

Manuscript Title

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Abstract

The Open NAP master is a general NAP developed based on best available IPCC science and other high quality science products covering sectors and systems typically encountered in development countries when developing National Adaptation Plans. One thing that is obvious from the extensive IPCC 5AR is the immense knowledge of how climate change impacts different systems and sectors, and how similar those impacts are between countries. It is unlikely we will discover new impacts or improve our basic understanding of climate change in order to develop improved adaptation plans. It is also clear that doing more and more generic impact or vulnerability assessments will have limited value - we can now take as is known and accepted that things like droughts, floods etc will have negative impacts, and will get worse as climate continues to change, and that any given system will be impacted by multiple hazards, climate-related and others.

The next frontier seems to be how to use the knowledge we have to design effective adaptation responses. In this exercise, we build on the collective knowledge that exists now, to design a general NAP that can be applied as an entry point for any country.

Executive Summary

The Democratic Republic of São Tomé and Príncipe is an archipelago...

Framework for the NAP

Essential Functions of the NAP Process

The process to embed adaptation into national policies has advanced in both developed and developing countries. Substantial headway has been made in the development of climate change adaptation (CCA) strategies and plans, which include legislation and national strategies. The National Adaptation Plan (NAP) for Sao Tome and Principe will follow a dynamic, iterative approach that imparts elements of continuous learning and improvement. Key to this, is the collection of lessons learned from community-based activities that will address the context-specific elements of climate change adaptation together with emerging barriers and limits to adaptation. Indeed, there is no single approach to adaptation planning due to the multifarious nature of adaptation, and more often a mixed approach of both top-down and bottom-up interactions occurs.

The ultimate objective for Sao Tome and Principe's adaptation planning process is to shift from a project-based system towards a coordinated and coherent approach, across key vulnerable sectors and at all levels. Linkages with local, subnational and national levels of government, incorporating the full participation of a broad range of stakeholders is imperative. Such approaches that lean on the traditional knowledge and technical expertise of the Saotomean society from national government officials and stakeholders to civil society organizations, academia and private sector actors, will stimulate dynamic responses in terms of climate change adaptation options and advance societal goals.

While national governments largely adopt a coordinating role in adaptation planning and implementation, at the state and local levels climate change adaptation responses have diverse processes and outcomes (Mimura et al., n.d.). Local actors face the complexity of adaptation with insufficient technical guidance and data on local vulnerabilities and potential impacts. Yet given the availability of information, local agencies and planners are inundated with adaptation options needed to address future climatic changes (Mimura et al., n.d.). This, coupled with the uncertain outcomes of

their decisions and the complexities of dynamic interlocked systems, highlights the importance of strengthening vertical linkages within government and horizontal nodes between sectors, actors and policies functioning at comparable levels. Furthermore, enhanced action on adaptation should follow a country-driven, gender-sensitive, participatory approach, guided by the best available science and indigenous knowledge, taking into consideration vulnerable groups, communities and ecosystems (National Adaptation Plans, 2012).

The NAP as the Umbrella Programme for Adaptation

The NAP process in Sao Tome and Principe proposes a measured approach towards transforming the country's ability to address climate change adaptation. In spite of gaps such as the lack of a comprehensive institutional framework to set up a coordinated and cross-sectoral approach to adaptation, and the need for a national investment plan to guide climate change adaptation investments, the NAP is veritably integral to ensure a cohesive approach to adaptation planning at all levels. The NAP intends to act as an umbrella programme for all climate change adaptation initiatives, projects and programs. It will enrich the collective actions undertaken and bridge the gaps with respect to climate data and information, capacity building, policy mainstreaming, adaptation finance and monitoring. In Sao Tome and Principe, the current institutional framework to support climate change adaptation include the following actors and their corresponding areas of work:

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The NAP intends to build on Sao Tome and Principe's third National Communication, which complements the adaptation measures recommended in the previous versions of the National Communication, as well as the NAPA and other relevant strategic documents. It will undertake scientific analysis on local vulnerabilities and climate change impacts in key sectors of the economy, including agriculture and livestock, water resources and coastal zones, among others.

Climate Change Adaptation Priorities Identified in Sao Tome and Principe's INDC

Sao Tome and Principe's Intended Nationally Determined Contribution (INDC) spotlights climate change adaptation as a priority for national authorities. It calls for financial resources as well as technology and capacity building support through international assistance, to implement adaptation and mitigation measures. Adaptation measures in the INDC are aimed at improving the country's ability to adapt to the adverse impacts of climate change and as a means to contribute to national development. This rationale takes into consideration Sao Tome and Principe's ecosystem services and its status as a sink of Greenhouse Gases (GHGs) with the capacity to sequester CO₂ from the atmosphere. As a Small Island Developing State (SIDS), the country demonstrates conditions of vulnerability across all sectors of the national economy including agriculture and livestock; forest and soil; water, energy and fishing; coastal zone and population; and health and education.

Contingent on international funding, Sao Tome and Principe pledges to implement the following actions in the short to medium term: (I) strengthen the National Service of Civil Protection and Fire by 2025 to respond to fires and other environmental disasters, increasing resilience to climate change and contributing to social well-being; (II) reduce the number of people living in vulnerable at-risk areas by providing housing in safer areas; (III) develop a national program for sustainable management of forest and agroforestry ecosystems by 2025; (IV) introduce radar reflectors on board all fishing vessels by 2025, to reduce the number of accidents at sea; and (V) train and equip fishermen to ensure safe fishing and proper use of fishing gear.

In conformance with the NAP technical guidelines, the NAP entails a medium- and long-term approach, integrated within national development planning processes and strategies to reduce vulnerability to the adverse impacts of climate change. In the medium to long term, Sao Tome and Principe has committed to implement adaptation activities subject to the availability of international support to subsidize its financial, technological and capacity-building needs. These include actions to: (I) reduce the illegal and indiscriminate felling of trees by 15% by 2030; (II) develop scientific and technical research on adaptation of new productive crop varieties with a broad spectrum of tolerance to adverse climate impacts by 2030; (III) promote forestry/planting of species resistant to dry and low rainfall by 2030; (IV) improve pasture with grazing selection by applying rotation management of the plots by 2030; (V) increase the resilience to erosion and maritime river and storm flooding of coastal areas through improved coastal protection for vulnerable communities; and (VI) reduce the use of nitrogen fertilizers in agriculture by 2030.

Gaps and Barriers to Adaptation as Identified in the INDC

- Limited availability and access to climate change information
- Lack of access to a centralized database
- Lack of capacity building for national experts on specific issues
- Limited access to efficient and modern technologies
- Inadequate technological skills in the national marketplace
- Limited capacity of the National Climate Change Committee
- Lack of policies and regulations for key sectors
- Limited access to finance
- Limited state budgets to create an enabling environment for private sector investment
- Relatively long period for returns on investment

Existing Initiatives and Projects on Climate Change Adaptation

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Lessons From Sao Tome and Principe's NAPA process

On account of the United Nations Framework Convention on Climate Change's (UNFCCC) Clean Development Mechanism (CDM), Sao Tome and Principe is a constituent of a group of countries that are categorized as carbon sinks, yet one that is particularly affected not only by climate change but also by the costs of adaptation and mitigation required to address it. All things considered, there is also a lack of appropriate adaptation solutions to address climate change in the country.

Sao Tome and Principe's NAPA narrowly focuses its efforts on assessing the country's adaptation priorities. In this way, it seeks to: (1) develop and implement projects based on vulnerability to current and future impacts of climate change; (2) protect human life and ensure wellbeing, protect infrastructure and safeguard the environment; (3) integrate adaptation measures into national policies across all relevant sectors; and (4) increase knowledge of the impacts of climate change and of local and national level adaptation activities.

Barriers to the implementation of the NAPA include limited capacity with regards to technical and institutional capacity within government institutions; insufficient information and knowledge on climate trends, climate impacts and adaptation options; and limited consideration of climate change in the policies, strategies and plans governing sectoral and national development⁵. An evaluation of the institutional landscape within the country's public administration indicates four key weaknesses that should be appropriately addressed, these include the lack of: political decision-making; organizational capacity and management; qualified human resources; and material and financial resources.

In an effort to prioritize adaptation options, the NAPA selected projects through a multi-criteria analysis. The identification of criteria for climate vulnerable sectors was grounded on Sao Tome and Principe's national priorities, including the specific and urgent needs of the population, poverty reduction with a focus on women and most vulnerable groups, in addition to the costs of adaptation options. The Saotomean government through the Ministry of Public Works, Infrastructure, Natural Resources and Environment (MPWINRE), is responsible for the implementation of the NAPA and the adoption of recommendations contained within. The demonstration of a stakeholder approach is clear. The goal of the latest version of the NAPA is to create a list of priority adaptation options guided by local knowledge and the experience of communities. In its implementation however, the INDC and NAPA combined, call for international support programs on account of limited financial resources to address or minimize the adverse effects of climate change.

Coherence with the National Development Context, SDGs, SFDRR and Other Relevant Frameworks

Consistent with the Third National Communication, there is an apparent lack of integration of climate change considerations embedded into broader national systems governing sectoral and national development in Sao Tome and Principe. Effective training tools and coherent cross-sectoral strategies and policies guided by a comprehensive institutional framework is needed to respond to the issue of climate change within national development policies. Certainly, climate change is a concern for the Saotomean population and a tremendous challenge for policy makers and decision-makers alike. Hence, a well-coordinated fully transparent approach is crucial for effective integration of climate change adaptation into existing governance, decision-making and institutional frameworks.

National Development Framework

The government has crafted a policy framework to address medium- and long-term priorities that foster poverty reduction and sustainable economic growth. Sao Tome and Principe's transformation agenda built on the Vision 2030 "the country we want", spotlights the post-2015 national development priorities grounded on four key areas, which comprise: (1) good governance for a strong democracy, (2) sustainable economic growth, (3) human development, and (4) cross-cutting issues such as behaviors and values. The 2nd Poverty Reduction Strategic Paper (PRSP) 2012-2016 closely mirrors the thematic priorities highlighted in the Vision 2030, although it covers a medium-term outlook. The Plan of Priority Action (PPA) 2013-2016, developed by the Ministry of Finance, Commerce and Blue Economy supports the implementation of the PRSP, per a dedicated budget and creates an enabling environment aimed at resource mobilization. The intended successor of the 2nd PSRP is the National Development Plan (NDP) 2017-2021.

The NDP is built on five strategic objectives, which aim to: - Improve the exploitation of the country's potential and strengthen its integration into the global economy, to achieve accelerated and sustainable economic growth, employment and poverty reduction

- Accelerate and deepen various reforms to significantly improve the human development index of Sao Tome and make substantial progress towards achieving the SDGs by 2030
- Improve strategic management capacity for national development, strengthen good governance and democracy
- Develop infrastructure for energy, transport, water and sanitation, and promote the development of telecommunications and ICTs, to reduce the costs of production, improve living conditions of the population and explore the opportunities offered by the public-private partnership.

- Improve land management and preservation of the environment

UNFCCC | Kyoto Protocol | Paris Agreement

Sao Tome and Principe demonstrated its firm commitment to tackling climate change by signing the United Nations Framework Convention on Climate Change (UNFCCC) in 1992, later ratified in 1999. The country is committed to the Convention and partakes in the Conference of the Parties (COP) meetings that convene every year to assess the effects of the measures taken and the progress made in achieving the central objective of the Convention. The process undertaken by Sao Tome and Principe has resulted in studies, national emission inventories, projects and appropriate adaptation actions that address the harmful effects of climate change. The country was also a signatory to the Kyoto Protocol in 1997, which was ratified in 2008. In 2015, Sao Tome and Principe signed the Paris Agreement, conveying its continued commitment to dealing with climate change and its impacts.

National Communication

The Second National Communication identifies a number of challenges to effective and coordinated adaptation planning, these include: (1) lack of adequate technical expertise at the level of national consultants; (2) absence of institutions that deal with climate change issues; (3) low disclosure of climate change information; (4) low institutional ownership of studies on climate change; and (5) low political interest in climate change issues. By and large, climate change issues are not integrated into national development priorities and lack the necessary institutional arrangements to support the development of National Communications. Specifically, Sao Tome and Principe needs a National Program that facilitates the integration of climate change considerations into national development plans and policies. The exception being that of primary, secondary and higher education level initiatives, which aim at integrating climate change considerations into curricula and teachers' pedagogical trainings. The follow up to the Second National Communications - the Third National Communication - has contributed to increasing awareness of national actors responsible for advancing climate change issues and its integration into national development policies. National planning authorities further expect to implement an ambitious and comprehensive reform agenda mentioned in part in the 2017-2022 National Development Plan, which builds on the ENRP-II.

The 2030 Agenda and its SDGs

In the MDG era, Sao Tome and Principe achieved a number of MDG targets. On Goal 2: *Achieve universal primary education*, primary-school enrolment has shown an upward trend, reaching 98% in 2016. With respect to Goal 4: *Reduce child mortality*, infant mortality dropped to 36 per 1000 live births in 2016, from 38 per 1000 in 2014. In terms of Goal 5: *Improve maternal health*, maternal mortality declined to 56 per 100 000 mothers in 2016, from 76 per 100 000 in 2015. Whereas, the implementation of the Sustainable Development Goals (SDGs) poses a pressing challenge for the country due to the ambitious nature of the global goals. For this reason, Sao Tome and Principe has prioritized 6 SDGs for implementation, which comprise: - SDG 1: End poverty in all its forms, everywhere

- SDG 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
- SDG 9: Build resilient infrastructures, promote inclusive and sustainable industrialization and foster innovation
- SDG 13: Take urgent action to combat climate change and its impacts

- SGD 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
- SDG 16: Promote peaceful and inclusive societies for sustainable development, provide access to justice for all, and build effective, accountable and inclusive institutions at all levels

Sendai Framework for Disaster Risk Reduction (SFDRR)

Sao Tome and Principe signed both the Hyogo Framework for Action (HFA) 2005-2015 and its successor, the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015-2030. Through the interim phase of the Sendai Framework, the government led by the National Disaster Preparedness and Response Council (CONPREC) undertook an assessment of the national capacity to reduce the risk of disasters. The study highlighted the need to strengthen national coordination for disaster risk reduction along with disaster prevention, risk mitigation, preparedness, response, recovery and reconstruction⁶. On account of the assessment, the Saotomean government further identified capacity needs and called for the establishment of a legal framework. Despite alignment with the Sendai Framework, the country lacks a national platform for disaster risk reduction that would serve as a coordination mechanism in the implementation, monitoring and review of the Sendai Framework to measure national level progress and reinforce effective coordination at all levels. National platforms for disaster risk reduction built through a nationally owned and led participatory process are multi-sectoral and interdisciplinary in nature and foster a multi-stakeholder composition in order to be effective and sustainable.

Challenges in the establishment of a legal and policy framework for climate change:

While the country has increasingly prioritized the integration of climate change adaptation in the broader development framework, there are still a number of challenges that exist in the establishment of a legal and policy framework for climate change, these include:

- The lack of understanding among various governmental and non-governmental stakeholders about climate change impacts, vulnerability characteristics as well as available adaptation options and their effects on the population
- Limited consideration of climate change and adaptation options into policies, strategies, plans and programmes especially at sectoral and local levels
- Lack of a comprehensive institutional framework in place at this time that supports a coordinated and cross-sectoral approach to climate change adaptation in the country
- Absence of a national investment plan to guide, coordinate and monitor climate change adaption investments that originate from dispersed projects
- Limited institutional, technical and financial capacity in the country to implement, monitor and maintain adaptation interventions

Approach and Methodologies

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National Context

Vision, Goals and Objectives of the NAP

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Climate Change Adaptation Assessment

The principal objective of the climate change adaptation assessment of key systems is to identify and assess key vulnerabilities, hazards and risks for the country and provide analysis on emerging trends and future climate scenarios. A key outcome of the assessment is the promotion of priority adaptation actions, projects and programs that respond to the current and future impacts of climate change on natural and human systems, taking into consideration the specific needs of local communities and vulnerable groups. Each of the mega systems identified, center on key areas critical to the advancement of Sao Tome and Principe's sustainable development pathway

The climate system in Sao Tome and Principe is influenced by the annual migration and dynamics of the Inter Tropical Convergence Zone (ITCZ). The climate is characterized as complex on the basis of it being a small archipelago endowed with a unique orography. Air temperature and rainfall data are only available at five meteorological stations, four stations are situated in Sao Tome and one in Principe. In effect, only the Sao Tome Airport weather station can detect climate change due to its longer time series data compared to other meteorological stations across the island with data series of less than a decade.

The Representative Concentration Pathways (RCPs), which involve four different 21st century pathways of GHG emissions and atmospheric concentrations, air pollutant emissions and land use⁸, were used to project their effects on key climate-related systems. The RCPs help project the impacts under various climate scenarios and are useful for the country's climate change adaptation assessment. The RCP scenarios detailed in this NAP, which include the intermediate scenario (RCP4.5) and the very high GHG emissions scenario (RCP8.5), are compared to the baseline scenario which represents a pathway without additional efforts to constrain emissions.

Exposure to Climate Impacts and Risks

Current Climate (Baseline):

Sao Tome and Principe is among 13 countries uniquely situated along the equator. Its characterized by a humid tropical climate with two seasons: a shorter dry season (gravana), which lasts approximately three months from June to August and a longer rainy season that extends to nine months from September to May. The seasons are influenced by the location of the Inter-Tropical Convergence Zone (ITCZ), which significantly affects rainfall in many equatorial countries. Longer term shifts in the ITCZ can lead to extreme droughts or flooding in neighboring regions. The ITCZ migrates from the southern hemisphere to the North, causing the peak of the rainy season to occur on average from February to May and then again from October to December when the ITCZ migrates back south. The period of roughly two months between December and January, referred to as Gravanito, experiences a slight reduction in rainfall.

Given the characteristics of the archipelago, Sao Tome and Principe has an average surface temperature of 25.6° C and high levels of humidity that can reach over 90% at higher altitudes. The country has many microclimates predominately as a function of rainfall, temperature and topographical relief. It therefore follows that temperatures drop as altitude increases. This is the case

for Pico de Sao Tome which sits at an elevation of 2024m in the central west part of the island and Pico de Principe at an altitude of 948m in the southern region. The country's orographic precipitation is determined by the volcanic massifs that result in rainfall gradients, which offer significant water potential. Average annual rainfall is 2000-3000 mm/year. The highest annual average rainfall of 7000mm is recorded in the southwest region of the island of Sao Tome (Quijá and Xufe-xufe river basins), which is home to dense tropical forests. The savanna is located in the northeastern parts of the island, where rainfall is measured at an annual average of below 1000mm. Parts of the northern regions of the island, namely the districts of Água Grande and Lobata, experience an average monthly rainfall of below 50mm during gravana. There are marked complexities of engaging in horticulture without irrigation, particularly in light of the fact that the highest population densities are situated in these regions.

Both the island of Sao Tome and the island of Principe are dealing with the impacts of climate change and extreme weather events. The country continues to be impacted by natural hazards, which include coastal and river flash floods, storms and droughts. Frequent flash floods and severe storms occur with high incidences of hail, lightening and strong winds that threaten the country. The sectors most affected by very frequent events are the services and agriculture sectors, which are impacted less than once every decade¹⁰. Under the current climate, 23 000 people on average, representing 12% of the total population in 2016, are annually affected by droughts and affected livestock (i.e., animals living in areas hit by droughts) represent 14% of the total livestock. Beyond this, under both present and future climates, physical crop losses are centered around four crops (banana, coconut, oil palm and taro).

Emerging Climate Trends:

Warming of temperatures and reductions in rainfall are of paramount importance to Saotomeans as this can decrease the river flow and influence the availability of subterranean water. In certain regions of Sao Tome and Principe climate impacts such as sea-level rise, flooding and coastal erosion have been observed at levels that risk damage and destruction to major infrastructure. According to the baseline, RCP4.5 and RCP8.5 scenarios, the annual average temperature trend reported by Sao Tome Airport's weather station, indicated an increase of 0.6 °C between 1960 and 2016, representing an average warming of around 0.01 °C per year. The warming comes into effect from the months of October until May. The highest annual average temperature of 26.2 °C was recorded in 1998, whereas the lowest annual average temperature of 24.7 °C was recorded in 1964. This demonstrates an increase in interannual variability of the climate in Sao Tome and Principe. Notably, the five warmest years to-date have occurred in the last 20 years, which further indicates an increasing trend of warming of annual average temperatures. Parallel to other countries in West Africa, temperature observations in Sao Tome and Principe reveal an increasing trend. The figures below, based on climate analysis from 1970 to 2015, demonstrate an average increase in temperature. Trends in average annual precipitation, however, are not clearly defined and are variable in time and space.

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Future Climate Scenarios: Projected Future Climate

A climate-based study on Sao Tome and Principe detailed in the Third National Communication, observed changes in total rainfall during the rainy season and dry season for the 2041–2070 period. In the RCP4.5 scenario, rainfall projections predict a rainier climate from October to May (rainy season) and normal to dry conditions from June to September (dry season). In the RCP8.5 scenario, projections indicate a reduction in rainfall for both rainy and dry periods, with the exception of December and January based on a monthly analysis, which demonstrates an increase in rainfall on the island of Sao Tome. This stands in contrast to the country's gravanito period under the baseline scenario where rainfall typically decreases in the months of December and January. In terms of

climate extremes, projections show a surge in total annual rainfall under RCP4.5 and an increase in rainfall intensity under both scenarios, particularly in the Caué and Lembá districts in the southwestern region of the island of Sao Tome. Further to this, there is a rise in the number of consecutive dry days that signals a prolonged dry season (gravana) and uneven temporal distribution of rainfall in the region. With respect to extreme temperature, climate projections under both scenarios (RCP4.5 and RCP8.5) indicate warming, with a surge in heat waves on hot days and an increase in annual minimum temperatures.

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Under future climate conditions and with the inclusion of socio-economic projections, GDP impacted by droughts (i.e., the economic value produced in areas hit by droughts) could rise to USD \$600 million¹³. The number of affected livestock is projected to marginally decline relative to current climate conditions. The agricultural production losses owing to droughts are projected to drop under future climate conditions for all six crops of banana, coconut, cocoa, fruits, palm oil and taro. Under future climate conditions, the agricultural loss decreases in both islands. Moreover, sea level is projected to rise by 0.13- 0.56 meters by 2090 compared to average levels over the 1980-1999 period¹⁴. Fishermen will be increasingly exposed to climate variability and will continue to be affected by the diminution of marine resources due to disruptions to coastal ecosystems, destruction of mangroves and increases in storms and other natural hazards.

Regional Projections:

As it concerns regional projections, under RCP4.5, global models predict an increase in rainfall in West Africa between the months of October to March. There is a variation in rainfall of about 10% to 20% over the 1986-2005 reference period. The climate models for the periods 2016–2035, 2046–2065, and 2081–2100 indicate that changes in temperature are consistent across the models. In the middle of the 21st century, specifically for the years 2046–2065, the average temperature increase ranges from 1° to 2°C in the Gulf of Guinea. A slight increase in average rainfall for the period 2036–2065 is observed, particularly from May to September during gravana in the Gulf of Guinea, including the islands of Sao Tome and Principe.

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Local Projections:

Local climate change projections for the 2041–2070 period is based on the 1971–2000 period, for which projections indicate warming of temperatures in the study belt, principally from October to May. During gravana warming is more pronounced in the central region of Sao Tome, where the altitude is highest. All in all, warming trends under both RCP4.5 and RCP8.5 is comparable, with an increase in intensity of warming in the RCP8.5 scenario. The local projections estimated for both islands on the basis of the ETA model, predict an increase in temperature of approximately 2.5 °C under RCP4.5 and 3°C in RCP8.5 in both rainy and dry periods. For both the rainy season and dry season under both scenarios, local scale projections do not demonstrate changes in annual temperature across the islands of Sao Tome and Principe.

Assessment by Key Systems

Agriculture

The agriculture sector is integral to Sao Tome and Principe's national economy and its vulnerability to climate change is captured, in part, by thermal stresses to the environment. Considering that

subsistence agriculture in the country is narrowly characterized by its fragility and poor planning techniques, it tends to import a large portion of its food for consumption. In Sao Tome and Principe, subsistence agriculture crop production consists of taro, corn, tomato, cassava, pineapple and breadfruit, among other crops. Its food commodity markets focus on the export trade of cocoa, coconut, coffee (Robusta and Arabica), flowers, vanilla, chili pepper and palm oil. On the whole, the agriculture sector employs 60% of the labor force but represents only 22.4% of GDP¹⁶. With respect to food security and access, 10% of households have low food consumption and 12.6% of households have limited food consumption.

Priority Area: Cocoa (*Theobroma cacao* L.) Production

At the turn of the century, Sao Tome and Principe was one of the global leaders in the production of cocoa beans. Among myriad factors, the tropical climate, heavy rainfall, and the fertile volcanic soils gave rise to the rapid development of cocoa plantations called roças. Sao Tome and Principe's cocoa is recognized for its superior quality and a burgeoning organic cocoa sector. Cocoa production constitutes a main share of the agriculture sector, accounting for roughly 17% of the Gross Domestic Product (GDP)¹⁷ as the main export commodity produced on plantations. Following the progressive redistribution of sizeable cocoa plantations at the outset of the 1990s, small farmers assumed responsibility of a majority of cocoa production as colonial plantations were nationalized. Cocoa farmers supplemented their income by producing additional crops such as vegetables, fruits, vanilla and pepper for trade. As a consequence of the 1998 international cocoa price crash, producers realized that cocoa production would not secure their livelihoods. Studies later suggested that combining organic cocoa production and fair-trade principles would improve farmers income. Notwithstanding the substantial contribution of cocoa to the domestic economy, its export share now comprises a negligible share of the global cocoa market.

Vulnerability of the Agriculture Sector

The following is a précis of key vulnerabilities affecting Sao Tome and Principe's agricultural landscape:

- Fragile and poorly organized subsistence agriculture
- Intensive agriculture in areas of great slope
- Increase in temperature throughout the entire country in recent years
- Decrease in rainfall and the subsequent reduction of river flows in the east
- Lengthened dry seasons
- Landslides due to torrential rains (particularly on mountain slopes)
- Lack of good handling practices and zootechnical/agroforestry management
- Absence of animal and plant species that are adapted to extreme weather conditions i.e., drought and desertification
- Lack of environmental education among the population

Exposure to Climate Impacts and Risks

In the agriculture subsector, greenhouse gas (GHG) emissions originate from enteric fermentation, manure management, agricultural soils, savanna fires and burning of agricultural wastes which in total amount to 12.5 Gg CO₂eq¹⁹. Further, studies on the risk index of agricultural crops such as taro, maize, cocoa and pepper were undertaken and reported in the Third National Communication. Projections for each crop indicated high risk to arable lands on account of the current climate.

Future Climate Scenarios: Projected Impact on Cocoa

As concerns cocoa, Sao Tome and Principe has experienced a decline in productivity in the last decade, as cocoa bean yields fell from 1333 hg/ha in 2008 to 1014 hg/ha in 2018 (FAOSTAT, 2020). The regions in north of Lembá, west of Lobata and Mé-Zóchi are of great import in terms of the local cocoa production. Climate change impacts such as intense tropical storms hamper production and cause destruction of the natural environment suitable for cultivating cocoa trees. Further impacts include increased temperatures and prolonged dry seasons that trigger thermal and water stress and bring about vulnerability to pest infestation. Protozoal diseases of cocoa trees such as Black pod disease thrive in humid climates linked to warmer temperatures. Under RCP4.5, there is moderate risk in Sao Tome due to low productive potential of the cocoa bean and water stress. In the RCP8.5 scenario, these cocoa growing regions- specifically the regions north of Lembá, west of Lobata and Mé-Zóchi are expected to sustain high exposure to climate risks due to water stress. The water resources sector in Sao Tome and Principe is among the most vulnerable to climate change. In effect, the reduction of groundwater contributes to the waning of water currents causing poor distribution of water resources to the population, with major impacts to soils critical for agricultural and agro-pastoral production. According to the literature, other regions of the island where risk classifications increased were among the main the contributors to water stress.

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Projected Impact on Taro

Along with risks to cocoa, projections for taro indicate an increased risk due to thermal stress (South of the Caué district), which could increase its exposure to taro plant disease such as taro leaf blight (TLB) (*Phytophthora colocasiae*). TLB which is a major disease of the taro plant is caused by a pseudo-fungus and could threaten food security in the country. The risk assessment of the taro plant has resulted in a moderate to very high-risk rating in most regions of the island of Sao Tome.

Future Climate Scenarios: Projected Impact on Corn

With regard to corn, there is high risk to corn production along the border regions of the Caué and Lembá districts. The high risk to corn is due to exposure to rust under RCP4.5. The rapid spread of corn rust takes place when favorable environmental conditions, for instance suitable temperatures and moisture, persist for a protracted period throughout the growing season. Considering a RCP8.5 scenario, there would be an upsurge in risks to corn production areas classified as very high risk, owing to an increase in thermal stress and exposure to rust diseases. In an alternative variety of corn, the risk exposure of corn production in a number of coastal regions increased from very low to high due to corn crop's low yield potential.

Climate Risks in Agriculture Production

The following list of climate risks, stem from the interaction between natural hazards in Sao Tome and Principe and the vulnerability and exposure of agricultural communities, their livestock and the natural systems within which they operate.

- Existing planting areas could be reduced due to the change in edaphoclimatic conditions leading to a decrease in agriculture production
- Heavy rainfall that can cause flooding, resulting in loss of microelements and nutrients in soil, critical for agriculture and grazing
- Phyto-pathogenic microorganisms such as fungi, bacteria and viruses that when exposed to conditions of precipitation and increase in temperature, become more reproductive and proliferate
- The warming of temperature in extremes, triggering the proliferation of parasites (carapatas) and affecting the metabolism of animals especially during the productive cycles of pastures, which could lead to a reduction in crop yields and animal numbers
- Reduction in productive agriculture leading to reduced farmers' income

Adaptation Options

The diversity of climate change impacts and adaptation options coupled with the complexity of adaptation process demonstrate the unrealistic assumption of perfect adaptation by individual farmers²⁰. Still, promising adaptation measures to smooth out fluctuations in agriculture yields (and indirectly social welfare), include:

- Examination into and enhancement of cultural practices to reduce the impacts of water and thermal stress
 - Surveying and development of crop varieties resistant to water and thermal stress, to ensure food security
 - Offering technical advice and extension services to producers on production techniques to generate high quality yields e.g., cocoa beans
 - Provision of guidance on how to use specialized equipment and storage facilities to limit spoilage after harvest e.g., solar cocoa dryers
 - Offering technical guidance on existing regulations and legal frameworks e.g., on organic cocoa regulations
 - Development and adoption of heat-resistant cultivars
 - Enhancement of farming practices that reduce pests and crop/plant diseases
 - Implementation of a seed distribution program of climate-resilient seeds for small holders
 - Development of appropriate cultivation techniques in sloping areas and other risk zones
- ‘Floodproofing’ measures (such as elevation of living spaces)
- Adoption of climate smart agricultural techniques
 - Institution of coastal protection measures (such as seawalls, bulkheads, and revetments)

Fisheries

The fishery sector plays a critical role in Sao Tome and Principe's national economy as it represents 3.7% of GDP. It generates employment, supports foreign exchange and provides the populations' nutritional needs in terms of animal protein, of which 70% is derived from fish. The jurisdictional waters of Sao Tome and Principe, represented by the Exclusive Economic Zone (EEZ), span almost 165,000km and offer a fishing potential of 29,000 tonnes²¹. Sao Tome and Principe's continental shelf, which is very narrow, covers 5-10km and reaches depths of less than 200 meters, is reputed to house the most ergonomic fishing grounds for artisanal fishing. Yet, marine fishery resources show a persistent and substantial decline as a consequence of overfishing and abandonment of traditional techniques in lieu of unsustainable practices. Two decades prior, Sao Tome and Principe's fish stock was gauged at 8500 tonnes of pelagic fish, among 185 fish species stemming from 67 families. Most recent data from 2013 indicate that the domestic supply of demersal fish stands at 1108 tonnes, while pelagic fish and crustaceans amount to 3073 tonnes and 15 tonnes, respectively for the same year (FAOSTAT, 2018).

INSERT IMAGES HERE

The fishery sector is among the most vulnerable to climate change and is further threatened by a hostile environment, notably the lack of large estuaries, which could sustain a variety of marine species and an absence of coastal upwelling that could give rise to rich nutrients that nourish the surface water and improve its biological productivity. As shown in Figure 3, small scale fishing and semi-industrial fishing contribute to the fishery sector, whereas industrial fishing is taken up by foreign vessels in Saotomean waters by way of bilateral fishing agreements. Unsustainable fishing techniques are diminishing fish resources at a faster rate than can be replenished. Artisanal fishing comprises a quarter of the country's workforce, signaling the importance of the sector in terms of social and economic development outcomes. While both men and women are active in the fishery sector, men's roles are centered on fish capture and harvest, while women focus, by and large, on bringing the fish to secondary wholesale markets. 3,051 artisanal fishermen work at 44 landing sites across the islands, 29 landing sites are situated on the island of Sao Tome and 15 on the island of Principe.

Priority Area: Fish Conservation

The conservation of coastal and marine biological diversity, particularly the conservation of fisheries, is critical to the ecological balance of the marine system, the social well-being of the population and the economic growth potential of the country. Rapid population growth is putting downward pressure on natural resources including fish stocks with predicted effects on biodiversity²⁴, calling into question the sustainability of the fishery sector. Causative to the decrease in fishing stocks is the use of unsustainable fishing techniques such as bay area fishing, use of dynamite and fine-meshed nets. At present, the unregulated exploitation of halieutic resources coupled with poor monitoring and surveillance capacities, limited knowledge of the configuration of national fisheries resources, and the anemic application of the 2001 Law of Fisheries (Law No. 9/2001) and the 2010-2025 Fisheries Plan, directly contribute to the steady depletion of fish resources off the coast of Sao Tome and Principe. This reduction of fish resources in turn reduces the income of fishermen including fish traders and engenders poverty among coastal inhabitants.

According to the objectives of the 2015-2020 National Strategy Plan for Biological Diversity, local conservation actions could include:

- Construction of a protected marine area on both islands in which fish stocks are monitored and provided the opportunity to mature and procreate

- Spatial ordering and sustainable management of Sao Tome and Principe's EEZ
- Sensitization of coastal populations to means of conservation
- Monitoring of actions to protect and conserve coastal areas
- Strengthening of inter-sectorial actions of various government institutions in the field of conservation and sustainable management
- Establishment of an action plan to ensure oversight
- Improving the monitoring and inspection of actions under the legal framework for fisheries

Vulnerability of the Fishery Sector

On the basis of views and perceptions of local communities', key vulnerabilities of the fishery sector were identified through the NAPA as well as the Convention on Biological Diversity (CBD) Sixth National Report. Sea level rise and lightning strikes were among the climate change impacts cited, which affect vulnerable groups such as artisanal fishermen and their families, rural inhabitants and farmers. Artisanal fishermen to date employ age-old fishing techniques. Due to the limited fish supply in their immediate vicinity, fishermen are routinely forced to travel the distance in pursuit of fish²⁵. As it happens, fishermen often vanish at sea or experience damage or destruction to their fishing gear and vessels due to extreme weather events, such as strong winds, fog and turbulence at sea. Squalls have wreaked havoc on fishing activities and caused rivers to flood, which has brought about hardships to fishing families. The land, boat moorings and beaches have also been impacted by coastal erosion. Sedimentation of river water during the rainy season has obstructed reproduction areas and growth zones critical to the proliferation of several demersal species and a number of pelagic species.

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Main vulnerabilities:

- Loss of materials and artisanal fishing equipment during fishing
- Loss of life due to disappearance at sea
- Partial or complete destruction of vessels at docks or beaches
- Damage to fishermen's dwellings on account of sea water intrusion
- An upsurge in the level of poverty among women due to loss of fishing equipment, livelihoods and lives of (fishermen) spouses
- Increase in the number of school-age children that drop out of school in order to economically contribute to the household through fishing
- Overexploitation of resources as a result of poor sectorial management
- Use of timeworn and unsafe vessels, and inadequate equipment e.g., the vessel fleets are mostly composed of single-person, wooden, non-motorized, small-capacity boats

- Weak infrastructure and poor governance
- Poor health and sanitation

Exposure to Climate Impacts and Risks

Humid wind currents, prevailing in the southwest regions, are intercepted by the Sao Tome and Principe's topological relief. Strong winds and storms have historically affected Saotomeans. Particularly in 2001, 301 people were affected in the agricultural community in Santa Catarina and later in 2009, 43 people were affected in Roça Santa Cecília. Recent climate-related disasters have been a result of the rain and wind regime. With respect to natural hazards, the potential increase in fog has been attributed to changes in the wind.

Future Climate Scenarios: Projected Impact on the Fishery Sector

On account of determining climate risks, wind speed indexes (mean, maximum and annual minimum values) were established under the climate-based study detailed in the Third National Communication. The wind speed indexes, which are based on projected changes in surface wind extremes indicate a tendency towards a reduction across all values of wind in future scenarios, under both RCP4.5 and RCP 8.5. There is a trend in the reduction of daily maximum winds that suggests a weakening of wind events under future climate projections²⁶. Still, there are numerous accounts on the effects of strong winds that trigger waves that cause damage to infrastructure and loss of life of fishermen. Expressly, the artisanal fishery sector has witnessed an increase in the number of days with strong winds and maritime turbulence²⁷. As a consequence, storms have contributed to the loss of life, in addition to fishermen who disappear on the high seas due to heavy fog. This impact is further experienced by communities in Neves, Pantufo and Praia Melão, where there is a high incidence of trolling and every 1 in 20 families is left orphaned or widowed. By and large, losses peak in February during the gravanito period (the foggy season), which are later registered in March as search and rescue efforts continue for nearly one month following the actual event.

What is more, an increase in the predicted temperature of 2.5 °C for the 2040-2060 period will likely cause turbulences in sea currents due to the crossing of cold currents in Benguela and warm currents in the Gulf of Guinea, which would cause an upwelling. The rise in sea temperature is expected to cause fish to migrate towards the poles towards deeper and colder waters. On account of a reduction in the quantity of halieutic resources, fishermen would have to travel father out to sea and attempt to reach 60 meters in depth to access fish. In some instances, it is reported that small-scale fishermen travel up to 40 miles from the shore and reach fishing ground depths between 100 and 250 meters²⁸. As aforementioned, reduction in fish catch is also attributable to the overexploitation of fishing resources and the use of unsustainable practices. In order to ensure the survival of the artisanal fishery sector, changes in current techniques are required to adapt to climate change. Sao Tome and Principe's NDC reveals that a 50% loss in artisanal fisheries production is forecasted as a result of climate change.

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Adaptation Options

Fish conservation and preservation:

- Investment in small-infrastructures and facilities for fishing communities e.g., cold storage, ice-machine and landing sites, with proper management systems to ensure their sustainable use
- Construction of conservation facilities for fish

- Means for reducing post-harvest losses in fisheries
- Means of preservation that will extend the storage life without substantially altering the nature of the raw material
- Selective fishing gear that avoids the capture, retention, and subsequent discarding of immature fish and unwanted species
- Systems to locate abandoned, lost, or otherwise discarded fishing gear (ALDFG) which continues to catch fish (causing unintentional mortality), resulting in “ghost fishing”
- Proper on-board handling of fish, for example ensuring fish are chilled and good hygiene conditions prevail to avoid cross contamination, as well as ensuring the physical integrity of fish to avoid bruising and damage to fish flesh and accelerated spoilage

Fishing safety and improvements to infrastructure:

- Investment in suitable fishing vessels, gear and protocols to ensure safety of fishermen
- Investment in trainings for fishermen on new technologies that help assess climate risks
- Delimitation of fishing zones with solar signaling buoys
- Implementation of an alert system for deep sea fishing navigation
- Construction and installation of Fish Aggregating Device (FAD) in coastal areas
- Distribution of portable navigation tools and rescue equipment (e.g., GPS, compasses and lifejackets) and installation of communication and rescue systems
- Construction of coastal defense mechanisms in affected areas
- Construction of quality floating docks at points of embarkation and disembarkation

Bilateral fishing agreements and good governance:

- Review of fishing and private license agreements in order for Sao Tome and Principe to tap into benefits of marine resources within its jurisdictional waters
- Address management challenges of maritime sectors and develop a Blue Economy through the use of Marine Spatial Planning (MSP)

National Adaptation Priorities

xxxx xxxx

Implementation Strategy for the NAP

xxx

Alignment with the GCF Country Programme

xxx

Mobilization of other Sources of Finance

xxx

Monitoring and evaluation of adaptation actions and process

xxx

Reporting

xxx

Further development of the programme to support future NAPs

xxx

Annex I: NAP Outputs

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Annex 2: Country Profile

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Annex 3: Data and information system to support the NAP

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References
