may be followed by the burning of biomass in situ or its use as firewood. In this process, part of the biomass is burned, and another part remains in the field, where it slowly decomposes. A small part of the burned material (5-10%) is converted to charcoal, which in the open weather resists decomposition for more than 100 years and the rest is instantly released into the atmosphere in the form of CO_2.

For the characterization of deforestation in Equatorial Guinea, several data area estimated without prior field studies, for example, according to FAO (2005), in Mugnier and Martinez-Plaza (2010), the estimated loss of forests corresponds to a annual deforestation rate of 0,9%. In the 2010 Global Forest Resources Assessment (FRA) (FAO 2010) it is estimated that Equatorial Guinea has lost 12.6% of its total forest cover from 1990 to 2010, which corresponds to an annual deforestation rate of 0.65%, while in the present study the estimated deforestation is 22 837, 73 ha for the whole country, which is equivalent to 0,8%, where 0,73% (20 246,2 ha) corresponds to the continental region and Bioko a 0,09% (2 592, 5 ha).

The total result of deforested forest carbon is 2718915.60 TC, equivalent to 9969.60 T CO_2 (9969.36 Gg of CO_2), Table 3.22.

Table 3.22. Total loss of carbon due to deforestation. Year 2013

Region	$D_{eforested}$ (Tons of C)	CO_2 (Gg)
Bioko	-2506725.60	9191.33
Continental	-212190.00	778.03
Total	2718915.60	9969.36

3.9.5 Land Use: NO_2 emissions from managed soils and CO_2 emissions derived from the application of lime and urea.

Usually nitrous oxide emissions from managed soils are estimated from aggregated (national level) data on N-fed soils, including the use and sales of nitrogen fertilizers, crop residue management, organic fertilizers and conversions in land use that enhance the mineralization of N in soil organic matter.

Similarly, it is typical that CO_2 emissions resulting from the application of liming and urea to managed soils are estimated using aggregate data (eg, national level). This submodule includes the following subcategories:

- Biomass burning emissions
- Lime application
- Urea application
- Direct N_2O emissions from managed soils
- Indirect emissions of N_2O from managed soils
- Indirect emissions of N_2O from the manure management system
- Rice cultivation

In the specific case of direct N_2O emissions from managed soils, the IPCC 2006 methodology includes the following sources of N:

- Synthetic N fertilizers (F_{SN});
- Organic N applied as fertilizer (e.g., animal manure, compost, sewage sludge, waste) (F_{ON});
- *N of urine and manure deposited in pastures, meadows and meadows by grazing animals (F_{PRP});*
- N in agricultural waste (aerial and underground), including N and forage fixing crops during pasture renewal (F_{CR});
- The mineralization of N related to the loss of soil organic matter as a result of changes in land use or in the management of mineral soils (F_{SOM}); and drainage/management of organic soils (e.g., histosols) (F_{OS}).

In this inventory, calculations of the direct N_2O emissions from managed soils were made, specifically those derived form urine and manure deposited in pastures, meadows and meadows by grazing animals.

To estimate the emissions, all subcategories of domestic cattle were taken (Table 3.14), therefore, both herbivorous and non-herbivorous animals (pigs and poultry) are included in this case.

The emissions of N_2O from this source category is only 0.009 Gg, and in this case the cattle contribute 95% to the total emission, the goat 3% and the rest of the species together, 2% (Table 3.23).

Table 3.23. Emissions of N_2O from managed soils product of N from urine and manure deposited in grasslands and Meadows by grazing animals, 2013

Species	NO_2 of manure deposited in Meadows and Prairie		
	Gg NO_2	Gg CO_2 eq.	Contribution by sector (%)
Cow	0.0089	2.7596	95.0
Sheep	0.0001	0.0236	0.8
Goats	0.0003	0.0868	3.0
Pigs	0.0000	0.0000	0.0
Chickens	0.0000	0.0000	0.0
Ducks	0.0001	0.0340	1.2
Total	**0.0094**	**2.904**	**100**

3.9.6 Module Summary

As a summary of this module, it can be said that in 2013 there was a net absorption of 8703,4 Gg of C O_2, product of 9969.4 Gg of emissions and 18672.8 Gg of absorptions, **Table 3.24.**

Table 3.24. Emissions and Absorption sector AFOLU

Sinks Categories and Sources	CO_2 Emissions	CO_2 Absorptions	CH_4	N_2O
3 – Agriculture, forest and other land uses	9969.4	-18672.8	0.274	0.009
3.A - Livestock			0.274	
3.A.1 – Enteric Fermentation			0.259	
3.A.1.a - Cattle			0.248	
3.A.1.d - Goats			0.0021	
3.A.1.e - Camels			0.0060	
3.A.1.j - Poultry			0.0032	
3.A.2 – Manure management			0.0149	NA
3.A.2.a - Cattle			0.0080	NA
3.A.2.c - Sheep			0.0001	NA
3.A.2.d - Goats			0.0003	NA
3.A.2.h - Pigs			0.0064	NA
3.A.2.i - Birds			0.0002	NA
3.B – Land use	9969.4	-18672.8	NE	NE
3.B.1 - Forestry	NE	-18672.8	NE	NE
3.B.1.a – Forest lands that remain as forest lands		-18672.8		
3.B.6 – Other lands	9969.4	0.000		
3.B.6.b – Land converted to other land	9969.4	0.000		
3.C - NO_2 emissions from managed soils and CO_2 emissions derived from the application of lime and urea	NE		NE	0.009
3.C.4 - Direct N_2O emissions from managed soils				0.009

NA – No applicable; NE – No estimated due to lack of activity data.

3.10 Module 5: Waste

This module deals with the estimation of CO_2 and CH_4 emissions form the incineration of open pit wastes, as well as the treatment and disposal of wastewater. Methane is the most important greenhouse gas generated by the disposal and treatment of waste, especially from the anaerobic systems used for the management of biodegradable waste resulting from human activities: sanitary landfills and wastewater treatment systems.

Also calculated are nitrous oxide (N_2O) emissions from the discharge and elimination, in aquatic environments, of man-generated sewage and greenhouse gas (GHG) emissions from incineration and open burning of waste.

3. 10. 1 Greenhouse Gas Emissions from DSM burned by open incineration

Open waste incineration can be defined as the combustion of unwanted combustible materials, such as paper, wood, plastic, textiles, rubber, oil waste and other was in the open air or in open dumps, where smoke and other emissions are released directly to the air, without going through a chimney or column.

Figure 3.7 Incineration, Malabo Landfill, Nov. 2014 (Photo: Consultant A. Micha)

Types of incinerated waste include: industrial waste; hazardous waste; municipal solid waste (DSM); hospital waste and sewage sludge.

In order to evaluate the emissions of Greenhouse Gases in this sector, CO_2 emissions from the incineration of open pit waste were considered. For this, the analysis included the interval 2002-2014, subdivided into three periods: 2002-2006, 2007-2010 and 2011-2014.

Open burning includes regular burning and sporadic burning. Regular burning means that it is the only practice used to destroy waste. Sporadic burning means that this practice is used in addition to others and, therefore, open burning is not the only practice used to destroy waste. For example, if the waste is not collected o burned for other reasons, such as avoiding costs.

In a developing country, especially in urban areas, the fraction of the population that burns wastes can be estimated approximately as the sum of the population, whose wastes are not collected by collection structures, plus the population, whose wastes are collected and disposed of in open dumps and then burn. In general, it is preferable to apply country-specific and regional data on waste management practices and waste streams. In this case, to calculate the fraction of the population that burns waste, the urban population of the district was taken as the numerator and the total population being the denominator.

The descriptive features of the analysis performed consist of the consideration of the two larges cities in the country, Malabo (administrative capital) and Bata (economic capital) for the first two periods studied. In the last period (2011-2014) municipal capitals were also included. For each period, the generation of waste per capita was determined based on studies conducted in the country on the subject, Table 3.25.

Table 3.25. Per capita waste generation

Period 2002-2006	Period 2007-2010	Period 2011-2014
0.114 [1]	0.302 [1]	0.493 [2]

[1] *Study on the production of waste by the population of Bata, conducted by ESONO MAYE* (2006)

[2] *Surveys conducted on "Study on the management of MSW in the city of Luba", (SHARPE, 2012) and the surveys carried out in Malabo, Bata, Evinayong, Ebibeyin and Mongomo during 2014*

The amount of DSM burned in the last period studied (2011-2014) is 23.9 Gg/year which results in a notable increase over previous periods, Table 3.26.

Table 3.26. Total amount of municipal solid waste burned by open incineration (Gg/year).

Cities Studied	Period 2002-2006	Period 2007-2010	Period 2011-2014
Malabo	2.204	5.980	9.997
Luba	-	-	0.662
Bata	2.201	5.976	9.990
Evinayong	-	-	0.587
Ebibeyin	-	-	1.441
Mongomo	-	-	1.262
Total	**4.405**	**11.956**	**23.939**

The observed trend of the total amount of solid waste burned by open incineration in the period 2002-2014, Figure 3.6. Is strongly determined by urban population dynamics; considering the important changes that have occurred in recent decades due to the migration factor. This migratory factor is characterized by two important phenomena:

- The rural exodus, that is, migratory flow whose destination is the urban environment.
- Prevalence of immigration, there is more entry of foreigners into the country than exit of natives abroad, and almost all those set national urban areas as residence.

In in the first period studied (2002-2006), CO_2eq emissions by urban solid waste (MSW) category were of the order of 0.7 Gg/year, while from 2007 to 20120, CO_2eq emissions by this same category were of 1.87 Gg/year; this registering an increase of 1.17 Gg/year with respect to the previous period, Table 3.27.

Table 3.27. Emission of Greenhouse Gases from the open incineration of municipal solid waste (Gg)

Targeted cities	Period 2002-2006			Period 2007-2010			Period 2011-2014		
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O
Malabo	0.044	0.014	0.000	0.120	0.039	0.000	0.200	0.065	0.000
Luba	-	-	-	-	-	-	0.013	0.004	0.000
Bata	0.044	0.014	0.000	0.120	0.039	0.000	0.200	0.065	0.000
Evinayong	-	-	-	-	-	-	0.012	0.004	0.000
Ebibeyin	-	-	-	-	-	-	0.029	0.009	0.000
Mongomo	-	-	-	-	-	-	0.025	0.008	0.000
Total	**0.088**	**0.028**	**0.000**	**0.240**	**0.078**	**0.000**	**0.479**	**0.155**	**0.000**

From 2011 to 2014, CO_2eq emissions by the category of urban solid waste (MSW) were 3.75 Gg/year; increasing 1.88 Gg over the previous period.

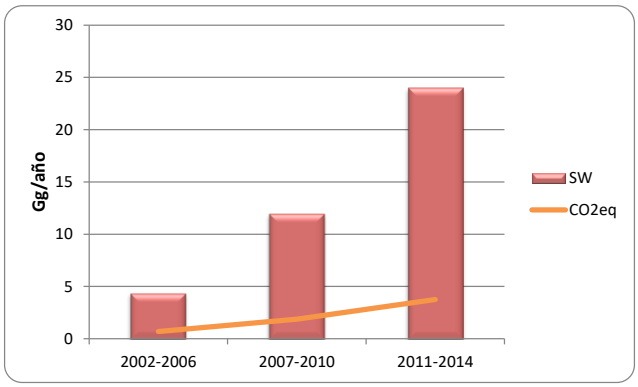


Figure 3.8. Total amount of municipal solid waste burned by open burning (Gg/year) and CO_2eq emissions for Equatorial Guinea

In fact, the time series from 2002 to 2014 shows that there is a tendency to increase emissions by this sector, **Figure 3.7,** which is because they depend on the amount of urban solid waste generated, conditioned by the urban population, which has been experiencing a considerable increase, **Table 3. 28.**

Table 3.28. CO_2eq emissions from the open incineration of municipal solid waste (Gg).

Targeted cities	Period 2002-2006	Period 2007-2010	Period 2011-2014
	CO_2 eq	CO_2 eq	CO_2 eq
Malabo	0.345	0.936	1.6
Luba			0.104
Bata	0.345	0.936	1.6
Evinayong			0.092
Ebibeyin			0.226
Mongomo			0.198
Total	**0.690**	**1.9**	**3.7**

3.10.2 Methane Emissions from the Treatment of Domestic Wastewater

Domestic wastewater is those generated in population settlements, schools, tourist facilities, public buildings and shopping centers, and are mainly composed of human-derived waste.

For this inventory, qualify data could not be available locally. This situation led to the use of default values recommended by the 2006 IPCC Guidelines, as well as estimates of wastewater generation based on available activity data, especially population data and information on the treatment systems used.

The most frequent treatment system in Equatorial Guinea for uncollected waters is latrines. The 2006 IPCC Guidelines recommend several options for them, according to the climatic conditions and the height of the water table in relation to the latrine.

The results obtained in this category show that the way of disposal of the most prevalent domestic waste in the country is the use of latrines, both in the urban and rural population, **Table 3.29.** The calculation of methane emissions for the inventory year yielded 0.18 Gg, equivalent to 3.85 Gg of de CO_2 eq, **Table 3.30.**

Table 3.29. Degree of use of the domestic waste treatment system

Domain	Disposal Modalities	Residential area	Type of housing	Estimated population (%)
Urban	River and sea disposal	By the sea or river	Any kind	18
	Latrine (Day climate, lower water table than latrine, reduced family (3-5 people)	Away from the river or sea	Homes of low- and middle-income families	14
	Latrine (Dry climate, lower water table than latrine, community use (many users)	Away from the river or sea	Homes of families with very low and low incomes	65
	Latrine (Wet climate/water discharge, water table higher than the latrine)	Away from the river or sea	Homes of families with medium and high incomes	3
Rural	River and sea disposal	By the sea or river	Any kind	1.5
	Latrine (Dry climate, lower water table than latrine, reduced family (3-5 people)	Away from the river or sea	Any kind	83.5
	Latrine (Dry climate, lower water table than latrine, community use (many users)	Away from the river or sea	Any kind	15

Table 3.30. Methane Emissions from the Treatment of Domestic Wastewater. Equatorial Guinea 2013 2013.

Category of sources	Gg de CH_4	Gg CO_2 eq.
Domestic wastewater treatment	0.18	3.85

3.10.3 Module Summary

Table 3.31 includes the summary of estimated GHG emissions in the Waste module for 2013. As can be seen, the emissions are not very high, and the greatest weight is CO_2 y CH_4.

Table 3.31. Total GHG emissions in the Waste module by source category (Gg). Equatorial Guinea, 2013.

Sinks Categories and Sources	CO_2	CH_4	N_2O
4 - Waste	0.480	0.342	0.000
4.C – Incineration and open waste incineration	0.480	0.156	0.000
4.C.2 – Burning of open pit wastes	0.480	0.156	NE
4.D – Wastewater treatment and disposal		0.186	0.000
4.D.1 – Treatment and disposal of domestic wastewater		0.186	NE

NE- No estimated due to the lack of activity data.

3.11 Evaluation of uncertainties.

Uncertainty estimates are an essential element of an emissions inventory, especially for comparing determined emissions. However, determining uncertainties in greenhouse gas emissions inventories is a complex task, given that the emission values calculated depend on a large and varied number of parameters and input data. In practice, it is nor possible to know all these parameters and data accurately and that is why those used in the calculations are referred to as “the best available estimates”.

The ranges of uncertainties should be given as 95% confidence intervals. For the estimation of percentiles, it is necessary to know a probability distribution. Emissions factors, activity data and emissions are normally positive values (apart from removals in the LULUCF sector).

Uncertainties in inventories come from at least three different processes (IPCC 2000):

- Uncertainties from the definitions (unclear or incomplete meanings, or incomplete definitions of an emission or absorption etc.)
- Uncertainties arising from the natural variability of the processes that produce an emission or acquisition.
- Uncertainties resulting from the evaluation of the processes, including, depending on the method used: i) measurement uncertainties; ii) sampling uncertainties; iii) uncertainties of referenced data that may be described incompletely; and iv) uncertainties of the expert criteria.

In this module for the determination of uncertainties, the methods recommended in the IPCC-CPG 2000 (IPCC 2000) are used in combination with the ranges of uncertainty, specific to each source category, indicated in the different modules of the inventory.

Determination of Uncertainties of Emission Factors and Activity Data

In order to determine the uncertainties of the emissions calculated in each source category evaluated in this report, three tables (corresponding to CO_2, CH_4, y N_2O) were constructed with “default values for the uncertainties of the factors of emission and activity data “used in each category of source and greenhouse gas.

The uncertainty values, associated with the 95% confidence intervals, incorporated in these tables, were applied in determining the uncertainties of the emissions in the year of this report.

The classification scheme included in Table 3.32 was used to support the expert judgment assessments.

Table 3.32. Scheme for the classification of uncertainties

Rank	Uncertainty	Uncertainty factor (FI)	Quality (qualitative description)	Uncertainty (qualitative description)
2- 10%	5%	1.05	Very high	Very Low
5-20%	10%	1.1	High	Low
10-50%	25%	1.25	Medium (high)	Medium
20-100%	50%	1.5	Medium (low)	High
50-150%	100%	2	Low	Very high
100-400%	200%	3	Very low	Extremely high

Tables 3.33, 3. 34 and 3.35 contain the "default values" of uncertainty of the emission parameters and activity data used in determining uncertainties for the categories of sources, greenhouse gases (CO_2, CH_4, y N_2O) in the year evaluated in this inventory report.

Table 3.33. Default values for the uncertainties of the emission factors and activity data related to the CO2 emissions selected for the evaluation of uncertainties in the inventory.

Source Category		Direct GHG	Uncertainties of Emission Factors	Uncertainties of activity data
		CO_2	Default range (95 % CI around the central estimate)	Default range (95 % CI around the central estimate)
1.A.1	Energy Industries	CO_2	± 5	± 25
1.A.2	Manufacturing and Construction	CO_2	± 5	± 25
1.A.4	Other Sectors (Residential)	CO_2	± 5	± 25
1.A.3	Others (includes transportation)	CO_2	± 5	± 25
1.B.2.a	Oil (venting and burning in torches)	CO_2	± 40	± 10
1.B.2.b	Natural gas (venting and burning in torches)	CO_2	± 40	± 10
1.B.2.a.iii.2	Oil (fugitive emissions)	CO_2	± 100	± 10
1.B.2.b.iii.2	Natural gas (fugitive emissions)	CO_2	± 100	± 10
2.B.8.a	Methanol production	CO_2	± 25	± 30
4.C.2	Open Waste Incineration	CO_2	± 40	± 100

Table 3.34. Default values for the uncertainties of the emission factors and activity data related to the CH_4 emissions selected for the evaluation of uncertainties in the inventory.

Source Category		Direct GHG	Uncertainties of Emission Factors	Uncertainties of activity data
		CO_2	Default range (95 % CI around the central estimate)	Default range (95 % CI around the central estimate)
1.A.1	Energy industries	CH_4	± 5	± 25
1.A.2	Manufacturing and construction	CH_4	± 5	± 25
1.A.4	Other sectors (residential)	CH_4	± 5	± 25
1.A.3	Others (includes transportation)	CH_4	± 50	± 25
1.B.2.a	Oil (venting and burning in torches)	CH_4	± 40	± 10

1.B.2.b	Natural gas (venting and burning in torches)	CH_4	± 40	± 10
1.B.2.a.iii.2	Oil (fugitive emissions)	CH_4	± 100	± 10
1.B.2.b.iii.2	Natural gas (fugitive emissions)	CH_4	± 100	± 10
2.B.8.a	Methanol production	CH_4	± 25	-80% a +30
3.A.1	Enteric fermentation	CH_4	± 30	± 5
3.A.2	Manure management	CH_4	± 30	± 5
4.C.2	Open waste incineration	CH_4	± 100	± 100
4.D.1	Sewage treatment	CH_4	± 30	± 50

Table 3.35. Default values for the uncertainties of the emission factors and activity data related to the N_2O emissions selected for the evaluation of uncertainties in the inventory

Source Category		Direct GHG	Uncertainties of Emission Factors	Uncertainties of activity data
		CO_2	Default range (95 % CI around the central estimate)	Default range (95 % CI around the central estimate)
1.A.1	Energy Industries	N_2O	± 5	± 25
1.A.2	Manufacturing and Construction	N_2O	± 5	± 25
1.A.4	Other sectors (residential)	N_2O	± 5	± 25
1.A.3	Others (includes transportation)	N_2O	± 50	± 25
1.B.2.a	Oil (venting and burning in torches)	N_2O	± 40	± 10
1.B.2.b	Natural gas (venting and burning in torches)	N_2O	± 40	± 10
1.B.2.a.iii.2	Oil (fugitive emissions)	N_2O	± 100	± 10
1.B.2.b.iii.2	Natural gas (fugitive emissions)	N_2O	± 100	± 10
3.A.2	Manure management	N_2O	± 50	± 5
4.C.2	Open waste incineration	N_2O	± 100	± 100
4.D.1	Sewage treatment	N_2O	± 30	± 50

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Chapter 4

Chapter 4. Attenuation of Greenhouse Gas Emissions

4.1 Introduction

Although, as a part of the UNFCCC, Equatorial Guinea does not assume commitments to reduce its greenhouse gas emissions (being a non-Annex I Party), for several years different actions and programs have been developed that are geared towards the ultimate goal of the Convention: "achieve stabilization of greenhouse gas concentrations in the atmosphere in order to prevent dangerous anthropogenic (human-caused) interference in the climate system".

Theses programs are part of the efforts made by Equatorial Guinea to achieve a higher level of economic and social development on sustainable bases, making more rational use of natural resources and are a first approximation of the country's potential to help mitigate global warming caused by greenhouse gas emissions.

The analysis was carried out for the energy, transportation and forestry sectors, considering the results of the National Inventory Emissions and Absorption of Greenhouse Gases. Some of the measures identified have already been partially introduced, as part of the existing socio-economic development programs in Equatorial Guinea, although they were not implemented as a direct response to the mitigation objectives.

4.2 Energy Sector

Equatorial Guinea is one of the largest oil producers in sub-Saharan Africa. The Ministry of Mines and Hydrocarbons (MMH) is the Ministerial Department overseeing the hydrocarbons sector and is responsible for establishing the regulatory body that oversees the oil industry, including the national oil company, GEPETROL, founded in 2002. At the same time, it manages the government interest in production, sharing agreements and joint ventures with the international oil companies operating in the country.

The energy sector plays a decisive role in mitigating greenhouse gas (GHG) emissions. The MMH, in collaboration with its companies and departments, and other national and foreign partners implements programs and actions for saving and efficient use of energy. Serious steps are taken to try that before 2030 all the energy produced in the mainland is from renewable energy. On the island side, gas is still used as energy in transit to other cleaner sources.

The magnitude of GHG emissions constitutes both a challenge and an opportunity for the sector. The challenge is to achieve a cleaner and more environmentally friendly energy sector, for which it is essential to reduce the volume of GHG emissions, without compromising economic growth and energy security in the country. Hence the importance of promoting investment (both domestic and foreign) in the use of renewable energy sources, inducing improvements in the transformation processes and boosting energy efficiency on the demand side.

The country has been making efforts to diversity its energy sources and improve electrification across the nation. The electricity sector is owned by the government company that owns its monopoly, the Electricity Society of Equatorial Guinea S. A., (SEGESA). The electricity supply is not reliable, mainly due to the age of equipment and, as a result, consumers suffer oscillations in the parameters that can affect

their equipment. That is why the government of Equatorial Guinea, headed by the figure of its president, Obiang NGUEMA MBASOGO, has proposed in the Third National Economic Conference (April through May 2019) to introduce the Sustainable Development Goals (SDGs) in economic planning, and in this the MMH is committed to achieve national energy production by clean energy.

In this sense, in recent years the country's electricity sector has undergone a profound transformation thanks to a strong public investment in electrical infrastructure and is currently in full expansion. The National Electrification Program is one of the priorities of the Government of Equatorial Guinea for the development of the country. The evolution of this electricity sector is conditions by the behavior of demand and future projects that will increase the country's electrical capacity.

Another priority of the government of Equatorial Guinea in energy matters is the non-dependence of external sources for internal supply. In this way, efforts have been aimed at taking advantage of the renewable resources available in the country, this avoiding having to import row materials to cover future energy needs. In recent years there has been a clear trend towards greater use of hydroelectric potential in the mainland and solar energy on the island of Annobon where a solar park of 5,0 MW of power is built.

4.2.1 Main mitigation actions in the Energy sector

As a summary, the most outstanding actions in terms of efficiency and rational use of energy include in the national electrification program in Equatorial Guinea are the following:

- Taking advantage of the hydrological potential of the Wele River: The Wele River (also known as the Benito or Mbini River) is the main river in the continental region of Equatorial Guinea. It originates in Gabon and has 338 km in length, crossing the country from east to west. Eight potential points have been identified throughout its course for the installation of hydroelectric plants with estimates of 2, 070 MW/year. The 120 MW Djiblho plant is already operational and the construction of the Snedje plant with 200 MW is nearing completion. The construction of new plants in the Wele is under study in view of possible variations in rainfall that may affect its capacity.
- Exploitation of the hydroelectric potential of the island of Bioko: In the insular region, gas is the main source of electricity production (1/30 MW turbo-gas and 2/126 MW turbo-gas), with about 96% of the island's electricity. The current distribution of the electrical capacities installed in Bioko Island shows a strong deficit in the use of hydrological resources, which is why its potential exploitation is studied.

  A report by Electricite de France (EDF) identifies 10 potential hydroelectric exploitation sites on six rivers of the island (Consul; Balaopi and Tiborones; Musola; Tudela and Moaba; Ilachi, Ruma and Grande; and Bao). The productivity calculations vary depending on the time of the year, since they are not large rivers and their flow productivity would be strongly conditioned to the level of rainfall recorded. The economic feasibility of the rehabilitation of the Riaba and Musola I and II hydroelectric plants, which are out of service, is being studied by the government.

The first steps are taken for the use of renewable energy sources in isolated areas of the distribution network and with potential. There are already some private companies that have solar panels as sources of energy support.

- Remodeling, expansion and adaptation of the electricity grid: The expansion of the available electrical capacity makes the adaptation of the electricity network necessary for the correct distribution and transport of electricity. The main projects for the modernization, expansion and adaptation of the electricity network of the big cities (Malabo and Bata) are executed and the transmission network of the 110 and 220 KV lines and their corresponding substations to the main cities and towns is expanded from the mainland and island. On the island of Bioko, the high voltage network (66 kV line is made of underground aluminum cables and has been extended to practically the entire island, what remains is to link this network with some isolated villages.
- Commitment to clean and renewable energy: According to international dynamics, Equatorial Guinea analyzes the future use of other renewable energies, where solar, wind or anaerobic gasification projects of urban solid waste are studied. The main projects committed by the government seek to harness the country's hydroelectric potential. The possibility of carrying out solar and wind energy projects is currently being assessed. In this sense, several studies have been carried out in the islands of Annobon and Corisco, lacking the same of usable water potential for electricity production.
- Creation of an Energy Law: The creation of an appropriate legal framework to harmonize the sector and include a regulatory instrument in its fundamental aspects has also been a necessity of the government of Equatorial Guinea and that is why this law has already been drafted and must enter into force in the present year 2019. This law is accompanied by a regulation for renewable energies which must give guarantees to increase national and foreign investment in said sector.
- Expansion of the electricity grid in rural areas: According to the 2018 Renewable Energy Action Plan (PAER) executed by the government of the country with the support of UNDP for the first time in Equatorial Guinea the generation capacity (394,718 MW) exceeds national demand.

  With the entry of Sendje (200 MW), diesel generation in the continental part (111,604 MW) can be reduced, which is mainly found in isolated villages. With the expansion of the high voltage network, many of these towns have been joining the national network. On the other hand, according to the 2017 Statistical Yearbook prepared by the World Bank (WB), 66,1% of the country's homes are electrified (262, 157 registered), mostly in cities and towns, leaving isolated areas that do not yet have those benefits. Agreements have been established to achieve an electrical interconnection with neighboring Gabon, to extend it to the rest of the CEMAC countries in the shortest possible time, prioritizing renewable energy generation.

4.2.2 Renewable energy projects

Regarding renewable energy, there is a strong interest of the government to develop other renewable energy sources as soon as possible in addition to the existing plans to develop the generation from hydroelectric power. Among the plans in execution the following ones can be cited:

- Solar Energy Project as Renewable Energy Source in Annobon: This project carried out by the government of Equatorial Guinea, through the Ministry of Industry and Energy, will allow residents on the island to have a greater generation of energy to meet the existing demand. A Solar Energy Park consisting of solar panel micro-networks is built with the collaboration of the US companies MAECI Solar, GE Power & Water System. The complex will consist of numerous panels to produce 5 MW, with capacity to expand up to 10 MW in the future.

  All these panels will be managed by an extensive solar energy control and storage system. The project must be completed in early 2020 and the potential to build plants with other energy sources (wind) is evaluated on the island. In the continental part, the potential of RE is evaluated and the services of foreign entities have been hired to evaluate the potential and demand of isolated towns with a view to building solar power plants mainly that generate the necessary demand.

- Sustainable Energy for All Project: Promoting small-scale hydropower in Bioko and other Clean Energy solutions for remote islands. The project has evaluated the potential of RE in Bioko, mainland and Annobon Island with the participation of experts, both national and foreign. The results will be proposed to the government to assess the desirability of executing RE sites in the selected sites according to their sector development plans or giving foreign companies the opportunity to do so and obtain their benefits from their exploitation.

4.3 Transportation Sector

The transport sector is recognized as an important GHG emitter. In the case of Equatorial Guinea, this represents 16% of CO2 emissions. Although the steps taken by the country in reducing GHG emissions in this sector are still considered insufficient. The greatest advances are observed in aviation, responsible for 42% of CO2 emissions in this sector which as agreements signed with the European Union to reduce emissions.

It increases the use of public transportation, as well as converting diesel engines to gas in the public sector and encouraging the use of hybrid or electric cars in the country. In the maritime transportation sector it is necessary to modernize the sector since its equipment has been operating for many years.

4.3.1 Main mitigation actions in the transport sector

Listed below are the mitigation actions implemented by Equatorial Guinea to mitigate the effects of CO2 emissions from aviation suggested by the European Union in collaboration with the national civil aviation:

- Development of high-tech aircraft (low fuel consumption models);
- Alternative fuels;
- Improvement of air traffic management related to the use of airport infrastructures;
- Efficient operations;
- Economic /market-based measures;
- Regulatory measures;

Equatorial Guinea is involved in a project that has 14 countries of the sub-region of Africa of CO2 mitigation that has been implemented by the International Civil Aviation Organization and the European Union (ICAO-EU), this project fights and protects the environment to mitigate the greenhouse effect of air transport in Equatorial Guinea.

In the land transport sector, studies are carried out for the design and implementation of public transport in such a way that this means of transport is used in a modern and efficient way to replace individual cars. As a complement, in this sense a serious study of road rearrangement should be carried out with a view or reducing the emissions due to traffic jams associated with the poor design of the road network. On the other hand, a road education campaign must be carried out that involves all road users to reduce inappropriate behaviors that cause material losses, human lives and increase emissions due to improper use of the road.

There are plans for the use of rail transport in the mainland, mainly for the movement of cargo inserted with the countries of the region which reduces emissions by being a less polluting mean than by road and much more efficient.

Another of the initiatives under study is the re-motorization of cars that run on diesel because they are four times more polluting than those that run on gasoline. And we are working on the possibility of implementing a law that regulates the importation of means of transport with a deadline for not importing highly consumption equipment that cannot circulate in other regions.

4.4 Forest Sector

The protection of forests has been reflected in the legislation of the country, so in 1991, the prohibition of large-scale timber extraction activities on the island of Bioko was established, through the enactment of Decree N°55. In 1997, a new law was approved for the forestry sector called Law N°1 on the use and management of forests (2005), with the objective of establishing the legal, economic and administrative regime for the rational use of forest resources, ensuring their use in a sustainable way, as well as the conservation of a healthy environment.

In addition, in 2000, the Ministry of Agriculture and Forestry (ministerial department overseeing agriculture at the time) created a national forest policy that established the government's priorities in the forestry sector. This policy has among its main objectives the protection and conservation of forest heritage and the preservation of forest ecosystems. In 2007, forestry regulation promoted the development of the timber industry by prohibiting the export of timber logs and roundwood.

The use of forest resources is one of the most important aspects for the livelihoods of the population of Equatorial Guinea. That is why the implementation of an integrated approach to forest management, which includes the integration of the components of agriculture to maintain the proper functioning of the country's forest ecosystems, is of such importance.

There is currently a general reference platform, which includes protected areas and sustainable management approaches adopted at the community level through the Ministry of Agriculture, Livestock, Forests and Environment, INDEFOR-AP (National Institute for Forests Development and Protected Areas management) and national and international NGOs.

4.4.1 Main mitigation actions in the forestry sector

The management of forest resources in Equatorial Guinea is governed by Law N°1/1997, dated February 18, on the Use and Management of Forests, and revised in 2005. This law organizes the National Forest Reserve (NFR) in two main categories of land management: The Production Domain (PD) and the Conservation or Protection Domain (CPD). The main conclusions of the data analysis of the first version of the Interactive Forest Atlas (2013) are the following, according to INEGE (2017):

- Land planning vs. Land occupation: In 2013, Equatorial Guinea covered 98% of forests and 2% of non-forested land (for example, urban areas, and surface waters). 74% of the forest area was dense forests and 24% mixed forests. Forest lands were divided equally between forests within the NFR and forests outside it.
- National Forest Reserve: In 2013, the NFR represented 50% (1,354,766 hectares) of the national total area. 61% of the NFR was assigned to the PD and 39% to the CPD. The NFR consisted of dense forests (83%), mixed forests (13%) and lands whose dominant vegetation was not forest (4%).

The fall in the price of oil led to an increase in the exploitation of forest resources with a view to increasing the collection of foreign exchange by the government, according to INEGE (2018), Figure 4.1.

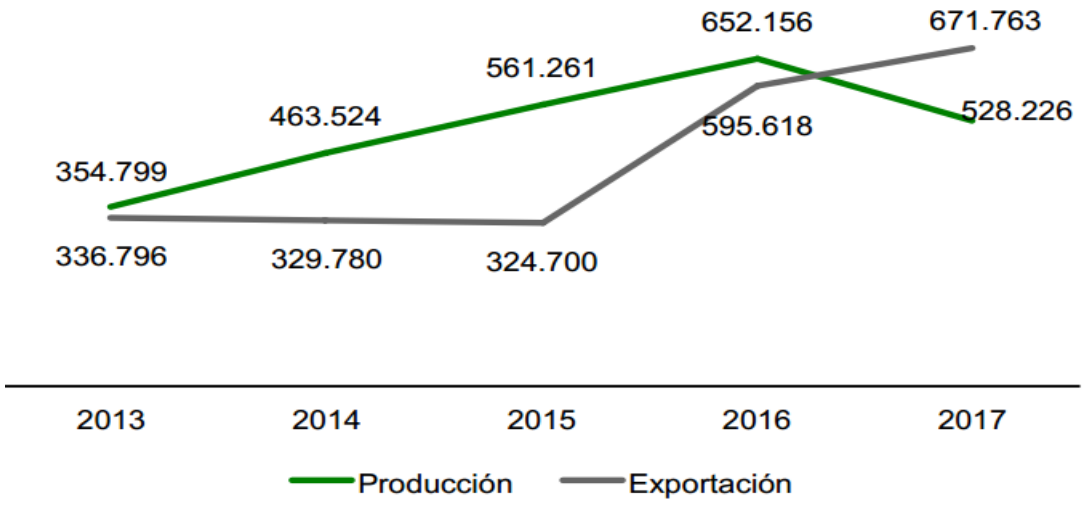

Figure 4.1. Wood production and export in m^3 period 2013-2017. Source INGE (2018)

However, many companies took advantage of the situation to increase their productions beyond the norm. Such a situation violates Decree N°61/2007 that established a maximum quota of 450,000 m^3/year per company. The greater control to the fulfillment of the regulations established in the sector

caused that the production of the wood in 2017 diminished by 19 % with respect to the previous year, which contributes to the increase of the mitigation by carbon absorption of forests.

The trend shows that companies were the main factor in the reduction of forest areas, so that a greater regulatory control was established over them. However, more recently agricultural activities along with the development of infrastructure such as roads, highways, power grids and water distribution systems, according to Obiang and Perez (2014) are the main causes of deforestation. Work is being done to establish a legal framework that controls the activities of the agricultural collectives because they are not regulated to date.

The recent development and improvement of the economy of Equatorial Guinea puts the country in a favorable starting point to reverse the rate of deforestation and forest degradation that allows it to become a model for the countries of Central Africa. That is why REDD+ projects (Reduction of Emissions from Deforestation and Forest Degradation) based on community forest management are a possible approach to achieve this objective. It works together with other CEMAC countries to implement an integrated reforestation system in the Congo Basin that increases absorption mitigation in the member countries.

The INDEFOR-COBAM project of Equatorial Guinea (*Agroforestry and communal forests for adaptation to climate change and its mitigation in the landscape of Monte Alén)* is part of a series of five pilot projects initiated by CIFOR's counterparts with the support of the project "Climate change and forests in the Congo Basin: synergies between adaptation and mitigation" (COBAM).

The objective of the project is to reduce the rate of *deforestation* and degradation by 30%. In terms of forest cover, the project also intends to conserve 50% of the communal forest and afforest/reforest 15% of agricultural land. As for nurseries, the project will produce at least 1000 seedlings of priority species. This will have an impact on *mitigation*, due to the increase in carbon stocks, and in the *conservation* of the ecosystem.

Afforestation and reforestation will conserve and protect watersheds, and the agroforestry management program will contribute to soil conservation. Plant *biodiversity* will be improved by selecting key species for nurseries, while animal biodiversity is expected to be favored by the restoration of green corridors.

National System of Protected Areas

Equatorial Guinea is one of the most biologically important places in the entire African continent. It is home to thirteen protected areas, which lack national capacities for the sustainable management of natural resources, water, soils, forests and the environment in general. Sanitation problems and human waste put these ecosystems at risk.

Other problems that are carried out in the country promoted by the United Nations Development Program (UNDP) and that help promote environmental sustainability in the country is the "Strengthening of the system of protected areas in Equatorial Guinea to effective conservation of representative ecosystems and globally significant biodiversity." The purpose of this project is to conserve globally significant biodiversity in Equatorial Guinea through the improvement of the political and legal context, governance practices, as well as institutional and individual capacities aspects of the National System of Protected Areas, which includes pollination, atmospheric regulation for CO2 emissions, water regulation, nutrient regulation and shelter value as indirect use values.

Sustainable Land and Forests Management

UNDP also promoted the project “Strengthening of individual, legal and institutional capacities, in order to reduce the continued degradation of land and deforestation, and in the long term achieve Sustainable Land and Forest Management (SLFM).

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Chapter 5

Chapter 5. Climate variability. Impacts and Adaptation

5.1 Climate research in Equatorial Guinea.

The first research referring to the climate of Equatorial Guinea go back to its colonial era. Most of the studies were conducted by Catholic priests. They collected meteorological data and prepared the first reports of the weather and climate behavior of the territories of what is today Equatorial Guinea. According to Lopez Vicario (1998) in the colonial era there were six weather stations on the island of Bioko (Conception, currently Riaba), Moka, Musola, Rebola, Baney and Ureka) and six other stations on the mainland located in Acurenan, Cabo San Juan, Mikomesent, Mongomo, Kogo and Neifang. Thanks to these observations, the behavior of variables as important as rainfall, temperature and wind at the time mentioned are currently known.

Among the works concerning the weather and climate of the colonial era, the one carried out by the German ethnologist Gunther Tessmann (1884-1969), established in Cameroon in 1904, refers to how the Bubi (mostly inhabitants of the island of Bioko) and the Fang (mostly settlers from the mainland) controlled and divided weather. Similarly, in the works of Father Amador Martin del Molino (1927-2015), one can see how they distributed the year in the Bubi culture, as well as the influence of weather on the life of the inhabitants of the island of Bioko, their rites and beliefs, Martin del Molino (1956; 1965 and 1989).

With a more specific sense from the climatic point of view, the work of Font Tullot (1951) shows the behavior of the main meteorological variables and some extreme phenomena such as tornadoes in the period 1940-1946, on the island of Bioko. In this same direction, the work of Capuz Bonilla (1961) analyzes the behavior of the meteorological variables throughout the territory of Equatorial Guinea as a guide by provinces.

With the arrival of aviation to Equatorial Guinea around 1926 (Laguna Sanquirico, 2008), the collection of meteorological data began at the Malabo airport and later in Bata. Around the same time, the cartography works of the Spanish army also provided interesting data regarding the weather and climate of the country. With the independence of the country in 1968, scientific research in the field of meteorology decreased significantly in relation to the colonial period, mainly due to the lack of personnel trained in the sector and the government's reluctance to deal with expatriates. After the Coup d'état of 1979, research in other areas of knowledge was increase, mainly in, the study of flora and fauna, which indirectly report the state of the climate in each area and period analyzed. Among the works that stand out in this regard are those of Nosti (1942), Lopez Vicario (1988), Butynski and Koster (1994) and Perez Del Val (1996) and (2001).

Currently, research is conducted at UNGE, in collaboration with MAGBMA in the field of meteorology. Among those that stand out are those carried out by Esono Asangono (2012) linked to climate variability in Equatorial Guinea, Obono Ebang (2012) regarding a diagnosis of drought in the country and Nso Edo (2010) on the variation of temperatures, humidity and rainfall in the period from 1990 to 2007 in the city of Malabo. Even though the country lacks a meteorological service they begin to take steps in the scientific investigations linked to atmospheric sciences.

5.2 Variations observed in the country's climate

Climate is variable by its own definition, at different time and space scales. The fluctuations observed in the climate in relatively short periods are known as "climatic variability". Such a situation can be observed in the analysis of any meteorological variable, how the valued oscillate throughout the year and between the years themselves. Therefore, to be able to compare and define the climate of a country, the "climatological norm" is used, which statistically represent the normal value or average value. The series of these oscillations around the normal values represents the climatic variability and its most commonly used assessment is the anomaly. According to UPT (2008), the anomalies allow to reveal deviations of the climatic statistics in periods of months, seasons or years, with respect to long-term statistics referred to the same period (month, season or year), allowing to estimate if there is variability in the climate of the locality or region. The climatic variability in a practical way can be understood as Martin Vide (2001) says in "insecurity", regarding the occurrence of the valued of the variable in question, always taking the mean as a reference. The greater the variability, the less certain that a value close to the average is reached.

All studies indicate that since the Earth got formed, Earth's climate has changed many times. Until relatively recently, all changes have been due to natural causes; however, in the post-industrial period, anthropogenic activity has changed the global climate, overlapping its natural variability, IPCC (2013). Hence the importance of analyzing the potential impacts of current and future climate change.

Equatorial Guinea currently only has weather stations with reliable data at the airports of Malabo and Bata. Meteorological stations have been installed at the newly constructed airports (Annobon, Corisco, Mongomeyen) and there are also at the Bioko Biodiversity Protection Program (BBPP) stations located in the towns of Moka and Ureka. Despite this, these stations are relatively recent and, therefore, in order to carry out studies on climate variability and climate change, the monthly temperature and precipitation data corresponding to the Climate Research Unit School of Environmental Sciences University of East Anglia.

The data used are known as CRUTS 2.1, according to Mitchely Jones (2005), and they have a grating point of 0,5° x 0,5°, **Figure 5.1.** They were extracted and manipulated by means of "The Grid Analysis and Display System'' (GrADS), a tool designed for ease access, manipulation and visualization of geophysical data and that is available on the website of the "Center for Ocean, Land, Atmosphere Studies" (Center for the Study of Earth, Ocean and Atmosphere) http://www.iges.org/cola.html.

The sample analyzed covers the period 1901-2009 and the 1971-2000 standard was used as the reference period. The data of the observations of the meteorological stations of the Bata and Malabo airports managed by the Agency for Aerial Navigation Safety in Africa and Madagascar (ASECNA) were also used. The statistical data obtained allowed us to observe the behavior of climatic variability in Equatorial Guinea and compare them with what is happening with the global climate.

For the analysis of the atmospheric circulation in the region, the average maps of the months of January and July were prepared with the data available in the NCEP/NCAR in the periods 1946-1975 and 1976-2005.

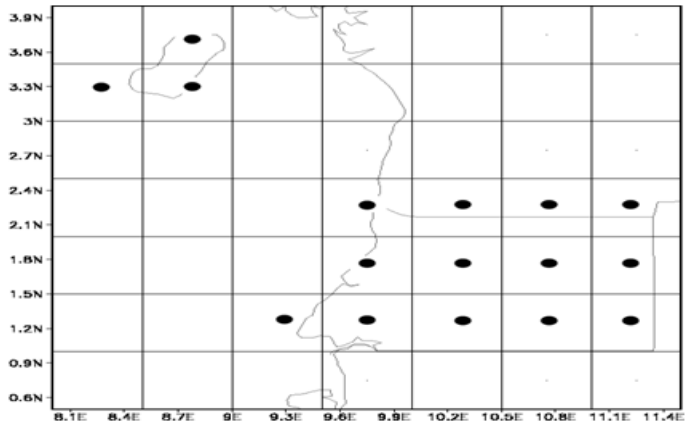


Figure5.1. Grid points used from the domain corresponding to the Island of Bioko and the continental region of Equatorial Guinea. Source: *Climatic Research Unit School of Environmental Sciences University of East Anglia*, period 1901-2009.

5.2.1 Atmospheric circulation

In general, the weather and climate of the country are mainly conditioned by the latitudinal displacement of the area of convergence of the trade winds on the surface (Intertropical Convergence Zone- ZIC) and the so-called African monsoon related to it. The latter is a seasonal wind, which dramatically changes its direction at a certain time of the year and brings with it a significant increase in rainfall in one of them; it is the results of the inversion of the pressure gradient between winter and summer due to the annual thermal variation between the oceans and continents.

In the case of the African Monsoon, when the prevailing winds are from the NE region, rain processes are inhibited, since they are very dry winds known as “dry monsoon” or “winter monsoon”. These are predominant from December to the end of February on the mainland, until March on the island of Bioko. The most extreme representation of these winds is called Harmattan. The wind from the NE is accompanied by desert dust (less than one hundred thousandths of millimeter in diameter), creating a fog that hides the sun for days.

When the prevailing winds are preferably from the SW region, it is loaded with heat and humidity, which together with the irregular orography that interposes in its route, favors the so-called orographic rains, especially in the south of the island of Bioko and in the central area from the Niefang mountain range in the mainland. This is the “summer monsoon” period, which extends from May to October on the island of Bioko. In the continental part it corresponds to the months from March to May, and from September to November.

The comparative analysis of the average pressure maps of the surface of the month of January and July for the periods 1946-1975 with respect to the period 1976-2005 show changes in circulation patterns which could have a significant influence on climate variability experienced in Equatorial Guinea, Figure 5.2. When comparing the average January maps of both periods, a narrowing of the area of equatorial lows and an increase in pressure in this area is observed. This situation seems to be related to a strengthening of the Azores-Bermuda anticyclone.

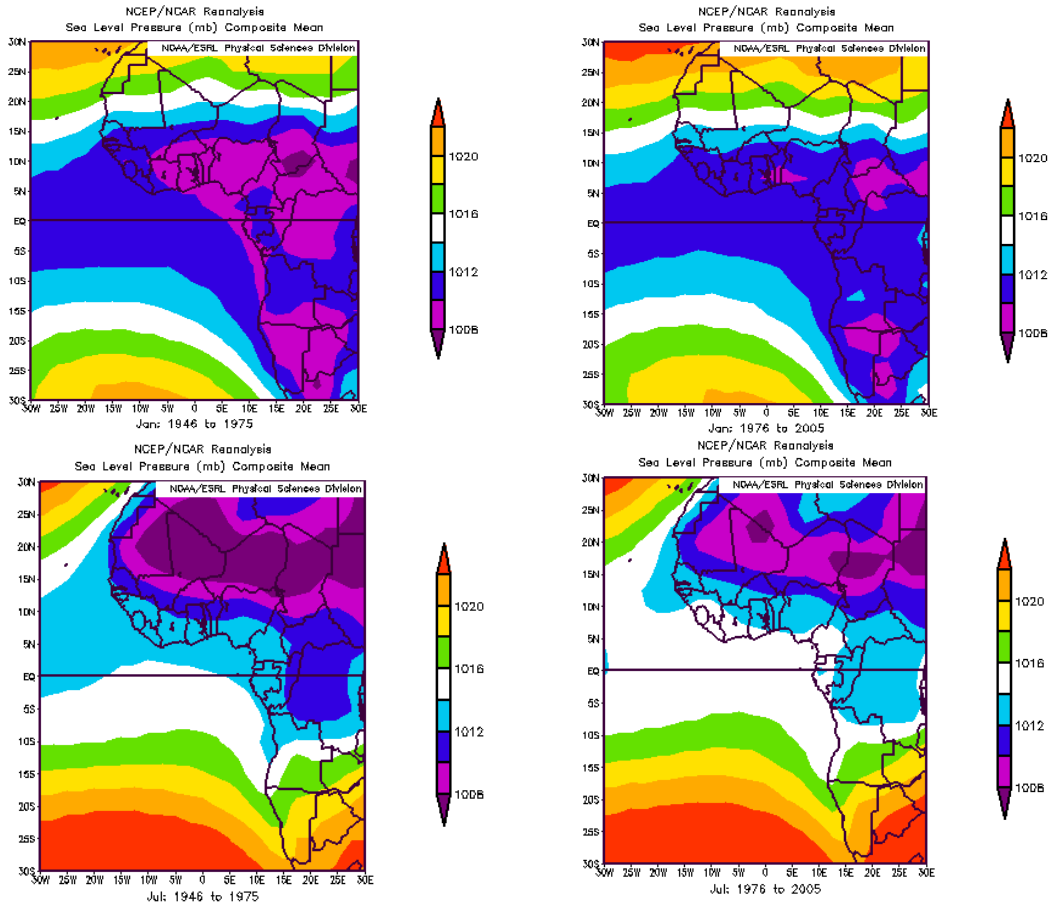


Figure 5.2. Average Surface pressure maps for the months January (upper) and July (lower) in the periods 1946-1975 (left) and 1976-2005 (right). Source: NCEP/NCAR.

In the comparison of the average maps corresponding to the month of July, there is also an increase in pressure in the area, related to the strengthening of the South African anticyclone, on the one hand and on the other to the weakening of the low pressures of the North Africa associated with the decline of northern India. This combination of factors promotes the penetration of a wedge of high pressures inside the Gulf of Guinea.

The variations observed in the permanent centers of the general circulation that influence the area have modified the amplitude of the oscillation and the speed of translation of the ZITC in the region, causing important changes in the local climatic variability.

The changes observed in the Sea Surface Temperature (SST) in the period analyzed, **Figure 5.3** (left), in the Tropical Atlantic Ocean could be modifying the circulation patterns of the atmosphere in West Africa, mainly in the position and intensity of the Anticyclone of the Azores-Bermuda in the winter period. These biases determine anomalies regarding the position of the ZITC over Equatorial Guinea causing changes in the local climate. At the mesoscale level, the SST in the Gulf of Guinea, **Figure 5.3** (right) has a great influence on the convective systems that form over the sea and travel to the mainland, especially on the island of Bioko. These systems bring significant changes in the weather with heavy rains and TLS at any time of day or night. **Figure 5.3** shows a tendency to increase the average annual temperature of the sea surface, both in the Tropical Atlantic (-24°L. South and 24°L. North), and in the Gulf of Guinea. Such an

increase in the SST will have direct consequences in the climate, which in the case of Equatorial Guinea are still to be studied.

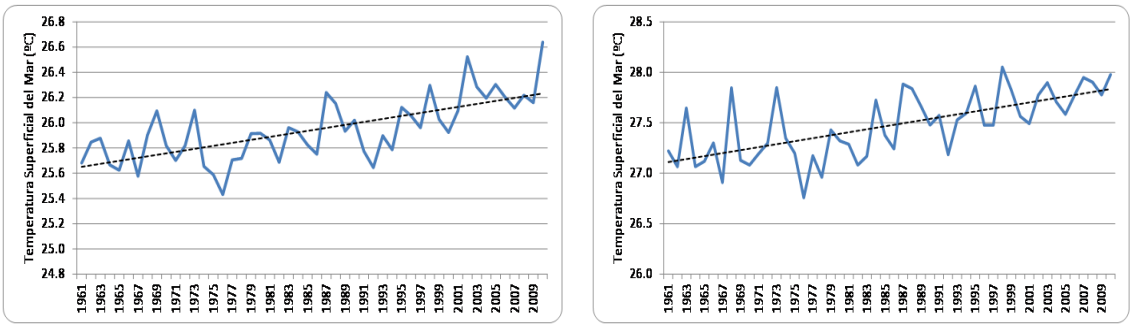


Figure 5.3. Average annual sea surface temperatures (SST) in the tropical Atlantic (left) and in the Gulf of Guinea (right), for the period 1961-2010. Source: NOAA Extended Sea Surface Temperature (SST).

5.2.2 Surface air temperature

In Equatorial Guinea, studies conducted by Fonseca et al., (2012) regarding the behavior of the monthly values of the surface air temperature in the country for the period 1951-2009 show great variability. In the analysis of the recorded data, the alternation of positive or negative anomalies throughout the series can be observed, Figure 5.4. However, from the 80's onwards, there is a tendency towards the predominance of positive anomalies, indicative of warming in both the insular and continental part. The year of greatest warming corresponds to 1998, and the warmest decade is the last of the twentieth century, which corresponds to the increase in surface air temperature observed globally.

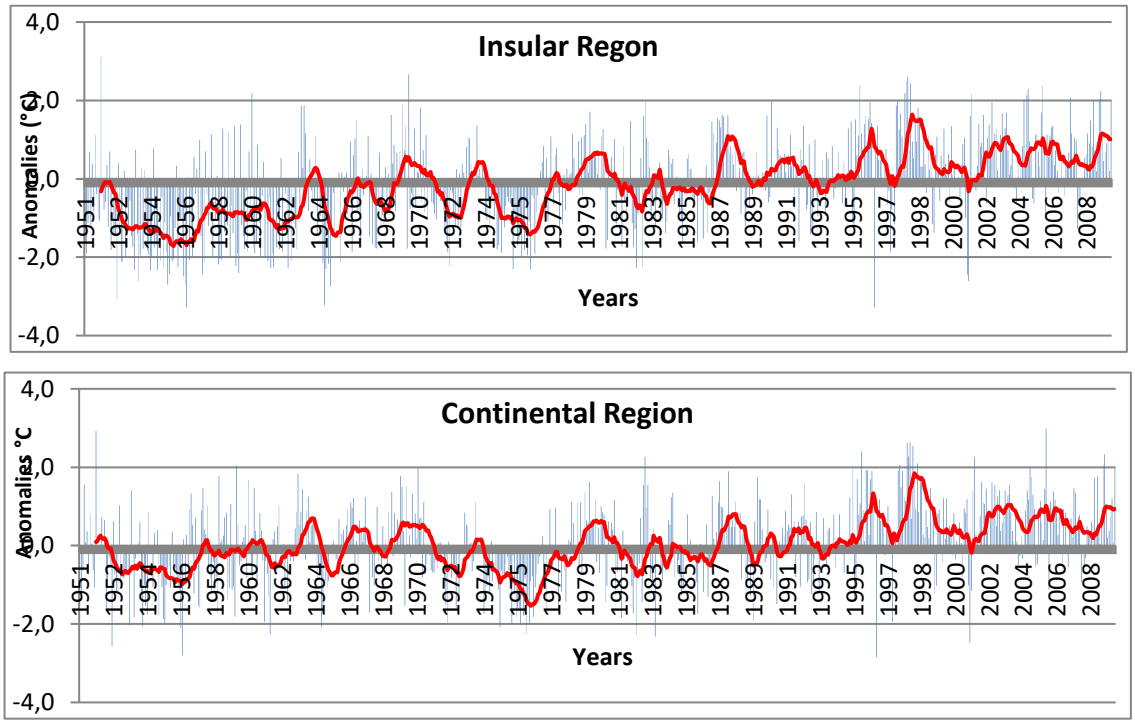


Figure 5.4. Variation of the monthly values of the surface temperature for the period 1951-2009. The red line represents a moving average of 12 points.

In the analysis of the series for the annual temperature values of the period 1901-2009 (see **Figure 5.5**), in the last decades there has been a tendency to the prevalence of positive anomalies coinciding with the climatic anomalies observed at regional and global level. The increase in anomalies is notable in the decade of 90s and first of 2000s, with a tendency to increase, both in the insular and continental part, which indicates the occurrence of a warming process in the country, in correspondence with what is happening globally.

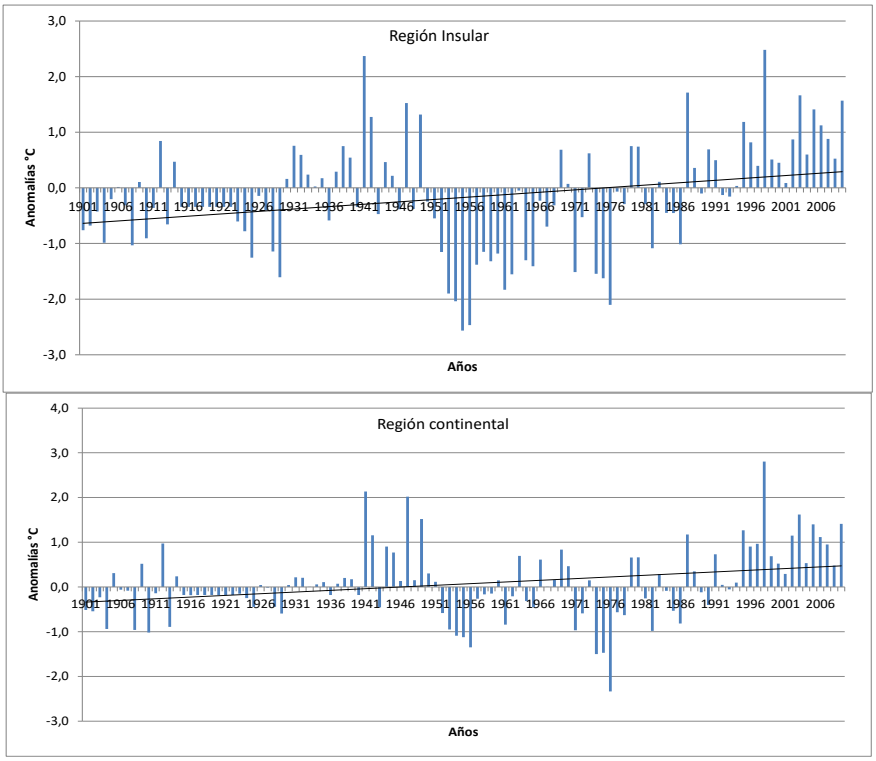


Figure 5.5. Annual anomalies of the average annual temperature in Equatorial Guinea for the period 1901-2009 relative to the norm of the period 1971-2009 and its corresponding trend line (black color). Insular region (upper) and Continental region (lower).

The study of the available data ensures that in Equatorial Guinea as in other regions of the planet there is an increase in minimum temperatures, more pronounced in the insular part (Bioko Island), **Figure 5.6.**

Such behavior of the minimum values has an unfavorable impact on the values of the Daily Thermal Oscillation (OTD), which usually translates into a decrease in the cold mornings (minimum ≤ 20°C), IPCC (2007). This situation increases the "thermal stress" on natural and human ecosystems and states as stated in the IPCC (2007-2013) that discernible human influences are not limited to average temperatures, but also cover other aspects of the climate.

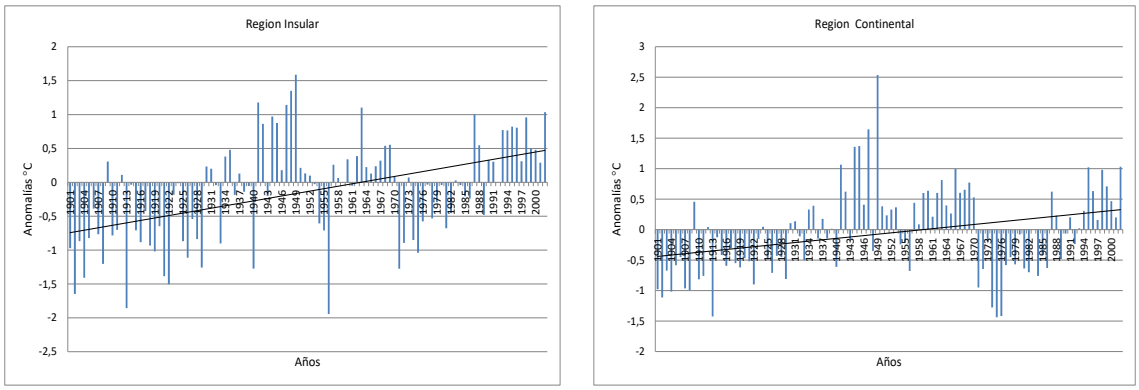
In 

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Figure 5.6. Annual anomalies of the average annual minimum temperature in Equatorial Guinea for the period 1901-2009 relative to the norm of the period. 1971-2000 and its corresponding trend line (black color). Insular Region (left) and Continental Region (right).

analysis of the behavior of the temperature at the level of 850 hPa, on the island of Bioko and the continental part of the country, an increase is also observed in this level, which highlights what has already been stated in the IPCC (2007) and ratified in the IPCC (2013) about an increase in temperature also at low levels of the atmosphere, **Figure 5.7.**

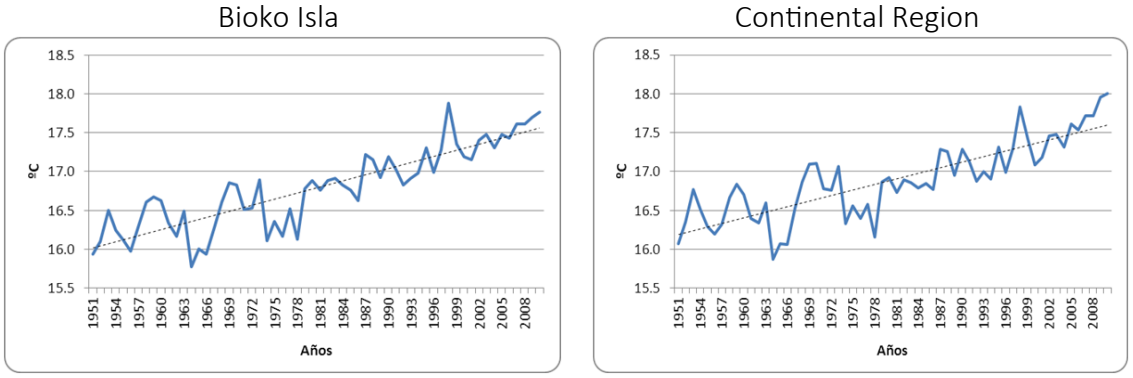

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Figure 5.7. Average annual temperature values in Equatorial Guinea at the level of 850 hPa and its trend over the period 1951-2010.Source: NOAA/ESRL Physical Sciences Division, Boulder Colorado from their Web site at http://www.esrl.noaa.gov/psd/".

5.2.3 Precipitation

The quantity and variability are the most significant characteristics of rainfall in Equatorial Guinea. There is great interannual variability in both the insular and continental part, **Figure 5.8,** with alternating periods of accumulated high and low rainfall according to Fonseca et al., (2012). However, in both regions of the country there is a predominance of positive anomalies after the decade of the 80s, period in which positive anomalies of medium and minimum temperatures are also manifested mainly.

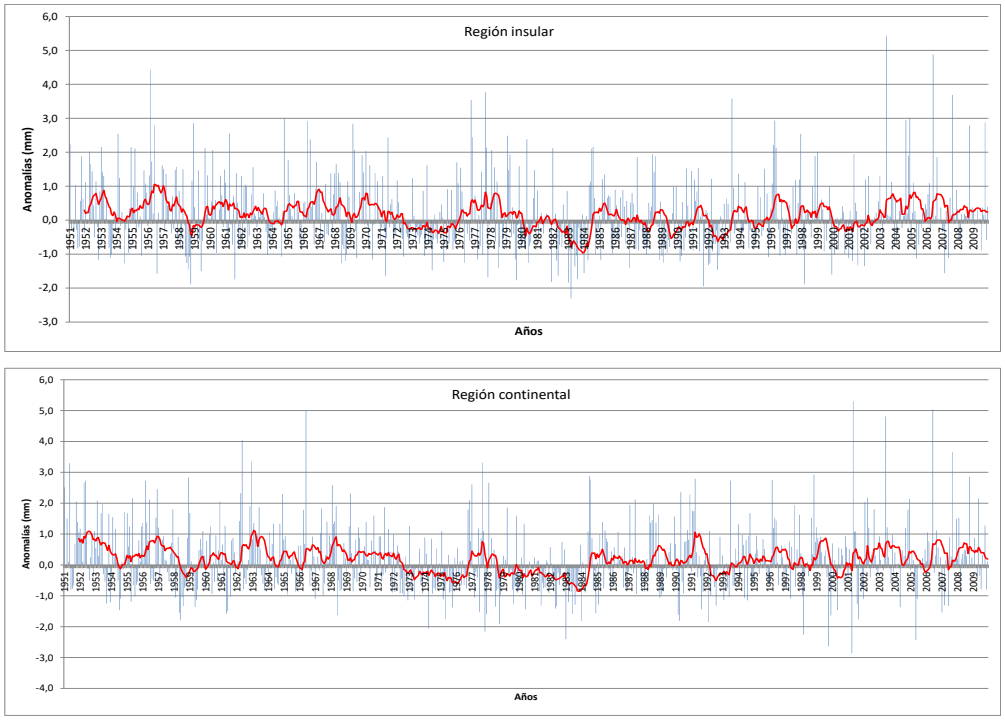
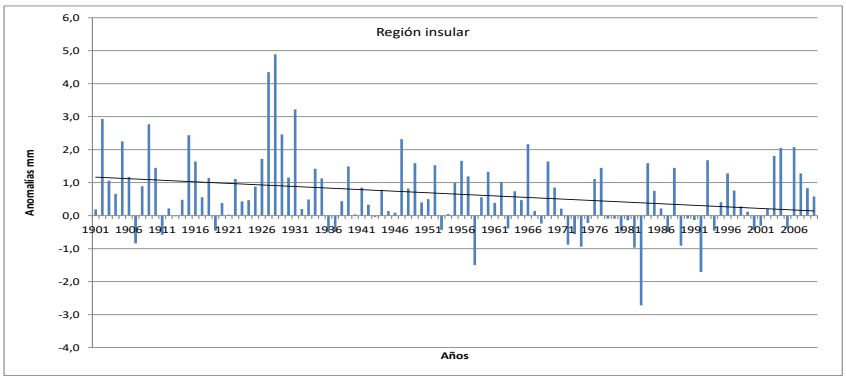


Figure 5.8. Monthly precipitation anomalies for the period 1951-2009. The red line represents a moving average of 12 points. Insular Region (upper) and Continental Region (lower).

This study of annual accumulated rainfall in the period 1901-2009 shows a decrease in the country that has been more significant on the island of Bioko and less marked on the mainland, **Figure 5.9.**

These results are in correspondence with the behavior of the variable in the region according to the IPCC (2013). However, it has been observed that the behavior of the number of days with precipitation is contradictory between both parts of the territory. On the island of Bioko the days with rains have decreased significantly, while on the mainland the days with rains have increased.



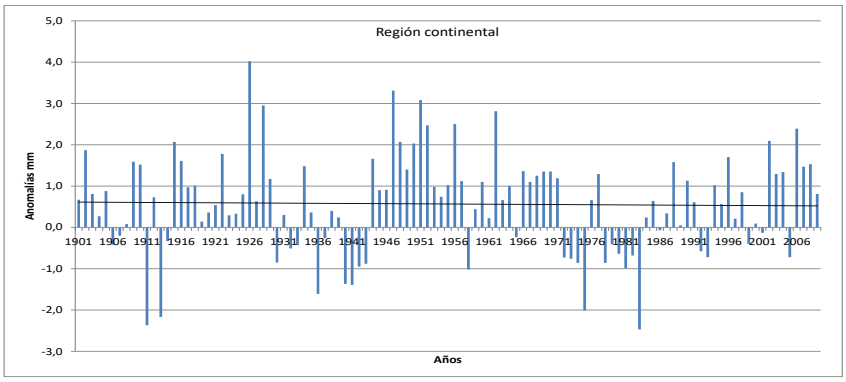


Figure 5.9. Annual precipitation anomalies for the period 1901-2009 referred to the norm of the period 1971-2000 in the Insular Region (upper) and Continental part (lower).

Regarding the behavior of "heavy rains" (≥ 100 mm in 24 hours or less) there are no statistics that can illustrate their behavior, but they are frequent in the southern part of the island of Bioko (Caldera de Luba) (Pérez del Val, 1996) and in Niefang Mountain Range (Atlas of Equatorial Guinea, 2001).

5.2.4 Severe Local Storms

According to Alfonso (1994), it is defined as Severe Local Storm (SLS), the storm, usually accompanied by electrical shocks that present one or more of the following phenomena: marine thrombus, tornadoes, hail and linear winds greater than 96 km/h. Records about these dangerous meteorological phenomena are scarce in the country, but references to them are found in the ethnic traditions that have populated Equatorial Guinea when referring to weather. The Bubi on the island of Bioko, according to Lopez Vicario (1988) referred to the month of October as "bulabula", which means tornado.

In general, tornadoes and marine waterspouts occur, but they are not frequent. Of the TLS mentioned above, the most common are "heavy rains" (≥ 100 in 24 hours or less) usually accompanied by electrical activity. On the island of Bioko, the months of greatest occurance of these tropical storms are those of April, May, June, July, August, September and October, while on the mainland they are March, April, May, September, October and November according to Lopez Vicario (1988). Related to these storms, there are often very strong linear winds that cause material damage and sometimes loss of human life.

On the mainland, these dangerous meteorological phenomena are mostly related to strong convective movements associated with daytime heating and the movement of the ZITC over the area. On the Island of Bioko, they are mainly related to the orographic lifting of the winds of the SW region loaded with heat and humidity, which, when colliding with the heights of the Caldera de Luba, produce abundant rains in the area. In some locations "rainy islets" are produced with estimated annual average rainfall exceeding 10, 000 l/m², according to Perez del Val (1996).

In the process of collecting the information for this project, it was observed according to the people interviewed throughout the country, that there are no significant increases or changes in the behavior of thunderstorms, tornadoes and the fall of hail. On the Island of Bioko, however, surveys indicate an increase in the severity of rainfall, a situation that is manifested in the data collected at the Malabo airport. The above corresponds to what was announced by the IPCC (2013), "it is very likely that at the end of this century the phenomena of extreme precipitation will be more intense and frequent in most of the land latitudes of medium latitude and in the humid tropical regions, as the global average surface temperature increases."

5.2.5 Coastal flooding

Equatorial Guinea is a country with an island and a continental part located in the Gulf of Guinea, at the gates of the North Atlantic. The country has 385 km of coastline (PEPGE, 2016) with important human settlements.

In the last report of the IPCC (2013), it is suggested that the average global average elevation rate of sea level has been 1,7 (1,5 to 1,9) mm/year^{-1}, between 1902 and 2010, from 2,0 (1,7 to 2,3) mm/year^{-1}, between 1971 and 2010, and from 3,2 (2,8 to 3,6) mm/year^{-1}, between 1993 and 2010. If it is considered that according to data from the population census of 2015, both the political capital (Malabo-256 916 inhabitants), and the economic capital (Bata- 294 806 inhabitants) are located in coastal areas and that both concentrate the 45,03% of the total population of the country (INEGE, 2018) can understood the concern generated by these phenomena to the population at risk and the government to manage the situation.

If to the above, the problems of territorial planning in risk areas are added; the little respect for the established norms; the extraction of sand for construction and other incorrect human activities, such as the destruction of mangroves, blocking of estuaries, etc., then you can understand the risk scenario presented by the country's coastal areas.

The main causes of coastline flooding in Equatorial Guinea are related to the rise in sea level, because of climate change. This situation has destroyed infrastructures built in the colonial era, both in the continental part and in the insular part. Other causes are mainly associated with TLS, such as sea waterspouts and strong winds that from the sea to impact in certain areas produce coastal flooding. No penetrations of the sea in the country are known for other natural causes such as tsunamis or strong "storms".

The bathymetry is low around the islands in the northern half of the island of Bioko it ranges between 20-50 m and extends to the Cameroonian coast. In the continental part it oscillates between 50-100 m and its extension on average exceeds 20 km offshore. This situation, together with the morphology of the main beaches, favors the deformation of the waves, which can be strong in some areas and times, favoring the loss of the sand dune.

In the country there are four changes of tides, two low and two high which are on average above the 1,20 m amplitude. This singularity aggravates the situation, since according to recent studies by the end of 21st century the sea level could be 1m above the msl[9].

5.3 Main Impacts of Climate Variability

The form of socioeconomic development that our societies have today determines not only vulnerability to impacts, but is also considered by some authors, such as Martin Vide (2001) as the sixth component of the climate system.

Climate variability in a region does not equally impact the societies present in it, as socioeconomic conditions dampen or exacerbate impacts. Situation given by the ability to identify risks (Assess), develop and implement programs to protect society and prevent losses (Select and Implement), y and establish a permanent Monitoring of the situation.

In Equatorial Guinea there is a great exposure to the impacts of climate variability, both in humans and in-built goods, mainly from those settled in coastal areas or that depend on the water resource. For

[9]msl: mean sea level.

being the most sensitive, especially in the case of those with lower resources. To all this, we must add a low capacity for adaptation, mainly due to the lack of information and organization.

The tendencies in the increase of the temperature and the decrease of the precipitations affect vital economic activities, like agriculture, the fishing (especially the terrestrial one), the human health, the tourism among others. The tendency to a warmer and drier climate affects the whole society, however, the preparation to face such a reality is very low or almost nil despite its clear manifestations. These manifestations are already visible in Bioko according to Salomon (2014).

In the case of extreme events (sever weather anomalies), the vulnerability is high because there is no observation and surveillance system that alerts and forecasts these situations, on the one hand. On the other hand, Equatorial Guinea is a country that grows economically at a dazzling pace, however, a large part of these created goods is susceptible to being damaged even before they finished, which further aggravates the situation.

Regarding the impacts of the ENSO[10] and NAO[11] low frequency variability patterns in Equatorial Guinea, they are not yet studied. It is known, according to Wanner et al.,(1994) that the positive phase NAO causes a shortage of rainfall in North Africa, while the negative phase, quite the opposite, in the same area. Similarly, that the variability of the tropical Atlantic influences the extreme weather events that take place in some regions of Africa, according to Lam (1978) and Folland et al., (1991). In the case of rains in western equatorial Africa it is more complex, but they show a dependence on the Sea Surface Temperature (SST) in the tropical Atlantic, according to Lamb and Pepler (1978). Other works show that the atmospheric circulation over Africa is also influenced by the Indian Ocean SSTs according to Folland et al., (1986) and by El Niño- Southern Oscillation (ENSO), according to Nicholson (1997).

The East Atlantic (EA) pattern, the second most important climatic index for the Atlantic after NAO, has a marked influence on rainfall in the western Mediterranean including North Africa, according to Luna et al., (2004). Other authors, such as Castro et al., (2008) relate the EA pattern with a significant negative correlation with the outcrop (replaces hot surface water with cooler warmer from deeper layers) along the entire west coast of the Iberian Peninsula and the northwest from Africa. However, both the EA and the AMO (Atlantic Multidecadal Oscillation) have little studied their mechanisms of teleconnection with Equatorial Africa, let alone their influence in Equatorial Guinea.

5.4 Adaptation to the impact of natural climate variability.

In Equatorial Guinea, the climate is currently warmer and drier, and indirectly there is a rise in sea level that is affecting many areas of the Equatorial Guinean coast. This behavior has important implications in key sectors such as agriculture. In the case of temperatures, an increase in average values is observed, mainly due to a significant increase in minimum temperatures. If we take into account the statements made by Martin Vide (2001), or the IPCC (2007), when observing the significant climatic increases or decreases in the mean values of the elements, we can say that we are in the presence of climate change.

The lack of National Meteorological Service and the availability of extensive and reliable climate data make it very difficult to determine whether the changes observed in the national climate are a consequence of climate change. In this sense, it is prudent and timely to make an analysis of the capacity of Equatorial Guinea to cushion the changes that are occurring in the climate, self-organize and learn and adapt to them. As Trosper (2002) says, the ability to develop resilience to global climate changes to be taken into account in the country's strategic development projection.

[10] ENOS: Fenómeno natural conocido como El Niño- Oscilación del Sur o fase cálida del ENOS.
[11] NAO: North Atlantic Oscillation

5.4.1 Institutional capacity for climate prediction and early warning in Equatorial Guinea.

In Equatorial Guinea there are only two conventional weather stations at the airports of Malabo and Bata managed by ASEGNA[12] to report to the agency the local weather. Apart from this, there is no institution in charge of observing, monitoring and predicting weather and climate in the country.

The personnel trained in meteorological sciences is very scarce. Most of them trained as specialists in Niamey (Niger) and Toulouse (France) through an ASECNA scholarship program. Currently there is no meteorology or similar degree at the National University of Equatorial Guinea (UNGE), where only the subjects of Climatology and Meteorology are taught in the degree in Environmental Sciences. It is therefore a reality that Equatorial Guinea does not have the infrastructure or specialized personnel to develop a short-term meteorological service in the country.

5.4.2 Institutional capacity to act in extreme events.

In Equatorial Guinea, citizen protection is provided by the General Directorate of Civil Protection (DGPC), belonging to the Ministry of Interior and Local Corporations. The DGPC was created on May 31, 2010 from Law No.4/2010 on Prevention and Civil Protection in Equatorial Guinea.

Currently, the organic structure of the General Directorate of Civil Protection is being put together, with the execution of the Construction, Equipment and Training Project of the National Civil Protection Corps of Equatorial Guinea. It is national in nature and includes the construction of appropriate infrastructure in all provincial headwaters, including Malabo and Bata.

In the latter, the construction of a National School for training of future managers and staff of the institution is planned. The Directorate General of Civil Protection through its regional and provincial delegates currently draws up an Action Plan in which both natural and man-made risks are identified at local level through local and sub-regional initiatives, such as the risk management project of the Economic Community of Central African States (CEEAC) (http://www.grc-ceeac.org/).

5.4.3 Strategic actions to reduce the impacts of climate variability

The knowledge of the possible climatic tendencies of the different meteorological variables allows to draw up the appropriate strategies to reduce the expected impacts of the climatic, with those intended to the adaptation to the climatic change.

Among the proposed actions, there are:

- Create an institution for the management of climate variability and climate change in the country: it will be responsible for the articulation of policies and actions regarding climate variability and climate change in Equatorial Guinea;
- Create the national meteorological service: the development of a network of land and sea stations throughout the country would allow to reliably know the behavior of weather and climate throughout the national territory and have an Early Warning System (EWS) to detect extreme phenomena;
- Strengthening the legal and institutional framework for environmental protection: it is urgent to adapt the regulatory and institutional framework to promote environmental protection and reduce the impacts of climate variability and climate change;

[12] ASEGNA: Agency for Aerial Navigation Safety in Africa and Madagascar.

- Promote the climate culture of the population: include climate issues at all educational levels, as well as permanently and novelty develop awareness of the population in general about climate variability and climate change;
- Develop international cooperation: Collaboration with recognized international organizations such as WMO, UNDP, GEF and others is necessary to develop capacities, infrastructure and public campaigns that generate resilience to climate change;
- Create the meteorology degree at UNGE: At the National University of Equatorial Guinea (UNGE), some subjects such as meteorology and climatology are taught in the Bachelor of Environmental Sciences, but the Meteorology degree or similar is not studied.

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Chapter 6

Chapter 6. Vulnerability and Adaptation to Climate Change

6.1 Introduction

Since its origins, the "Man" has been exposed to the weather and climate, its inclemency and, above all, dangerous meteorological phenomena. Reducing vulnerability[13] to these phenomena has been a constant concern of all societies.

Climate change has become humanity's greatest environmental challenge that not only endangers human existence itself, but all life on the planet. It is therefore essential to implement adaptation[14] measures to reduce the observed and potential impacts[15] of climate change, regardless of mitigation[16] measures. Such haste is conditioned to the existence of other factors that aggravate its effects, such as poverty, unequal access to resources, food insecurity, trends in economic globalization, conflicts, and the incidence of diseases, such as HIV/AIDS, among others according to the IPCC (2007).

According to the IPCC (2007 and 2013), the Congo Basin, where Equatorial Guinea is located, is one of the geographical areas where the projected impacts of climate change will be significant. Taking this situation into account, within the framework of the project for the preparation of the First National communication of Equatorial Guinea to the UNFCCC, a study has been carried out to determine the country's vulnerability to climate change and, in correspondence, a set od adaptation proposals. Such proposals are aimed at designing a resilience[17] strategy that allows cushioning alterations, develops the capacity for self-organization, learning and adaptation.

The research strategy focused first on determining the impacts of climate change that are currently observed, and those projected of the country. For this, the entire national territory was visited, and interviews and meetings were held with the residents and authorities to learn about the community's perception of climate change.

On the other hand, the projections of the future climate (climate scenarios) for the island of Bioko and the continental part of the country were determined. The socioeconomic sectors identified were: water and health; farming; fishing; forests and biodiversity; infrastructure and construction and energy.

In the development of the research, the vulnerability and proposed adaptation measures were determined under the guidance of decision 28/ Conference of Parties, according to FCCC (2001), as part of the country's strategy to implement the Framework Convention of the United Nations on Climate Change and the Kyoto Protocol.

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[13]**Vulnerability**: According to the IPCC (2007), it refers to the level at which a system is susceptible, or is not able to withstand, the adverse effects of climate change, including climate variability and extreme phenomena. Vulnerability is a function of the character, magnitude and speed of the climatic variation to which a system is exposed, its sensitivity, and its adaptability.

[14]**Adaptation**: According to the IPCC (2007), it refers to initiatives and measures aimed at reducing the vulnerability of natural and human systems to the real or expected effects of climate change; they act on the consequences of climate change.

[15]**Impacts**: According to the IPCC (2007), they are the consequences of climate change in human and natural systems. There are two types: *potential impacts* (all the impacts that can happen given a projected change in the climate, regardless of adaptation measures) and *residual impacts* (the impacts of climate change that may occur after adaptation).

[16]**Mitigation**: According to the IPCC (2014), it is the human intervention aimed at reducing sources or enhancing greenhouse gas sinks.

[5]**Resilience**: According to UNDP (2009), it is defined as the ability of groups or communities to absorb external tensions and disturbances as a result of social, political or environmental changes. From the point of view of climate change, it refers to cushioning impacts, learning and adapting.

6.2 Projections of the future climate in Equatorial Guinea

The studies conducted by Fonseca et al. (2012) in the framework of the preparation of this document, they allowed to know the future changes in the climate of Equatorial Guinea. The analysis was developed taking into account the patters of change in MMS (*Multi Nodel Statistics*) for the periods 2011-2040, 2041-2070, 2071-2099 with respect to the period 1951-1990.

Changes in the mean and variability (standard deviation), reproduced by the representation of the dispersion of the models through the standard deviation between them, were analyzed. Likewise, the signal/noise ratio was estimated as a way of representing the level of uncertainty in future projections.

The results are described in accordance with the MAU[18] (Maurer *et al.* 2009) for the SRESA1B and SRESA2 emission scenarios, also representing the uncertainty associated with different GHG emission scenarios.

6.2.1 Future changes in temperature.

One of the clearest responses, related to the increase in greenhouse gas (GHG) concentrations in the atmosphere, is the increase in air temperature. Estimates indicate temperature increases for Equatorial Guinea on the order of 1°C for the period 2011-2040, 2°C for 2041-2070 and above 2,5 °C for the period 2071-2099 (Figure 6.1). For the first two periods, the differences in the estimates under the SRESA1B and SRESA2 scenarios are very similar and only at the end of century is the most intense effect of the SRESA2 scenario on the SRESA1B. Here the "almost linear" relationship between the increase in GHG concentrations and the increase in air temperature becomes evident. The significant increases that are projected and their lower uncertainty have implication on the potential volumes of water available on the territory of Equatorial Guinea, with a foreseeable decrease in rainfall.

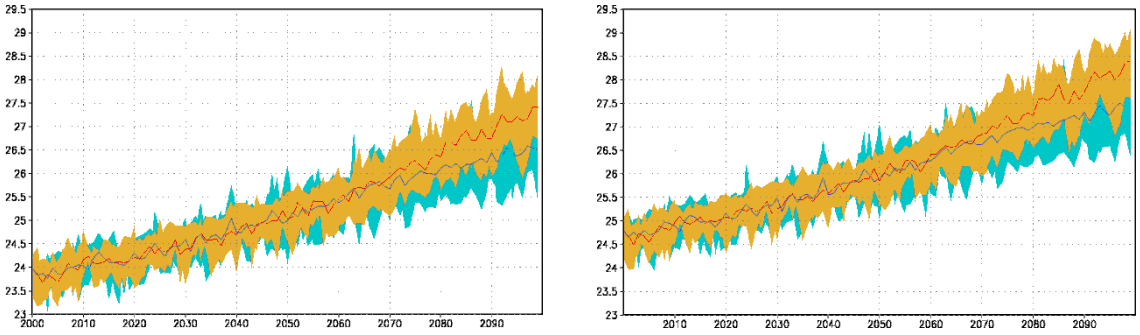

Figure 6.1. Time series of the annual temperature values projected by all models (shaded areas) and by the multi-modals average (lines). The red line and the orange shading correspond to the SRESA2 scenario, while the blue ones are associated to the SRESA1B. On the left the values corresponding to the island of Bioko and on the right, those corresponding to the continental part of Equatorial Guinea.

6.2.2 Future changes in precipitation

Rainfall projections on Equatorial Guinea have a significant level of uncertainty. Figure 6.2 shows the series of projected annual values for the period 2000-2099 for Bioko Island and the continental zone of Equatorial Guinea. In general terms, the rainfall regime on Equatorial Guinea does not present any significant future changes. The values on the island of Bioko have very little variation (they range between 4,5 and 7mm/day), while for the continent the variations are approximately double. In both cases it is detected that the dispersion between the estimates of the different models increases with

[18] **MAU**: International reference to the works of Maurer et al. 2009

the passage of time. This result does not correspond to those registered at the Malabo and Bata land stations, which may be due to the lack of precision of the global models in the precipitation of these two zones.

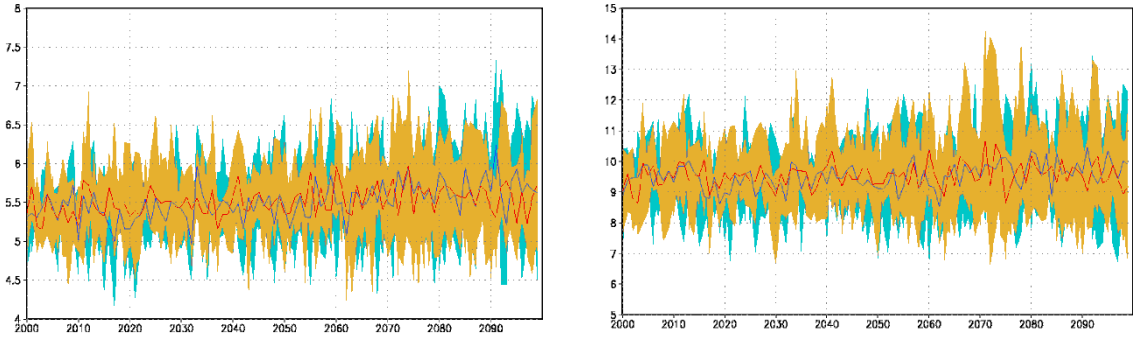

Figure 6.2. Time series of the annual precipitation values projected by all models (shaded areas) and by the multi-modals average (lines). The red line and the orange shading correspond to the SRESA2 scenario, while the blue ones are associated to the SRESA1B. Note that the axis scale is different on the island of Bioko (left) and in continental Equatorial Guinea (right).

6.2.3 Future changes at sea level

Since 1993, thermal expansion of the oceans has represented approximately (57%) of the sum of the estimated contributions to sea level rise, while the decrease in glaciers and ice caps contributed by approximately one (28%), and the losses of the polar ice sheets contributed the rest. Between 1993 and 2003, the sum of these contributions has been within the margin of uncertainty, consistent with the total increase in sea level observed directly, therefore, the increase in sea level is a consequence of the global increase in temperature, Figure 6.3.

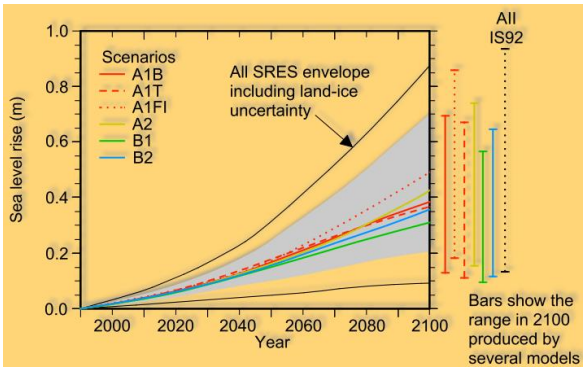

Figure 6.3. Projections of sea level rise for the different scenarios of the IPCC (2007)

If it is taken into account that according to the IPCC (2007), depending on the development model adopted by humanity in the future, the global average temperature increases can be in the range of 1,8 and 4,0 °C with respect to the average from 1980-1999, even higher that 6,4°C, then sea levels can exceed all current expectations. The over-elevation of the sea level, according to future scenarios would have disastrous consequences in those low areas of the coast, especially in small island states or territories, such as Annobon, Bioko, Corisco and the Elobeyes.

6.3 Climate change impacts

All living things need to develop a suitable physical environment, according to Smith and Smith (2001), so that Global Climate Change will have repercussions for life on Earth and natural processes. According

to the IPCC (2007), some systems, sectors and regions will be particularly affected by climate change. In this sense, Africa is the most affected, both because of the magnitude of the expected impacts, as well as its low adaptive capacity. According to the White Paper (2009), understanding the impacts of climate change, developing and applying measures to ensure an optimal level of adaptation is the challenge for policy makers in all countries.

6.3.1 Human health

The impact of a warmer and drier climate will cause: changes in morbidity-mortality; negative health effects related to the increase in extreme weather events (floods, storms, droughts, precipitation, etc.), air pollution, increased diseases transmitted by food, water or by infectious vectors and rodents. On the other hand, in the social sphere, it is shown that people with fewer resources are more vulnerable to the effects of climate change. According to Braman (2010), this is likely to increase the need for humanitarian services, both in terms of disaster preparedness, risk reduction, health, water and sanitation, food security and shelter.

6.3.2. Forest and biodiversity

Possible effects of climate change on forestry sector in Equatorial Guinea include:

- Changes in the productivity and health of forests, as well as in the area of geographical distribution of some tree species;
- Increase in the frequency of forest fires and pests affecting forests;
- Water deficit, capable of causing changes in woodland or species density.

According to FAO report (2011) between 1990-2010 there has been an annual forest loss of 0,69%. Studies conducted in 2018 reflect a deforestation rate of 0,3% and 0,9% degradation according to FAO and MAGBOMA (2018).

The deforested area is greater in Bioko while the mainland and Annobon have suffered greater degradation. If the current rate of exploitation continues, together with the projected climate change, the forests of Equatorial Guinea could be one of the most impacted sectors.

The situation is more critical for endangered or endemic species, such as the four subspecies and two species of endemic primates of Bioko (Cronin *et al.,* 2015). Marine ecosystems that host a great diversity of species of high commercial or biological value such as turtles will also be affected. In mountainous areas the impacts will cause a redistribution of the altitudinal profile, especially in island territories such as Bioko and Annobon where few studies on its biodiversity have been carried out except for flora (Velayos *et al.,* 2014).

6.3.3 Agriculture, fisheries and food security

Agriculture and fisheries are very poorly developed in Equatorial Guinea and are practiced extensively, although the country's potential is very high (FAO, 2016). However, the impacts of climate change can cause very serious problems to the precarious existing agriculture, mainly in:

- The duration of the crop cycles;
- Physiological changes due to exposure to temperatures outside the allowed threshold;
- Water deficiencies and responses to new concentration of atmospheric CO2;
- Availability of nutrients in the soil;
- Increase in populations of parasites, pests and diseases;
- Population flows indirectly affect agriculture activities.

The effects of climate change will be very important on marine and coastal ecosystems causing reduction of fish sizes (between 14 and 24%) and their movements and biological cycles, which will limit fishing. There may be changes in the chemical composition of the water, its currents, reduction of the availability of oxygen, the bleaching of corals. Territorial fishing would be greatly affected by the high temperatures and reduced rainfall that reduce the channels and nutrients of the rivers and lagoons.

6.3.4 Energy, industries and mines

In Equatorial Guinea the industries with the highest risk are those found in coastal areas or at sea; depend on the water resource or located in areas where an increase in extreme weather events is projected, such as heavy rains or prolonged droughts, such as thermal power plants and extractive plants. The territories that depend on hydroelectric power will also be affected, since the electricity demand cannot be met if rainfall decreases and therefore the contributions to the river basins.

6.3.5 Water resources

The increase in temperature and the decrease in rainfall in Equatorial Guinea will cause a reduction in the existing water contributions. As another stress factor we can talk about the existing management of the resource at present, because for example, in Malabo only 45% of the population has access to drinking water, according to the PNSA (2012). Therefore, the impacts of climate change on water resources depend not only on rainfall, but also on available water resources and their management.

6.3.6 Infrastructure and construction

The availability of water for construction projects, the increase in aggregates and formwork wood will have a significant impact on construction plans. The energy demand for the sustainability of buildings will be more expensive, mainly dependent on water resources threatened by prolonged periods of drought.

Severe meteorological phenomena will affect the most precarious and modern constructions that do not take into account extreme risks in their construction quality standards such as lightning protection in tall buildings or anti-impact windows. Roads and bridges can also be affected in the presence of torrential rains or extreme droughts.

Infrastructures built in low-lying areas, prone to flooding or along the shoreline threatened by the rising of sea level will be seriously threatened and in danger of being destroyed.

6.4 Vulnerability to climate change in Equatorial Guinea

The tour around the country by the Technical Team has allowed us to identify the impacts of climate change on all natural and human systems and evaluate the socioeconomic conditions of the population. The work carried out combines research strategies of the “top-down” type with a centralized and descending approach and those of the “bottom-up” type that have a decentralized and ascending character.

The combination of both strategies allowed to evaluate the vulnerability of Equatorial Guinea to climate change and to design the corresponding adaptation measures. With the results obtained in this study, as in PANA (2013) it is concluded that Equatorial Guinea is currently “highly vulnerable” to the effects of climate change.

6.4.1 Community perception of climate change and its impacts

The information was obtained through interviews with seniors responsible for the communities, with prominent members in the main productive activities (hunters, fishermen and farmers) and in a special way, women were interviewed for having a role as known in Africa very important in the sustenance and

maintenance of the family. In all communities, towns and cities it was found that "weather was changing", according to the population's claims. Some of them are detailed in Table 6.1.

Table 6.1. Community perceptions on climate change referred by the local population interviewed in Equatorial Guinea.

Continental Region	Community perceptions on climate change
In coastal areas	Temperature: - The weather is warmer in recent years, with hot days more frequent. Precipitation and seasonality: - More intense rainfall - More variable rainfall stations and difficulty predicting the seasons. Increase in sea level and coastal dynamics: -Marked rise in sea level, with high tides that go much further than in previous decades; in many cases, coastal erosion can be seen in the damage to the infrastructure of the coast and the changes in the morphology of the beach. -Increased frequency of storms and intense waves. -The elimination of mangroves has aggravated the situation.
In the interior	Temperature: -Increase in temperatures, hotter and warmer days than in the past. Precipitation and seasonality: - Usually drier weather, but stronger storms and intense rainfall. -More variable rainfall stations and more difficulty predicting the seasons now.
Insular Region	Community perceptions of climate change

Bioko	Temperature: - It is usually warmer, especially with sunnier and lighter days than decades ago, much hotter days than years ago. Precipitation and seasonality: -Usually less rainfall. -Less cloudy days, more days entirely clear. -In Moka (in the mountainous part) less fog than in previous decades. Rain falls later, greater seasonal variability ("it rains when we don't need it and it doesn't rain when we need it"). -Increase in the intensity of rainfall and storms. Winds: - Winds stronger and more frequent than in the past. -Directional changes of the winds. Increase in sea level and coastal dynamics: -The sea has grown significantly (it has demolished colonial roads) in recent decades. -Stormy seas.

Table 6.2 shows some of the impacts of climate change on their lives or activities. Similar results were obtained by Solomon (2014), in a study conducted in Bioko.

Table 6.3. Impacts of climate change referred by the local population on their lives or activities, Equatorial Guinea.

Observed climate change	Observed impacts	Other pressure factors
Heat increase (rising temperatures)	- Increased fishing in por condition. - Food insecurity -Lost crops. -Fluctuations in the prices of local markets. - Increase of insects and pests -Loss of livelihoods. -Health problems. -Lower soil production. -Change in species (reduction of wild meat and others that were not before).	- Precarious land management, agricultural logging and burning practices. -Destruction of forests for urbanization and for the timber industry. -Excess hunting, conflicts over fauna and flora that give rise to their disappearance.

Precipitation decrease (les annual accumulated, less rainy days and seasonal variation).	- Lost crops -Disorders at harvest times -Changes in species and migrations. -Dry streams- problems of access to water. -Loss of livelihoods. -Food insecurity (fishing) -Descent of river currents (problems of access to water and hydroelectric energy).	- Excess hunting -Soul management and precarious agriculture practices. -Excessive use of river systems (hydroelectric power and water).
Greater intensity of rainfall, storms and floods.	- Destruction of infrastructure and housing, greater maintenance. -Well pollution (health), increased typhoid fever and water-related diseases. -Mud landslides, river banks that overflow and cause loss of human life. -Stagnant waters increase malaria and other water-related diseases.	-Abstraction of resources without rehabilitation measures leading to areas vulnerable to landslides. -Proximity to wells and latrines -Lack of management of wells and latrines. -Urbanization of areas prone to flood.
Sea level rise and rising storms	- Destruction of infrastructure, housing and housing developments. -Changes in fish species and change in the amount of fish caught and their size. -Fishermen cannot go fishing so often. -Loss of livelihoods. -Food security.	-Elimination of mangroves for urbanization and other uses. -Excessive development near the coast. -Overfishing -Increase population

6.4.2 Vulnerable groups

The main vulnerability factor in Equatorial Guinea is the poverty of an important part of the population according to the PNSA (2012), which limits the capacity to adapt. To this added the growth and distribution of the population by emigration from rural areas to urban areas and the low level of preparation. This situation leaves children, women and elderly people who have many difficulties in meeting their elementary needs because of lack of assistance.

6.4.3 Sector vulnerability, adaptability and resilience mechanisms

To reduce vulnerability, it is necessary to act on the impacts of climate change (adaptation measures) or on the causes that cause them (mitigation measures). Some of these measures were proposed and developed in the National Economic and Social Development Plan (PNDES, 2007), and reoriented in the Third National Economic Conference 2019. They are designed on the guiding principles of the UNFCCC: precaution, equity and sustainability.

6.4.3 a) The Health Sector

The political will of the government is to reverse in the shortest possible time the deficiencies of the national health system, through the reorientation of the PNDES of 2007 through the III National Economic Conference (ANGE, 2018) adapting development policies to the SDGs (Agenda 2030) and the 2063 Agenda of the African Union. The proposals that are recommended below together with the proposals of the PANA (2013) should give the country's government the lines of action to build resilience to climate change in the human health sector, Table 6.4.

Table 6.4. Adaptation proposals in the human health sector, Equatorial Guinea.

Develop the hospital infrastructure throughout the country (hospital coverage), as well as the preparation and training of associated health and logistics staff (statistics, supplies, maintenance, etc.).
Strengthen programs to fight and prevent HIV/AIDS epidemics; Malaria, as well as high incidence diseases (Typhoid Fever and tuberculosis) and the fight against the spread of vectors.
Prepare Emergency Medical Plans (Ministry of Health) before natural disasters (epidemics, heavy rains, earthquakes, volcanic eruptions, etc.) and anthropological (conflicts, technological and industrial accidents, etc.), not existing in the country.
Ensure accessibility to "Drinking Water" (according to WHO) and Sanitation to the entire population in urban and rural areas.
Expand the Health Centers for the mentally handicapped and the homeless.
Make awareness campaigns on Family Planning issues and reduction of promiscuity in adolescents; mother's health (prenatal care and childbirth); vaccination coverage and breastfeeding and child nutrition.
Implement surveillance programs and control of urban pollution due to the high incidence of acute respiratory infections (ARI), among others.
Adequate constructive legislation, with a planned urban planning that avoids human overcrowding and shields risk areas (low coastal and flood zones).
Develop (equip, train and train) the General Directorate of Civil Protection (GDCP). Design a "Civil Protection System" with national coverage in situations of "Extreme or Catastrophic".
Creation of bromatological laboratory that controls the quality standards of food sold throughout the country.
Implement the National Plan for Food Security (PNSA, 2012) that solves the problems of food and nutrition of most of the population, which negatively affects human health.
Strengthen the health information system (SIS) to collect information on the diseases with the greatest impact on human health.

6.4.3 b) Forests and Biodiversity

Among the probable effects of climate change on the forestry sector, there are changes in productivity, health of forests and in the area of geographical distribution of some tree species. Such a situation will

put added pressure on agriculture and fisheries in forested areas. It is important to develop the integration of climate change adaptation into rural development projects and policies, improve the environment and quality of life in these areas using sustainable methods of forest exploitation and agricultural management that create resilience to change climate in the sector. The While Paper (2009) indicates that…"*green infrastructure*[19]" can play an essential role in adaptation by providing basic resources for social and economic purposes in extreme climatic conditions. The state must encourage private investment, especially national and local, to promote development and sustainably exploit forest resources and biodiversity, Table 6.5.

Tabla 6.5. Propuestas de adaptación en el sector bosques y biodiversidad en Guinea Ecuatorial

New modes of governance are required that allow significant stakeholder participation and secure land tenure and respect for the rights of forest users, as well as enough financial incentives.
To strengthen the National Forest Guard System with means and trained personnel to exercise better surveillance of forest resources. Create and Early Warning system against potential hazards in forested areas (fires, droughts, etc.).
Sustainable management of forests (reduced exploitation, forest sanitation, increase water reservoirs, cutting down very dense groves, etc.).
Prepare forest technicians to exercise a "Joint Management" of adaptation, taking into account the characteristics of the inhabitants and the locality.
Effectively establish synergy relations with international policy regimes, so as to strengthen adaptation mechanisms (financing, training, legislation, etc.).
Develop and encourage research on the state of wildlife in forests which would allow for the establishment of adequate policies for the conservation of threatened species.
Create corridors between reserves of great biodiversity, which ensures that the species have natural areas to mitigate, thus helping to prevent their extinction due to habitat loss.
Train "in-situ" on the exploitation of non-timber resources (plant origin) to originate sources of income in rural areas without damaging the environment.
Avoid that the development of crops is carried out at the expense of converting the forest into plantations, as well as practicing as far as possible a low intensity forestry.
Promote the development of "dendro-energy" in forest exploitation areas as an alternative way to obtain energy from forest exploitation wastes.
Develop community projects that allow increasing the production of animal protein sources (livestock or aquaculture) to create jobs and reduce pressure on forest biodiversity.
Develop research related to the topic to reduce current uncertainties about the effects of climate change on forests and populations and to improve knowledge about management measures and adaptation policies.
Apply as far as possible, in conjunction with the adaptation mechanisms, the mitigation measures recommended by the REDD+ mechanisms.
Make the inventory of all the flora and fauna existing in the country.
Construct zoos and botanical gardens where animals, plants and genes of endangered species or of great scientific value can be conserved and investigated. They will also serve as recreation and environmental awareness, as well as a source of employment and income.

[19]**Green infrastructure**: According to the White Paper (2009), it is the interconnected network of natural spaces, including some agricultural land, such as greenways, wetlands, parks, forest reserves and communities of native plants, as well as marine spaces that naturally regulate stormwater flows, temperatures, flood risk and water quality, air and ecosystems.

Develop programs of reforestation and soil conservation in the areas after logging in which the local population participates as a manager of natural resources. Protect and increase mangroves in coastal areas, estuaries and marshes.
Perfect, execute and supervise the protection of Threatened Species projects (primates, wild elephant, sea turtles, etc.).
"Avoid" the construction of human barriers, such as roads, urbanizations or areas of exploitation in protected areas. Create refuge and buffer zones.
Restructure the management plan, infrastructure, protection and surveillance of Protected Areas (interconnection between them).
Develop capacities in environmental training. Activate a center for training, research and monitoring of biodiversity in Monte Alen.
Approve the draft of the existing hunting law, as it is not effective given the presence of "forest meat" in the markets, when even protected species are commercialized.
Make awareness campaigns on the consumption of forest meat. Enforce the Hunting Law and punish offenders (in the country there are no causes or arrested for this).
Activate national inspection in industrial fishing areas leased to foreign companies, to control agreed volumes, species and sizes.

6.4.3 c) Agriculture, fisheries and food security.

The tolerance thresholds of crops, plants and animals to the new climatic conditions will be out of their possibilities so they must be ensured, through appropriate cultivation techniques, good practices, more resistant species, breeding and artificial crops of commercial species, etc., Table 6.5. In general, an increase in pests and diseases is expected, so it will be necessary to redesign phytosanitary control and train farmers in the control and surveillance of crops. Encouraging the raising of small livestock is strategic in the search for sources of rural work, and root protein in the population.

In the fishing sector, it is essential to train national personnel and provide them with inputs to sustainably exploit the marine resources of the EEZ, apart from promoting the cultivation of fish and algae in the coastal and inland part of the country.

Table 6.6. Adaptation proposals in the agriculture, fisheries and food security sector in Equatorial Guinea.

Build nurseries of species of great commercial and fruit value more resistant to the impacts identified, as well as banks of species (preferably native) and /or genetically improved to new climatic conditions.
Rationally use available water, with efficient irrigation systems (drip or other) and develop storage capacities for the most critical periods.
Revitalize the economic relations of rural areas to create capacity and productive sustainability through appropriate infrastructure and technologies. Link local governments and populations in the execution of projects and in decision making.
Implement the Law on Land Tenure already drown up and awaiting approval by parliament. (Develop a modern system of agrarian property).
Develop an Early Warning System (SAT), with national coverage to anticipate and comabat forest fires, pests and diseases.
Use clean technologies as a source of energy (wind, sunlight, energy, among others).
To have a “Central State Reserve” for situations of Disasters or food crisis.
Develop artificial barriers of alternative refuge to the deterioration of coral reefs, natural refuge or platform fish.
Relocation of the populations on the “coastline” and promote the reforestation of mangroves as a natural barrier to avoid the degradation of the coasts.
Encourage agricultural production, so that “Men” participate more in the production process. The main role is played by women in field work.
Establish new forms of agricultural production (cooperatives, etc.) that leave subsistence farming and self-consumption behind.
Create a National Phytosanitary Control Center where the health status of plantations is monitored and specialists and farmers are trained on pests and diseases.
Develop programs in rural areas to obtain animal protein (livestock rearing) and eliminate the pressure of hunting on forests.
Complete the inventory of fishery resources that are found in the country’s Exclusive Economic Zone (EEZ).
Develop National Industrial Fishing (deep sea fishing) to exercise total control over such an important resource.
Create a Fisheries Research Center where the behavior of national fishery resources is monitored, trained and researched.
Create an Agricultural Research Center.
Develop marine fish farming as an alternative source of obtaining important marine resources and employment in coastal areas.
Create a National Aquaculture Development Program in both coastal and inland areas, which would develop jobs and an important source of protein for the population.
Develop the agro-transformation of some high demand products to guarantee their consumption throughout the year and assess export possibilities in the region.

6.4.3 d) Infrastructures y constructions

Equatorial Guinea must develop a sustainable infrastructure, with less carbon footprint; more inserted in the landscape; to manage your waste; with clean sources of energy and reusing raw materials, Table 6.6.

Territorial planning is very important, which shields vulnerable areas, such as coastal lines; riverside or flood areas. All public and private investment in the environment must be supported by an environmental impact study and sustainability criteria must be incorporated in the construction standards to protect them from the new prevailing climatic conditions and redesign the maintenance and protection standards for infrastructures already built.

Table 6.7. Proposals for adaptation in the infrastructure and construction sector, Equatorial Guinea.

Develop the "sustainable architecture" as the guiding principle of the development of all the infrastructure built, especially in public buildings.
Develop a public tree plan of native species that reduce GHG emissions and urban temperatures, improve the visual impact on cities.
Perfect the design of the road infrastructure of the main cities, as well as develop collective public transport.
Improve infrastructure in national and international telecommunications (coverage, cost and rates, diversification of operators, etc.).
Build markets with the sanity conditions regulated for the conservation, transformation and commercialization of food products, especially meat products for the necessary special requirements.
Perform Environmental Impact Studies of the over-elevation of the sea on the existing and projected port infrastructure.
Reform and modernize education centers at all levels of education.
Preserve the natural landscape as an economic resource, which can be exploited sustainably.
Promote the implementation of modern architecture with energy self-sufficient buildings.
Incorporate slope protection mechanisms on the roads that requite it.

6.4.3 e) Energy, industries y mines

Hydropower is the least polluting but is subject to the availability of water resources. It is strategic to design and Early Warning System (EWS) to monitor rainfall and water course capacity, which would allow the management of river basins in order to maintain vital systems such as water consumption, agriculture and electricity generation. It is also necessary to diversify electricity generation through the energy sources, emphasizing renewable sources, Table 6.8.

In the industrial and mining sector, environmental impact studies and mining rehabilitation must be a priority within strategic development plans. In both sectors the use of water must be reassessed.

Table 6.8. Adaptation proposals in the energy, industry and mining sector, Equatorial Guinea.

Evaluate the effects of the projected hydrological scenarios for the nineteenth century on the energy action system dependent on water resources.
Cartography of the climatic potentialities (positive and negative) of the country to produce renewable energies under different scenarios of climate change.
Evaluation of the effect of climate change on energy demand in Equatorial Guinea by region and by economic sector.

Perform feasibility research on the use of other technologies, preferably from renewable sources and alternatives to obtain energy (used oils and garbage, gas, solar, wind, dendro-energy, biomass of inedible plants.
Improve electricity transport and distribution systems, especially in cities. Develop awareness and savings campaigns (replacing incandescent bulbs with more efficient ones).
Resolve the problems of duality of functions in environmental terms between ministries (existence of environmental inspectors at MAGBMA as well as at MMH).
Develop contingency plans for disasters before the occurrence of dangerous natural phenomena or accidents caused by the "Man" in the operating industries in the country.
Make an inventory of the GHG provided by polluting sources.
Make the inventory of the mining production areas in the country.
Establish precise legal terms of mandatory in the rehabilitation of quarries for the companies that operate them. Find alternatives for those already abandoned in the country.
To study the economic feasibility of developing the recycling industry (glass, paper and aluminum) as a sources of employment and resources.

6.4.3 f) Water resources

The water resources sector will be one of the most impacted by climate change in the region, according to the IPCC (2013). It is therefore very important to monitor rainfall and river basins to draw the right strategy in the management of such a valuable resource: usable water potential; study of watersheds; groundwater potential; regulated water capacities etc.

The shared watersheds with the neighboring countries must also be included to design a sustainable exploitation with public policies aimed at informing, sensitizing and educating in value for the life of such a resource that reaches all sectors of society, such as agriculture, health, mines, energy, etc., Table 6.9.

Table 6.9. Adaptation proposals in the water resources sector in Equatorial Guinea.

Implement a National Water Resources System that monitors the state and availability of reservoirs and water courses throughout the country.
Develop the National Hydrological Plan with a systemic approach (the Ministry of Fisheries already has a project).
Water reorganization program using the river basins as a management unit.
Create inter-institutional coordination mechanisms for the development of actions related to the integrated management of natural resources at the river basin level.
Develop guidelines to incorporate into the process of "Environmental Impact Assessments" considerations related to the impacts of climate change for the plans and projects of the hydrological sector.
Develop public awareness campaigns on water use.
Create a laboratory for monitoring and control of water (surface and underground).
Develop an efficient supply network, which reaches most of the homes without losses or contamination.
Design in the urbanization projects proposals for the use of rainfall for different uses (domestic, industrial, others).
Map the availability of groundwater in the country (water availability map, water quality, etc.).
Monitoring the possible salinization of groundwater and estuaries in low-lying coastal areas (delimiting saline inclusion).

Improve water availability through alternatives sources, for dry periods (dams and reservoirs; wetlands; aquifers; lagoons and tanks).
Increase the availability of water by mobilizing resources from areas rich in the resource to regions where demand exceeds supply.
Use Good agricultural practices, such as efficient irrigation systems: drip irrigation; organoponics; changes in the irrigation calendar.

6.5 National Adaptation Action Plan (NAP).

Among the main actions carried out by Equatorial Guinea in developing resilience to climate change is the elaboration of the first National Adaptation Action Plan (NAP).

The methodology used in the investigation to determine vulnerability and adaption measures to cushion impacts, organize and learn and adapt were determined following the guidelines for the preparation of national adaptation programs, of decision 28/CP 7 of the FCCC (2001).

The main objectives of NAP (2013) are according to the document prepared:

1. Develop strategies, policies and adaptation measures in Equatorial Guinea based on a plan of priority activities that address the urgent and immediate impacts of climate change;
2. Attract a wide variety of stakeholders from the country and foster a PANA process driven by specific national circumstances on vulnerability and adaptation (V&A);
3. To improve the institutional and technical capacities of Equatorial Guinea to face the consequences of climate change;
4. Develop links with palliative mechanisms and previous existing environmental initiatives;
5. Sensitize society and decision makers on climate change and its impacts in the country.

6.5.1 Priority projects of PANA

The adaptation proposals must have as guiding principles what the UNFCCC establishes: caution, equity, and sustainability and bearing in mind the beneficial effects on issues such as:

- The strengthening of civil society structures and organizations, especially at the grassroots level;
- The generation of income from profitable productive activities;
- The possible restoration of the environment and the affected natural resources;
- The sustainable management of natural ecosystems;
- The adoption of land management plans;
- Strengthen ties in and out of the country.

In face of global climate change, adaptation has received less attention than mitigation. However, adaptation must be the "center" of future policies as they act directly at the base, on the most vulnerable sectors to minimize their effect. However, the ideal is that lines of measures are taken together, as they complement and interrelate, which allows an "integrated approach" to combat climate change.
A summary of the five projects selected within the workshops held in Malabo and Bata is shown below:

1. *Promoting Resilience to Climate Change in the Water Sector in Equatorial Guinea.*

It is necessary to develop an Integrated Water Resources Management System (IWRMS) that will allow the creation of an Early Warning System (EWS) in the face of extreme natural situations, such as droughts and floods. Regulated Water (RW) systems would be developed to sustainably manage power

generation, water pipes and reservoirs for multiple uses and purposes. Complete and strengthen water supply infrastructure in rural and urban areas through innovative and renewed pilot programs.

2. *Promote the development of infrastructure, urban and rural, resistant to climate, and the responsible extraction of resources in Equatorial Guinea, especially in vulnerable areas.*

This project aims to jointly integrate climate risks and development plans in the infrastructure sector focusing on:

a.) The incorporation of climate risks to the planning of mechanisms for the public sector, to avoid climate risks in infrastructure;
b.) The strengthening of public works of the development of a climate-resistant infrastructure through investments in pilot plans;
c.) The improvement of the capacity of promotion and development of facilities with climate resilience and the extraction of construction materials.

3. *Improve resistance to climate change in the fisheries sector with a view to improving food security and livelihoods.*

Implement the Strategic Fisheries Plan in Equatorial Guinea (PEPGE, 2016). Regarding cross-cutting issues, the project will focus on:

a.) Increase understanding of the impacts of climate change on the fisheries sector in Equatorial Guinea;
b.) The design and development of management plans with integrated climate resistance for the main fishery resources and;
c.) State community-based management approaches with a gender focus, including inland and marine aquaculture.

4. *The sustainable management of the forests of Equatorial Guinea to maintain ecosystem integrity and ensure food security.*

Agriculture and the use of forest resources are two of the most important aspects for the livelihoods of the population of Equatorial Guinea. An integrated ecosystem-based approach in forest management must be implemented. In relation to cross-cutting issues, the project will focus on:

a.) The integration of climate change adaptation and ecosystem maintenance approaches in the planning of sustainable, global and coordinated agricultural and forestry management, and a high level of decision-making (including all users);
b.) The sustainable integral management of forests with practical pilot plans at community level, to improve agricultural production and ecotourism;
c.) Capacity building and communication strategies for specific groups to integrate their own considerations and coordinate the use of forests in all areas.

6.5.2 Limitations and barriers to the implementation of PANA

Ignorance of the environmental problem at all levels of society, together with the lack of information and continuous and reliable records of the different sectors involved, as well as the lack of technical capacity, limited human capital, limited financing, climate data, lack of private sector participation and coordination between the different institutions constitute the fundamental barriers in the process of implementing a National Strategy for Adaptation (NSA) to Global Climate Change.

To achieve this strategy (NSA), the Ministry of Agriculture, Livestock, Forestry and Environment is the operational and functional structure of the State responsible for coordination, management, monitoring of the plan, as well as facilitating integration of adaptation policies and strategies in national development policies through the General Directorate of Environment and Conservation (DGCMA).

Other ministries involved are: Ministry of Health and Social Welfare; of Industry and Energy; Public Works, Housing and Urban Planning; of Finance, Economy and Planning; of Transport, Post and Telecommunications; of Fishing and Water Resources. The implementation of the plan also involves scientific communities, the private sector and the NGOs collaborating in safeguarding the environment (ANDEGE, ADELO, ADMAD, AMICFLORA, BBPP and MicamAfan) whose work and contribution help the implementation of the plan.

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Chapter 7

Chapter 7. Systematic Observation and Research

7.1 Introduction

In Equatorial Guinea there is no institution that has among its attributions the research, observation, monitoring and surveillance of "Weather", "Climate" and air quality throughout the national territory. Currently, the systematic observation of weather is restricted to the international airports of Malabo, Bata (Figure 7.1), Annobon, Mongomeyen and Corisco whose data collected is managed by the Agency for the Safety of Air Navigation in Africa and Madagascar (ASEGNA, for its acronym in French).

This

Figure 7.1. Aerial image of the airports of Malabo and Bata where meteorological observations are made.

existing problem, despite the efforts made by the country to develop scientific knowledge, has a negative impact on both economic and social issues. The current development of the ways and methods of extraction of natural resources, industrial production and the construction of various infrastructures to facilitate or improve people's lives, are responsible for the main environmental problem facing humanity today: global climate change.

The development of an institutional capacity to beneficially guarantee the observation of the state of "Weather", "Climate" and air quality throughout the national territory is a "sine qua nom" condition to foster a climate change strategy global.

7.2 Observation of the meteorological variables.

At present, the International Meteorological Vocabulary defines as "climatic element" any property or condition of the atmosphere that defines the physical state of the weather or the climate of a given place, for a given period or moment of time. Among the most representative considered internationally are: temperature, humidity, atmospheric pressure, wind, solar radiation, cloudiness and precipitation.

The behavior of these variables in the different spatial scales is what defines the weather and climate of a region. Hence the importance of having extensive and reliable meteorological data bases, as they are the "Scientific Base" of any study or research carried out in this regard.

On the other hand, being able to have a network of weather stations that cover the national territory makes it possible to monitor not only the physical state of the atmosphere, but also the quality of the air we breathe. With all the information obtained, Early Warning Systems (EWS) can be created in the event of dangerous meteorological phenomena and significant changes in the climate and reduce the

risks of “natural hazards”. On the other hand, the country also does not have weather radar stations currently needed as a complement to the SATs and for investigations into the complex physical processes existing in the atmosphere.

7.2.1 Weather and Climate Watch

As mentioned earlier the first studies of weather and climate, according to Lopez Vicario (1998) date back to the colonial era and most of these works were carried out by Catholic priests based in the country. These studies according to the aforementioned author were based on observations made in the localities of Conception (now Riaba), Moka, Musola, Rebola, Baney and Ureka on the island of Bioko.

On the mainland, the stations were in Akurenan, Cabo San Juan, Mikomeseng, Mongomo, Kogo and Niefang. Of those data collected in the past, there is no copy available in the country, although according to some authors such as Perez Del Val (2001), in Spain, meteorological data from some localities of the former colony can be found today.

After independence, the relations between the old metropolis and its former colony deteriorated markedly, which also affected the activities carried out by Catholic priests related to the monitoring of weather and climate. Such activity was totally suspended, and the data currently collected does not appear in the custody of any state institution. After the Coup d’état in 1979, the same conditions were maintained, so time monitoring was only continued at the airports of Malabo and Bata.

The data registered at airports are for public use and are available in digital format for all people and institutions. However, there is no Centralized Meteorological Database in the country, (each airport contracts its own) as we as enough personnel for the maintenance and updating of those already existing at the airports.

It is important to note that there is no rainfall network in the country that allows monitoring rainfall. This meteorological variable is one of the main ones to consider when assessing the impacts of climate change. In Equatorial Guinea, its need is much more marked given the country’s dependence on water resources for power generation, especially in the mainland.

On the other hand, Equatorial Guinea is a country with more than 644 km of coastline and with an insular part (Bioko, Annobon, Corisco and the Elobeyes among the main ones), however, there is no station that monitors the state of the sea in the different coastal areas of the country. In the Economic Exclusive Zone (EEZ), with more than 314, 000 km2 of territorial waters where ships of different nationalities and cargo operate, information on the state of the sea and the atmosphere is also recorded.

The lack of extensive and reliable meteorological data of the meteorological variables, of the air quality and the lack of an institution that has the functions of meteorological surveillance, of the climate, of the general composition of the atmosphere, hinders not only the progress of atmospheric sciences, but also the sustainable development of the country.

7.2.2 Air quality

In Equatorial Guinea there are no scientific studies that demonstrate air quality. Taking into account the development experienced in the country after the start of oil exploitation in the late 1990s, it can be presumed that the main polluting sources are associated with:

- Automotive transport: the experienced economic boom has led to the massive import of fossil fuel consuming cars. The lack of urban public transport must also be considered, which increases the tendency to use individual transport to the detriment of air quality, especially in urban areas. Internationally it is known that the main chemical contaminants associated with transport are: Carbon Monoxide (CO), Nitrogen Dioxide (NO2), Sulfur Dioxide (SO2), and Particulate Material in Suspension (PMS).
- Energy and Industry Production: The power generation industry in Equatorial Guinea is mainly hydroelectric, so the pollution levels associated with it are low. Among the main air polluting industries is the oil extraction and construction materials industry. With respect to the first among the main pollutants, the following stand out: Sulfur Dioxide (SO2), Nitrogen Oxides (NOx), Suspension Particulate Material (SPM);
- The construction materials industry: Procedures severe alterations to the soil and its properties, loss of flora and fauna, landscape etc. Among its main pollutants to the atmosphere are dust, noise and vibrations emitted, although it also affects surface and groundwater;
- Biomass burning: It occurs mainly in rural areas, associated mainly with two factors: the clearing of forest for extensive family farming and to obtain the fuel used by most of the population located in these areas. Among the main polluting compounds are: Particulate Material in Suspension (PMS), Carbon Oxides (CO and CO2);
- Noise: It is evident in urban areas mainly associated with automotive transport and sound equipment of entertainment venues and outdoor music

The air quality in the country is also affected by natural sources, such as Harmattan (wind that carries dust from the desert with less than one hundred thousandths of a millimeter in diameter), creating a fog that hides the sun for days. This powder produces an increase in Acute Respiratory Infections (ARI), conjunctivitis and irritability in people. Also, the emissions of Basile Peak on the island of Bioko, which has had sporadic eruptions that have been recorded from 1897 to February 2013 (last recorded eruption occurred in the Cupapa area) with visible emissions of volcanic gases. Of more recent dates no any other eruptive facts are known of.

7.2.3 International contribution

Despite the lack of a National Meteorological Service in Equatorial Guinea, the country contributes with the limited information it has to the global exchange of meteorological data through ASECNA. Outside this little exchange, the country neither provides nor receives information from the main data collection networks of the Hydrometeorological Observations of the World Meteorological Organization (WMO), such as the World Meteorological Surveillance (WMS) network, Global Atmosphere Surveillance (GAS), of the Global Climate Observation System (GCOS) and the Global Ocean Observation System (GOOS).

Regarding air quality, the country does not participate in the program of the Global Monitoring Network of the Air Pollution Fund (GMNAPF), nor does it have control over the main sources of trace gases (nitrogen compounds, sulfur and carbon) primarily responsible for climate change. The country also

does not participate in other international atmospheric state monitoring programs such as those referring to measurements of atmospheric ozone, trace gases, water vapor and Ultraviolet (UV) radiation among others, nor of air quality control in cities and towns such as recommend exchange protocols between WMO and WHO.

7.3 Scientific research

The concept of industrial development that prevailed until the first half of the 19th century on the growth agendas of most countries was the intensive exploitation of natural resources. This hypothesis established the transformation of natural resources into economic resources, without taking into account the protection of the environment.

It is not until the twentieth century that ecological issues begin to be the patrimony of numerous groups. Of course, their approach to this problem has differed according to the cultures, traditions and needs of each group. As man affirmed himself as a substantive identity against nature, he began to assume an anthropocentric attitude that has not been lost to this day. This "past" reality led to a linear interpretation of development.

The alternatives of development worldwide that were given in the 90s of the twentieth century seek to conclude a new image of development and the problems associated with it. Ecology has ceased to be the heritage of academic sectors to become one of the important bases for global level decision making and policy formulation. It is therefore a matter of the state of development of scientific of scientific research in all sectors, considering the principles of sustainable development wielded since 1982 that the World Commission on Environment and Development has created.

From here, for the sake of this "Common Future", lines of increasingly progressive development principles were drawn up and in The World Conference on Environment and Development (Rio-91) the problems of the large dispossessed majority were raised. Since then, 27 principles of ethical and philosophical character were established, based on the human being as the center of the concerns directed to look for a development model in harmony with the environment.

In the current circumstance, there is complexity of the problem given by the serious deterioration that the planet has suffered with its corresponding negative consequences for life in general and the human species in particular. The concepts of economic and social development today are based on the preservation of the environment form the perspective of scientific knowledge. Science if the engine and guarantor of the new economic development model that is needed today, to raise the quality of life of the population while preserving nature.

Scientific research is very scarce in Equatorial Guinea, and the existing one is mostly linked to higher education centers. Most of these are undergraduate degree theses which in many cases do not correspond to the real scientific needs of the country or after they are carried out, they are not applied or replicated in the rest of the country. There is also in these educational centers scientific exchange with other universities, mainly, North American and Spanish that unilaterally or jointly finance research projects aimed primarily at the protection of the environment.

On the other hand, state institutions also carry out scientific studies int their areas of competence, mostly linked to research projects, in some cases financed by the government itself; by international organizations (UNDP) or Non-Governmental Organizations (NGOs). In this regard, the Scientific and Technological Research Council (CICTE), an entity responsible for managing research at the national level, exists at the Government level. In practice, the organization needs to improve its ability to encourage, coordinate, manage, disseminate and sensitize scientific activity to tall social strata as an engine of economic and social development in the country; guarantor of the rational use of natural resources and the application of technologies compatible with the environment.

7.3.1 Potential impacts of climate change in Equatorial Guinea.

According to PANA (2013) Equatorial Guinea is highly vulnerable to climate change. In the first place, given the magnitude of the expected impacts and secondly due to the country's low capacity for adaptation related to high poverty rates, the unequal distribution of resources and the lack of sustainable implementation of its development plan.

In Equatorial Guinea the observed changes and future climate scenarios show the evolution to a warmer, drier and extreme climate, with a significant increase in the mean sea level. This change in climate will cause important impacts on health, agriculture, forests, water resources, coastal areas, and on species and protected areas. Therefore, given the climatic reality, the priority of science is to develop "resilience" to climate change through the integration (mainstreaming-mainstreaming) of projects, strategies and policies (local, national or international) to reduce risks to current impacts and expected.

According to Trosper (2002), resilience to climate change must be aimed at developing in society: the ability to cushion alteration; the ability to organize and the ability to learn from the situation created and adapt. At present, most of the research carried out is aimed at cushioning the impacts of climate change, they have "in themselves" mostly a reactive nature. The Equatoguinean society has not developed the capacities at present to organize itself to face climate change and draw experiences of what is happening and adapt.

The potential impacts on the different socioeconomic sectors of the country were identified in the PANA (2013). Many of the actions subsequently carried out by the government aimed at strengthening resilience took into account the impacts identified above.

Currently, some Research and Development (R&D) projects are being carried out in the so-called priority sectors whose objectives is mitigation measures or adaptation to climate change. Among these can be mentioned:

- <u>Forests and Biodiversity</u>
    - Bioko Biodiversity Protection Program;
    - Projects for the creation and maintenance of protected areas in the country;
    - REDD+ Project for the conservation and management of forests;
    - Project for the study of desertification and drought;

- Biodiversity project;
- Study of the impact of migratory movements from rural areas to cities;
- Projects of ecological tourism programs;
- Projects for the reduction of forest meat in markets;

- Agriculture
  - Development of the National Food Security Plan (PNSA, 2012);
  - Project for granting loans to women farmers;
  - Project of investigation of the relation height-weight in the island of Bioko;
- Fishery
  - Inventory of the existing economic species throughout the EEZ;
  - Project of development of aquaculture, mariculture and fish farming;
  - Projects for industrial exploitation and sustainable fishing;
  - Projects for training human resources in the sector;
  - Impact of climate change in fisheries.
- Infrastructure and Construction
  - Projects for urban development and social protection housing;
  - Investigations on infrastructure with low carbon footprint;
  - Construction of the new National University of Equatorial Guinea (UNGE);
  - Studies of impact on the infrastructure of coastal areas;
  - Project of drinking water supply for the city of Malabo;
  - Project of sewage canalization for the city of Bata and Malabo;
- Energy
  - Programs for the development of "Clean Energies" and energy security in Equatorial Guinea, mainly in isolated areas such as Annobon and Corisco (SE4ALL);
  - Study of the impact of climate change on water resources;
  - Study of the impact of the use of fossil fuel in electricity generation;
  - Study of the waste management generated in the Equatorial Guinea Liquefied Natural Gas (EG.LNG);
  - National Plan "Energy for All";
  - Project for the preparation of an Electricity Law and its implementing regulations.
- Water and Health
  - Studies of the impacts of climate change on human health;
  - Studies of the impacts of pollution on human health;
  - Training of human resources in the health and water sector;
  - National plan of "Water for All;
  - Education and awareness campaigns on waterborne diseases.

7.3.2 Impairment of the environment

The activity carried out by man at a global level in order to achieve economic and social development has resulted in a deterioration of the natural environment, of increasingly widespread and serious dimensions. These impacts are magnified in those areas with large concentrations of people such as cities and in those from which the natural resources necessary to meet the growing needs of citizens are extracted. In this sense, the two main lines of research in Equatorial Guinea move:

- Identify the main causes of environmental deterioration in cities and propose the corresponding corrective measures and;

- The sustainable transformation of natural resources into economic resources.

In the main cities of the country (Malabo and Bata) the deterioration of the environment is closely related to the increase in population, poverty, overcrowding, unhealthiness, urban disorder, lack of access to drinking water, precarious constructions, etc. All this has as background the weak application of public policies and a lack of awareness and education in all social spheres.

The legal and institutional framework that protects the environment exists, and may be subject to modifications and improvements, but its implementation is currently deficient and should be encouraged. With respect to natural resources, there is still an unsustainable use of them in the country. Among the main effects is the transformation of forests into farmland, deforestation, poaching and indiscriminate extraction of fauna and flora, destruction of the landscape and other cultural and religious values.

In the work of Engonga (2011), the four main environmental problems in Equatorial Guinea are identified according to the author: pollution of water, soil, air and the human residential environment; degradation of solids and vegetation cover; loss of biological diversity and decrease in the availability of basic resources for the national economy.

At present, all present and expected impacts of climate change have the aggravating effect of the underlying environmental deterioration, poverty, unhealthiness and food security increase the risks of the most vulnerable groups such as the poor, women, children and the elderly. To reduce the aforementioned risks, the entire scientific policy of the country must be directed, integrated into a National Environmental Strategy for climate change resilience.

7.3.3 Sustainable Development

The government of Equatorial Guinea in the international sphere has signed and/or ratified more than 20 agreements in the field of environment or sustainable development, promoted by the UN according to the Rio + 20 Report (2012). However, according to this report there are problems in the implementation of the commitments made internally on the one hand and on the other, the environmental laws that have been issued have a sectoral and corrective nature. It is necessary, then, to address environmental problems with an integrative vision between international and national legislation, in order to obtain a seamless regulatory framework that is complemented by permanent and effective control. However, sustainable development is closely related to other factors that are not environmental, such as social and economic. Thus, to achieve sustainability there must be a harmonious balance in the development of environmental, economic and social factors, Figure 7.2.

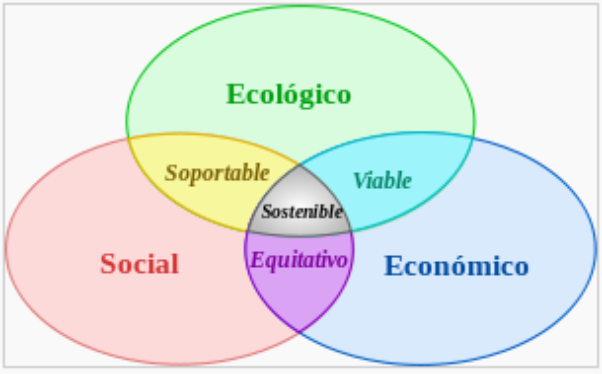

Figure 7.2. Pillars of "sustainable developments" (economic, social and ecological) according to the United Nations Environment Program (UNEP).

Science is currently a transforming agent of society, and the role it has played in government and academic awareness of the social and natural dimensions of current technological change and its environmental impact is recognized. In this sense, in recent decades they have been a tool and a stimulus to jointly with citizen participation develop public policies on regulation of technological change and environmental protection. An example of this are: clean electricity generation technologies; smart constructions with low carbon footprint (CO); refusal and recycling to pollute less. In summary, the development of science and technology is extremely important for sustainable development. All this in a framework of economic growth and improvement of people's standard of living, of ecological and social conditions so that development lasts over time. In this sense, let's see what the status of some sectors is:

- Energy

In Equatorial Guinea, steps are taken in the application of new technologies (renewable sources) in the development of electricity generation. Regardless, the main source of energy in the country is hydraulics, which is not very polluting. A solar park is built in Annobon with a generation capacity of 5 MW and small parks have been installed in isolated places for private use such as at the Basile peak.

In the rest of the country it is important to develop research that allows predicting what the hydrological scenario will be in the face of climate change in order to develop alternative energy sources if necessary. The future climatic scenarios for the country show great uncertainty in the field of rainfall, while in temperatures there is marked increase which would lead to a significant increase in electricity demand. It follows that the search for new sources of renewable energy is an imperative need for sustainable development in Equatorial Guinea.

- Infrastructures

There is much to do in this sector in the country, regardless of the one with the greatest progress and resources allocated. And what to do is not in the quantity, nor in the size or complexity of the works, but in the principle of sustainability. This principle is because every work built must be conceived within a territorial order and a previous study of environmental impact, something that some works promoters currently do not comply with. Secondly, every work to be build must:

- Insert into the environment with the least possible landscape and ecological impact;
- Use low carbon footprint construction materials and prioritize the 3 R Principle (recycle, recover and reuse);
- The use of renewable energy;
- In the case of homes or public buildings (smart buildings) sustainable waste management.
- Certify construction companies that comply with the above principles to stimulate their hiring.

It is very important to consider in the plans and designs of the infrastructure the Disaster Risk Reduction (DRR) that may occur in the country, whether of natural or anthropic origin. These plans strengthen resilience to the occurrence of potentially destructive events of infrastructure, especially the case of Equatorial Guinea of those located in irrigation areas such as coastal areas of flood areas and on the slopes of the mountains.

- Food

The country is highly vulnerable in the food sector. There is no food security and much less food sovereignty and this is reflected in the PNSA (2012) and PANA (2013). In both documents, the situation of the country in the food issue is thoroughly analyzed and different solutions initiatives with a sustainable principle are presented.

In the fisheries sector, another of the most important in its contribution to people's food and despite the great potential of available resources in the country does not currently satisfy the existing demand. In the PNDES 2020 (2007) the main lines of development of the fishing sector were drawn up to diversify the economy and exploit marine and river resources in a sustainable way. The development of this sector not only allows the population to increase food sources and nutrients, but also to be a source of employment and a means of relieving pressure on systems such as the forest in the acquisition of wild meat. This vision was reoriented and updated in the Fisheries Plan of Equatorial Guinea (PEPGE, 2016).

In another important aspect, the country makes progress in the development of the food industry of conservation and industrialization. This would allow to conserve an important part of seasonal foods throughout the year, at the same time as it would boost the production and commercialization of the products.

- Social

Despite the advances and efforts of the government, there are many and complex social problems that remain today in Equatorial Guinea, according to PNDES 2020 (2007).

In the research carried out in PANA (2013), the country had the highest income in Central Africa that year, however, 77% of the population lives in poverty, 57% do not have access to drinking water and the 16% of children under five suffer from chronic malnutrition. Regarding the situation of women, discrimination persists, especially in matters related to marriage, family life, property and inheritance. According to PEDSGE (2011), 63% of women say they have been victims of physical violence at some time in their lives, 32% have been victims of sexual violence and 65% in the Continental Region, 71% in the islands, have experienced some form of domestic violence.

In the 2018 United Nations Report, Human Development Indexes and Indicators, the Republic of Equatorial Guinea is among the countries of a "medium development" in the 141st place (Human Development Index of 0,591). According to this report, life expectancy at birth is 57,9 years and the average expected years of schooling are nine, while the average years of schooling are 5,5.

- Human health

In Equatorial Guinea, progress has been made in the human health sector, but the situation is still fragile for most of the population. If we consider that the World Health Organization (WHO) defines health as a "state of complete physical, mental and social well-being and does not consist only in the absence of conditions or diseases," we can understand how dissimilar the causes are that condition it. According to the GEO Cities Agenda 21 Project launched by UNDP in 2001, the main health problems that afflict the world population have as their main cause poverty, accelerated population growth and consumerism in some countries that they maintain inappropriate development styles.

To solve these problems, once must work in the country to achieve sustainable development in the sector, in which internationally according to Schaeffer (1994) the main environmental factors that affect human health are:

1. The supply of drinking water and sanitation;
2. Environmental pollution;
3. Housing and habitat;

4. Accidents and traumas on the roads (mainly associated with alcoholism);
5. The diet;
6. The use of chemical products;
7. Occupational risks.

In Equatorial Guinea the first four factors have the main environmental weight on the deterioration of human health, although the effect of the others increases significantly over time, for example: the use of uncontrolled chemicals for agriculture.

In the country, the development of environmental health[20] should be prioritized with a strategy that enhances the activities of basic sanitation and environmental quality, with a "holistic" approach, since preserving health is a multidisciplinary issue that involves "everyone".

7.4 Limitations

Equatorial Guinea is one of the few countries that does not belong to the World Meteorological Organization (WMO), nor does it have a network of meteorological or hydrological observations. Such a situation is not appropriate considering the need for studies on weather and climate, at the present time when climate change represents the main environmental challenge facing humanity in the present century.

The availability of reliable and long-standing meteorological data from across the national territory would provide the bases for studying climate can weather on a fine scale, as well as climate change and its impacts on the national territory. The absence of a National Meteorological System (NMS) prevents the provision of meteorological services to all spheres of economic or social activities carried out by man, mainly those most dependent on elements such as agriculture, fishing, water management, etc. This situation also has an impact on risk management due to the impossibility of creating Early Warning services for dangerous weather events, forest fires, floods, etc.

[20]**Environmental health**: According to the WHO it is that part of the environmental sciences that deals with the risks and effects that human environment represents the environment that inhabits and where it works, the natural or artificial changes that this place manifests and the pollution produced by man himself in that environment.

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Chapter 8

Chapter 8. Capacity Building, Education and Public Awareness

8.1 Introduction

The response to climate change involves all spheres of society, hence the importance of implementing and developing awareness and education programs regarding the impacts that affect Equatorial Guinea and adaptation and mitigation measures to address it. The subject in question is known in the country, but in a general way and in many cases not correctly.

In Equatorial Guinea there are few professionals who have in their training atmospheric sciences, meteorology and other sciences related to climate change. In fact, the country does not have a National Meteorological Service, which makes it difficult to have extensive and reliable databases as well as trained personnel.

In this sense, the National University of Equatorial Guinea (UNGE) has been making progress. It has in its curricula the problem of climate change, mainly linked to the study of Environmental Sciences. In no other career is such a problem taught, and although it is approached very briefly in the Baccalaureate (Higher Secondary Education), it should be extended to other levels of education and deepen the subject.

In the media, the problem regarding climate change is scarce, and in many cases, it is not addressed by experts on the subject or by qualified personnel. So public awareness regarding the issue is still at a low level for current needs, which should be taken into account when drawing up strategies to combat climate change.

There are, therefore, in the treated aspects two great challenges to overcome to face the climate in Equatorial Guinea. Firstly, develop national capacities and, on the other, raise awareness and educate national public opinion and decision makers on the problem of climate change. In this sense, it is also a challenge to link the business sector, mainly to the SMEs (Small and Medium Enterprises) given the relationship they have with the population at the local level and for their contribution to the economic and social development of the country.

On the other hand, the National Office of Climate Change (NOCC), still under development, is responsible for coordinating all information on climate change prepared in the country, as well as its official disclosure. Its scope is still incipient, given the scarce human and financial resources necessary to do its work at the desired level. This chapter mentions some of the actions carried out in Equatorial Guinea aimed at building capacities and raising the general culture of the population in relation to climate change as established by the UNFCCC in its article 6.

8.2 Technical capacity building on the issues of climate change

8.2.1. National initiatives and efforts

Equatorial Guinea is a country identified with the solution to the environmental problems that currently exist worldwide. His government has ratified all (20) of the Environmental and Sustainable Development Conventions promoted by the United Nations (UN). Among the conventions that the country has signed and/or ratified are the Convention to Combat Desertification and Drought; the Convention on Biological Diversity and the United Nations Framework Convention on Climate Change (UNFCCC). In relation to the first two, there have been training processes for personnel involved, strengthening institutional capacity and improving the quality of life of the population. With respect to the UNFCCC, the Republic of Equatorial Guinea has signed and ratified the Paris Agreement, this integrating the group of countries that strive to combat climate change.

In the preparation of the First National Communication (FNC) on Climate Change, actions have been carried aimed at training Equatorial Guinean experts on issues related to climate change, and the methodologies and methods of preparing National Communications in general. Training workshops have been developed on topics related to methodologies for inventories of Greenhouse Gases (GHG). In other areas of knowledge related to climate change in the professional sector, progress has been made, but they are still insufficient for what the country needs immediately in such a problem.

The economic advances experienced by the country since the first years of the 90s, following the discovery and exploitation of important oil fields increase their GDP significantly. Period in which significant progress was made especially in infrastructure, social housing, construction of public buildings, hospitals, increase in electricity generation and transformation, as well as the distribution of drinking water in cities and inland areas. With the global economic crisis, from the years 2015-2016 Equatorial Guinea has been involved in a process of economic recession which has affected access to its sources of foreign exchange mainly due to the fall in oil prices. This situation has had an impact on all actions related to training and education plans in the environmental sector from the institutional sector.

Despite this, the country has built a new university with great effort on the mainland: the African-American University of Central Africa, where national and foreign professionals will be trained in careers related to Environmental Sciences.

Therefore, in Equatorial Guinea the difficulties in training sensitization and education regarding climate change, are not due to lack of funding or political will, it is a problem to adequately prosecute the management of the country's potentialities, on the one hand and on other hand to overcome the existing administrative obstacles.

It is important to highlight, international cooperation with governments and/or Non-Governmental Organizations (NGOs), on issues related to climate change mainly developing adaptation programs, especially in rural areas, considered among the most vulnerable to climate change. With respect to mitigation, different actions are carried out, including the implementation of renewable energies and the increase in forest areas (carbon sinks) as protected areas. In all these projects, training and awareness programs have been carried out for the officials involved as well as for the population in general.

Regarding national NGOs that are involved in the environmental sector, it is necessary to intensify the role they play as well as diversify their actions. Among those currently continuing to collaborate with the government for the protection and conservation of the environment, as well as capacity building, we can mention:

- ANDEGE (Friends of Nature and Development of Equatorial Guinea); AMIFLORA (Friends of Flora); ADELO (Action for Local Development); ASAMA (Association for the Support of African Women and the Environment); ECOGUINEA (Ecosystems of Equatorial Guinea); MAySER (Environment and Reproductive Health) among others.

8.2.2. Collaboration with the National University of Equatorial Guinea (UNGE).

The UNGE embodies a national program that trains Equatorial Guinean personnel and, why not, the region in careers related to climate change. For this purpose, basic subjects such as meteorology, climatology, environmental pollution and descriptive meteorology of the tropical zone have been introduced. These new subject programs have been implemented as part of a collaboration plan between UNGE and the ministry overseeing environmental management and responsible for capacity development according to the needs of the country.

The teaching of subjects such as those mentioned above allows Equatorial Guinea to have an elementary staff trained to develop the foundations of a National Meteorological Service in charge of the observation, surveillance, and study of the country's weather and climate. It is not ideal, but steps are taken to reach the moment to start an elementary service.

In the university institution other programs related to climate change are developed, not linked to the observation and monitoring of weather and climate. These programs are mainly aimed at the conservation of biodiversity and forest resources, mainly two sectors considered by the IPCC (2007-2013) vulnerable to climate change. An example of this collaboration is the one developed with Drexel University of the United States, in the protection of Monkey Dril on the island of Bioko. The Bioko Biodiversity Protection Program (BBPP) is also currently being developed with the National Institute for Forestry Development and Protected Areas Management (INDEFOR-AP) and the United Nations Program for Development (UNDP) as entities that together with UNGE) manage this research.

It is important to highlight the role played by ASEGNA (Agency for Aerial Navigation for Africa and Madagascar), which monitors the weather in the airports of Equatorial Guinea. Some of the professionals working in this entity collaborate as professors at UNGE, contributing their vast experience and knowledge to students in subjects related to climate change and meteorology in general.

At UNGE, academic exchange plans with other universities are developed, such as those carried out with the Spanish university of Alcala de Henares since the late 1990s. These programs are mainly aimed at raising the academic level of teachers primarily in environmental matters, between which include issues related to climate change.

In general, the plans and programs that are developed in the UNGE, have not included in them until today the training and qualification of professionals related to climate change that could soon take the reins of the country in that sense. There are also no training plans for these professionals in academic

exchange plans or scholarships in foreign universities. This situation is very worrying, since the infrastructures of a service of surveillance, monitoring and study of weather and climate, at least in Equatorial Guinea could be done in a relatively short time, but the training of its staff requires much more time. In that sense, the country lags behind even with respect to the countries of the region. For this reason, it has been proposed to the ministry in charge of Environment and UNGE jointly develop a teaching program so that in the shortest possible time the degree in meteorological sciences is implemented in the department of environmental sciences.

8.2.3. National Climate Change Adaptation Action Plan (PANA)

Since the beginning of 2013, the United Nations Development Program (UNDP), in the framework of supporting the development of the National Climate Change Adaptation Action Plan (PANA), evaluated the country's impacts and vulnerabilities to this environmental problem caused by "humans".

This project develops a series of recommendations and priority activities that must be executed by the government of Equatorial Guinea to reduce the country's vulnerabilities to climate change in the shortest possible time. As part of the activities carried out in this program, actions were carried out to educate, sensitize and inform the population and decision makers, mainly in those areas most vulnerable to face the impacts of climate change. In this sense, a program of workshops, colloquiums and conferences throughout the country was carried out, prioritizing the most vulnerable areas and the greatest citizen participation.

It is good to inform that, within the framework of the execution of this program, general cognitive capacities on climate change were developed, but no qualified personnel were trained in this regard.

8.2.4. GEF/UNDP Project "First National Communication of Equatorial Guinea to the UNFCCC"

The First National Communication of Equatorial Guinea to the UNFCCC began in 2009 with funds from UNDP. This document shows the current state of Equatorial Guinea to face climate change, allowing the identification of weaknesses and opportunities in the country to face the most serious environmental problem facing humanity today: climate change.

Within the framework of this program, a series of actions have been carried out aimed at developing national capacities for the implementation of this type of projects. For this, a series of workshops, conversations and exchanges have been given in which Equatorial Guinean specialists have been trained to lead the working groups, as well as develop the consultancies required by the document. For the development of these activities, we have had the collaboration of national experts trained both inside and outside the country; from expatriates of different nationalities including Cuban collaborators assigned to the ministry of environment.

As part of this project, an awareness, education and information campaign were carried out in the media whose main objective is to raise the culture of the population on issues related to climate change. Among these actions a group of conferences have been developed, discussions and round tables on issues related to climate change, in vulnerable communities and sectors of the population throughout the national territory. These exchanges are very beneficial for both the neighbors and the facilitators, as

it allows them to be in contact with the citizens' problem at the grassroots level and design adaptation and mitigation policies with knowledge of the cause.

8.2.5. International Collaboration

In Equatorial Guinea, several international NGOs work with an environmental profile that have developed training, awareness and education activities on issues related to the impacts of climate change, mainly on biodiversity and forests. In this regard, the activities carried out by Conservation International (CI) until the middle of this decade were highlighted. This organization executed workshops, seminars and conferences to sensitize, educate and train Equatorial Guinean personnel on issues ranging from the preservation of endangered species to implementation of mitigation policies managed through REDD+.

Wildlife Conservation Society (WCS) was established in 2012 in Equatorial Guinea, and since then works closely with INDEFOR-AP, supporting the conservation of coastal protected areas of the Continental Region. This has allowed the strengthening of the communities, with the creation of alternative activities, offering inputs for the promotion of agriculture, fisheries and other activities that help them better adapt to the impacts of climate change. The WCS project is funded by the Noble Energy oil company, as part of its efforts to improve the quality of life of the Equatorial Guinea population.

At the regional level, the Central African Forest Commission (COMIFAC) has been developing research and development projects on issues related to climate change and its impacts on forest ecosystems. Among the actions carried out is the training of its technicians, mainly those found in logging areas and/or in afforestation or reforestation areas. The main exchanges of the sector have been carried out with the neighboring countries of Cameroon and Gabon.

Among the international organizations that collaborate with the government on environmental issues are the United Nations Development Program (UNDP); the United Nations Environment Program (UNEP); the United Nations Framework Convention on Climate Change (UNFCCC); the United Nations Food Organization (FAO); the Global Environment Facility (GEF); The Green Climate Fund (GCF) within the UNFCCC; the World Bank (WB); etc.

In international cooperation, Equatorial Guinea has established multiple bilateral or multilateral agreements with different countries on issues related to the environment. In this regard, it has maintained close collaboration with the Republics of China, France, and Cuba, as well as with the Kingdom of Spain, the United States of America, among others.

At the business level, private groups working in Equatorial Guinea (oil, construction, gas companies etc.) collaborate in programs related to the environment. In most of the cases in the solution of local problems that directly affect the population or the training of the national personnel in necessary subjects referred to the sector. From the national point of view, the Equatorial Guinean businessmen are not sufficiently involved with environmental issues.

8.3 Education and public awareness

8.3.1 Current status

The issues of education and public awareness on the issue of climate change is a pending issue in Equatorial Guinea. Well, there is much that must be advanced in the subjects to be at acceptable levels to international standards. The teachings in this regard must be implemented within the national education plans if the subject is to be advanced. And there is a contradiction difficult to explain, among the steps taken by Equatorial Guinea on issues related to climate change. On the one hand, at the international level there is a correct projection, aimed at inserting into the agreements that are

happening in the world to combat climate change, but nevertheless they are not disclosed within the country. Therefore, most people, even those linked to the problem, are unaware of the commitments made regarding how to deal with climate change. Such a situation is complicated, given that when signing international agreements in relation to climate change, the country must assume obligations that are strictly enforced, and the state institutions responsible for overseeing such agreements do not perform it.

This situation mentioned above, in the first place undermines the country's credibility with international organizations and, on the other hand, continues to worsen the environmental situation that triggers climate change: the increase in GHG. Therefore, the dissemination of commitments made internationally is a strategic issue in the face of climate change, as it shows citizens that they are part of a global commitment that they must assume.

Despite the above, currently in schools, subjects related to climate change are taught in the middle levels of education. The objective is to ensure that issues related to the environment in general and climate change should start form the first grades of schooling, so that children are trained with the values of preserving the environment, as another ethical or moral value.

The support provided in education and awareness of the aforementioned NGOs and other entities, such as student groups (example: Voice of the Environment), university institutions (UNGE) is important; the ministerial departments (General Directorate for Environmental Conservation /DGCMA), among others.

8.3.2 Future actions

The actions that are planned in the future aimed at raising awareness and public education about climate change and its impacts, must first solve the current problem and, secondly, adapt to the new challenges and opportunities that originate with the development.

Among the actions to take:

- Include in all levels of education the problem of climate change, adaptation measures (to reduce their impacts) and mitigation measures (to reduce GHG emissions);
- Public awareness and education on issues related to climate change must be interrelated with all current environmental issues such as the protection of the ozone layer, deforestation, the use of clean energy, etc. Climate change cannot be considered as an isolated, unique and independent environmental problem;
- Incorporation of the environmental dimension in the sectors: political and social as quickly as possible;
- Decree that the population in the State media be disseminated and sensitized to the current environmental problem;
- Encourage and disseminate citizen participation in the solution of environmental problems at local and national level;
- Design regional and international collaboration plans in the training of media personnel on environmental issues.

  In general, the problems of sensitization, education and training on issues related to climate or environmental changes in general depend on:
- Develop appropriate public disclosure policies;
- Strengthen the legal and institutional framework;
- Financing and advice to develop outreach plans;

- Regional and international collaboration.

"*The basic idea of dissemination is to bring science to the public and help the common man overcome his fears in relation to science*." Manuel Calvo Hernando (1967-present).

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Chapter 9

Chapter 9. Priority Projects and Technology Transfer

9.1 Introduction

The global climate change response strategy is based on two main lines: adaptation and mitigation. Both must be implemented together, as they complement each other. Both must be implemented together, as they complement each other. Although adaptation measures are designed to develop resilience to climate change (reduce vulnerability) and act on the consequences, mitigation measures act on the causes (reduce net GHG emissions). To implement both, you must have a very clear vision of the situation in which the country is in all economic and social sectors to face climate change.

This strategy of confrontation first happens to know in detail the behavior of weather and climate throughout the national territory. Such knowledge allows us to observe the variability of the climate in the country and identify the climate change that may or may not be manifesting. These evidences cause impacts on natural and constructed ecosystems, which can endanger the very existence of life on the planet, at least as we know it today.

The First National Communication of Equatorial Guinea to the UNFCCC, gives a thorough diagnosis of the country's situation to face climate change. It identifies the most vulnerable economic and social sectors and proposes adaptation and mitigation strategies to face the observed changes. This document determines the future climatic scenarios, which together with the impacts observed today help to anticipate potential damage and design coping strategies.

9.2 *Priority Adaptation Projects*

Global climate change is currently the greatest environmental challenge facing humanity. Their impacts are not going to happen, they are happening, and they mainly affect the most vulnerable, such as women, children, the elderly and the most disadvantaged classes. In general, adaptation[21] projects are aimed at reducing vulnerability focused on three fundamental aspects:

- The "Exhibition" (is essentially what is rick from climate change, which is exposed), e.g.: population groups, settlements and infrastructure or natural resources that may be affected by climate change;
- "Sensitivity" (the degree to which a system is affected, both adversely and beneficially, by climate relates stimuli). Climate related stimuli encompass all elements of climate change;
- "Adaptability" (the ability of a system to adjust to climate change, including climate variability and extremes), essentially cushioning impact, reorganizing an adapting.

[21]**Adaptation**: According to the IPCC (2007), it is the adjustment in natural or human systems in response to current or expected climatic stimuli, or other impacts, which reduces the damage caused and enhances beneficial opportunities.

In general, adaptation projects aim to reduce vulnerability, reduce exposure and sensitivity and increase adaptive capacity. According to CARE (2010), the adaptation of human systems is a process that requires the commitment of a wide range of participants acting at multiple levels, in almost all sectors.

In the case of adaptation projects aimed at conservation, it is necessary to add a series of elements and considerations throughout the different phases of its design and execution to take into account the possible effects of climate change on the conservation object, understood as certain species, habitats and /or ecological processes that represent and understand the entire biodiversity of the project, Figure 9.1.

The

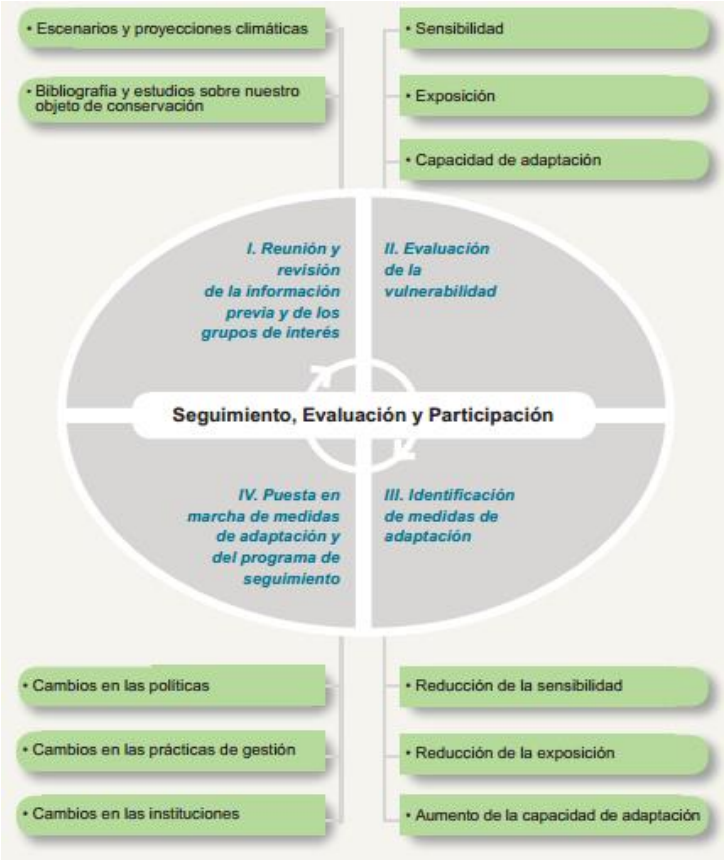

Figure 9.1. Representation of the Adaptation Management Cycle, according to WWP (2012).

analysis set out in the aforementioned figure can be taken into account not only for adaptation projects aimed at conservation, but for everyone in general as the impacts of climate change affect all socio-economic sectors. The following aspects must be included in your work protocol:

- Analysis of vulnerability to climate change: identification and assessment of the present and potential impacts of climate change;
- Development and implementation of climate change adaptation measures understood as actions to increase the resilience of the conservation object to climate change;

- Involvement of the relevant actors form the early stages of the process as a fundamental aspect for success in integrating the adaptation approach in conservation projects;
- Integrated approach: the inclusion of adaptation must be carried out taking into account the conservation of nature and the sustainable development of local communities.
- Establishment of monitoring systems to assess the responses of ecosystems and local communities to the impacts and adaptation measures designed.

Regardless of whether the main objective of adaptation projects is to reduce vulnerability, they also differ from each other based on the type of impact it acts on: whether it is a potential[22] or residual[23] impact; if executed by the government or private institutions. Based on this, they are classified as shown in Table 9.1.

Table 9.1. Classification of Adaptation Projects according to the vulnerability associated with different types of impacts and the nature of the executor.

Classification of Adaptation Projects	Characteristics
Preventive	They are intended to avoid the effects of an expected or known impact, eg: the increase in temperature leads to the appearance of pests and diseases in crops. The preventive measures are aimed at the search and implementation of more resistant and/or productive varieties under the new climatic conditions.
Reactive	These are adaptation measures that are implemented as a result of an impact on natural and/or human systems, for example: the increase in sea level causing the destruction of coastal areas and the infrastructures located there.
Public	These are the adaptation measures that the state implements independently or in collaboration with non-governmental organizations, e.g. projects to increase the productivity of crop areas, by delivering resources technologies to farmers with payment facilities.
Private	The adaptation measures implemented by the common citizen, NGOs and private companies, e.g.: protection of sea turtles in the southern part of Bioko Island.
Planned	They can be any of the above that is expected within the country's adaptation plans or by entities, citizens or organizations without being involved in national strategies.
Autonomous	They can be any of the above that is executed outside the country's adaption plans.

In Equatorial Guinea, according to the results obtained in the PANA (2013), there are some projects underway and others in the portfolio aimed at reducing certain vulnerabilities in the country, but there

[22]**Potential Impact**: Any impact that could occur in relation to a projected climate change, regardless of adaptation, according to IPCC (2013).
[23]**Residual Impact:** Any impact that remain following the implementation of the mitigation measures proposed, according to IPCC (2013).

is not integrative strategy that draws priorities on adaptation issues: a National Plan of Adaptation -PNA. The PANA (2013) represents the fist national effort to identify the impacts of climate change, assess vulnerabilities and propose adaptation measures in the most vulnerable sectors. Its main objectives were:

1. Develop strategies, policies and adaptation measures in Equatorial Guinea based on a plan of priority activities that address the urgent and immediate impacts of climate change.
2. Attract a wide variety of stakeholders from the country and foster a PANA process driven by specific national circumstances on vulnerability and adaptation (V&A).
3. To improve the institutional and technical capacities of Equatorial Guinea to face the consequences of climate change.
4. Develop links with palliative mechanisms and previous or existing environmental initiatives.
5. Sensitize society and decision makers on climate change.

Taking as experience the proposals made of priority projects from the base, in a participatory manner of all the economic and social sectors made by PANA (2013) and those estimated in this document, the proposal of some projects considered as such to promote resilience to climate change in Equatorial Guinea. The adaptation to the expected impacts of climate change is "inescapable" in order to implement sustainable development in the country.

9.2.1 Brief review of each one.

In this chapter, a group of Priority Projects are proposed, which differ from those proposed in the PANA (2013). However, regardless of these differences, in both proposals four strategic integration considerations are considered, which are shown in Table 9.2.

Table 9.2. Strategic considerations that are integrated into the priority projects proposed in the PANA (2013) and in this document.

The integration of policies, implementation and institutional strengthening	Incorporation of climate change considerations into high level policies, programs and processes of decision making, as well as the strengthening of institutions towards a more integrated management of climate risk.
Pilot tests of innovative demonstrations	Demonstration of innovations through initiatives carried out, which aim to improve the adaptability of existing mechanisms.
Capacity development, education and public awareness	Improve technical capabilities through innovative methods of adult learning, the integration of climate change considerations into national education programs and the development and implementation of communication strategies for public awareness.
Gender mainstreaming	Incorporation of approaches with a gender perspective and strengthening of adaptation approaches instead of continuing with gender roles in communities.

Below are the priority projects considered in this research. For this, the criteria for assessing vulnerabilities at the community level and those carried out by PANA (2013) were taken into account:

1.) Proposal for the creation of the "*National Hydrometeorological Service in Equatorial Guinea*"

This project has as its main objectives the strengthening of the institutional capacity to face climate change, since having this service enables the scientific basis of all the studies on weather, climate and especially on climate change that can be carried out in the country. In this sense, the National Hydrometeorological Services (NHS) and the knowledge acquired in the field of meteorology and climatology, constitute a key piece in terms of minimizing or mitigating the adverse effects of meteorological and climatic phenomena which will contribute in turn to make better use of the climate as a natural resource.

According to the World Meteorological Organization (WMO), the National Hydrometeorological Service (NHS) are, in addition, the instrument to fulfill the government commitments regarding data exchange and essential products with other countries. It allows several investigations related to: climate change, air quality, Early Warning Systems (against forest fires and dangerous meteorological phenomena and sea penetrations among others), safety in navigation (air, naval and road), agrometeorological services, etc.

It would allow to have this service, a very useful weather and climate information for almost all the services provided by man, mainly those most exposed to the environment such as: agriculture, fishing, tourism, among others.

2.) Promote "*Food Security in Equatorial Guinea*"

Despite the enormous economic potential of the country, more than 90% of the food consumed in the country is imported. Hence the need to develop the economic sectors involved in the supply of food such as agriculture, fisheries, livestock and the processing and conservation industry. It is also important to develop projects that enable the creation of employment alternatives in rural areas, linking men and women without distinction of gender to relieve pressure on forests, on which a large part of the population depends. The PNSA (2012) shows lines of development in the agricultural and livestock sector mainly that can promote not only food security, but also nutrition.

3.) Promote the "*Sustainable Management of Water Resources"*

It is essential to develop the institutional capacity of the country's water resources to improve access to water in urban and rural areas, mainly those affected by poverty. The impact of climate change on the country's water sector will be one of the most significant, given the increase in temperatures and variations in precipitation cycles.

Such a situation causes a conflict over the control and use of water resources among the different managers, so there must be an independent institution that processes them at the basin level for the management to be sustainable. In this direction, we must also work on the control of water quality with a monitoring system that does not currently exist. In these times, it has been observed that there is an overexploitation of aquifers, and even bad management has caused their contamination in some populated areas, so that such activity must be regulated and supervised by the state or in which it is designated.

4.) Strengthening and /or develop the "*National Health System, Phytosanitary and Veterinary Surveillance"*

According to the IPCC (2013) the impact of climate change will be significant in natural and human systems. With the increase of the temperature, the plagues and diseases increase, as well as the availability of drinking water and the loss of quality of the same ones will cause an increase of the diseases that are transmitted by vectors and by the water. The decrease in rainfall will increase the salinization of estuaries and wetlands affecting human health and associated biodiversity.

It is therefore very important to develop projects that allow the health coverage of the whole country with national personnel well prepared for both human health, as phytosanitary and veterinary, especially in the latter areas where there is practically no infrastructure, or related activities.

5.) Implement in the country a "*National Disaster Risk Management System"*

Currently, the increase in natural phenomena considered dangerous endangers the development of any country. Hence the need to develop a System for Disaster Risk Management (SDRM) that allows to trace policies, strategies and actions that reduce risks to current and future natural and human impacts.

It is therefore very important for the development of the country, to develop a document (A Base project) that allows to know the real situation of disaster risk (Hazards, Vulnerabilities and Risks-PVR). This document will define risk scenarios and their conditioning factors, priorities and strategic lines, as well as the main challenges and challenges to avoid economic and social losses, but above all to preserve human life.

6. Develop a *"National Land Management System"*

Especially in cities, mainly in Bata and Malabo for the implementation of urban governance as one of the Sustainable Development Goals (SDGs) No11. They are the places where the world population lives, where poverty is fought and where it generates wealth, where young people or women achieve their autonomy. The availability of territorial planning is an important and basic step for the implementation of all public policies involved in sustainable development and a link to achieve the implementation of the rest of the SDGs at the urban level

9.3 Priority Mitigation Projects

The signing of the United Nations Framework Convention on Climate Change (UNFCCC) of Rio de Janeiro in 1992 by more than 150 Heads of State or Government ratified Climate Change as the main global threat to the environment and the economic development of humanity, previously announced by Houghton *et al* (1996). Given this situation, the Kyoto Protocol (1997) establishes for the first time a road map or legal framework of commitments of the States Parties (SP) for the reduction of Greenhouse Gas (GHG) emissions. These mitigation[24] measures are intended to establish global standards that reduce the causes of climate change and this contribute to the "sustainable development" described by Brundtland (1987).

In general, mitigation measures are intended primarily in two directions. Measures that are intended to reduce net GHG emissions (depletion measures) or those aimed at increasing the fixation Carbon (CO) in land deposits or sinks (capture measures). These measures contribute to reducing the causes of global climate change, which according to the IPCC (2013) will continue to increase in the coming decades despite the efforts made. Hence the importance of developing mitigation projects at the local level, which in one way or another contribute to a global scale to the reduction of net emissions.

For this, the main thing is to establish an inventory of GHGs, to identify the most polluting sectors and the types of pollutants present in them. The knowledge of both situations allows the development of direct measures that combat pollution at the sources (reduction of emissions) through more efficient techniques of new technologies such as the known renewable sources of energy or clean energies, in the case of electricity generation.

[24]**Mitigation**: According to the IPCC (2007), the mitigation measures related to climate change are those carried out by governments, NGO or any component of society aimed at reducing GHG emissions and strengthening sinks.

In another direction that mitigation projects are also being developed is in the direction of increasing CO sinks. This route is very important because it is not aimed at reducing sources, but at reducing the amounts of CO present in the atmosphere. One of the most used forms for this purpose is through the promotion of forest mass, known afforestation or reforestation. It is worth highlighting the REDD+ work (Reduction of Emissions Derived from Deforestation and Degradation) in the conservation of forest ecosystems and soils, as well as in the contribution to local development.

9.3.1 Brief review of each one

The proposed mitigation measures are based primarily on the results of the Greenhouse Gases (GHG) inventory, and the emission mitigation measures set out in chapters 3 and 4 respectively. Below are the priority projects considered in this research that will contribute to reducing GHG emissions in Equatorial Guinea, regardless of whether the country's contribution to these gases is low.

1.) Develop the "*Renewable Energies"*

In Equatorial Guinea, hydroelectric power represents 62% of the country's total generation, according to PANA (2013). In the future climatic scenarios, there is a lot of uncertainty about the behavior of rainfall in the coming years, which puts at risk an extremely important sector for the country such as electricity generation. On the other hand, a significant percentage of electricity generation is form burning fossil fuel, which directly affects air quality and contributes to the increase of GHG in Equatorial Guinea. This situation forces the development of feasibility projects for the use of renewable energies in the country, which would create resilience to the impact of climate change, on the one hand and on the other, the levels of air pollution associated with the activity are maintained, this contributing to mitigate GHG emissions.

2.) Promote the" *Replacement of Energy and Changes in Energy Demand"*

In the country a large part of the population depends to cook the food od the collected firewood, even in the cities. In rural areas, most of the population that depends on this resource uses two methods mainly: harvesting (collecting the dry parts scattered throughout the forest) or cutting (cutting green parts and drying them at home). It is especially in the case of the latter where the impact on forest resources is in some sever areas. This practice is commonly recorded in the coastal towns of the Kogo area in the continental region of the country and is mostly related to the purpose of smoking fish.

It is also important, as part of the project, to raise awareness among the general population to modify their patterns of electricity consumption. In this direction, the replacement of traditional (incandescent) light bulbs with efficient or energy saving light bulbs can be used; changes of highly consuming public lighting for other modern savers and automatic disconnection and efficient handling of household appliances (stand by equipment) among others.

3.) Promote the "*Use of Public Transportation"*

In the country an extensive network of excellent roads has been built that extends to the most remote corners, however in Equatorial Guinea there is practically no collective public transport. In the city of Malabo there is network of small transports that provide services between the capital and the surrounding towns, both to transport people as food and other products. From the city of Bata to the towns of the interior there are lines of minibuses that transport the personnel and their accompanying loads at more less established schedules.

In relation to the subject, it is important that the project that is developed takes into account: the "road system", since the exiting one favors the traffic jams and concentration of pollutants in urban areas and the burning of more fuel; another source of individual transportation, such as bicycles, does not have

habits of use in the country; that cars pass annual gas emissions tests to be able to drive; creation of pedestrian areas and given the large reserves of gas that develops a program of progressive replacement of gasoline with gas or hybrids, among others.

4.) Promote and/or Develop the *"Public Woodland in Equatorial Guinea"*

In spite of the fertility of its soils and abundant rainfall, the country has not developed in its cities a public tree that allows to dampen the heat, provide shade on sunny days and capture part of the CO2 generated mainly by the consumption of fossil fuel in the transportation and power generation. Trees absorb atmospheric carbon dioxide (CO2) along with elements in soil and air to turn them into wood that contains carbon and is part of logs and branches.

Approximately 42% to 50% of the biomass of a tree (dry matter) is carbon which was captured mainly while the tree reaches maturity. The University of Sevilla has carried out a study on the use of trees as CO2 sinks. The report reflects that tree plantations are an effective instrument for the fight against climate change, so that in rural areas a strategy can be drawn up as part of the project to promote reforestation, sustainable forest management and forest recovery, recovery of degraded forest ecosystems such as mining areas of coastal areas, mainly in the southern part of the continental region.

5.) Implement and develop the "*Integrated Waste Management (IWM)"*

Develop a project that effectively prevents or minimizes the risks to humans and the environment caused by industrial and urban waste mainly in Equatorial Guinea. Work should be done primarily on those that are dangerous and that increase GHGs in the atmosphere.

In the country, for example, urban waste from large cities is collected and transferred to landfills, there are no sanitary landfills, so the final disposal of these is inconvenient due to the damage caused to the environment. This type of project can promote the use of gases generated in the decomposition of garbage (methane) as alternative energy source.

6.) Develop" *Sustainable Architecture in the country"*

In Equatorial Guinea, there is currently an accelerated "development" of infrastructure, but most of them do not consider climate risks or environmental considerations in the increasingly growing demand for natural resources. Therefore, it is a challenge for the country to develop sustainable architecture, whose elementary principles are:

- Insert into the landscape (respect for the environment and less possible impact);
- Use products with low carbon footprint (refuse and recycle building materials);
- Use of renewable energy;
- Self-management of generated waste.

It is very important that a territorial ordering be established, as the current model of constructive expansion is chaotic, which accentuates the risk of the expected and remaining impacts of climate change.

7.) Promote "*Climate Smart Agriculture in the country*"

Globally, the climate-agriculture relationship has been remarkably linked since FAO introduced the concept of Climate Smart (ICA) or Smart Climate-Based Agriculture at the World Conference on Agriculture, Food Security and Climate Change held in the Hague in 2010.

In order to address the specific challenges posed by climate change for sustainable food and agriculture, FAO promotes ICA as an approach capable of transforming and reorienting agricultural systems so that

they are effective in supporting development and ensuring food security in conditions of an increasingly changing climate.

9.4 Communication and implementation strategy

In previous chapters, the topic of education and awareness on issues related to climate change and its impacts in Equatorial Guinea has been discussed. Regardless of this, it is essential to develop projects that raise the general culture of the population and of the decision makers on these issues by officially channeling them through prioritized projects. In this sense, a group of projects is proposed that can improve the perception of irrigation as the main premise to face climate change. The following can be mentioned in them:

1.) Promote the "*Training of media professionals in climate change issues*"

The mass media in Equatorial Guinea are not sufficiently developed at present, so they do not have journalists specialized in specific environmental issues. This problem conspires against the quality of the information that the population receives, so in advance, instead of promoting resilience to climate change, it is misinformation.

2.) Introduce the "*Climate Change: Impacts and Adaptation and Mitigation Measures" into the National Teaching System*.

Most of the people in Equatorial Guinea are young, according to the PEDSGE (2011), however they have not received in their educational life any subject that tells them about climate change; its impacts and evidence. Such situation forces to design educational plans referring to the subject that must be treated with the students to elevate their culture and to influence the consequences.

9.5 Technology Transfer

The transfer of technology from the perspective of sustainable development is a complex and multifaceted process. The IPCC (2000) defines "technology transfer"…"as a broad set of processes that cover the contribution of specialized knowledge, experiences and equipment to mitigate and adapt to climate change and that take place between different stakeholders, such as governments, entities from the private sector, financial institutions, Non-Governmental Organizations (NGOs) and research institutions. "According to this report, the term "transfer" is much broader and more general as it covers the diffusion of technologies and technological cooperation between countries and within them. It also covers the processes of technology transfer between developed countries, developing countries and countries with economies in transition. It also includes the learning process necessary to understand, use and replicate technology, including the ability to choose it, to adapt it to local conditions and integrate it into native technologies.

In recent years, the volumes of Foreign Direct Investment (FDI) have increased significantly, including a greater contribution from the private sector. However, in order to make successful transfers between stakeholders, it is necessary to create strong partnerships between them, which must be provided by governments. The main stakeholders include facilitators; the owners; suppliers; buyers; receivers and users of technologies; financial institutions and donors; governments at different levels, international institutions; NGOs and groups.

Regardless of the complexity of the transfer processes, in all of them the needs, the choice of technology, the evaluation of the transfer conditions, the agreement and the implementation must be very well identified. Always valuing and adjusting to local conditions and valuing the possibility of replicating the experience to other areas of the country. Basic stages of technology transfer to

evaluation, agreement, implementation, assessment and adjustment and replication are therefore considered.

There are neither predetermined answers, nor recipes to maintain efficient technology transfers. All processes depend on the characteristics of the country in question and the rest of the interested parties, but without a doubt the creation of capacities, the existence of an enabling environment and the existence of mechanisms for transfer of technologies favor the effectiveness in these complex and necessary processes especially for developing countries.

9.5.1 The transfer of technology to Climate Change

As part of the objectives of the UNFCCC, humanity needs a technological innovation, as well as a rapid and widespread transfer and application of technologies that allow the mitigation of GHGs and adaptation to climate change, according to the IPCC (2018).

Therefore, one of the main aspects that must be addressed in technology transfer process is to reduce GHG emissions and stabilize them as quickly as possible. To achieve this, it is indisputable that changes in the mentality and the way of acting of human beings with respect to nature must be made. Among these ways of acting if they include radical technological changes that modify the patterns of exploitation of natural resources, IPCC (2018).

Current development patterns, based on current knowledge, offer other alternatives to avoid unsustainable development practices of the past. To achieve this goal, it is essential to help developing countries mainly in their human capacity (knowledge, techniques and management attitudes), to strengthen their appropriate institutions and networks, as well as necessary computer equipment. It should always be achieved that the transferred technologies respond to local needs and priorities, which favors first the chances of success and on the other hand that Environmentally Friendly Technologies (EFT) can be applied. These technologies in the current context of sustainable development should further favor the transfer of mitigation and adaptation technology.

9.5.2 Recommendations for sector action

The most necessary mitigation and adaptation technology transfers depend on the country's own conditions. Depending on these intrinsic characteristics, the neediest sectors vary from one country to another, as well as from one sector to another. This particularity of the conditions also determines the main wright or role in the participation of the performers because in some countries it is the government and in others it is the private sector or community organizations, although the ideal is that all sectors participate.

Some EFT actions are recommended below by sectors that have been effective in other parts of the world and focused mainly on mitigation, which makes them more universal. Successful adaptation proposals in other locations must be previously evaluated given their particularities:

Buildings

The most advanced current proposal on building construction issues is aimed at achieving its energy efficiency, minimizing the use of conventional energies in order to save and reduce the associated Carbon footprint:

- *Low energy building*: generically, a low energy building is a type of building that uses les energy than a conventional building or dwelling;
- *Ultra-low energy building*: Minimize the importance of energy for its operation at almost zero levels;

- *Zero energy building*: the energy comes from the same building through renewable energy sources that must be equal to the energy demanded by the building (energy demand= energy generation) ;
- *Energy de plus building*: are those that produce an excess of energy which can be sold or contributed to the general electrical system

Transport

From the technological point of view, we can mention: a better design and maintenance of technologies, the use of alternative or improved fuels (from gas as fuel-hybrids or electric), change in the use of vehicles or changes in modality and alternative transport (increase the use of bicycles and public collective transport). From the non-technological point of view a modern planning of transport management and road reordering.

Industry

The use of new processes, the efficient use of energy and resources the substitution of resources, the substitution of materials, the design changes and the manufacturing of products that allow greater reuse and recycling. The stimulus to agreements between industry and government for the use of EFT. Promote in the public sector the capacity to evaluate technologies and information Distribution Centers so that it is available to the entire sector. Invest to develop local capacities.

Energy supply

Increase the participation of the private sector in the production and management of electric energy, mainly in the use of Renewable Energy Sources (RES). Strengthen the role of banks to encourage investment in the government-backed sector in the incentive for the application of RES in all public and private constructions. Especially in the construction of houses in isolated or remote areas.

Farming/Agriculture

The development of Agricultural Research Bases (ARB) to obtain information on, among others, the improvement of species and crop varieties, irrigation facilities, different plowing and crop management systems, and the treatment of cattle manure, including recovery systems, which can facilitate and promote the transfer of adaptation and mitigation technologies in/and between countries and integration into local solutions. Government should incentivize credit and savings plans in the sector as well as encourage the transfer of EFT in the performance of crops and management of agricultural products. Establish links with the Consultative Group on International Agricultural Research (CGIAR) to promote the flow of information through R+D network models. Implement Climate Smart Agriculture, which implies an approach to develop Food Security in the context of Climate Change.

Forestry

Governments, the community and international organizations and conservationists have played a leading role in the transfer of forest technologies. The transfer of practices such as sustainable forest management (including reduced impact logging, certification techniques and forestry practices), recycling, bioenergetic technologies and agroforestry can contribute to CO2 mitigation.

Some of the actions that can promote the transfer are: clearly defined property rights, participatory forest management, use of financial incentives and disincentives, the optimal use of regulations and the strengthening of monitoring and valuations institutions.

Waste management

National governments can act as facilitators of municipal, private and community-based initiatives. The private sector is playing a growing role in waste management. The participation of community organizations is also increasing, as support is defined between the link between the community support and project sustainability. It is also important that projects give special relevance to the implementation of locally appropriate technologies and minimize the development of large conventional and integrated waste management systems in situations where lower cost and simpler alternatives can be used without compromising the public health of the quality of the environment.

Human health

An operational health system can help cope with the impacts of adverse climate change on health. The transfer of existing health technologies in /and between countries can help achieve that goal. It is appropriate to achieve greater awareness in the population regarding possible health effects, carefully monitor health effects, and provide training to health professionals. Thus, from the point of view of technology transfer, it is necessary to have technologies at national and local level to deal with any change in the level of diseases that could lead to climate change.

Coastal zones

The transfer of technology should focus on proven technologies with a view to adapting the coasts, and autonomous solutions. The restoration and conservation of wetlands are an example of such technologies. The effective transfer of adaptation technologies is part of the integrated coastal management plans or programs, which is carried out with the participation of local experts.

Since coastal management is a public activity, the transfer of technology in coastal areas is driven by the government. Fragmented organizational and institutional relations, as well as lack of access to financial resources, constitute important obstacles to the transfer of technologies for adaptation of the coasts. Coastal adaptation programs, based on a close partnership.

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