ISLAND INSIGHTS

Surging Seas and Increasing Rains

Analyzing Flood Risks in São Tomé e Príncipe, District by District

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WACA
West Africa Coastal Areas
Management Program

Disclaimer

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Praia Melão, São Tomé and Príncipe

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Abbreviations

AAL	Average annual loss
CBA	Cost-benefit analysis
CONPREC	*Conselho Nacional de Preparação e Respostas às Catástrofes* (National Disaster Preparedness and Response Council)
CRA	Cell-based risk assessment
DTMs	Digital terrain models
GDP	Gross domestic product
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic information system
GTSM	The Deltares Global Tide and Surge Model
INE	Instituto Nacional de Estatística (National Statistics Institute)
JRC	Joint Research Center for the European Commission
MIRNMA	*Ministério das Infraestruturas, Recursos Naturais e Meio Ambiente* (Ministry of Infrastructure, Natural Resources, and Environment)
RAP	Região Autónoma do Príncipe (Autonomous Region of Príncipe)
SIDS	Small Island Developing State
ST	São Tomé
STP	São Tomé and Príncipe
US$	United States dollars
WACA	West Africa Coastal Areas Management Program
WACA PIU	West Africa Coastal Areas Management Program Project Implementation Unit

Malanza, São Tomé e Príncipe

Executive Summary

Santa Catarina, São Tomé e Príncipe

São Tomé and Príncipe (STP) is a Small Island Developing State (SIDS) with a fragile economy, enduring double-insularity and high susceptibility to external shocks. It is especially vulnerable to the effects of climate change through increased precipitation and sea-level rise, because most of the population lives along the coast and near rivers.

Communities in STP have already experienced devastating losses of life and property due to water-related hazards. For example, floods due to intense rainfall in December 2021 caused up to about €33 million (US$ 36 million) in damages—for a rainfall event associated with a return period of about 20 years. As climate conditions continue to change, the country will confront a series of increasingly costly adaptation choices to protect essential infrastructure such as schools, hospitals, and government buildings.

This study's aim was to assess the growing flood risk STP faces due to climate change. It achieved this by carrying out a nationwide risk assessment for riverine and coastal flooding. The study used recently completed high-resolution national flood hazard data for the present climate (2020) and two projected climates (in 2050 and 2080), based on the climate scenario Shared Socioeconomic Pathways (SSP)3-7.0, a medium to high reference scenario resulting from no additional climate policy under the SSP3 socioeconomic development narrative.

This flood risk assessment examines the potential impacts and risks to people, buildings, healthcare facilities, the education sector, and tourism under both present and future climate conditions. It shows that flood risk is driven frequent flood events. There is a significant increase of flood risk under future climate conditions.

The study's results highlight the following:

- **The expected yearly losses due to floods, on average, are projected to be 1.9 percent of STP's GDP in 2020, 2.8 percent in 2050, and 4.1 percent in 2080.** This means that the overall flood risk more than doubles within 60 years, not considering other developments during that period such as population increase and socioeconomic growth.
- **Under present climate conditions, about 18,500 people are affected by flooding each year on average**, which represents 8 percent of STP's total population. The number of people affected by floods on annual average is expected to increase to 23,000 in 2080—an increase of 25 percent from 2020. Under current climate conditions, the subdistricts of Malanza and Santa Catarina are most affected, at 33 percent and 41 percent of their populations, respectively. However, the highest total number of people affected is in the subdistrict of São Tomé, with almost 4,500 people (5.4 percent of the subdistrict's population) affected on annual average.
- **Healthcare infrastructure risk results show a seemingly low average annual loss (AAL) of US$66,000 per year under present climate conditions.** However, due to the relatively low density of healthcare facilities on STP, access to healthcare could be limited for up to 45,000 inhabitants (20 percent of the country's population). This estimate is higher than the number of people directly affected by floods, highlighting the large impact of healthcare infrastructure damage for the citizens of STP.
- **The tourism sector is exposed to a high level of flood risk.** This is unsurprising, given that most assets are located in close proximity to the coast. The AAL for tourism buildings is US$470,000 per year, increasing to US$660,000 per year in 2050 and US$1 million per year in 2050 (an increase of 42 percent and 113 percent, respectively). As the scale of this study does not consider every local flood defence built by hotel developers, Chapter 3.5 will explain how to interpret these expected annual damages.

Figure 1: Key results for different sectors and climate conditions investigated in this flood risk assessment for São Tomé and Príncipe

All buildings

2020: US$8.4 million/year	**1.5% of GDP (2023)**
2050: US$12.1 million/year	2.2% of GDP (2023)
2080: US$17.9 million/year	3.3% of GDP (2023)

Population affected

2020: 18,500 people/year	**8% of the population**
2050: 20,500 people/year	9% of the population
2080: 23,000 people/year	10% of the population

Health sector

2020: US$66,000/year	**20% of the population**
2050: US$77,400/year	33% of the population
2080: US$116,200/year	37% of the population

Education sector

2020: US$58,800/year	**3,000 pupils affected**
2050: US$83,400/year	3,500 pupils affected
2080: US$160,600/year	7,700 pupils affected

Tourism sector

2020: US$468,000/year	**27% of touristic assets**
2050: US$665,000/year	32% of touristic assets
2080: US$1,000,000/year	38% of touristic assets

Total flood risk

2020: US$10.5 million/year	**1.9% of GDP (2023)**
2050: US$15.1 million/year	2.8% of GDP (2023)
2080: US$22.3 million/year	4.1% of GDP (2023)

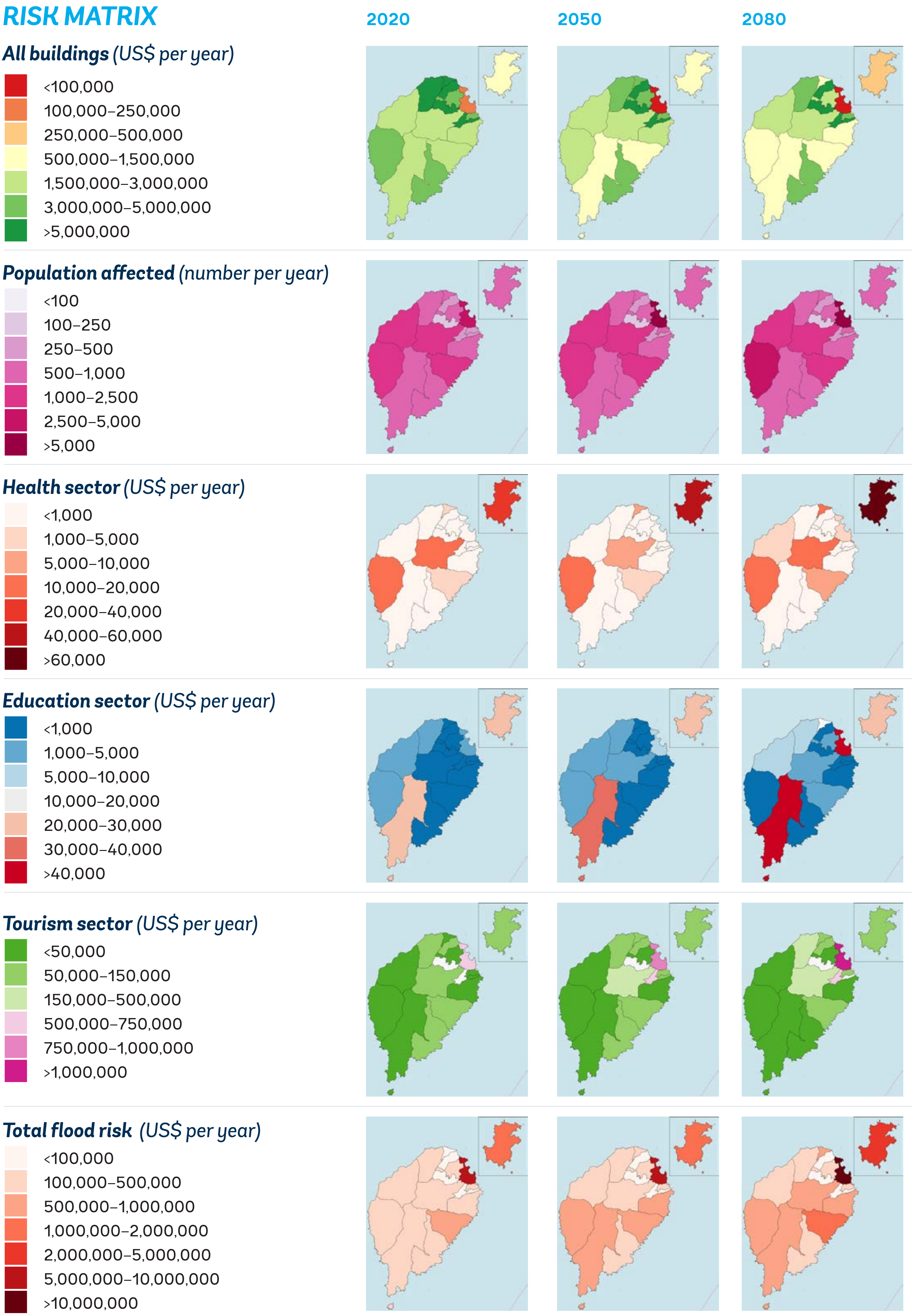
One objective of the study was to provide a macro-scale flood risk assessment on a national scale. Due to insufficient data, this assessment could not quantify indirect impacts such as that on learning outcomes. Instead, it highlights the relative change (trend) of direct flood impacts and risks for each sector as a result of climate change (Figure 1 and Figure 2).

Indirect flood losses for the tourism, health, and education sectors are expected to be larger than the direct losses calculated in this study. Such losses may result in considerable loss of revenue for the tourism sector, or cause serious impacts to people's wellbeing or advancement in the cases of the health and education sectors. However, indirect losses are less straightforward to quantify and were not part of the present study's scope.

The final outputs should be seen as approximations of the expected flood risk patterns, based on the available input data. While these risk maps, tables, and insights can be used to feed national and subdistrict (macro) cost-benefit analyses (CBAs), they cannot be used to determine the risk to specific buildings and streets without further local studies to identify higher-risk areas and to inform adaptation measures.

This study is the first national flood risk study for STP at this level of detail. It gives valuable insights into how the country will be impacted by climate change in the future. The results of this study support the ongoing activities of the West Africa Coastal Areas Management Program, including joint efforts by government, NGOs, and communities to boost local preparedness measures, accelerate flood protection investments, and enhance risk communication initiatives.

Figure 2: Overview risk maps for buildings, population, and assessed sectors under present and future climate scenarios



1

Introduction

São Tomé City, São Tomé e Príncipe

São Tomé e Príncipe (STP) is a Small Island Developing State (SIDS) and one of the African countries most vulnerable to the effects of climate change.

In particular, the country is vulnerable to increased precipitation and sea-level rise, with most of the population and country assets situated along the coast and near rivers. STP is characterised by a fragile economy, enduring double insularity[1] and high susceptibility to external shocks.

STP is the second-smallest African state after Seychelles. The country is located 200 kilometers (km) off the west coast of Africa (Figure 3). In 2023, STP was estimated to have about 230,000 inhabitants and in 2022 the country's GDP was US$547 million (World Bank, 2023a).

Figure 3: Location of São Tomé and Príncipe

Source: StoryMap STP with data from OpenStreetMap

Communities in STP are already experiencing devastating losses of life and property due to water-related hazards. For example, flood damage due to intense rainfall in December 2021 was estimated at €33 million (US$ 36 million)—for a rainfall event with a return period of about 20 years.

STP's unique location represents many opportunities for the country's economic growth and development. Decreasing the population's future vulnerability will depend on climate change adaptation options such as developing green and grey coastal infrastructure, improving early warning systems, and promoting planned retreats.

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[1] The Island of Príncipe is on the periphery of another small island and is only accessible through São Tomé, leading to increased goods and service prices and additional logistical challenges for disaster relief or reconstruction efforts.


Malanza, São Tomé e Príncipe

The project

The World Bank established the West Africa Coastal Areas Management Program (WACA)[2] to strengthen the resilience of targeted communities and areas in STP and other countries in the region. WACA, which is ongoing, has enabled STP to make significant strides towards strengthening the resilience of targeted communities and affected areas. It has also allowed the country to design and test adaptation strategies, and mobilize knowledge and finance, particularly through stronger regional dialogue and networks. To address additional challenges and fill key knowledge gaps for the implementation of projects proposed by the ongoing investment plan, the World Bank, through the PROBLUE multidonor trust fund, recently approved a project to strengthen the knowledge base for coastal resilience and raise awareness about climate change impacts to coastal areas and potential solutions.

Figure 4: WACA's key accomplishments in São Tomé (ST) and *Região Autónoma do Príncipe* (RAP, Autonomous Region of Príncipe)

*Since the WACA project in São Tomé (ST) and the Autonomous Region of Príncipe (RAP) **started in April 2018**, the key accomplishments until January 2024 includes:*

Approximately

US$ 15
MILLION

5 years

12 COMMUNITIES

10 in São Tomé (ST)
2 in Autonomous Region of Príncipe (RAP)

Around 20,730 beneficiaries

The project activities aim to increase the number of direct beneficiaries **from 8,000 to 20,730** people, which represents nearly **11**% of the total population, of which **44**% are women.

Approximately

816 households

less exposed to flood risks.

Training of 1,000 artisanal fishermen

and distribution of approximately **1,250** maritime safety kits to fishermen.

Development of more than **8** diplomas for improved coastal and disaster risk management.

3 Schools constructed,

benefitng around **320 students** per year.

6 Breakwaters

2 Protecive walls
3 Rock revetments

7 Safe Expansion Zones

created in communities vulnerable to climate risks.

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[2] For more information, see https://www.wacaprogram.org/

The results of this study contribute to both objectives by creating national datasets on flood risk in STP. The study used the recently completed high-resolution national flood hazard maps from an independent knowledge institute, Deltares, and assessed flood risk for the present climate (2020) and for two future conditions: 2050 and 2080, assuming the projected climate scenario SSP3-7.0 (Deltares, 2023).

The available high-resolution flood hazard dataset dictated the choice of time horizons, which included maps for the climates of 2020, 2050, and 2080. That hazard modelling study—completed in September 2023 as part of the WACA project—selected those specific future dates to provide two equally spaced snapshots indicating increased climate change effects, without going too far into the future where climate predictions are less certain (and decisions might become too abstract). Currently, many global infrastructure decisions are made for mid-century climate conditions, in other words, of 2050.

This study was designed and performed as a macro-level risk study, intended to provide the Government of STP with quantitative information on the expected financial impacts from the dominant hazards in the country (heavy rainfall events causing runoff flooding downstream, flooding on the coast from ocean storms, and their combined impacts) and on their predicted trends in the coming decades.

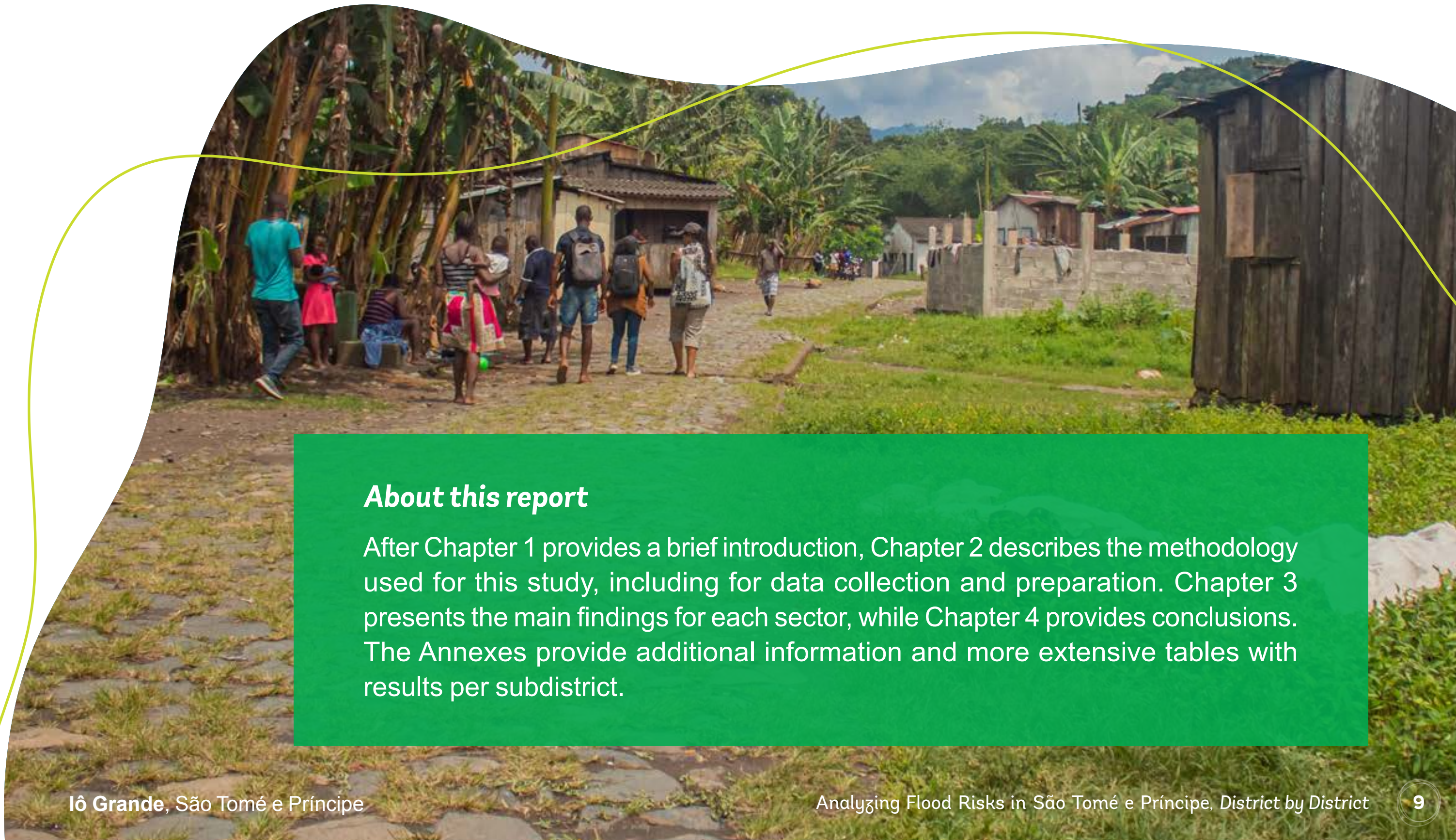
Results

The study defined risk as the product of: (i) the probability that a given hazard will occur; (ii) the value of the exposure (assets) that are affected by that hazard; and (iii) the vulnerability of that exposure to the hazard. The study covered impacts and risks for people, buildings, healthcare facilities, education sector, and tourism. Flood impacts were expressed per return period in United States dollars (US$), while risk was expressed as annual average loss in US$ per year.

The risk numbers were derived primarily for the entire country and estimated for all sectors combined. These values, along with the predicted trend, are considered the most relevant for high-level decisions on climate adaptation. This integrated approach was also the result of limited available data on exposure and vulnerability, and of the desired scope and timeline to complete the study. Only direct damages to infrastructure were quantified into US$ values.

Despite being a relatively small country, STP has large geographical variations. The study therefore made additional effort to aggregate risk by subdistrict and provide deeper insights wherever data availability allowed. Risk results with added granularity were derived in greater detail for some sectors (education, health, and tourism) to differentiate risk by various building typologies; the number of pupils, patients, or tourists affected per year; and so on.

National flood risk maps and aggregated insights strengthen the knowledge base in STP. In turn, this will help prioritize investments for sustainable economic development in STP and enhance visualization and public communication.



About this report

After Chapter 1 provides a brief introduction, Chapter 2 describes the methodology used for this study, including for data collection and preparation. Chapter 3 presents the main findings for each sector, while Chapter 4 provides conclusions. The Annexes provide additional information and more extensive tables with results per subdistrict.

Iô Grande, São Tomé e Príncipe

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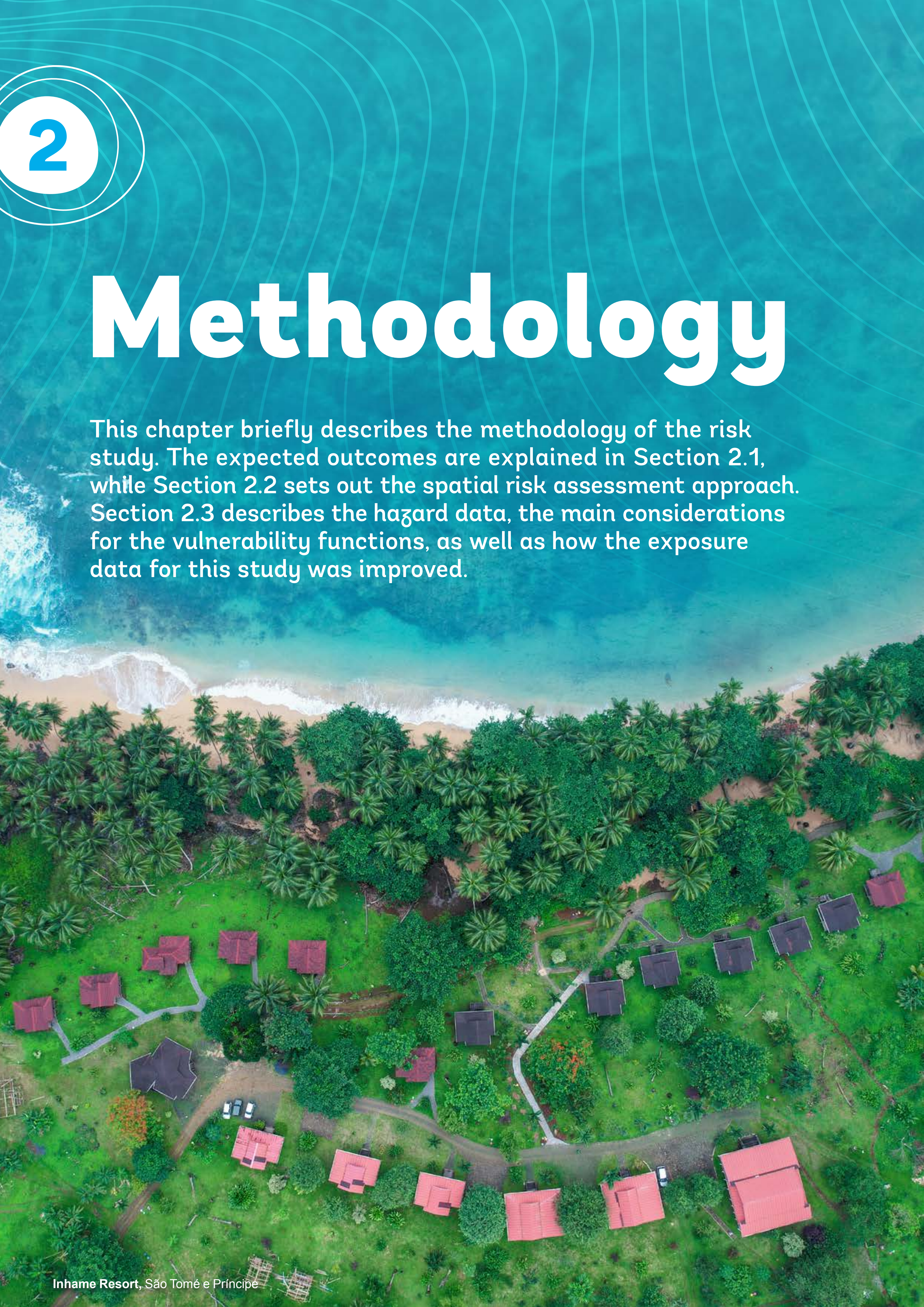
Methodology

This chapter briefly describes the methodology of the risk study. The expected outcomes are explained in Section 2.1, while Section 2.2 sets out the spatial risk assessment approach. Section 2.3 describes the hazard data, the main considerations for the vulnerability functions, as well as how the exposure data for this study was improved.



Inhame Resort, São Tomé e Príncipe

2.1 Expected Risk Outcomes

This study provides valuable insights how climate change may impact STP in future. The results will help stakeholders, including officials and development partners, recognize the need for sustained efforts towards a more liveable and resilient future.

For this purpose, a high-resolution spatial flood impact and risk assessment was carried out, using the latest flood hazard datasets and improved national exposure data, as described below.

Flood impact and risk estimates were produced for five different sectors or classes of assets (typologies are described in more detail in Section 2.3.2):

- Buildings (all types of buildings, using two different building typologies)
- Population (no further subdivision)
- Healthcare facilities (three different typologies)
- Education facilities (six different typologies)
- Tourism sector (three different typologies).

In addition, the study estimated the total flood risk and presented the results as tables and maps on a (modified) subdistrict level,[3] as well as on a national level for the three climate conditions.

The results will allow the World Bank and the Government of STP to better understand the "costs of doing nothing" in a concrete way. Moreover, they could serve as inputs for targeted cost-benefit analyses comparing various coastal defenses and adaptation strategies. Despite the high spatial resolution of risk assessment, the datasets produced are not intended for use in local, detailed analysis beyond the subdistrict level because most of the exposure data is available as indicators on subdistrict level only.

2.2 Approach to Risk Assessment

The study defined flood risk *(R)*, as the product of the probability that a flood hazard will occur in a given year *(P)*, the value of the exposure that is affected by that hazard *(E)*, and the vulnerability of the exposure to the flood hazard *(V)*.

The risk equation for a single flood event reads as follows:

$$R = P \cdot E \cdot V \qquad (Eq.1)$$

The probability of a flood hazard *(P)* is expressed by the return period *(RP)* of each flood hazard dataset, with $P = 1/RP$. Furthermore, V is expressed as a damage fraction (in percent) using a relative depth-damage function, while E states the maximum damage (for example, in US$) for each asset at risk. Hence, the product of $E \cdot V$ results in the damage (D). Note that for potential adverse consequences of flooding the terms "damage", "loss", and "impact" are used interchangeably in this study.

The flood risk R for several return periods—the annual average loss (AAL)—was calculated, creating a risk curve by integrating over the entire range of P, leading to Equation 2:

$$R = \int_0^\infty P \cdot E \cdot V = \int_0^\infty P \cdot D \qquad (Eq.2)$$

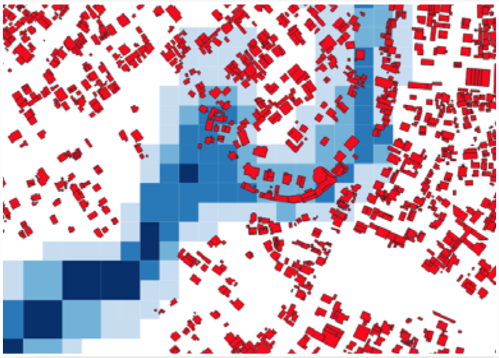
The cell-based risk assessment (CRA) concept developed by Burzel *et al*. (2015) was used to calculate flood impacts and risks on a spatial basis. The CRA concept is a geographic information system (GIS)-based risk assessment approach that enables flexible, yet efficient flood impact and risk calculations. The CRA can combine several standardized workflows with different input data formats (for example, points, lines, and polygons) and consider multiple parameters for the calculation of flood losses. A CRA follows four main steps (Burzel *et al*., 2015):

- **Compartmentation** divides the study area into a grid
- **Transformation** sees all hazard and exposure data transferred into gridded spatial data
- **Assessment** calculates flood impacts and risk for each grid cell
- **Mapping** sees flood impact and risk results stored and displayed on the grid structure.

The CRA approach makes it possible to combine different spatial resolutions into a computational subgrid and refine the risk assessment in areas where this is necessary. In the past, subgrid approaches have only been used for hydrological models and rapid flood hazard mapping.

Because of STP's small size, initial calculations with a uniform resolution of 125m indicated that nearly the entire country experiences a high level of flood risk. To better identify those areas that are most at risk, a 50m resolution, complemented with 25m grid resolution for areas where buildings are present, provided more detailed insights. This method balances the need for a high-resolution risk model with the desire for computational efficiency. After CRA compartmentation, the island of Príncipe contained 9,400 cells and the island of São Tomé 48,100 cells.

Figure 5: Illustration of the computational CRA-subgrid



An illustration of the computational CRA-subgrid with combined 25m and 50m resolution. The flood hazard (resampled water depth) is indicated in blue, while the overlay of building exposure is indicated in red. Note the refined grid in the proximity of buildings.

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[3] To increase the level of detail of the results of this study, the official subdistrict division was slightly modified. The city of São Tomé is divided into three parts (Norte [North], Centro [Center], Sul [South]) and the island of Príncipe is divided into the city of Santo António and the rest of the island in the result tables.

2.3 Data Collection and Preparation

Data on hazard, vulnerability, and exposure was collected, critically reviewed and—where necessary and possible—further improved. This process ensured a reliable basis for subsequent flood impact and risk assessment.

The collection of the exposure data was a joint effort with the West Africa Coastal Areas Management Program's Project Implementation Unit (WACA PIU) and national agencies such as the *Instituto Nacional de Estatística* (INE, National Institute of Statistics), *Conselho Nacional de Preparação e Respostas às Catástrofes* (CONPREC, National Disaster Preparedness and Response Council), the *Ministério da Saúde e dos Direitos da Mulher* (Ministry of Health and Women's Rights), and the *Ministério da Educação, Cultura e Ciências* (Ministry of Education, Culture, and Science).

The subsequent sections briefly describe the data collection and preparation process and the most relevant steps to improve the exposure data are explained.

2.3.1 Hazard Datasets

The Dutch independent research institute, Deltares, modelled the flood hazard data in parallel to the first phase of this flood risk assessment (during mid-2023). This study used the flood maps of the combined flooding from pluvial and fluvial (or rainfall-runoff) and coastal flooding mechanisms.

Deltares also produced separate hazard maps for each type of flood, but the present study did not differentiate these. The section below is based on the technical note by Deltares (2023):

The flood maps were created using hydrodynamic modelling. The most recent digital elevation model (DEM),[4] a new bathymetry dataset,[5] together with multi-year precipitation and water level time series were used as input for the model.

The precipitation time series were generated by constructing several return periods from the available precipitation measurements on São Tomé and Príncipe. Climate change effects on the boundary-conditions were taken from sources such as the IPCC's[6] 6th Assessment Report and the Deltares Global Tide and Surge Model (GTSM)[7].

The emissions scenario SSP3-7.0 was selected, representing a likely middle-of-the-road scenario, and future dates of 2050 and 2080 are chosen. This choice affects both atmospheric (i.e. rainfall) and coastal (i.e. sea level rise) variables.

The flood hazard data was provided with a horizontal resolution of 5m. For each climate condition (2020, 2050 and 2080), six return periods are available: 1-in-1, 5, 10, 25, 50 and 100 years (see Table 1 and Table 2).

Table 1: Flood scenarios for the island of São Tomé.

	RETURN PERIOD (YEARS)					
Climate	**1**	**5**	**10**	**25**	**50**	**100**
Present (2020)	✓	✓	✓	✓	✓	✓
SSP3-7.0, 2050	✓	✓	✓	✓	✓	✓
SSP3-7.0, 2080	✓	✓	✓	✓	✓	✓

Table 2: Flood scenarios for the island of Príncipe.

	RETURN PERIOD (YEARS)					
Climate	**1**	**5**	**10**	**25**	**50**	**100**
Present (2020)	✓	✓	✓	✓	✓	✓
SSP3-7.0, 2050	✓	✓	✓	✓	✓	✓
SSP3-7.0, 2080	✓	✓	✓	✓	✓	✓

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[4] In 2019, the Ministério das Infraestruturas, Recursos Naturais e Meio Ambiente (MIRNMA) commissioned new high-resolution light detection and ranging topographic digital terrain models (DTMs) for both São Tomé and Príncipe islands from OFEK Aerial Photography (OFEK 2019). The DTMs have a spatial resolution of 5m x 5m and a reported maximum vertical root mean-square error of 0.2m, which is roughly equivalent to 0.4 m precision.

[5] Satellite-derived bathymetry (SDB) in the nearshore areas (down to approximately -22.5 meters) for both islands was procured by World Bank from EOMAP in 2023. SDB was generated using optical satellite imagery and has a spatial resolution of 10m x 10m. Vertical uncertainty ranges from 0.5m in very shallow water, to up to 3m in the deepest areas (Deltares, 2023).

[6] Intergovernmental Panel on Climate Change.

[7] GTSM is a depth-averaged hydrodynamic model with global coverage. GTSM can be used to dynamically simulate water levels and currents, that arise from tides and storm surges (Deltares, 2024).

The flood hazard data was critically reviewed before use in the risk assessment. Overall, the maps showed good results with regard to the representation of water depths and flood extents when comparing with aerial imagery (see examples in Annex 1). Moreover, Deltares performed a qualitative validation by comparing simulation results against the flood event of December 2021 in São Tomé. In general, it found that “the simulated flood results (the 10-year flood map for northern ST) are in good agreement with the actual flood of December 2021” (Deltares, 2023).

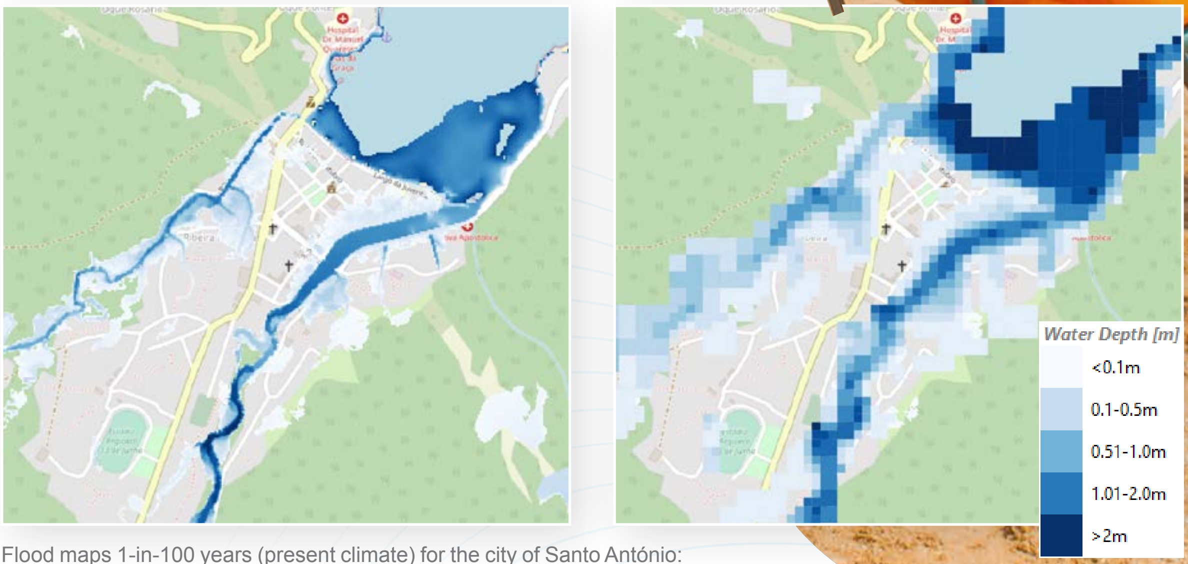
Nevertheless, it is important to highlight that rivers and coasts are part of a natural and dynamic environment and therefore, morphological developments can lead to changes in flood depths and extent. Also, local effects such as log jams on bridges, can lead to unexpected changes in water depth and flood extent, particularly for flood events with lower probability.

To account for those spatial uncertainties, this study resampled the flood hazard to a lower horizontal resolution of 50m as a baseline. The grid was refined with a resolution of 25m in areas with buildings that require a higher degree of detail (Figure 6).

All hazard datasets were resampled into the CRA-subgrid as mean water depths to serve as input for the flood risk assessment. The mean water depth per grid cell was then used to determine the vulnerability *(V)* from the depth-damage functions described in the following subsection. In addition, for the calculation of flood risk, the return periods were translated into the probability of flooding *(P)*.


Praia Gambôa, São Tomé e Príncipe

Figure 6: Flood maps for the city of Santo António



Flood maps 1-in-100 years (present climate) for the city of Santo António: 5m flood hazard raster (left) and resampled 25 and 50m resolution subgrid (right).

2.3.2 Exposure data

To ensure a reliable basis for the flood risk assessment, phase one of this study identified, collected, and reviewed suitable exposure data. Where possible, data was further improved by means of geostatistical operations and data analysis, which included geolocating and mapping relevant assets to be considered in the risk analysis.

GENERAL BUILDINGS

Total numbers

Exposure information for buildings was derived from a nation-wide building footprint dataset, which itself was derived from the high-resolution digital surface model commissioned by *Ministério das Infraestruturas, Recursos Naturais e Meio Ambiente* (MIRNMA, Ministry of Infrastructure, Natural Resources, and Environment) as described in Section 2.3.1. The dataset contains a total of 133,066 features as building footprints. The dataset did not contain further information, such as building use, height, number of storeys or ground-floor elevation.

The building dataset was compared to Google's recently published Open Buildings dataset[8] to check if the data could be considered complete. The comparison did not show significant differences between both datasets.

5,228 footprints smaller than 10 square meters—representing side-buildings, sheds, or processing artefacts—were filtered out from the dataset and the remaining 127,837 features were used to calculate building losses and risks for STP. 61,722 individual buildings were identified and mapped in STP after merging adjacent polygons (which is equivalent to one building per 3.8 inhabitants).

From this subset, 60 building footprints were removed as their size exceeded 2,000 square meters. Those footprints represent industrial halls, hangars, canopies, and stadiums, which have different damage characteristics compared to regular building structures.

Figure 7: Building footprints with individual polygons

Building footprints with individual polygons indicated in red. Footprints smaller than 10 square meters (orange) that were not connected to larger polygons were removed from the analysis.

General buildings: typologies

The micro-scale community study on STP previously carried out by Deltares in 2019 described four different building typologies, and associated total exposure values and ground floor elevations for six different communities on STP. The predominant building typologies on STP are timber houses (mostly on stilts) and (elevated) concrete houses (Figure 8).

Figure 8: Examples of predominant building typologies in São Tomé and Príncipe

Examples of timber houses on stilts (left) and elevated concrete houses (right) in STP.

Source: *João de Lima Rego/World Bank.*

Unfortunately, the building dataset described above did not contain information about the building type. Field visits in several communities in STP defined and confirmed a generalized ratio between the two main building typologies, namely:

- Rural areas: 70 percent timber, 30 percent concrete
- Urban areas: 30 percent timber, 70 percent concrete.

Rural and urban areas were distinguished by using the population dataset, where two categories are specified: either rural (rural) or urbano (urban).

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[8] For more information, see: https://sites.research.google/open-buildings/

Stock and replacement values

To define the exposure value (E), the asset values from the Deltares 2019 community study were averaged as shown in Table 3 below, leading to a mean value of US$233 per square meter for concrete buildings and US$65 per square meter for timber buildings.

Table 3: Average exposure values for the building typologies (timber and concrete buildings) derived from the 2019 community study

	EXPOSURE VALUES IN US$ PER SQUARE METER	
Community	**Timber**	**Concrete**
Iô Grande	35	284
Praia Melão	48	188
Pantufo	58	188
Praia Lochinga	74	222
Micoló	47	260
Praia Abade	126	260
MEAN	**65**	**233**
(Standard deviation)	(32)	(41)

Source: *Deltares, 2019. See Annex 4.*

The values are lower than the exposure values for other Sub-Saharan countries analysed in the R5 project of the Global Facility for Disaster Reduction and Recovery (GFDRR). In the R5 project, ImageCat (2017) found average replacement values of US$300 to US$500 per square meter for permanent residential buildings, and replacement values being roughly one third to one half for semi-permanent (adobe, brick) structures and one sixth to one quarter for temporary structures. This can be explained with the lower building standard on STP compared to other Sub-Saharan countries. A direct comparison with Cabo Verde in the R5 study shows more similar replacement values—US$360 per square meter for permanent buildings and US$67 per square meter for temporary structures.

After consultation with local experts, costs for the island of Príncipe were multiplied by a factor of 1.5 to account for additional reconstruction and repair costs as a consequence of double insularity.

POPULATION

Spatial distribution

The population dataset was provided by the INE as a point dataset with total number of inhabitants (attribute: POP_total) within each administrative unit (attribute: COD_AE).

The dataset was first processed to calculate the number of inhabitants per point by dividing the total number of inhabitants by the number of points within the same administrative unit.

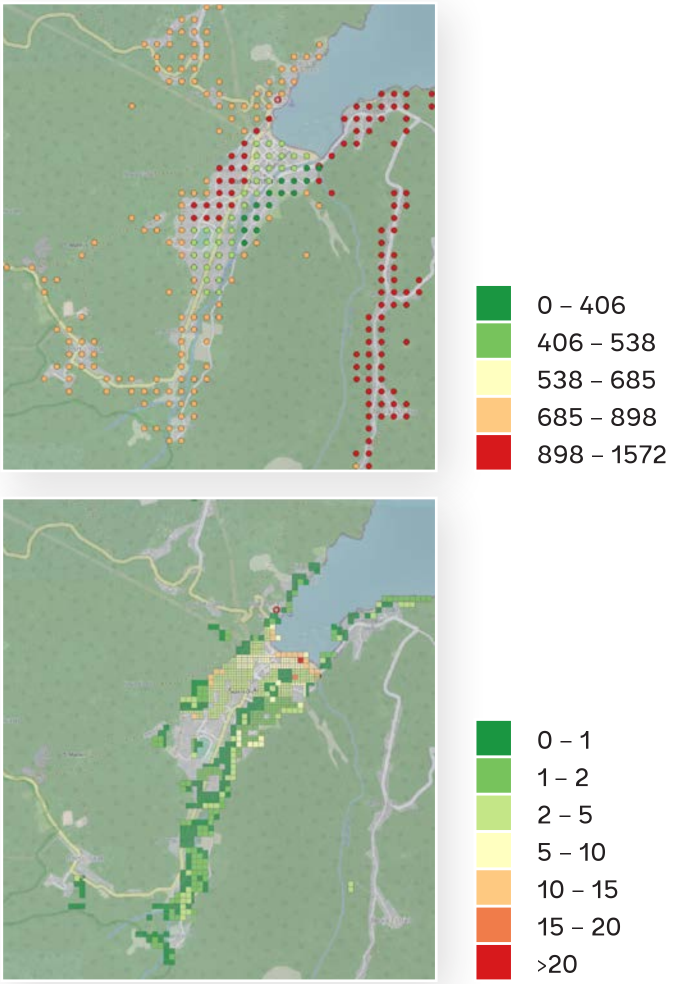
Updating the total population

The INE dataset stated a population of 178,092 inhabitants. Though the dataset had “2017” in its file name, we inferred that the underlying data was from an earlier time point, as in 2017 there were officially 208,036 inhabitants according to the World Development Indicators shown in the Data Bank of World Bank (World Bank, 2023a).

According to the World Bank Data Bank, the population in 2021 was 223,107 inhabitants, with a growth rate in the previous few years of between 1.5 percent and 2.0 percent. Assuming a growth rate of 1.5 percent, STP would have a population of 229,850 inhabitants in 2023.

As there was no available information on where population growth has taken place over the last six years, the study increased the 2017 INE dataset uniformly by 29 percent, after consultation with the World Bank team and the local WACA PIU team. Hence, the population values are multiplied with a factor of 1.29 to correct for population growth, resulting in a total population exposure of 229,627 inhabitants. Figure 9 shows the comparison between the INE data and final CRA-subgrid for the city of Santo António.

Figure 9: Comparison between INE data and the final CRA-subgrid for Santo António



Example of the population distribution for Santo António based on statistical units (INE-dataset, left), and final 25m/50m CRA-subgrid (right). Note that for the CRA-subgrid, only cells where flooding can occur are displayed. Other cells are ignored to minimize the number of computational cells.


Mocoló, São Tomé e Príncipe

HEALTH SECTOR INFRASTRUCTURE

The Ministry for Health provided a healthcare dataset that covered hospitals, medical centers, and medical posts for STP. Figure 10 shows the dataset for the district of São Tomé.

The first step of the analysis classified the health dataset into three typologies to assess the flood impacts and risks for the health sector. The classification followed the Safer Hospitals study carried out for Mozambique (Deltares, 2021) and contained:

- Primary health facilities, for example rural health posts (41 facilities)
- Secondary health facilities, for example rural hospitals (11 facilities)
- Tertiary health facilities, for example provincial hospitals (3 facilities).

Figure 10: Example of the healthcare facilities dataset in the area of São Tomé

Source: *Ministry of Health healthcare dataset.*

The next steps focused on primary and secondary health facilities only, as flooding does not affect any tertiary health facilities on STP due to their slightly elevated locations relative to primary and secondary facilities.

The Safer Hospital study identified exposure values for the three different classes. However, as those values are size-based, there was first a need to calculate the average size of healthcare facilities per class. An average building footprint of 265 square meters was calculated for primary facilities from a set of 12 randomly chosen primary facilities on STP. The average building footprint was 320 square meters for secondary facilities, based on the sizes of seven randomly chosen secondary facilities. The values are shown in Annex 2 (Table 9) in more detail.

Similarly, an average exposure value (E) for both structure and content combined was calculated from the different types of facilities (as specified in Table 4.3 in the 2021 Deltares study). The average exposure value was US$524 per square meter for primary facilities, and US$934 per square meter for secondary facilities.

Unfortunately, there is no information available about the number of patients per healthcare facility in STP. Dividing the number of healthcare facilities by the number of inhabitants resulted in roughly 10,000 inhabitants for each primary facility, and 20,000 inhabitants for each secondary healthcare facility. The assumption that 50 percent of the inhabitants are able to visit another facility enabled us to roughly estimate the number of people without access to healthcare facilities per return period and on annual average.

EDUCATION INFRASTRUCTURE

The Ministry of Education, Culture and Science initially provided information on education in a shapefile. However, those shapefiles only indicated location and school type and were missing information on the number of pupils. Through INE and local experts, information was obtained on the number of pupils per school in the form of tables. The information from the tables went through several iterations and was geo-referenced by matching the initial dataset, as well as reviewing OpenStreetMap, Google Maps and other sources.

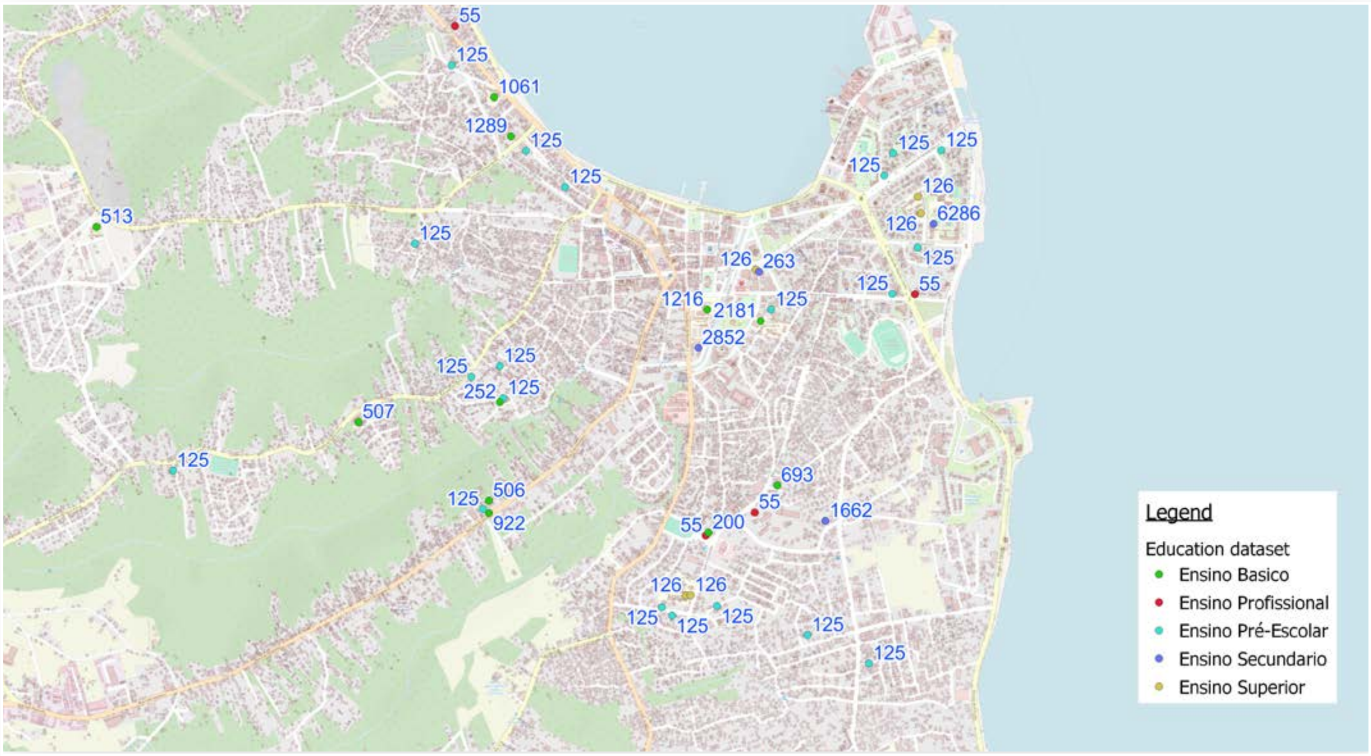
The resulting, improved, education dataset identified 232 features, including preschools (102), primary schools (92), secondary schools (25), vocational training centers (25), and university level locations (7), where the attribute NumberStud indicates the number of students enrolled. The values were validated through INE's Boletim Estatístico da Educação (Bulletin of Educational Statistics) 2021/2022.

Note that the total number of students in the dataset is slightly higher than in the 2021/2022 INE report (67,355 versus 55,662), but in line with the more recent numbers provided by local experts. Six locations do not have a number of pupils assigned in the dataset—those are either duplicates or schools under construction and thus were not considered. Figure 11 shows the resulting dataset for the city of São Tomé.

The next step built on the relationship between the number of students per location and the size of the school. Based on 15 randomly chosen locations, a value of 0.78 square meter footprint area per student was calculated. For each individual school building, this value was multiplied with the number of students to estimate the size of the school building.

We multiplied the calculated building size by US$233 per square meter—the maximum damage value for concrete houses obtained previously. The calculation of the mean values is shown in Annex 2 (Table 10) in more detail.

Figure 11: Example of school dataset with school type and number of students per point in the area of São Tomé



TOURISM SECTOR

The necessary exposure data for the study was not available from government institutions.[9] Therefore, local World Bank experts provided exposure data for the tourism sector as a kml-file, which contained property boundaries, asset type (resort, hotel, or lodge), and bed number.

Building footprints within the boundaries of the property were assigned from the national building dataset to calculate building damages. However, no other building characteristics such as ground floor elevation or building material were available for the analysis.

With the existing data, direct damages to the buildings could be calculated using the general vulnerability function for buildings and the previously established maximum damage value for concrete buildings of US$233 per square meter. Though the number of tourists on STP per year and number of nights per visit were available for this study (World Bank, 2023b and 2023c), our methodology did not allow for straightforward calculations of indirect losses on a national level from these indicators.

KEY LIMITATIONS

The availability of nationwide, consistent, and recent spatial data is an important prerequisite for flood risk assessments. In contrast to the high-resolution flood hazard datasets for present and future climate conditions described in this report, the quality of exposure data was relatively low and the main limitation in this study.

We undertook significant efforts—in close collaboration with local authorities and other World Bank teams—to improve exposure data as described in the previous sections, and have identified several aspects to improve future risk assessments. For example, the existing building dataset should be further expanded by including important building characteristics such as building type (permanent, temporary structure), ground floor elevation, occupation (residential, commercial, industrial), building material (adobe, wood, stone, concrete), and ground floor elevation relative to street level. The latter is particularly relevant due to the relatively high fraction of elevated buildings (residential houses on stilts) in STP.

2.3.3 Vulnerability functions

The damage fraction *(V)* in the risk equation was derived from non-linear, relative depth-damage functions which depend on the flood depth and are expressed as a fraction of the total exposure value *(E)*.

GENERAL BUILDINGS

Several studies were reviewed to identify the most suitable depth-damage function for buildings. In addition to the depth-damage function presented in the Deltares 2019 micro-scale community study for STP, two other functions were identified.

De Villiers et al. (2007) defined curves for South Africa that accounted for the structure and content of residential buildings. The Joint Research Center of the European Commission (JRC) developed the second set of global flood depth-damage functions for a subset of African countries (Huizinga et al., 2017). Though not stated explicitly, the function in the JRC study is likely to be based on the 2007 De Villiers study, combined with a function based on a post-disaster loss assessment from Mozambique.

We selected the function from the De Villiers 2007 study due to its consistency with the depth-damage function in the 2019 Deltares community study. Tests with the function from Huizinga et al. (2017) showed only small sensitivity of the AAL values in the order of 1 percent.

Figure 12 shows the depth-damage function as well as its polynomial approximation. The latter is used to directly calculate the damage fraction (V, in percent) based on the flood depth.

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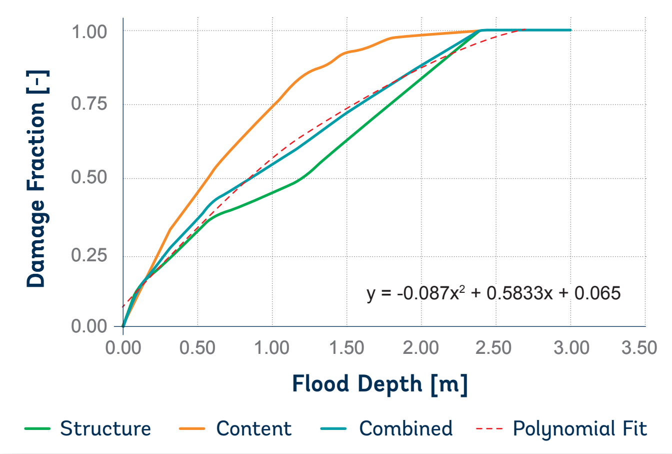
[9] The WACA+ project was developed with the recognition of the informational deficits in the tourism sector and foresees investments to strengthen tourism information collection and management.

The Deltares 2019 study specified the average ground floor elevation for different building typologies as, on average, 0.3m. Even though there are local variations, João de Lima Rego confirmed this value as reasonable during field visits. To account for this, the average ground floor elevation was subtracted from the mean water depth at the building footprint.

Figure 12: Depth-damage function for buildings from De Villiers et al. 2007 with polynomial fit and its equation



Depth-damage function for buildings, including structure (green line), content (orange line), and the combined function (blue line) with polynomial fit (dotted line) and its equation.

POPULATION AFFECTED

The study identified the number of people affected by flooding by using a binary function (true/false) with a fixed threshold. If the mean water depth within a grid cell exceeded the threshold, it meant that the flood hazard affected the population in such a way that they could not proceed with its daily life without flood water hindrance.

We selected a threshold of 0.2m. At this water depth, flooding can no longer be characterized as simply a nuisance as, for example, streets cannot be passed safely anymore.

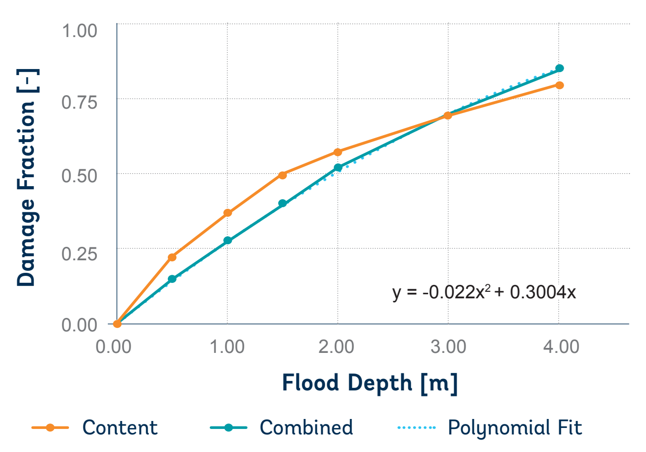
The number of people affected is an important indicator showing how many people experience flooding. However, no conclusions can be drawn about the intensity of the hazard or the possibility of injuries or fatalities as this depends on flood current strength, suddenness of flood wave arrival, the quality of early-warning systems, individual swimming ability, and other factors.

HEALTH

Two depth-damage functions for healthcare facilities were compared in this study. The first function was from the 2017 study from JRC for global depth-damage functions, while the second function was used in the Safer Hospital Mozambique project (Deltares, 2021). The latter study found that the building characteristics of healthcare centres in Mozambique are most alike to conventional classrooms (Deltares, 2021). Therefore, the damage function for classrooms was applied in this study.

As STP has a slightly lower building standard compared to Mozambique, we selected the slightly lower function from the JRC study for this study (Figure 13), after consultation with other experts.

Figure 13: Comparison of depth-damage functions for healthcare facilities from two previous studies



Comparison of depth-damage functions for healthcare facilities, with blue function based on industrial buildings from JRC and orange function based on the classrooms in Mozambique. The polynomial fit is presented as a dotted line and the equation is given as well.

EDUCATION

For educational facilities, the depth-damage function as described for general buildings was selected. During field visits it was observed that recently built school buildings were slightly elevated by 0.3m (Figure 14), and—due to lack of information on existing school buildings—assumed the same average ground floor elevation of 0.3m as was found for general buildings.

Figure 14: School building in the village of Santa Catarina (Santa Catarina district)

Source: João de Lima Rego/World Bank.

TOURISM SECTOR

We selected the same vulnerability function as for general buildings when calculating damages for tourism buildings.

In addition to calculating building damages, a binary (true/false) function was defined to identify the number of tourist assets at risk, with a fixed threshold of 0.2m.

3

Main Findings

This chapter discusses the main findings per sector, namely: all buildings, population, health, education, tourism, and finally, the total (estimated combined) flood risk in STP.

Malanza, São Tomé e Príncipe

3.1 All buildings

We calculated an AAL of US$8.4 million per year under present climate conditions for buildings, about 1.5 percent of the national GDP (Table 4).[10] Note that AALs are heavily affected by the low return periods, in other words, floods occurring on average up to once every 10 years.[11] In particular, a significant share of the most vulnerable housing category, wooden constructions on stilts, are directly located in the beds of rivers and creeks.

On annual average, 1,400 buildings (9 percent of all buildings in STP) are at high risk. The districts of Micoló and Santa Catarina are most affected, with almost 30 percent of buildings affected on annual average.


Praia Gambôa, São Tomé e Príncipe

The largest cities also stand out—São Tomé Norte (estimated 18 percent), Pantufo (estimated 16 percent), and Santo António with an estimated 21 percent of buildings affected. Table 12 to Table 18 in Annex 5 show further results such as building damages per typology, numbers of buildings affected, and damages per climate scenario (present climate, 2050 climate, and 2080 climate).

Table 4: Direct economic flood risk for buildings under present climate (2020)

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Buildings**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2,595	138,182	161,628	164,753	165,118	185,369	**86,959**
Conde	1,167	49,500	57,924	52,280	52,810	55,665	**30,627**
Micoló	679	109,523	125,078	154,053	155,254	179,871	**70,480**
S. Amaro	3,336	295,129	312,487	468,737	473,616	486,064	**190,952**
Neves	3,656	402,117	430,879	556,863	550,902	549,253	**254,200**
S. Catarina	823	297,871	379,928	481,568	563,612	663,417	**202,104**
Trindade	6,791	465,628	509,384	688,868	680,881	724,829	**298,924**
Bombom	3,385	159,762	173,105	210,704	221,607	243,587	**101,147**
Madalena	1,314	15,597	25,859	36,076	35,784	41,396	**11,688**
Caixão Grande	2,386	37,074	40,870	51,049	51,088	59,737	**23,657**
Almas	1,854	38,977	36,989	50,646	52,632	55,933	**24,153**
São Tomé – Norte	2,295	1,738,450	1,809,793	2,139,356	2,182,855	2,311,903	**1,080,081**
São Tomé – Centro	11,531	4,402,984	4,789,104	5,851,215	6,129,932	6,685,908	**2,790,758**
São Tomé – Sul	7,709	902,210	940,931	1,201,716	1,272,692	1,372,500	**569,015**
Pantufo	1,161	460,805	478,004	545,668	549,062	594,875	**284,588**
Santana	3,893	605,350	647,311	736,548	746,996	786,184	**376,652**
Ribeira Afonso	1,943	726,551	810,642	933,083	934,282	1,027,230	**458,545**
S.J. Dos Angolares	1,371	198,750	213,568	221,625	223,313	239,050	**122,323**
Malanza	634	552,043	570,357	700,832	765,335	844,070	**346,222**
Príncipe – S.António	927	1,299,225	1,344,116	1,350,708	1,417,773	1,429,069	**788,912**
Príncipe – Resto	2,272	531,311	551,491	588,217	628,362	604,068	**325,225**
TOTAL	**61,722**	**13,427,037**	**14,409,447**	**17,184,566**	**17,853,906**	**19,139,976**	**8,437,213**

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[10] 2023 GDP of STP: US$547 million (World Bank, 2023a).

[11] Because of the disproportionate contribution of the 1-in-1 flood event to the total AAL (almost 40 percent) and due to the vast uncertainties regarding the exact strength and initial damage threshold for informal buildings, following other international studies (see Section 3.6) here the 1-in-1 floods were not included when calculating the AAL. The AAL was interpolated linearly for between 1-in-1 and 1-in-5 floods. The relative change for different climate conditions was not sensitive to this choice. Nevertheless, the team wants to highlight that annual flooding does lead to damages in STP, also due to the absence of flood protection measures.

Pantufo, São Tomé e Príncipe

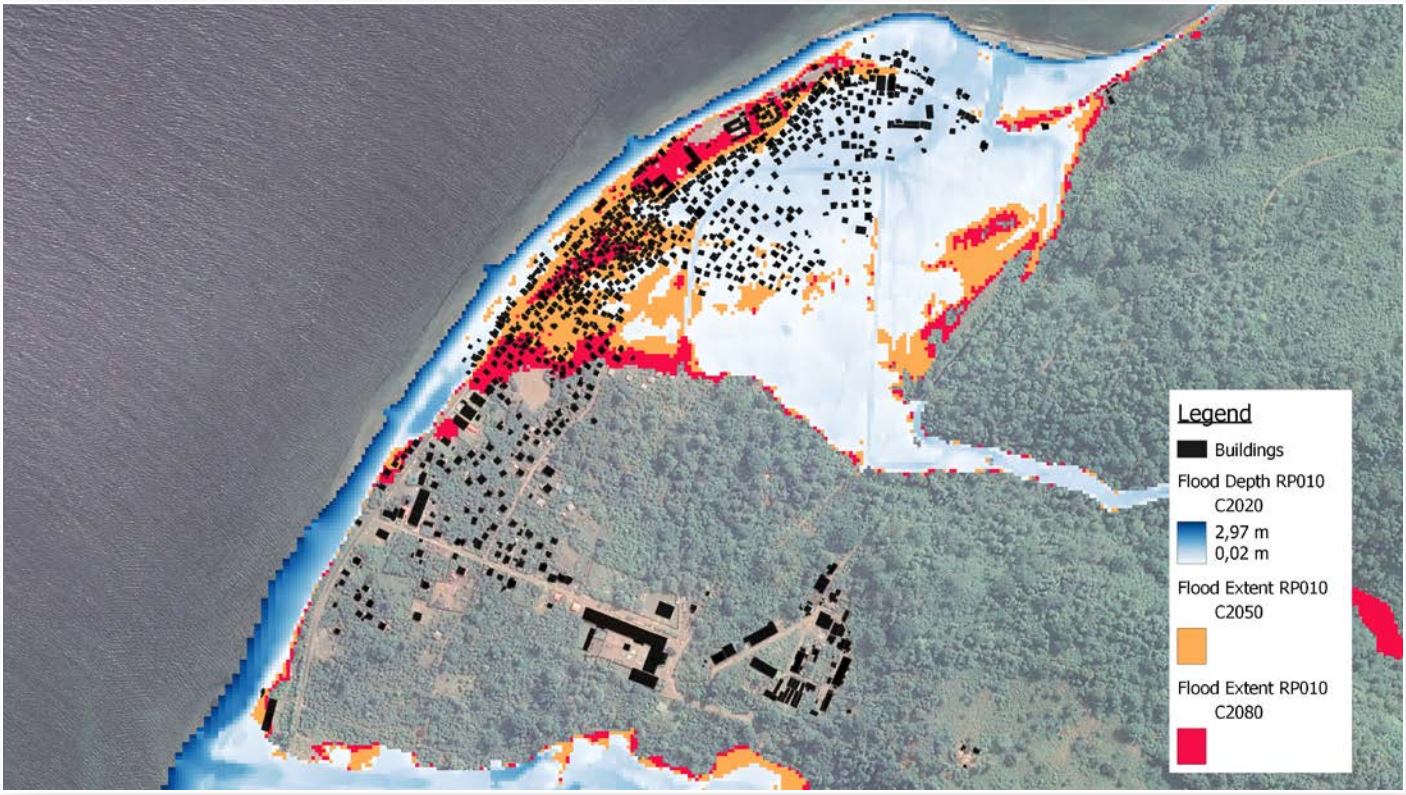
Under 2050 climate conditions, the AAL will increase by 43 percent to US$12.1 million per year (Table 17), which is equivalent to 2.2 percent of the country's 2023 GDP. Compared to 2020, risks to buildings will more than double until 2080, with an AAL of US$17.9 million per year (Table 18), corresponding to 3.3 percent of the GDP.

Under future climate conditions in 2080, more than 30 percent of buildings in Micoló and Santa Catarina will be affected, while 25 percent and 18 percent of buildings in São Tomé Norte and Pantufo will be affected on annual average, respectively.

In Santo António, 23 percent of buildings are estimated to be affected in 2080. All areas show significant increases due to larger water depths and increased flood extent in the future.

Figure 15 compares the flood extent for a 10-year flood in Santa Catarina for the three climate conditions. Annex 5 displays the results for buildings impacts in more detail for present and future climate conditions, also including the relative indicators.

Figure 15: Santa Catarina with present and future flood extents



Santa Catarina with present (blue) and future flood extents (orange: 2050, red: 2080).

3.2 Population affected

The flood impact and risk assessment for population was carried out using the improved population dataset (described in Section 2.3). The key indicator for population was the number of people affected, both per return period and on annual average.

As described before, a fixed threshold of 0.2m was applied to assess the number of people affected. If the mean water depth within a grid cell exceeded the threshold, the population was considered as affected by the flood hazard and their daily life hindered by the flood water.

Under present climate conditions, 18,500 people are affected on annual average—about 8 percent of the total population of STP. The subdistricts of Malanza and Santa Catarina are affected the most, with 41 percent and 33 percent of their populations affected respectively. However, the highest number of people affected is in the subdistrict of São Tomé, where more than 4,500 people are affected on annual average, some 5 percent of the total population.

Under future climate conditions, the AAL increases to 20,000 people per year in 2050, and to 43,000 people per year in 2080. This is an increase of 11 percent and 24 percent compared to 2020, respectively. Note that population growth is not yet considered for future climate conditions, which means the increase may be significantly higher in the future.

Table 5 shows the number of inhabitants per (modified) subdistrict and number of people affected by flooding based on a threshold of 0.2m under present climate conditions. Tables in Annex 5 provide more detail for future climate conditions (Table 19 and Table 21), as well as the relative indicator (percentage affected, Table 22 to Table 24).

Table 5: Number of number people affected by flooding under present climate conditions

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	1,213	1,273	1,308	1,344	1,389	**741**
Conde	3,452	638	650	662	659	671	**385**
Micoló	2,824	981	1,045	1,103	1,162	1,224	**605**
S.Amaro	9,730	1,565	1,616	1,692	1,768	1,819	**955**
Neves	15,141	2,870	2,876	2,959	3,042	3,129	**1,733**
S. Catarina	3,804	2,541	2,700	2,978	3,014	3,145	**1,571**
Trindade	24,694	2,523	2,657	2,792	2,927	2,949	**1,548**
Bombom	12,416	749	787	810	834	880	**458**
Madalena	4,029	181	201	215	229	236	**113**
Caixão Grande	9,214	513	535	566	573	574	**313**
Almas	7,300	478	483	499	500	510	**289**
São Tomé – Norte	7,387	1,305	1,352	1,431	1,452	1,498	**797**
São Tomé – Centro	45,195	3,941	4,129	4,853	4,871	4,988	**2,446**
São Tomé – Sul	31,897	2,084	2,195	2,442	2,518	2,653	**1,289**
Pantufo	4,349	721	770	822	837	898	**445**
Santana	13,949	1,557	1,571	1,660	1,662	1,685	**943**
Ribeira Afonso	8,235	2,534	2,619	2,639	2,659	2,744	**1,537**
S.J. Dos Angolares	5,571	1,085	1,104	1,113	1,123	1,143	**655**
Malanza	2,157	1,172	1,188	1,259	1,263	1,276	**711**
Príncipe – S. António	3,381	712	717	722	756	767	**429**
Príncipe – Resto	6,071	880	903	942	955	983	**535**
TOTAL	**229,627**	**30,242**	**31,371**	**33,469**	**34,147**	**35,157**	**18,497**

3.3 Health sector infrastructure

The risk assessment for healthcare infrastructure showed a relatively low AAL of US$66,000 per year under present climate conditions (Table 6). On annual average, four primary and one secondary health facility are affected. The 2050 climate condition resulted in an AAL of US$77,000 per year with no significant differences in the number of facilities affected. For the 2080 climate, the AAL increased to US$116,000 per year, with an additional three primary facilities affected.

Table 6: Direct economic flood risk for healthcare facilities under current climate conditions

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2	–	–	–	–	–	–
Conde	1	–	–	–	–	–	–
Micoló	2	7,734	8,822	10,653	10,901	11,921	4,954
S.Amaro	2	–	–	–	–	–	–
Neves	1	–	–	2,479	1,031	2,608	154
S. Catarina	1	16,838	18,282	21,730	21,025	21,944	10,554
Trindade	4	20,439	23,132	25,802	25,052	27,158	12,864
Bombom	1	–	–	–	–	–	–
Madalena	3	–	–	–	–	–	–
Caixão Grande	1	–	–	–	–	–	–
Almas	–	–	–	–	–	–	–
São Tomé – Norte	1	–	–	–	–	–	–
São Tomé – Centro	7	–	–	–	–	–	–
São Tomé – Sul	4	1,399	1,519	1,772	1,642	1,978	876
Pantufo	1	–	–	–	–	4,647	70
Santana	7	–	–	–	–	–	–
Ribeira Afonso	4	6,827	7,766	7,331	6,473	7,896	4,202
S.J. Dos Angolares	1	–	–	–	–	–	–
Malanza	1	–	–	–	–	–	–
Príncipe – S. António	2	42,936	45,059	52,065	55,370	56,968	26,694
Príncipe – Resto	9	8,960	9,420	10,246	10,506	11,391	5,524
TOTAL	**55**	**105,134**	**114,001**	**132,078**	**132,000**	**146,511**	**65,891**

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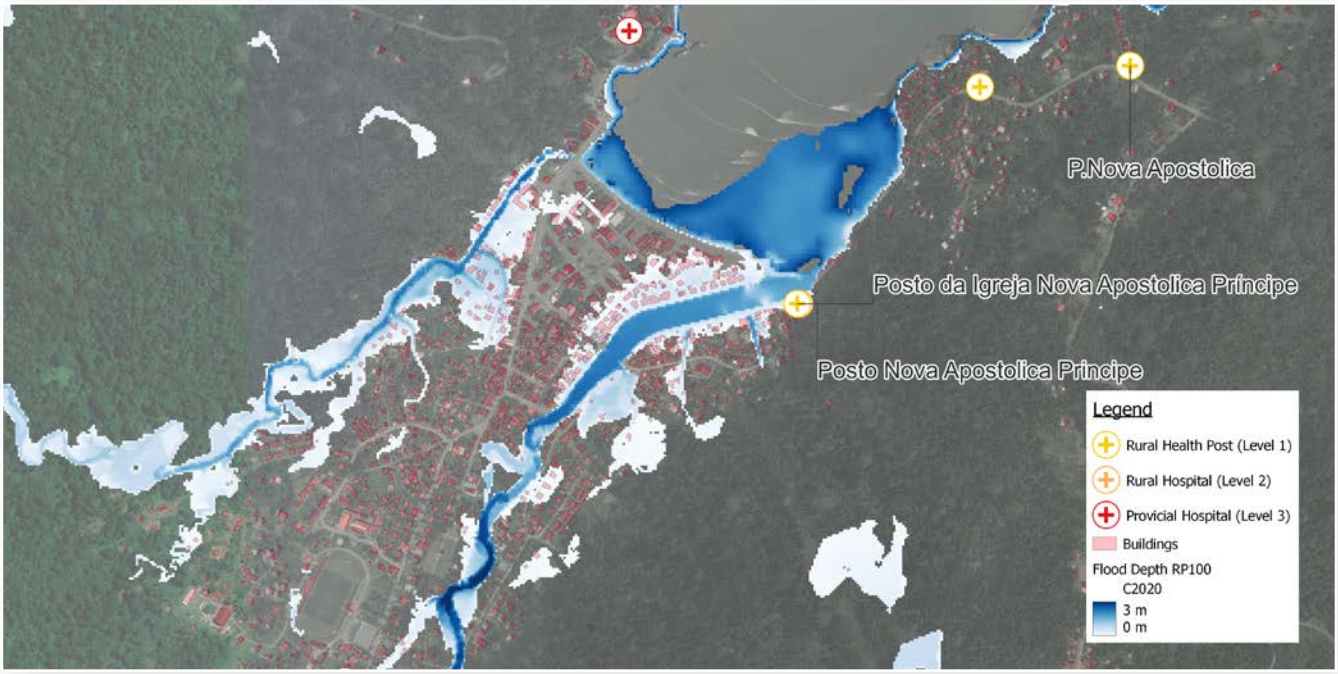
However, due to the relatively low density of healthcare facilities on STP—and thus the large catchment area for each site—the number of people affected in case of damages to healthcare facilities is very high.

Under present climate conditions, on annual average 45,000 inhabitants are potentially impacted when healthcare facilities are affected (Table 25). This value increases to 75,000 patients for the 2050 climate scenario, and 84,000 patients for the 2080 climate scenario.

It is important to emphasize that these estimates are higher than the results for the number of people directly affected by floods (Section 3.2), showing the large impact for the citizens of STP despite relatively low direct monetary damages.

Certain exposed sites can generate the largest impact on citizens, as illustrated by the secondary healthcare facility Posto Novo Apostólica in the city of Santo António on Príncipe. Figure 16 shows the flood map for the 1-in-100 flood scenario (present climate) for the affected facility, in which flooding potentially affects some 10,000 inhabitants indirectly.

Figure 16: Flood map for the 1-in-100 flood scenario (present climate) for Posto Novo Apostolica in the city of Santo António on Príncipe



3.4 Education sector infrastructure

The risk assessment for the education sector was based on the improved education dataset which contained 232 entries: preschools (102), primary schools (92), secondary schools (25), vocational training centers (25) and university level locations (7). As the scope of this study was to provide a macro-scale flood risk assessment on a national scale, and due to the lack of sufficient data, this study did not focus on quantifying indirect impacts on the education sector, such as the impact of floods on learning outcomes.

The results for the education infrastructure impacts show an AAL of US$59,000 per year on annual average under present climate conditions (Table 31). About 3,000 pupils are affected on annual average (Table 8), which is about 3.7 percent of the total student population. The AAL increases to US$83,000 per year for 2050 and US$161,000 per year for 2080 (173 percent increase compared to 2020) (Table 32 and Table 33). On average 3,500 are affected for 2050 (4 percent of the total student population), and 7,700 pupils are affected for 2080 (9 percent of the total student population). Table 7 shows the number of pupils affected on annual basis per type of school.

Table 7: Number of pupils affected on annual average per climate scenario and school type

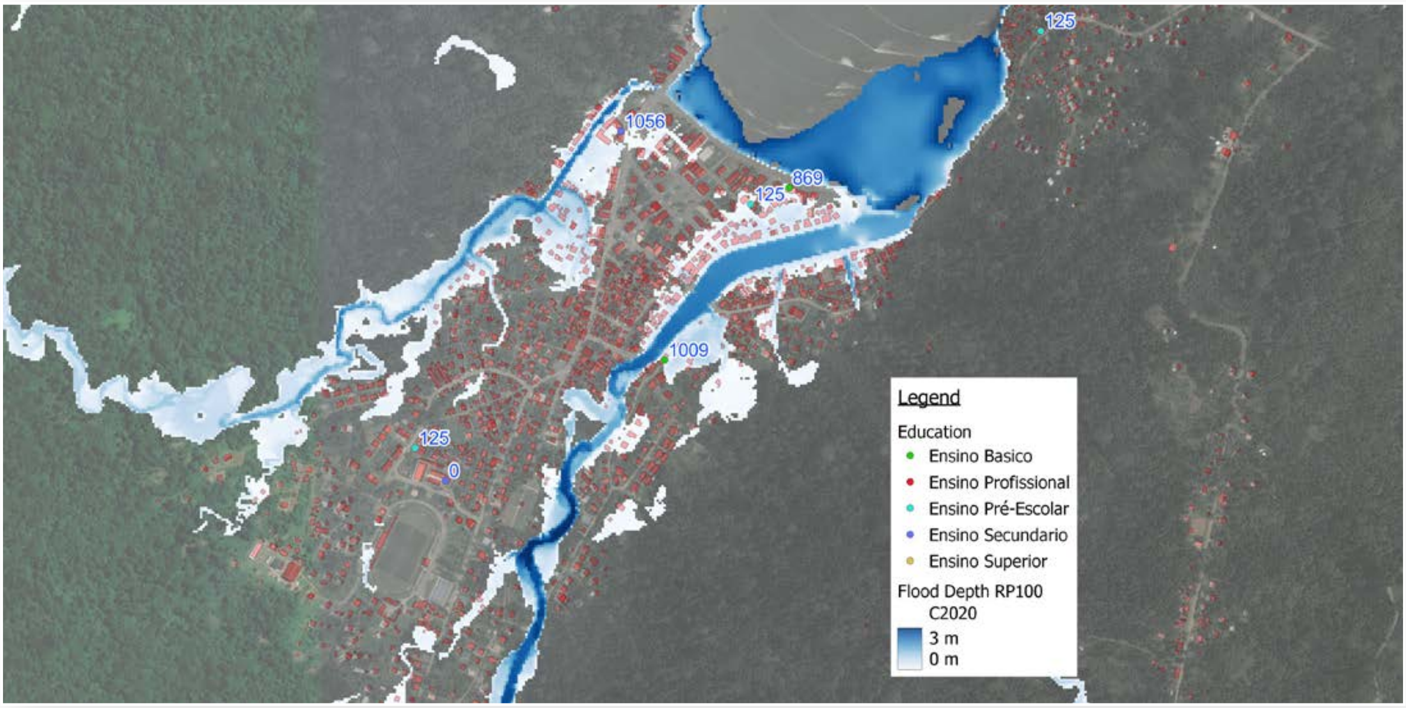
	SCHOOL TYPE		
Climate scenario	**Preschool**	**Primary**	**Secondary**
2020	394	1,701	881
2050	634	1,732	1,109
2080	937	4,268	2,475

The results show a significant increase of the flood risk for education infrastructure—more than doubling in the next 60 years. This is comparable with the increase in risk for general buildings and can be explained with the fact that school buildings are typically located in the same residential areas which are at flood risk. Figure 17 shows the flood map for the 1-in-100 flood scenario (present climate) for the city of Santo António on Príncipe, where about 1,000 schoolchildren could be affected due to the flooding of the Escola Básica Rua Feliz.

Table 8: Number of schoolchildren affected by flooding under present climate conditions

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	125	125	125	125	125	**75**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	–	–	–	–	125	**2**
S.Amaro	3,387	–	–	–	–	–	**–**
Neves	6,114	67	170	170	170	859	**66**
S. Catarina	1,481	125	125	125	125	125	**75**
Trindade	9,671	–	125	125	125	125	**19**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	1,216	1,216	4,068	4,068	4,068	**929**
São Tomé – Sul	6,918	125	125	125	270	270	**79**
Pantufo	1,338	125	125	125	125	125	**75**
Santana	4,705	–	–	–	–	–	**–**
Ribeira Afonso	3,191	1,138	1,138	1,138	1,138	682	**676**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	624	624	624	624	624	**374**
Príncipe – S. António	3,184	1,009	1,009	1,009	1,009	1,009	**605**
Príncipe – Resto	2,135	–	–	–	–	–	**–**
TOTAL	**81,303**	**4,554**	**4,782**	**7,634**	**7,779**	**8,137**	**2,976**

Figure 17: Flood map for the 1-in-100 flood scenario for Santo António education infrastructure



Flood map for the 1-in-100 flood scenario (present climate) for the city of Santo António (Príncipe) with education infrastructure and numbers of students indicated in blue.

3.5 Tourism sector infrastructure

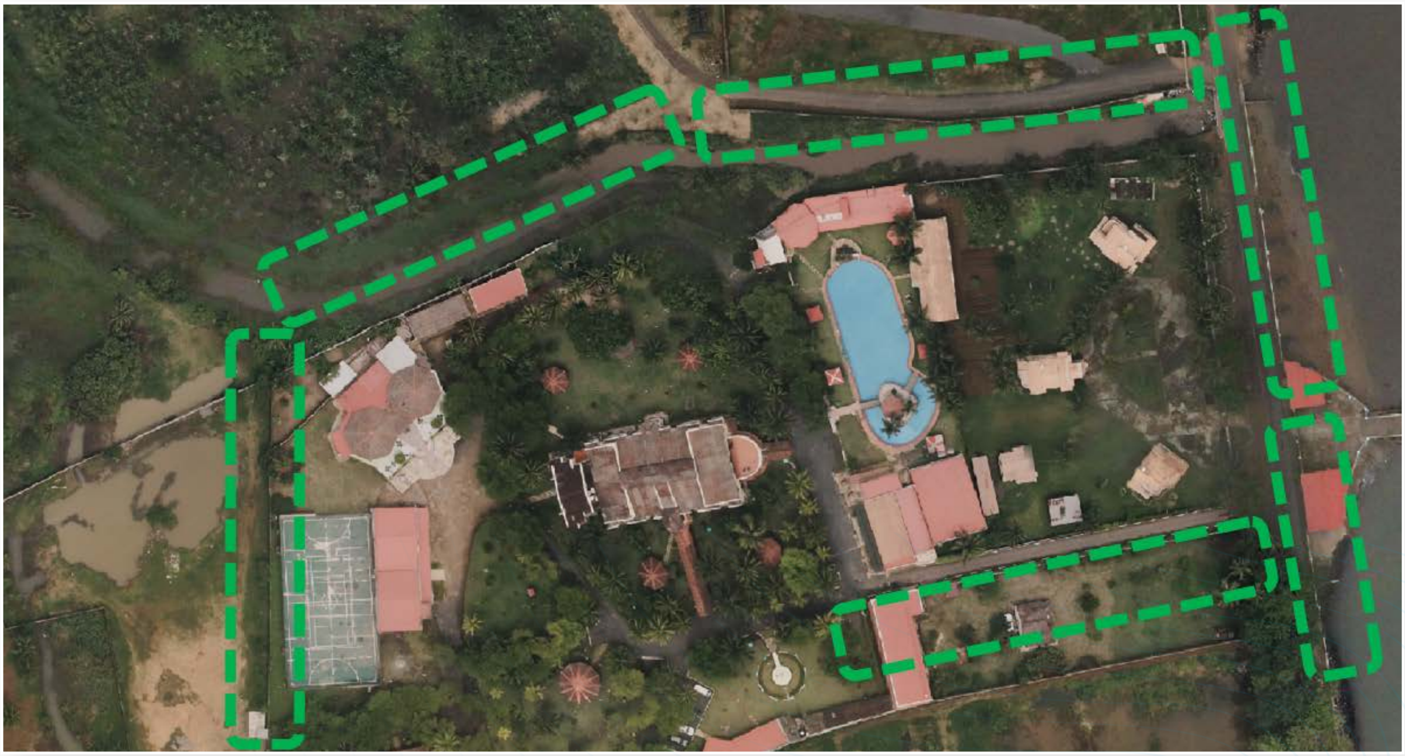
Results show high risk levels for tourism infrastructure. This does not come as a surprise, given that most assets are in close proximity to the coast to benefit from the unique landscape. On average, 25 percent of the property area and 27 percent of the built area was at risk under the present climate condition, with water depths of almost 1m on annual average (Table 40). The AAL for buildings was US$470,000 per year (Table 9), and will increase to US$660,000 per year (42 percent compared to 2020) in 2050 and US$1 million per year (113 percent compared to 2020) in 2080. (Table 37 and Table 39).

The tourism sector is important for the economy of STP, as it accounts for 5.5 percent to 10.8 percent of the national GDP (between US$30 million and US$45 million in 2020). Even a loss of revenue of 10 percent would translate into between US$3 million and US$4.5 million in indirect losses. The exposed nature of tourism buildings at the coast therefore poses significant challenges in the future.

Table 9 shows the building damages for the tourism sector under present climate conditions. Hotel Praia (US$185,000 per year) and Hotel Pestana (US$93,000 per year) show the highest risk estimate. Note that these high values represent the annual expected damages if existing local flood defenses, such as ad-hoc flood walls or elevated bungalows built by hotel developers, are not considered. The national flood hazard study conducted by Deltares in 2023, had a fine-resolution output of 5m x 5m, but also had a relatively coarser numerical grid of 50m x 50m which did not take into account nor resolve fine-scale effects of local, developer-built flood defenses. That limitation influences the results of this risk study.

Figure 18 shows the location of coastal and fluvial flood protections through small-scale flood walls around the Hotel Praia complex. Other examples of flood protection measures are coastal protection by beach nourishment and beach profile stabilization using rocks (for example along the Hotel Pestana seafront) and pluvial flooding protection by elevating individual buildings. Annex 3 illustrates these in greater detail.

Figure 18: Aerial photo showing the network of coastal and fluvial protection walls around Hotel Praia



A high-resolution aerial photo (20cm pixels) around Hotel Praia, showing the “network” of coastal and fluvial protection walls marked in green.
Source: *Abnilde Ceita Lima/WACA PIU*

This set of flood protection techniques is a useful and "organic" illustration of either original or retro-fitted solutions to reduce flood damage and allow for the profitable operation of tourist infrastructure—even in very exposed locations, which are often the most beautiful. However, to build a network of flood protections walls or to invest in a strengthened stretch of beach for hundreds of meters requires some financial power, which is not necessarily available to most communities.

Historically, reality shows an "ad-hoc adaptation" with each family protecting its own house by elevating it on stilts (see Section 2.3.2). This results in precarious protection that depends on each family's skills and wealth in that moment, other works upstream of local flooding, and the effects of climate change.

Table 9 shows the building damages for tourist buildings exposed to flood risk, and Annex 5 contains more result tables.

Table 9: Tourist buildings' economic flood risk under present climate conditions

	RETURN PERIOD (YEARS)					RISK
Location	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Praia Inhame	32,878	32,322	31,280	33,697	38,095	**19,709**
Gumbela Ecolodge	12,566	13,795	16,374	14,490	16,366	**7,876**
Jale Ecolodge	7,641	8,686	4,369	5,477	9,632	**4,535**
Domus Jalé Lodge	–	–	–	–	–	**–**
VANHA turismo rural	–	–	–	–	–	**–**
Ngembu rest & lodge	–	–	–	–	–	**–**
Mionga rest & Lodge	32,798	35,565	40,091	42,918	46,014	**20,542**
Tortue Ecolodge	6,159	10,000	9,846	10,455	12,913	**4,316**
Club Santana	81,768	85,302	102,247	111,210	120,535	**51,186**
Pestana hotel	154,411	159,282	170,229	159,969	138,474	**93,513**
Omali Lodge	–	–	–	–	–	**–**
Emoyeni Gardens	7,094	6,502	8,696	9,196	11,246	**4,367**
Hotel Miramar	–	–	19,057	26,175	32,780	**1,647**
Hotel Praia	290,916	313,860	401,480	419,536	451,860	**185,151**
Bigodes rest e hotel	86,191	86,480	92,489	96,285	92,153	**52,230**
Mucumbli ecolodge	–	–	–	–	–	**–**
Bom Bom resort	9,988	9,641	4,396	10,933	10,645	**5,765**
Sundi Eco-resort (HBD)	18,537	9,504	8,947	9,857	10,651	**9,768**
Sao Pedro Guesthouse	–	–	–	–	–	**–**
Hotel Central	11,542	13,130	15,953	15,973	16,995	**7,377**
Hotel Vitoria	–	–	–	–	–	**–**
TOTAL	**752,491**	**784,069**	**925,455**	**966,171**	**1,008,359**	**467,983**

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3.6 Total risk

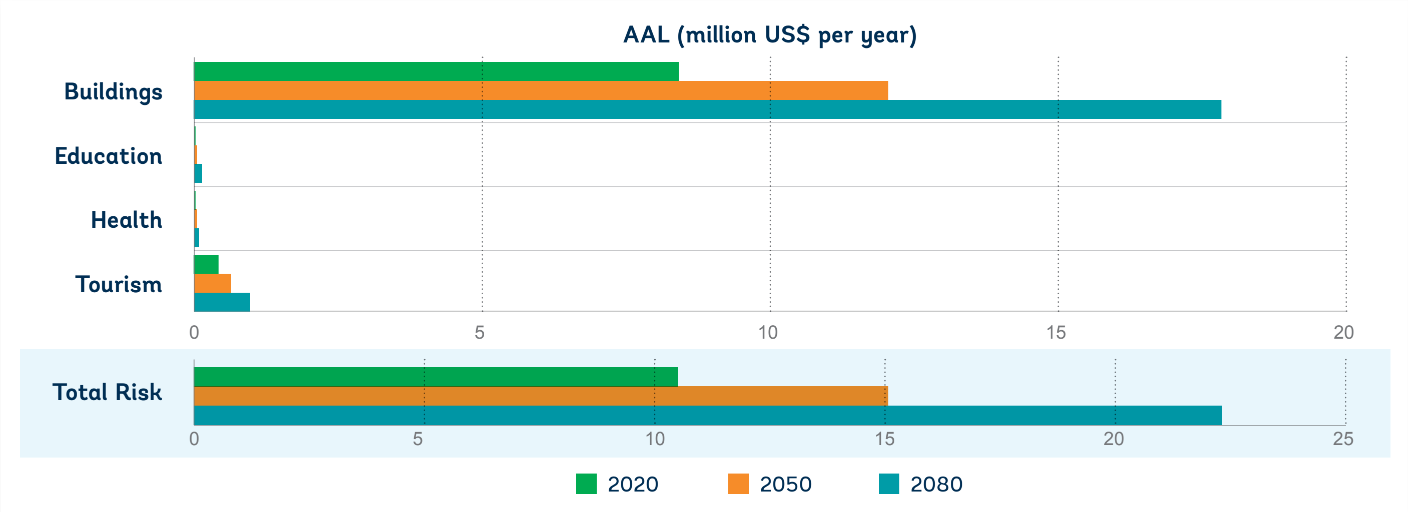
A review of comparable risk studies, including the GFDRR risk profiles for Comoros and Madagascar, shows that the AAL of building stock contributes about 80 percent to the overall flood risk (GFDRR 2016a, b).[12] Therefore, this study used the AAL for buildings to derive an estimate for the total flood risk for STP (Figure 19).

The study estimates the expected yearly losses due to floods, on average, to be 1.9 percent of STP's GDP in 2020, 2.8 percent in 2050, and 4.1 percent in 2080. For context, the flood AAL, and 10 and 50-year event damages, are two to four times higher than those estimates published for Comoros, Madagascar, and Mauritius in 2016 and 2019. However, those values have been shown too optimistic after cyclones Kenneth, Ana, Batsirai, and Freddy caused damages 10 times larger than original predictions. The 2019 GDFRR study from Mozambique shows flood risk values comparable to those reached here as percentages of GDP, or 1.5 to 2.5 times larger in the Mozambican case.

Following the same trend as the general buildings, the overall flood risk more than doubles within 60 years (not yet considering socio-economic growth). Reaching an annual loss of 4.1 percent of GDP is a very stark estimate.

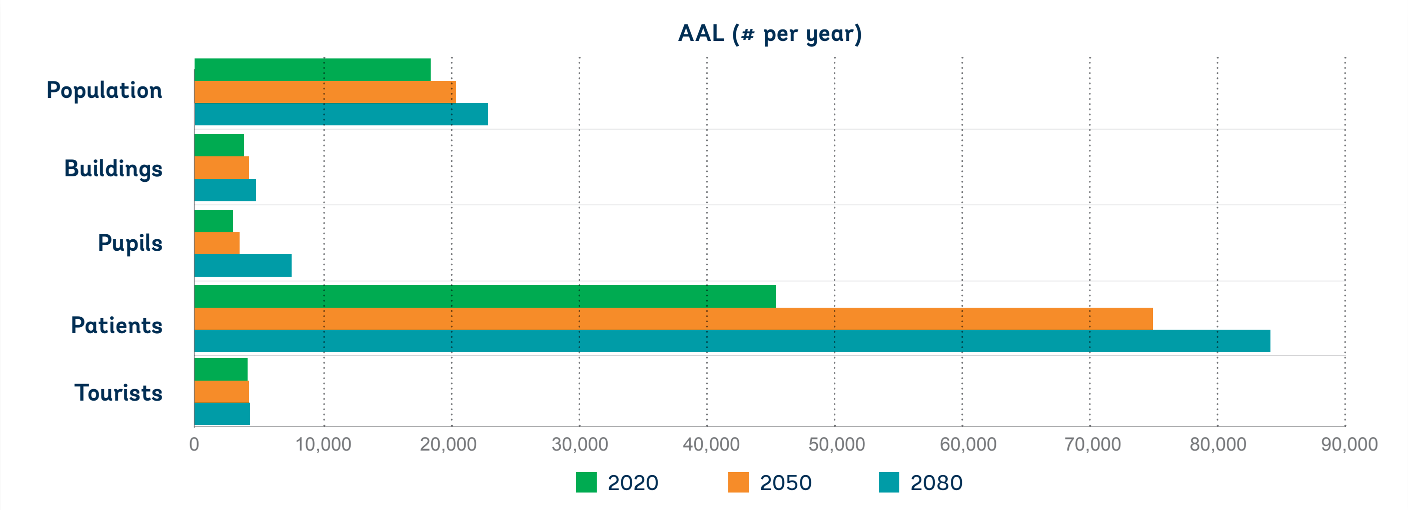
Though associated with higher uncertainties, the numbers for affected pupils, patients, and tourists show the significance of flood risk for STP (Figure 20). The fact that even flood events with a high probability—in the range of once a year up to once every 10 years—lead to significant impacts, shows the high level of flood susceptibility of STP.

Figure 19: An overview of direct economic flood risk per sector and total economic flood risk for STP



Overview of direct flood risk per sector (buildings, education, health, and tourism) and total flood risk (AAL in US$ per year) for STP for three climate scenarios: present (in yellow), 2050 (in orange), and 2080 (in red).

Figure 20: An overview of annual flooding impacts per sector



Annual flooding impacts per sector (population, buildings, pupils, patients, and tourists) with the AAL expressed as number per year for three climate scenarios: present (in yellow), 2050 (in orange), and 2080 (in red).

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[12] The case studies of Mauritius and Mozambique used values of 70 percent and 90 percent, respectively.

3.7 Summary

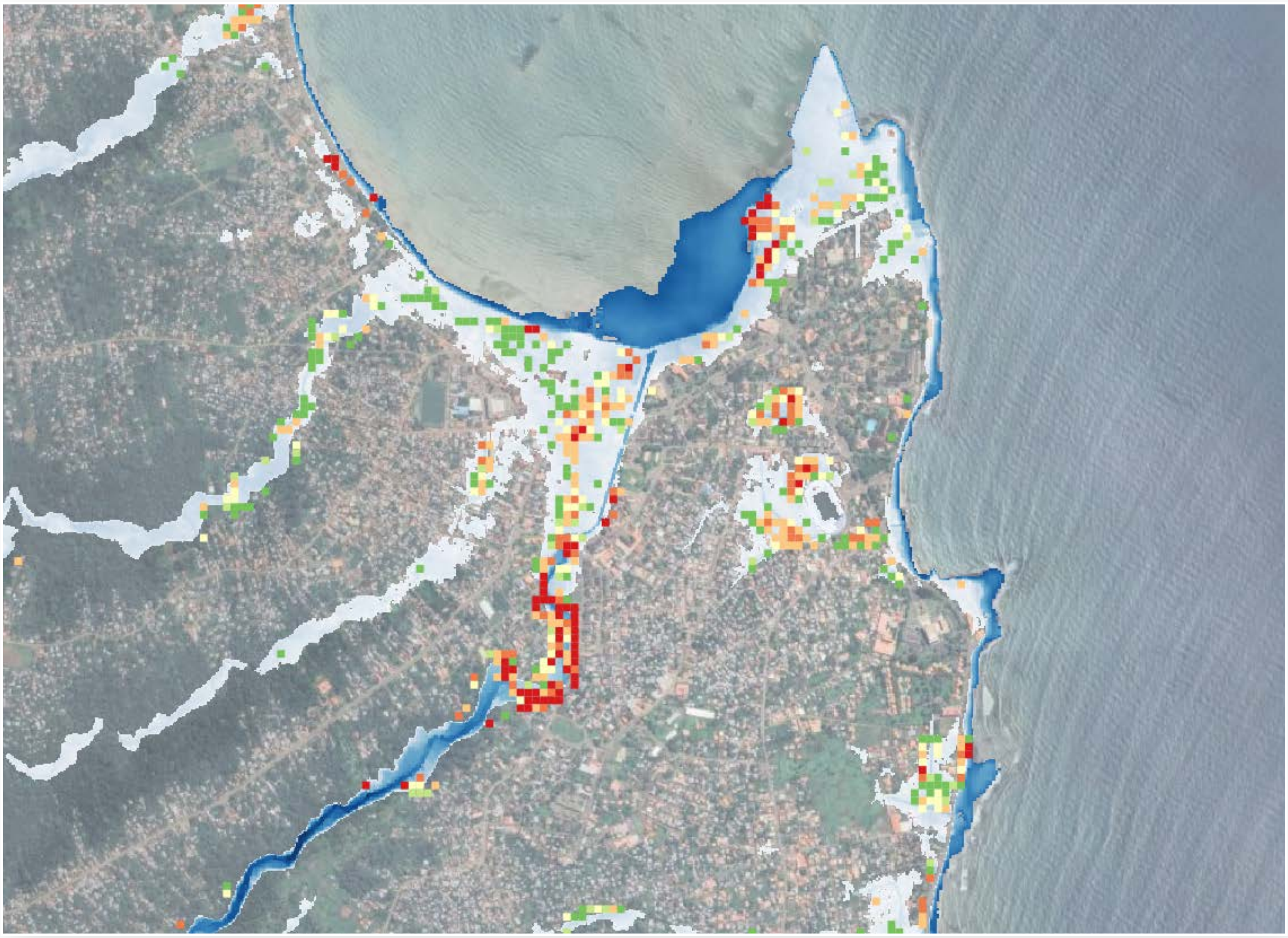
The flood risk assessment carried out in this study showed that STP already has a high flooding risk under present climate conditions. For all sectors, flood risk was driven by low return periods—floods occurring on average once a year up to once every 10 years.

Figure 21 shows an overview of the results for all sectors and climate conditions investigated in this flood risk assessment, up to a subdistrict level. This "matrix" allows for a quick and instinctive differentiation in space and time of the expected damages by flooding in the country.

A final note regarding the availability of metadata: Although the results from this flood risk assessment discussed here were mainly based on tables of results by subdistrict level, calculations were carried out on a fine-resolution subgrid of 25m and 50m horizontal resolution.

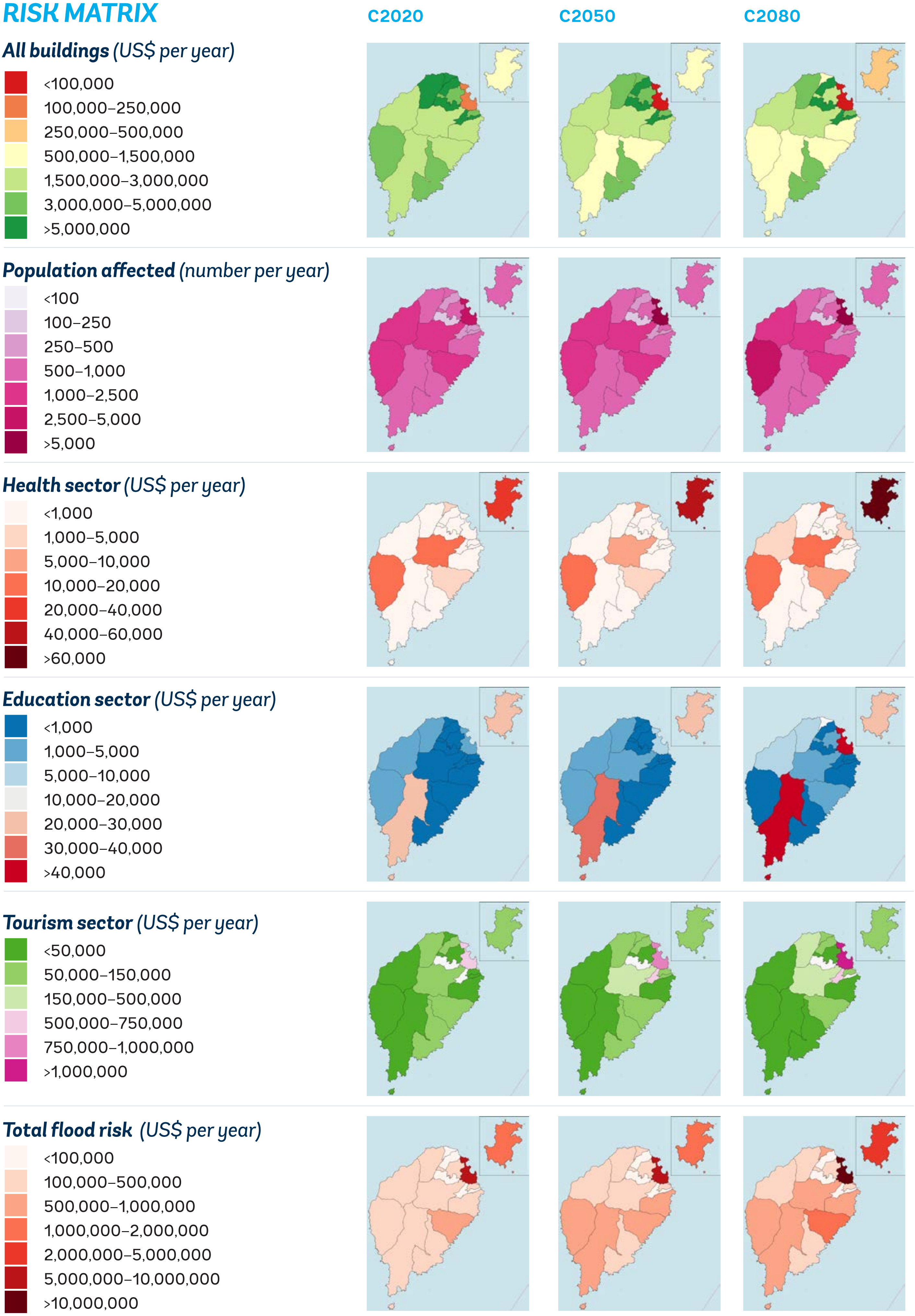
View the online data at https://datacatalog.worldbank.org/search/dataset/0065823/S-o-Tom--e-Pr-ncipe-s-Flood-Risk-Study---WACA-STP-project-. The results (GIS-shapefiles) can be made available for other studies (for example, Figure 22).

Figure 22: Fine-resolution flood risk results for the city of São Tomé



Fine-resolution flood risk results for the city of São Tomé using the cell-based risk assessment approach as the basis for the tabular results per (modified) subdistrict.

Figure 21: Overview risk maps for buildings, population, healthcare facilities, education sector, tourism sector, and total flood risk under present (2020) and future climate conditions



4

Conclusions

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This study assessed the flood risk to São Tomé and Príncipe under present and future climate conditions to better understand the challenges STP is likely to face due to climate change. To achieve this, a nation-wide risk assessment was carried out, taking into account pluvial, riverine, and coastal flood hazards. The assessment covered potential risks for people, buildings, healthcare facilities, education facilities, and tourism facilities.

All findings are approximations of the expected flood risk patterns based on the available input data. These risk maps, tables, and insights can be used to feed national and subdistrict (macro) cost benefit analyses, to identify higher-risk areas, and to inform adaptation measures. The data cannot be applied to high-detail modelling, such as individual buildings, due to the relatively low spatial resolution of the grids and subgrids used in the study.

The risk assessment shows a high flood risk level under present climate conditions, as well as a significant increase of flood risk in the future. It predicts expected yearly losses due to floods, on average, to be 1.9 percent of STP's GDP in 2020, 2.8 percent in 2050, and 4.1 percent in 2080. This means that the overall flood risk more than doubles within 60 years, not considering socio-economic growth. The number of people affected by floods each year is expected to increase from around 18,500 today to 23,000 in 2080 (not considering population growth), quantifying the "cost of doing nothing" in a concrete way.

Communities in STP already experience devastating losses of life and property due to water-related hazards, such as the damages caused by the floods due to intense rainfall in December 2021. In this study, the direct losses for a flood event with a 25-year return period is estimated at being US$17.2 million, which correlates well to the official post-disaster estimate for the 2021 flood event.

It is important to emphasize that low return periods—floods that occur on average once per year, up to once every 10 years—drive the flood risk in STP, especially as flood protection measures such as levees or dunes are not present even for low return period floods.

This means that the population of STP is already highly exposed to flood events, for instance, the most vulnerable housing category—wooden constructions on stilts—is often directly located in the beds of rivers and creeks. So although some adaptation measures have been employed, climate change could intensify the hazards after only a few decades.

Climate change increases the frequency and intensity of events due to higher temperatures, more intense rainfall, and sea level rise (Deltares, 2023) and STP faces a significant increase in flood risk. The study results underline this increased risk for all classes of assets: AAL increases by 43 percent in 2050 and more than 110 percent in 2080 relative to 2020. Expected population growth, improved living standards, and increased GDP will further amplify the increase in flood risk.

For buildings, an AAL of US$8.4 million per year was calculated under present climate conditions—about 1.5 percent of the national GDP. On annual average, 1,400 buildings (2.2 percent of total buildings) are at flood risk.

Under present climate conditions, 18,500 people are affected on annual average—about 8 percent of the total population of STP. The subdistricts Malanza and Santa Catarina are affected the most—33 percent and 41 percent of their total populations respectively. However, the highest number of people affected is in the subdistrict of São Tomé—almost 4,500 people affected on annual average.

The risk assessment for healthcare infrastructure shows a relatively low AAL of US$66,000 per year under present climate conditions. However, due to the relatively low density of healthcare facilities on STP, the number of people affected in case of flood damage to healthcare facilities is significantly high, with 45,000 people (20 percent of the total population of STP) potentially impacted under current climate conditions. The fact that these estimates are higher than the results for the number of people directly affected by floods shows the large indirect impact of flooding on the citizens of STP.

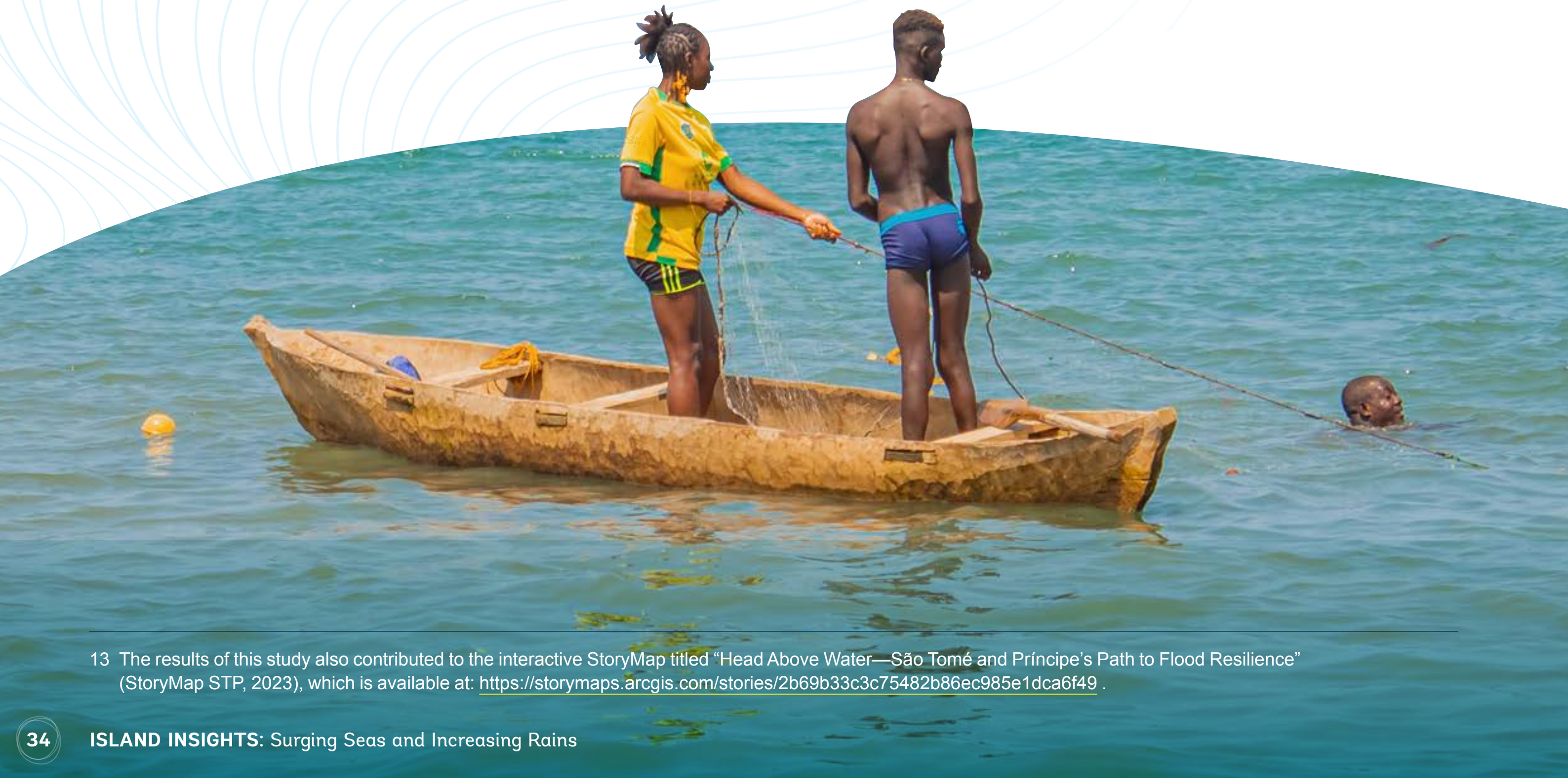
For the education sector, results show a significant increase of the flood risk. The AAL more than doubles in the next 60 years, rising from US$58,000 per year in 2020 to US$160,000 per year in 2080. The number of affected pupils rises from 3.7 percent on annual average in 2020 to 9.4 percent in 2080. Given the importance of education for the development of the country, this is a concerning result.

Flood risk is relatively high for the tourism sector, but represents the estimated damages if local flood defenses are not erected—something which most non-tourist buildings cannot afford to implement. Although the study calculated direct flood losses and AAL values for tourism assets (resorts, hotels and lodges), it concluded that indirect losses can be the most significant for this sector due to lost revenue, and increased expenses as result of supply-chain and infrastructure disruptions after flood events.

Flood damages to tourism assets cause long-term consequences if they lead to negative guest experiences, both during their stay, but also due to rebooking if a hotel needs to undergo repairs or reconstruction. Future studies could assess possible impacts and risks on an asset level, factoring in ground floor elevation and presence of local flood protection measures.

One positive expected impact of this risk study is that it will help identify which communities could benefit from more holistic adaptation strategies, and which protection solutions are worth considering. This could be enhanced by more complete CBAs, such as the 2018 and 2021 Deltares multi-hazard studies for schools and for hospitals, in Mozambique, or at a more targeted level (for example community scale and flood-only), respectively.

To summarize, this study shows that the flood risk level on STP is already high under present climate conditions and will significantly increase in the medium- to long-term (30 and 60 years onward). Figure 23 summarizes the main findings per sector. Currently, vulnerable communities may be able to withstand these shocks—but only just. Ongoing activities such as the WACA program that includes joint efforts by government, NGOs, and communities to boost local preparedness measures, accelerate flood protection investments, and enhance risk communication initiatives help to limit the rapid increase of flood risk and to create a path to flood resilience.[13]



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[13] The results of this study also contributed to the interactive StoryMap titled "Head Above Water—São Tomé and Príncipe's Path to Flood Resilience" (StoryMap STP, 2023), which is available at: https://storymaps.arcgis.com/stories/2b69b33c3c75482b86ec985e1dca6f49 .

Figure 23: Key findings for the different sectors and climate conditions investigated in this flood risk assessment for São Tomé and Príncipe

All buildings

2020: US$8.4 million per year
2050: US$12.1 million per year
2080: US$17.9 million per year

1.5% of GDP (2023)
2.2% of GDP (2023)
3.3% of GDP (2023)

AAL for buildings is about 1.5% of the GDP. **In 2080, ALL is expected to increase by 110% compared to 2020.**

Population affected

2020: 18,500 people per year
2050: 20,500 people per year
2080: 23,000 people per year

8% of the population
9% of the population
10% of the population

Under current climate conditions, 8% of the polulation is at floodrisk. **Malanza and Santa Catarine are most severely affected**, with 41% and 33% of its population affected on annual average.

Health sector

2020: US$66,000 per year
2050: US$77,400 per year
2080: US$116,200 per year

20% of the population
33% of the population
37% of the population

On annual average, every **fifth inhabitant is potentially affected** due to healthcare facilities at risk.

Education sector

2020: US$58,800 per year
2050: US$83,400 per year
2080: US$160,600 per year

3,000 pupils affected
3,500 pupils affected
7,700 pupils affected

Under current climate conditions, **4% of the pupils are affected** because of educational facilities at flood risk.

Tourism sector

2020: US$468,000 per year
2050: US$665,000 per year
2080: US$1,000,000 per year

27% of touristic assets
32% of touristic assets
38% of touristic assets

27% of touristic buildings are exposed to flooding. **Indirect losses may be significantly higher** than calculated AAL for tourism buildings.

Total flood risk

2020: US$10.5 million per year
2050: US$15.1 million per year
2080: US$22.3 million per year

1.9% of GDP (2023)
2.8% of GDP (2023)
4.1% of GDP (2023)

Within 60 years, flood risk for STP more than doubles, without even considering increase in population and socio-economic growth until then.

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Bibliography

Burzel A, Dassanayake DR, and Oumeraci H. 2015. "Spatial modeling of tangible and intangible losses in integrated coastal flood risk analysis." Coastal Engineering Journal 57(1): 1–31. https://doi.org/10.1142/S0578563415400082.

Deltares. 2018. "Multi-hazard risk assessment for the schools sector in Mozambique." Briere C, Leite C, Maarse M, Stuparu D, Burzel A, de Bel M., Tijssen A., and de Lima Rego J. Deltares Report 1230818–002. Deltares, Delft, The Netherlands.

Deltares. 2019. "Geomorphology studies and coastal dynamics and vegetative options for coastal protection of communities Iô Grande, Praia Melão, Pantufo, Praia Lochinga-Gambôa-Cruz, Micoló and Abade." Deltares, Delft, The Netherlands.

Deltares. 2021. "Multi-hazard risk assessment for the health sector in Mozambique." Delft, The Netherlands.

Deltares. 2023. "Technical approach note. São Tomé e Príncipe combined coastal and pluvial modelling." Geertsema T.J., Vandebroek E., de Wilde T., Eilander D.M., and Ogunwumi T.S. Deltares report 11209318-002-ZWS-0001, Delft, The Netherlands.

Deltares. 2024. "Global modelling of tides and storm surges – Global Tide and Surge Model." Available from https://www.deltares.nl/en/expertise/projects/global-modelling-of-tides-and-storm-surges.

De Villiers, G., Viljoen, M.F., and Booysen H.J., 2007. "Standard residential flood damage functions for South African conditions." *Suid-Afrikaanse Tydskrif vir Natuurwetenskap en Tegnologie (South African Journal of Science and Technology)*. 26(1): 26–36. https://doi.org/10.4102/satnt.v26i1.122.

EOMAP (2023). Metadata accompanying satellite-derived bathymetry for São Tomé and Príncipe. Generated on February 13, 2023.

GDFRR (Global Facility for Disaster Reduction and Recover). 2016a. "Disaster Risk Profile Madagascar." Simpson, A.L., Philips, E., Balog, S.A.B., Murnane, R., Deparday, V., Fraser, S.A., Jongman B., and Parmelee, L.F. Washington, DC. World Bank. https://www.gfdrr.org/sites/default/files/madagascar.pdf.

GDFRR (Global Facility for Disaster Reduction and Recovery). 2016b. "Disaster Risk Profile Comoros." Simpson, A.L., Philips, E., Balog, S.A.B., Murnane, R., Deparday, V., Fraser, S.A., Jongman B., and Parmelee, L.F. Washington, DC. World Bank. https://www.gfdrr.org/sites/default/files/comoros.pdf.

GDFRR (Global Facility for Disaster Reduction and Recovery). 2016c. “Disaster Risk Profile Mauritius.” Simpson, A.L., Philips, E., Balog, S.A.B., Murnane, R., Deparday, V., Fraser, S.A., Jongman B., and Parmelee, L.F. Washington, DC. World Bank. https://www.gfdrr.org/sites/default/files/mauritius.pdf.

GDFRR (Global Facility for Disaster Reduction and Recovery). 2019. “Disaster Risk Profile Mozambique.“ Simpson, A.L., Philips, E., Balog, S.A.B., Murnane, R., Deparday, V., Fraser, S.A., Jongman B., and Parmelee, L.F. Washington, DC. World Bank. https://www.gfdrr.org/en/publication/disaster-risk-profile-mozambique.pdf.

Huizinga, J., de Moel, H., and Szewczyk, W. 2017. “Global flood depth-damage functions. Methodology and the database with guidelines.” EUR 28552 EN Publications Office of the European Union. Luxemborg. doi: 10.2760/16510.

ImageCat. 2017. “GFDRR Africa Disaster Risk Financing–Result Area 5, Exposure Development, Replacement Cost Refinements To the Exposure data”. Unpublished report prepared for the World Bank.

OFEK Aerial Photography. 2019. “Relatório sobre Ortofotomapas e Cartografia Vectorial.” Reference No.: PNAT 03/2016. Unpublished report prepared for the World Bank.

World Bank. 2023a. “World Development Indicators Data Bank”. Online database. https://databank.worldbank.org/source/world-development-indicators#.

World Bank. 2023b. “Plano Estratégico e de Marketing para o Turismo São Tomé e Príncipe | 2018-2025 Com propostas a 2030.” Internal World Bank presentation.

World Bank. 2023c. “Circular and Resilient Tourism on Small Islands and in Coastal Destinations - São Tomé & Príncipe: Tourism Gap Analysis and Market Sizing.” Internal World Bank report.

World Bank. 2023d. “StoryMap STP: Head Above Water—São Tomé and Príncipe’s Path to Flood Resilience.“ Webpage. https://storymaps.arcgis.com/stories/2b69b33c3c75482b86ec985e1dca6f49.

Annexes

Pantufo, São Tomé e Príncipe

ANNEX 1

Hazard data review

Figure24: Flood extent and destroyed bridge in Santa Catarina (Santa Catarina district)

Figure25: Flood extent for Neves (Lemba district)

Santa Catarina, São Tomé e Príncipe

ANNEX 2

Calculation of average exposure values

The average size of healthcare facilities and schools was calculated from randomly chosen locations on STP. The average size was required for the calculation of direct flood damages, as the exposure value is expressed as per square meter. In most cases, the exact size per facility was unknown.

The average size of healthcare facilities in STP was determined, while the size per student was calculated for school buildings, as the number of students per location was available for this study.

Table 10: Average size of healthcare facilities for primary (L1) and secondary (L2) facilities (standard deviation in brackets)

	BUILDING FOOTPRINT	
Sample	**L1 (m^2)**	**L2 (m^2)**
1	65	125
2	75	118
3	50	608
4	61	504
5	111	475
6	124	174
7	139	235
8	408	
9	259	
10	180	
11	1586	
12	102	
AVERAGE	**263,33**	**319,85**
(STD)	(428,81)	(203,38)

Table 11: Average school size per student for the calculation of school building size (standard deviation in brackets)

Sample	Students	School size (m^2)	m^2/student
1	506	870	0,58
2	922	975	0,95
3	2852	1320	2,16
4	397	716	0,55
5	738	517	1,43
6	1467	1240	1,18
7	386	267	1,45
8	304	331	0,92
9	418	975	0,43
10	127	500	0,25
11	153	355	0,43
12	41	266	0,15
13	449	2025	0,22
14	270	464	0,58
15	125	300	0,42
AVERAGE	–	–	0,78
(STD)	–	–	(0,56)

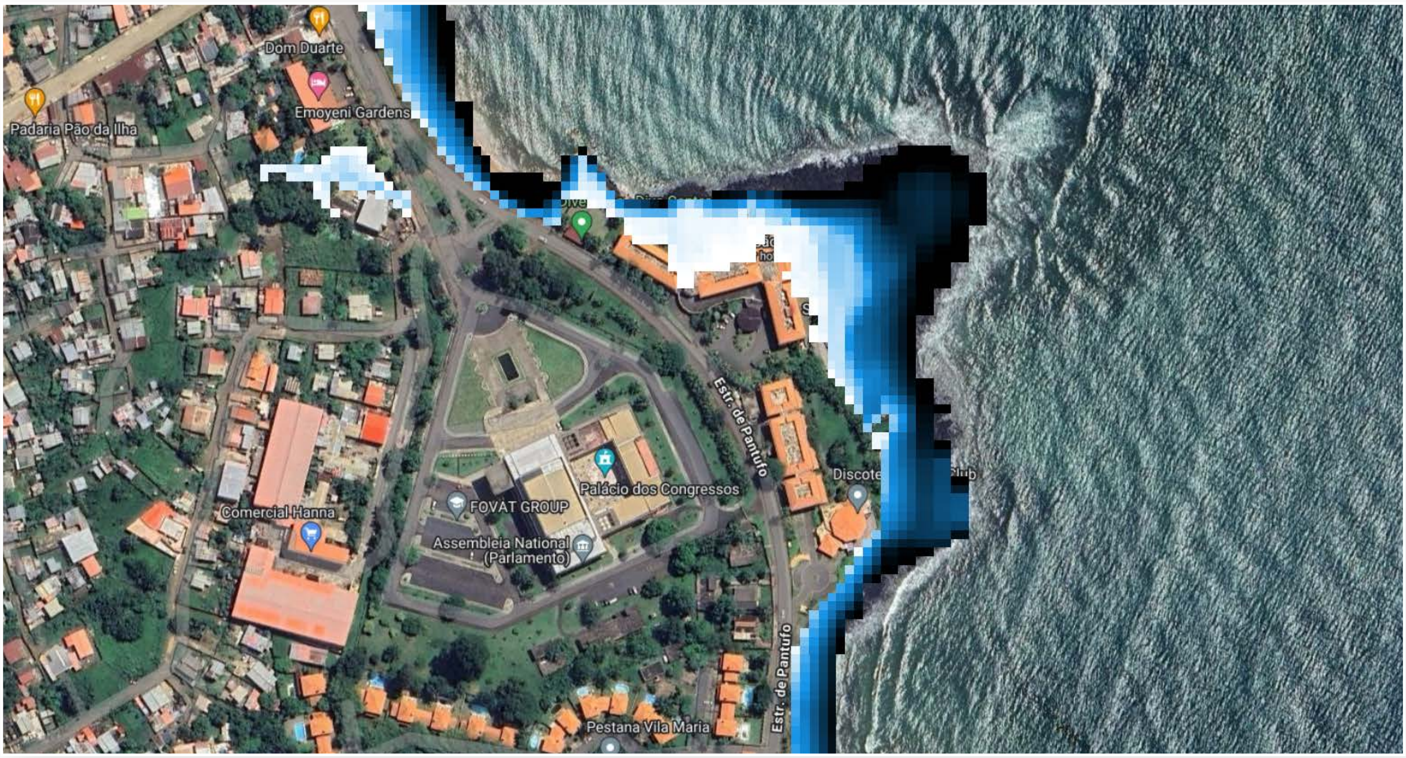
ANNEX 3

Examples for small scale flood protection measures

Figure 26 and Figure 30 below illustrate the flood depth and extent for a 1-in-10 years event (Deltares, 2023) when bespoke flood defenses are not taken into account. Figure 27 and Figure 31 show where the other *in situ* photos were taken, demonstrating those existing flood defenses. They include:

- Figure 28 and Figure 29: **Coastal protection** by beach nourishment and beach profile stabilization using rocks, along the Pestana seafront.
- Figure 32: **Coastal and fluvial protections** by erecting (small-scale) flood walls, around the Hotel Praia complex.

Figure 26: Overhead view of the area around Hotel Pestana overlaid with hazard map



Area around Hotel Pestana (Google Maps Satellite Imagery), overlaid with hazard map: 2020 climate scenario, 1-in-10 year event (flooded depth, color scale between 0.05 and 3m).

Figure 27: Area around Hotel Pestana highlighting where the next two photos were taken

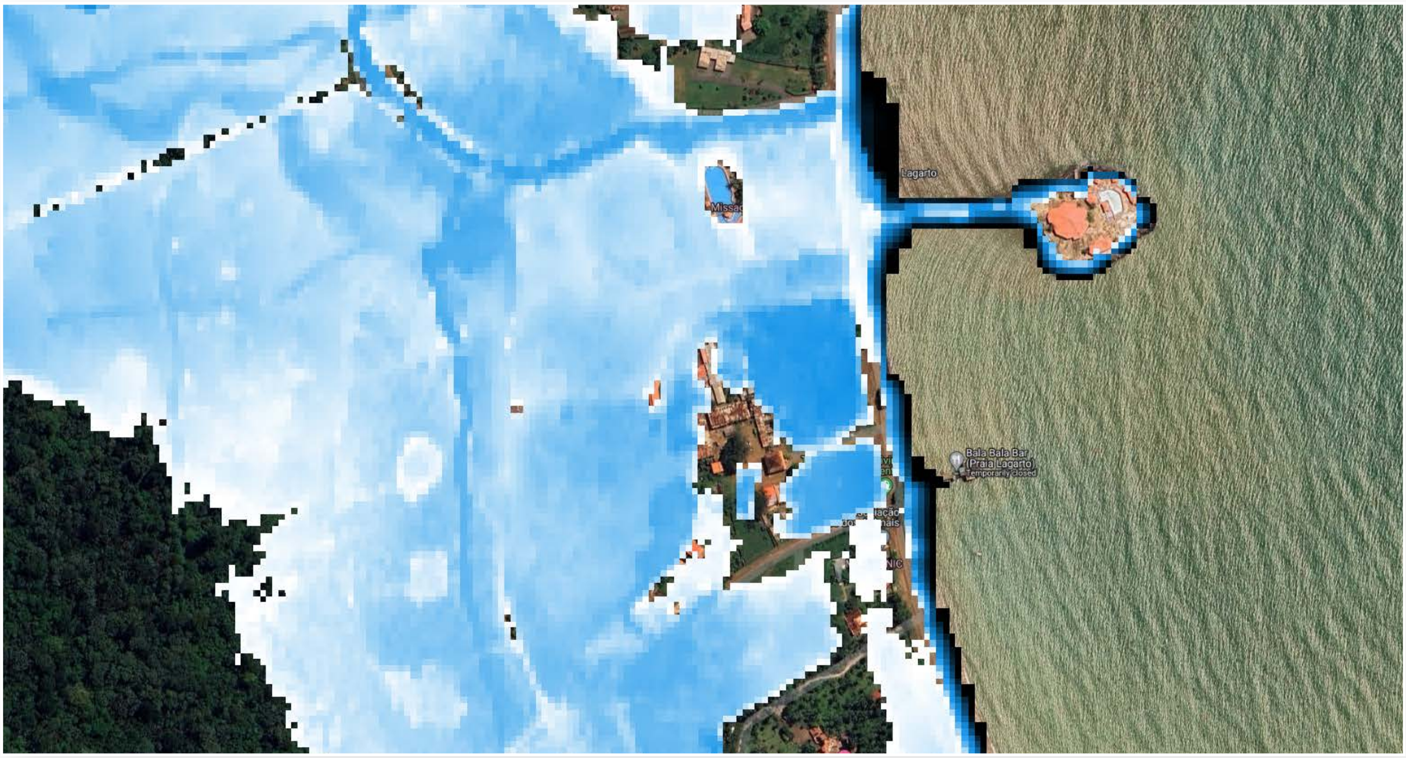
Figure 28: Photograph of Hotel Pestana (northern edge)

The northern edge of Hotel Pestana showing the transition from private to public coastal area. ***Source:*** *Abnilde Ceita Lima/WACA PIU.*

Figure 29: Photograph of Hotel Pestana (southern edge)

The southern edge of Hotel Pestana showing the transition from private to public coastal area. ***Source:*** *Abnilde Ceita Lima/WACA PIU.*

Figure 30: Overhead view of the area around Hotel Praia overlaid with hazard map



Area around Hotel Praia (Google Maps Satellite Imagery), overlaid with hazard map: 2020 climate scenario, 1-in-10 year event (flooded depth, color scale between 0.05 and 3m).

Figure 31: Area around Hotel Praia highlighting where the next three photos were taken

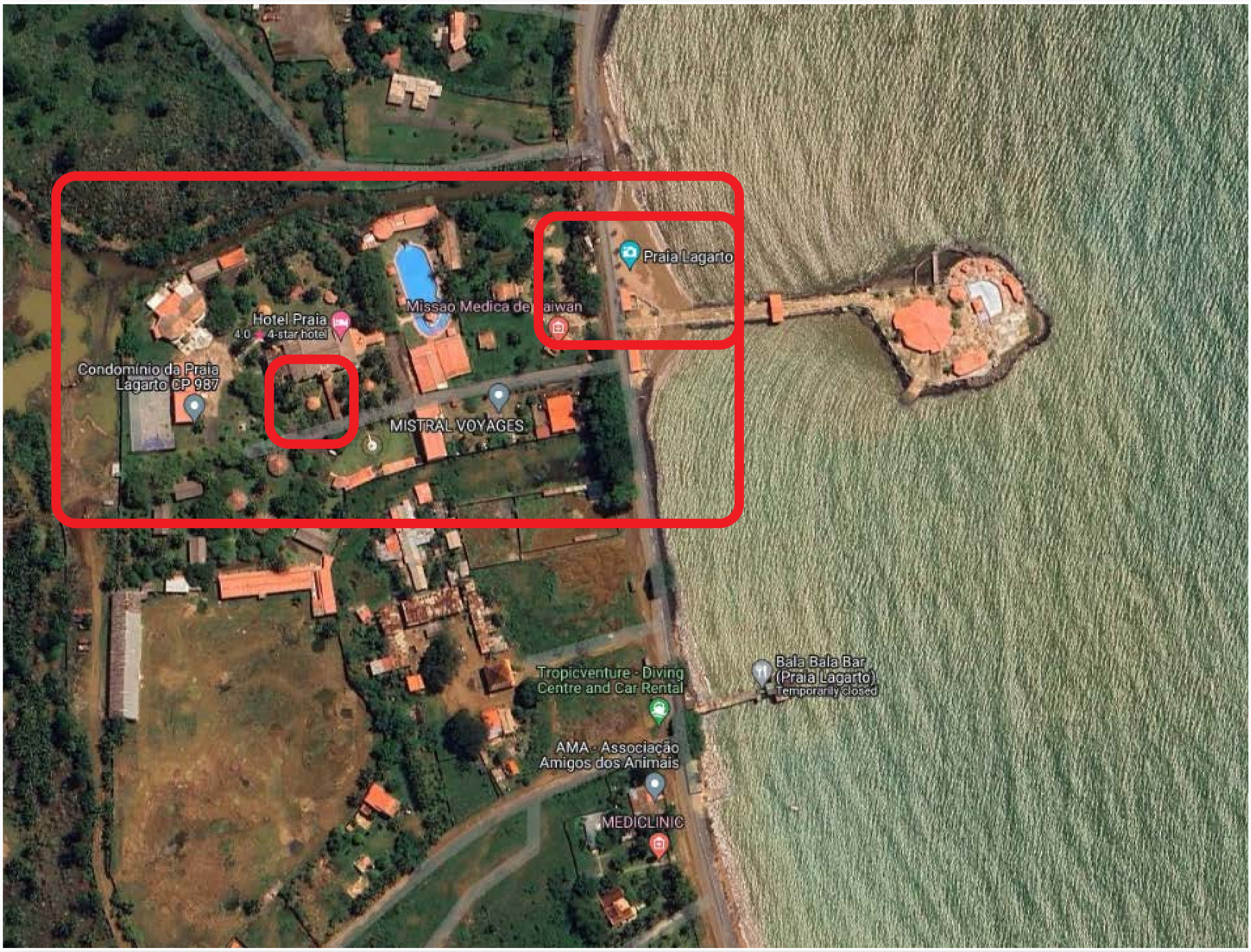


Figure 32: Example of coastal walls near Hotel Praia

Example of coastal walls near Hotel Praia (on both sides of the road). ***Source:*** *Abnilde Ceita Lima/WACA PIU.*

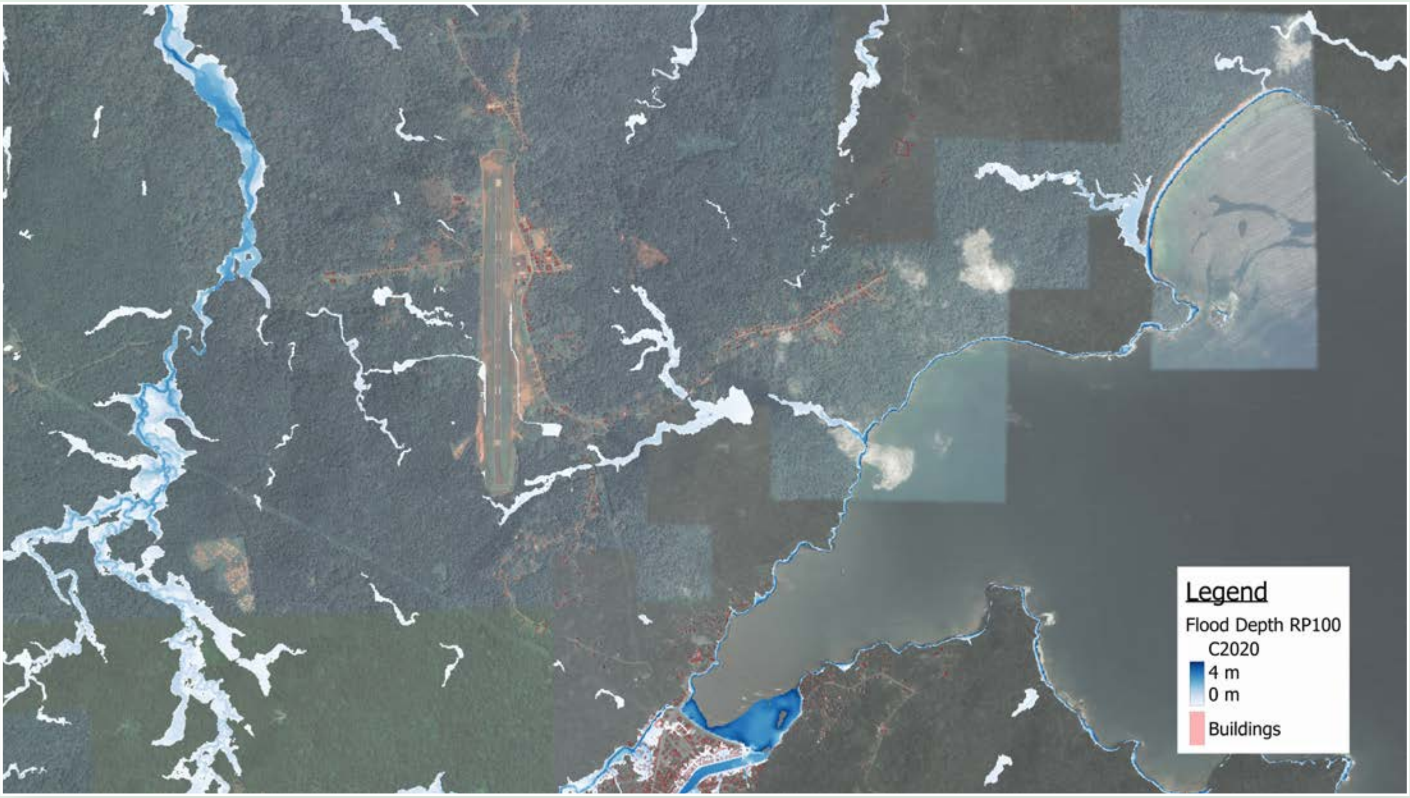
ANNEX 4

Flood maps for selected locations of touristic importance

Figure 33: Overhead view of São Tomé airport and access roads overlaid with hazard data

Airport of São Tomé and access roads (flood hazard RP100, present climate).

Figure 34: Overhead view of Príncipe airport and access roads overlaid with hazard data

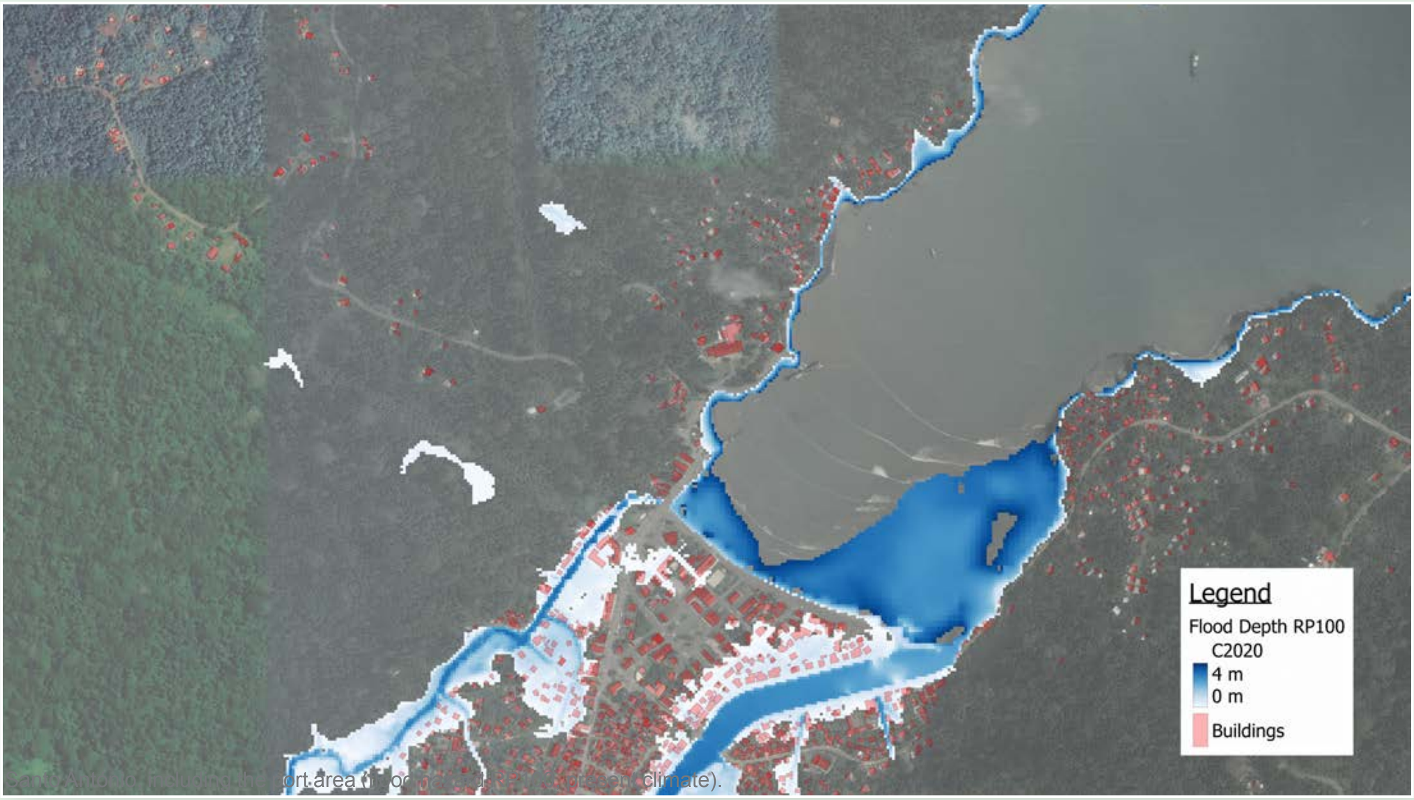


Airport of Príncipe and access roads (flood hazard RP100, present climate).

Figure 35: Overhead view of National Road EN2 near Ió Grande overlaid with hazard data

National Road (EN2) to the South near Ió Grande (flood hazard RP100, present climate).

Figure 36: Overhead view of Santo António overlaid with hazard data



Santo António, including the port area (flood hazard RP100, present climate).

ANNEX 5

Average annual loss tables per sector

BUILDINGS

Table 12: Total number of buildings affected by flooding (threshold: 0.2m), 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Buildings**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,595	112	119	130	136	135	**69**
Conde	1,167	71	74	80	81	79	**43**
Micoló	679	323	326	333	333	363	**195**
S.Amaro	3,336	225	235	255	254	269	**138**
Neves	3,656	416	430	474	490	490	**255**
S. Catarina	823	367	391	413	416	428	**226**
Trindade	6,791	296	313	361	367	383	**184**
Bombom	3,385	261	275	283	281	292	**159**
Madalena	1,314	21	23	25	25	31	**13**
Caixão Grande	2,386	60	64	68	69	69	**37**
Almas	1,854	45	46	57	58	58	**28**
São Tomé - Norte	2,295	670	718	805	833	853	**416**
São Tomé - Centro	11,531	1,226	1,276	1,420	1,421	1,475	**754**
São Tomé - Sul	7,709	735	775	842	835	869	**452**
Pantufo	1,161	307	310	330	341	343	**186**
Santana	3,893	134	151	171	172	179	**84**
Ribeira Afonso	1,943	377	375	405	403	405	**228**
S.J. Dos Angolares	1,371	104	108	120	118	118	**64**
Malanza	634	160	182	183	184	187	**99**
Príncipe - S. António	927	324	327	338	337	360	**196**
Príncipe - Resto	2,272	229	236	236	238	234	**138**
TOTAL	**61,722**	**6,463**	**6,754**	**7,329**	**7,392**	**7,620**	**3,967**

Table 13: Percentage of small buildings (below 180 square meters) affected by flooding (threshold: 0.2m), 2020 climate

		RETURN PERIOD (YEARS)						RISK
Subdistricts	**Buildings**	**1**	**5**	**10**	**25**	**50**	**100**	**AAL (%/year)**
Guadalupe	2,595	4%	4%	5%	5%	5%	5%	**4%**
Conde	1,167	6%	6%	6%	7%	7%	7%	**6%**
Micoló	679	47%	48%	48%	49%	49%	53%	**47%**
S.Amaro	3,336	7%	7%	7%	8%	8%	8%	**7%**
Neves	3,656	11%	11%	12%	13%	13%	13%	**11%**
S. Catarina	823	43%	45%	48%	50%	51%	52%	**45%**
Trindade	6,791	4%	4%	5%	5%	5%	6%	**4%**
Bombom	3,385	8%	8%	8%	8%	8%	9%	**8%**
Madalena	1,314	2%	2%	2%	2%	2%	2%	**2%**
Caixão Grande	2,386	3%	3%	3%	3%	3%	3%	**3%**
Almas	1,854	2%	2%	2%	3%	3%	3%	**2%**
São Tomé - Norte	2,295	28%	29%	31%	35%	36%	37%	**29%**
São Tomé - Centro	11,531	10%	11%	11%	12%	12%	13%	**11%**
São Tomé - Sul	7,709	9%	10%	10%	11%	11%	11%	**9%**
Pantufo	1,161	26%	26%	27%	28%	29%	30%	**26%**
Santana	3,893	3%	3%	4%	4%	4%	5%	**3%**
Ribeira Afonso	1,943	19%	19%	19%	21%	21%	21%	**19%**
S.J. Dos Angolares	1,371	7%	8%	8%	9%	9%	9%	**7%**
Malanza	634	24%	25%	29%	29%	29%	29%	**25%**
Príncipe - S. António	927	32%	35%	35%	36%	36%	39%	**34%**
Príncipe - Resto	2,272	9%	10%	10%	10%	10%	10%	**10%**
TOTAL	**3,816**	**14%**	**15%**	**16%**	**17%**	**17%**	**17%**	**15%**

Table 14: Percentage of all buildings affected by flooding (threshold: 0.2m), 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Buildings**	**5**	**10**	**25**	**50**	**100**	**AAL (%/year)**
Guadalupe	2,423	4%	5%	5%	5%	5%	**2,7%**
Conde	1,119	6%	7%	7%	7%	7%	**3,8%**
Micoló	638	49%	49%	50%	50%	54%	**29,4%**
S.Amaro	3,131	7%	7%	7%	7%	8%	**4,0%**
Neves	3,449	11%	11%	13%	13%	13%	**6,8%**
S. Catarina	780	46%	49%	52%	52%	54%	**28,3%**
Trindade	6,372	4%	5%	5%	5%	6%	**2,8%**
Bombom	3,333	8%	8%	8%	8%	9%	**4,7%**
Madalena	1,235	2%	2%	2%	2%	2%	**1,0%**
Caixão Grande	2,313	3%	3%	3%	3%	3%	**1,6%**
Almas	1,818	2%	3%	3%	3%	3%	**1,5%**
São Tomé - Norte	2,106	29%	31%	35%	36%	37%	**17,9%**
São Tomé - Centro	10,562	9%	9%	10%	10%	11%	**5,6%**
São Tomé - Sul	7,303	9%	10%	11%	11%	11%	**5,7%**
Pantufo	1,136	26%	26%	27%	28%	29%	**15,5%**
Santana	3,689	3%	4%	4%	4%	5%	**2,1%**
Ribeira Afonso	1,798	20%	20%	21%	21%	21%	**11,9%**
S.J. Dos Angolares	1,247	8%	8%	9%	9%	9%	**5,0%**
Malanza	581	27%	31%	31%	31%	31%	**16,9%**
Príncipe - S. António	793	34%	34%	35%	35%	38%	**20,3%**
Príncipe - Resto	2,080	10%	10%	10%	10%	10%	**6,1%**
TOTAL	**57,906**	**15%**	**16%**	**17%**	**17%**	**17%**	**9,2%**

Table 15: Percentage of large buildings (above 180 square meters) affected by flooding (threshold: 0.2m), 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Buildings**	**5**	**10**	**25**	**50**	**100**	**AAL (%/year)**
Guadalupe	172	3%	3%	3%	3%	4%	**2.1%**
Conde	48	2%	2%	2%	2%	2%	**1.3%**
Micoló	41	29%	29%	34%	34%	41%	**18.0%**
S. Amaro	205	9%	10%	10%	10%	10%	**5.7%**
Neves	207	16%	16%	17%	17%	18%	**9.9%**
S. Catarina	43	19%	19%	19%	19%	21%	**11.2%**
Trindade	419	3%	3%	5%	5%	5%	**1.8%**
Bombom	52	12%	13%	13%	13%	13%	**7.2%**
Madalena	79	3%	3%	3%	3%	3%	**1.5%**
Caixão Grande	73	1%	1%	3%	3%	3%	**0.9%**
Almas	36	0%	0%	0%	0%	0%	**0.9%**
São Tomé – Norte	189	34%	34%	37%	38%	40%	**20.6%**
São Tomé – Centro	969	28%	29%	32%	33%	34%	**17.0%**
São Tomé – Sul	406	16%	16%	17%	17%	17%	**9.4%**
Pantufo	25	68%	68%	72%	72%	76%	**41.1%**
Santana	204	4%	5%	5%	5%	5%	**2.7%**
Ribeira Afonso	145	15%	15%	17%	17%	17%	**9.2%**
S.J. Dos Angolares	124	2%	2%	2%	2%	2%	**1.5%**
Malanza	53	4%	6%	8%	8%	8%	**2.7%**
Príncipe – S.António	134	43%	43%	43%	43%	46%	**25.9%**
Príncipe – Resto	192	9%	9%	9%	10%	10%	**5.6%**
TOTAL	**3,816**	**15%**	**16%**	**17%**	**17%**	**18%**	**9.3%**

Table 16: Total building damages, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Buildings**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2,595	138,182	161,628	164,753	165,118	185,369	**86,959**
Conde	1,167	49,500	57,924	52,280	52,810	55,665	**30,627**
Micoló	679	109,523	125,078	154,053	155,254	179,871	**70,480**
S. Amaro	3,336	281,238	312,487	468,737	473,616	486,064	**184,701**
Neves	3,656	402,117	430,879	556,863	550,902	549,253	**254,200**
S. Catarina	823	297,871	379,928	481,568	563,612	663,417	**202,104**
Trindade	6,791	465,628	509,384	688,868	680,881	724,829	**298,924**
Bombom	3,385	159,762	173,105	210,704	221,607	243,587	**101,147**
Madalena	1,314	15,597	25,859	36,076	35,784	41,396	**11,688**
Caixão Grande	2,386	37,074	40,870	51,049	51,088	59,737	**23,657**
Almas	1,854	38,977	36,989	50,646	52,632	55,933	**24,153**
São Tomé – Norte	2,295	1,738,450	1,809,793	2,139,356	2,182,855	2,311,903	**1,080,081**
São Tomé – Centro	11,531	4,402,984	4,789,104	5,851,215	6,129,932	6,685,908	**2,790,758**
São Tomé – Sul	7,709	902,210	940,931	1,201,716	1,272,692	1,372,500	**569,015**
Pantufo	1,161	460,805	478,004	545,668	549,062	594,875	**284,588**
Santana	3,893	605,350	647,311	736,548	746,996	786,184	**376,652**
Ribeira Afonso	1,943	726,551	810,642	933,085	934,282	1,027,230	**458,545**
S.J. Dos Angolares	1,371	198,750	213,568	221,625	223,313	239,050	**122,323**
Malanza	634	552,043	570,357	700,832	765,335	844,070	**346,222**
Príncipe – S.António	927	1,299,225	1,344,116	1,350,708	1,417,773	1,429,069	**788,912**
Príncipe – Resto	2,272	531,311	551,491	588,217	628,362	604,068	**325,225**
TOTAL	**61,722**	**13,413,146**	**14,409,447**	**17,184,566**	**17,853,906**	**19,139,976**	**8,437,213**

Table 17: Total building damages, 2050 climate

	RETURN PERIOD (YEARS)					RISK
Subdistricts	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	167,054	168,297	195,053	216,654	234,639	**103,210**
Conde	52,709	49,705	58,466	65,897	68,256	**32,046**
Micoló	215,680	251,628	305,157	506,123	635,852	**146,522**
S. Amaro	322,742	432,548	523,775	598,979	618,409	**219,049**
Neves	542,281	542,699	591,545	671,686	720,060	**331,980**
S. Catarina	617,055	732,125	909,951	1,080,854	1,248,444	**407,582**
Trindade	536,196	675,994	793,168	831,892	877,540	**352,736**
Bombom	225,497	220,550	263,136	287,756	306,405	**138,556**
Madalena	26,125	35,094	45,538	61,282	60,172	**18,207**
Caixão Grande	36,313	48,412	65,751	76,595	68,104	**25,015**
Almas	40,687	48,270	51,511	64,060	56,663	**26,042**
São Tomé – Norte	2,515,892	2,585,404	2,963,168	3,245,135	3,498,405	**1,558,663**
São Tomé – Centro	6,750,010	7,001,698	8,439,120	9,374,005	10,199,771	**4,228,812**
São Tomé – Sul	1,418,773	1,515,070	1,920,810	2,193,150	2,549,982	**907,633**
Pantufo	602,853	608,505	688,106	713,177	754,811	**369,508**
Santana	803,919	825,551	934,380	992,258	1,060,277	**495,971**
Ribeira Afonso	978,484	1,083,877	1,256,878	1,435,993	1,572,873	**622,436**
S.J. Dos Angolares	230,862	244,984	255,802	273,670	290,880	**142,187**
Malanza	872,641	889,220	1,036,125	1,110,020	1,170,413	**539,478**
Príncipe – S.António	1,559,360	1,675,883	1,773,418	1,803,920	2,041,303	**964,398**
Príncipe – Resto	712,108	744,655	754,520	793,295	804,467	**434,168**
TOTAL	**19,227,242**	**20,380,168**	**23,825,377**	**26,396,398**	**28,837,724**	**12,064,199**

Table 18: Total building damages, 2080 climate

	RETURN PERIOD (YEARS)					RISK
Subdistricts	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	184,494	210,076	228,467	256,268	287,273	**117,120**
Conde	59,985	65,094	70,611	74,101	83,953	**37,396**
Micoló	835,555	934,235	706,434	1,410,910	1,597,954	**524,129**
S. Amaro	477,164	516,312	551,812	668,234	818,926	**300,408**
Neves	580,638	684,956	693,543	891,721	1,030,843	**372,664**
S. Catarina	1,189,831	1,358,664	1,593,358	1,762,004	1,916,691	**763,032**
Trindade	713,615	767,949	888,115	930,516	1,053,748	**447,851**
Bombom	272,998	294,731	318,764	341,604	374,051	**169,913**
Madalena	35,341	46,139	58,897	60,998	72,463	**23,952**
Caixão Grande	52,505	66,254	74,761	64,524	73,683	**33,991**
Almas	59,689	63,777	57,693	56,869	73,159	**36,220**
São Tomé – Norte	3,878,549	3,921,053	4,461,600	4,898,934	5,236,593	**2,389,528**
São Tomé – Centro	10,255,485	10,501,182	12,601,040	13,591,397	14,760,025	**6,384,376**
São Tomé – Sul	2,685,002	2,782,607	3,438,844	3,779,944	4,136,654	**1,687,162**
Pantufo	823,167	846,010	1,040,773	1,181,239	1,354,672	**517,775**
Santana	1,006,014	1,045,574	1,151,431	1,221,860	1,281,239	**619,956**
Ribeira Afonso	1,449,787	1,599,201	1,874,204	2,046,210	2,227,154	**919,409**
S.J. Dos Angolares	276,555	286,650	306,391	305,650	324,985	**169,097**
Malanza	1,196,885	1,211,150	1,363,666	1,422,100	1,475,053	**733,494**
Príncipe – S.António	1,828,159	1,917,897	2,188,691	2,395,057	2,719,872	**1,140,375**
Príncipe – Resto	767,172	786,805	854,901	903,272	955,512	**470,250**
TOTAL	**28,628,589**	**29,906,315**	**34,523,994**	**38,263,411**	**41,854,504**	**17,858,099**

POPULATION

Table 19: Number of people affected by flooding, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	1,213	1,273	1,308	1,344	1,389	**741**
Conde	3,452	638	650	662	659	671	**385**
Micoló	2,824	981	1,045	1,103	1,162	1,224	**605**
S. Amaro	9,730	1,565	1,616	1,692	1,768	1,819	**955**
Neves	15,141	2,870	2,876	2,959	3,042	3,129	**1,733**
S. Catarina	3,804	2,541	2,700	2,978	3,014	3,145	**1,571**
Trindade	24,694	2,523	2,657	2,792	2,927	2,949	**1,548**
Bombom	12,416	749	787	810	834	880	**458**
Madalena	4,029	181	201	215	229	236	**113**
Caixão Grande	9,214	513	535	566	573	574	**313**
Almas	7,300	478	483	499	500	510	**289**
São Tomé – Norte	7,387	1,305	1,352	1,431	1,452	1,498	**797**
São Tomé – Centro	45,195	3,941	4,129	4,853	4,871	4,988	**2,446**
São Tomé – Sul	31,897	2,084	2,195	2,442	2,518	2,653	**1,289**
Pantufo	4,349	721	770	822	837	898	**445**
Santana	13,949	1,557	1,571	1,660	1,662	1,685	**943**
Ribeira Afonso	8,235	2,534	2,619	2,639	2,659	2,744	**1,537**
S.J. Dos Angolares	5,571	1,085	1,104	1,113	1,123	1,143	**655**
Malanza	2,157	1,172	1,188	1,259	1,263	1,276	**711**
Príncipe – S.António	3,381	712	717	722	756	767	**429**
Príncipe – Resto	6,071	880	903	942	955	983	**535**
TOTAL	**229,627**	**30,242**	**31,371**	**33,469**	**34,147**	**35,157**	**18,497**

Table 20: Number of people affected by flooding, 2050 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	1,339	1,355	1,429	1,510	1,524	**814**
Conde	3,452	663	672	697	731	743	**402**
Micoló	2,824	1,188	1,253	1,362	1,462	1,524	**734**
S. Amaro	9,730	1,672	1,782	1,907	1,998	2,034	**1,032**
Neves	15,141	2,966	3,084	3,213	3,342	3,402	**1,811**
S. Catarina	3,804	3,007	3,202	3,414	3,552	3,692	**1,854**
Trindade	24,694	2,752	2,916	3,054	3,157	3,235	**1,690**
Bombom	12,416	813	848	901	1,005	1,020	**500**
Madalena	4,029	237	250	284	307	325	**148**
Caixão Grande	9,214	543	563	584	593	599	**331**
Almas	7,300	508	519	519	519	533	**307**
São Tomé – Norte	7,387	1,533	1,557	1,651	1,731	1,783	**933**
São Tomé – Centro	45,195	4,425	4,870	5,332	5,714	6,117	**2,772**
São Tomé – Sul	31,897	2,642	2,779	3,202	3,401	3,614	**1,644**
Pantufo	4,349	862	928	973	1,008	1,070	**532**
Santana	13,949	1,616	1,661	1,746	1,768	1,793	**983**
Ribeira Afonso	8,235	2,630	2,733	2,806	2,896	2,937	**1,602**
S.J. Dos Angolares	5,571	1,117	1,138	1,165	1,181	1,185	**676**
Malanza	2,157	1,275	1,287	1,292	1,298	1,307	**768**
Príncipe – S.António	3,381	726	750	781	784	838	**442**
Príncipe – Resto	6,071	916	950	973	1,003	1,038	**558**
TOTAL	**229,627**	**33,431**	**35,096**	**37,283**	**38,961**	**40,312**	**20,532**

Table 21: Number of people affected by flooding, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	1,422	1,456	1,530	1,551	1,577	**864**
Conde	3,452	685	717	737	760	769	**418**
Micoló	2,824	1,499	1,509	1,519	1,612	1,664	**905**
S. Amaro	9,730	1,909	1,970	2,033	2,101	2,133	**1,162**
Neves	15,141	3,272	3,339	3,364	3,550	3,742	**1,983**
S. Catarina	3,804	3,400	3,515	3,711	3,804	3,804	**2,074**
Trindade	24,694	2,986	3,066	3,208	3,254	3,337	**1,816**
Bombom	12,416	881	925	1,022	1,065	1,082	**543**
Madalena	4,029	277	292	307	326	331	**170**
Caixão Grande	9,214	589	590	601	601	605	**354**
Almas	7,300	539	539	539	545	550	**324**
São Tomé – Norte	7,387	1,841	1,869	1,918	1,967	2,014	**1,114**
São Tomé – Centro	45,195	5,370	5,615	6,257	6,576	6,932	**3,319**
São Tomé – Sul	31,897	3,291	3,430	3,721	3,885	4,032	**2,023**
Pantufo	4,349	1,118	1,124	1,212	1,250	1,334	**680**
Santana	13,949	1,721	1,749	1,791	1,801	1,815	**1,040**
Ribeira Afonso	8,235	2,891	2,955	2,980	3,004	3,015	**1,747**
S.J. Dos Angolares	5,571	1,159	1,180	1,199	1,199	1,209	**700**
Malanza	2,157	1,172	1,302	1,308	1,314	1,322	**723**
Príncipe – S.António	3,381	785	818	871	944	1,009	**483**
Príncipe – Resto	6,071	950	991	1,044	1,077	1,123	**582**
TOTAL	**229,627**	**37,755**	**38,951**	**40,870**	**42,187**	**43,401**	**23,025**

Table 22: Percentage of people affected by flooding, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	14%	14%	15%	15%	16%	**8,4%**
Conde	3,452	18%	19%	19%	19%	19%	**11,2%**
Micoló	2,824	35%	37%	39%	41%	43%	**21,4%**
S. Amaro	9,730	16%	17%	17%	18%	19%	**9,8%**
Neves	15,141	19%	19%	20%	20%	21%	**11,4%**
S. Catarina	3,804	67%	71%	78%	79%	83%	**41,3%**
Trindade	24,694	10%	11%	11%	12%	12%	**6,3%**
Bombom	12,416	6%	6%	7%	7%	7%	**3,7%**
Madalena	4,029	4%	5%	5%	6%	6%	**2,8%**
Caixão Grande	9,214	6%	6%	6%	6%	6%	**3,4%**
Almas	7,300	7%	7%	7%	7%	7%	**4,0%**
São Tomé – Norte	7,387	18%	18%	19%	20%	20%	**10,8%**
São Tomé – Centro	45,195	9%	9%	11%	11%	11%	**5,4%**
São Tomé – Sul	31,897	7%	7%	8%	8%	8%	**4,0%**
Pantufo	4,349	17%	18%	19%	19%	21%	**10,2%**
Santana	13,949	11%	11%	12%	12%	12%	**6,8%**
Ribeira Afonso	8,235	31%	32%	32%	32%	33%	**18,7%**
S.J. Dos Angolares	5,571	19%	20%	20%	20%	21%	**11,8%**
Malanza	2,157	54%	55%	58%	59%	59%	**32,9%**
Príncipe – S.António	3,381	21%	21%	21%	22%	23%	**12,7%**
Príncipe – Resto	6,071	15%	15%	16%	16%	16%	**8,8%**
TOTAL	**229,627**	**13%**	**14%**	**15%**	**15%**	**15%**	**8,1%**

Table 23: Percentage of people affected by flooding, 2050 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	15%	15%	16%	17%	17%	**9,2%**
Conde	3,452	19%	19%	20%	21%	22%	**11,6%**
Micoló	2,824	42%	44%	48%	52%	54%	**26,0%**
S. Amaro	9,730	17%	18%	20%	21%	21%	**10,6%**
Neves	15,141	20%	20%	21%	22%	22%	**12,0%**
S. Catarina	3,804	79%	84%	90%	93%	97%	**48,7%**
Trindade	24,694	11%	12%	12%	13%	13%	**6,8%**
Bombom	12,416	7%	7%	7%	8%	8%	**4,0%**
Madalena	4,029	6%	6%	7%	8%	8%	**3,7%**
Caixão Grande	9,214	6%	6%	6%	6%	7%	**3,6%**
Almas	7,300	7%	7%	7%	7%	7%	**4,2%**
São Tomé – Norte	7,387	21%	21%	22%	23%	24%	**12,6%**
São Tomé – Centro	45,195	10%	11%	12%	13%	14%	**6,1%**
São Tomé – Sul	31,897	8%	9%	10%	11%	11%	**5,2%**
Pantufo	4,349	20%	21%	22%	23%	25%	**12,2%**
Santana	13,949	12%	12%	13%	13%	13%	**7,0%**
Ribeira Afonso	8,235	32%	33%	34%	35%	36%	**19,5%**
S.J. Dos Angolares	5,571	20%	20%	21%	21%	21%	**12,1%**
Malanza	2,157	59%	60%	60%	60%	61%	**35,6%**
Príncipe – S.António	3,381	21%	22%	23%	23%	25%	**13,1%**
Príncipe – Resto	6,071	15%	16%	16%	17%	17%	**9,2%**
TOTAL	**229,627**	**15%**	**15%**	**16%**	**17%**	**18%**	**8,9%**

Table 24: Percentage of people affected by flooding, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	8,831	16%	16%	17%	18%	18%	**9,8%**
Conde	3,452	20%	21%	21%	22%	22%	**12,1%**
Micoló	2,824	53%	53%	54%	57%	59%	**32,1%**
S. Amaro	9,730	20%	20%	21%	22%	22%	**11,9%**
Neves	15,141	22%	22%	22%	23%	25%	**13,1%**
S. Catarina	3,804	89%	92%	98%	100%	100%	**54,5%**
Trindade	24,694	12%	12%	13%	13%	14%	**7,4%**
Bombom	12,416	7%	7%	8%	9%	9%	**4,4%**
Madalena	4,029	7%	7%	8%	8%	8%	**4,2%**
Caixão Grande	9,214	6%	6%	7%	7%	7%	**3,8%**
Almas	7,300	7%	7%	7%	7%	8%	**4,4%**
São Tomé – Norte	7,387	25%	25%	26%	27%	27%	**15,1%**
São Tomé – Centro	45,195	12%	12%	14%	15%	15%	**7,3%**
São Tomé – Sul	31,897	10%	11%	12%	12%	13%	**6,3%**
Pantufo	4,349	26%	26%	28%	29%	31%	**15,6%**
Santana	13,949	12%	13%	13%	13%	13%	**7,5%**
Ribeira Afonso	8,235	35%	36%	36%	36%	37%	**21,2%**
S.J. Dos Angolares	5,571	21%	21%	22%	22%	22%	**12,6%**
Malanza	2,157	54%	60%	61%	61%	61%	**33,5%**
Príncipe – S.António	3,381	23%	24%	26%	28%	30%	**14,3%**
Príncipe – Resto	6,071	16%	16%	17%	18%	18%	**9,6%**
TOTAL	**229,627**	**16%**	**17%**	**18%**	**18%**	**19%**	**10,0%**

HEALTHCARE FACILITIES

Table 25: Number of people affected by flooding of healthcare facilities, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2	–	–	–	–	–	**–**
Conde	1	–	–	–	–	–	**–**
Micoló	2	10,000	10,000	10,000	10,000	10,000	**6,000**
S. Amaro	2	–	–	–	–	–	**–**
Neves	1	–	–	5,000	5,000	5,000	**350**
S. Catarina	1	5,000	5,000	5,000	5,000	5,000	**3,000**
Trindade	4	20,000	20,000	20,000	20,000	20,000	**12,000**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	–	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	5,000	5,000	5,000	5,000	5,000	**3,000**
Pantufo	1	–	–	–	–	5,000	**75**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	5,000	5,000	5,000	5,000	10,000	**3,075**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S.António	2	25,000	25,000	25,000	25,000	25,000	**15,000**
Príncipe – Resto	9	5,000	5,000	5,000	5,000	5,000	**3,000**
TOTAL	**55**	**75,000**	**75,000**	**80,000**	**80,000**	**90,000**	**45,500**

Table 26: Number of people affected by flooding of healthcare facilities, 2050 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2	–	–	–	–	–	**–**
Conde	1	–	–	–	–	–	**–**
Micoló	2	20,000	20,000	20,000	20,000	20,000	**12,000**
S. Amaro	2	–	–	–	–	–	**–**
Neves	1	–	10,000	10,000	10,000	10,000	**1,500**
S. Catarina	1	10,000	10,000	10,000	10,000	10,000	**6,000**
Trindade	4	20,000	20,000	20,000	20,000	20,000	**12,000**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	-	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	10,000	10,000	10,000	10,000	10,000	**6,000**
Pantufo	1	–	10,000	10,000	10,000	10,000	**1,500**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	20,000	20,000	20,000	20,000	20,000	**12,000**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S.António	2	30,000	30,000	30,000	30,000	30,000	**18,000**
Príncipe – Resto	9	10,000	10,000	10,000	10,000	10,000	**6,000**
TOTAL	**55**	**120,000**	**140,000**	**140,000**	**140,000**	**140,000**	**75,000**

Table 27: Number of people affected by flooding of healthcare facilities, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2	–	–	–	–	–	–
Conde	1	–	–	–	–	–	–
Micoló	2	20,000	20,000	20,000	20,000	20,000	**12,000**
S.Amaro	2	–	–	–	–	–	**–**
Neves	1	10,000	10,000	10,000	10,000	10,000	**6,000**
S. Catarina	1	10,000	10,000	10,000	10,000	10,000	**6,000**
Trindade	4	20,000	20,000	20,000	20,000	20,000	**12,000**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	–	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	10,000	10,000	10,000	10,000	10,000	**6,000**
Pantufo	1	10,000	10,000	10,000	10,000	10,000	**6,000**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	20,000	20,000	20,000	20,000	20,000	**12,000**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S. António	2	30,000	30,000	30,000	30,000	30,000	**18,000**
Príncipe – Resto	9	10,000	10,000	10,000	10,000	10,000	**6,000**
TOTAL	**55**	**140,000**	**140,000**	**140,000**	**140,000**	**140,000**	**84,000**

Table 28: Healthcare facilities economic flood risk, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Population**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2	–	–	–	–	–	**–**
Conde	1	–	–	–	–	–	**–**
Micoló	2	7,734	8,822	10,653	10,901	11,921	**4,954**
S. Amaro	2	–	–	–	–	–	**–**
Neves	1	–	–	2,749	1,031	2,608	**154**
S. Catarina	1	16,838	18,282	21,730	21,025	21,944	**10,554**
Trindade	4	20,439	23,132	25,802	25,052	27,158	**12,864**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	-	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	1,399	1,519	1,722	1,642	1,978	**876**
Pantufo	1	–	–	–	–	4,647	**70**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	6,827	7,766	7,331	6,473	7,896	**4,202**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S.António	2	42,936	45,059	52,065	55,370	56,968	**26,694**
Príncipe – Resto	9	8,960	9,420	10,246	10,506	11,391	**5,524**
TOTAL	**55**	**105,134**	**114,001**	**132,078**	**132,000**	**146,511**	**65,891**

Table 29: Healthcare facilities economic flood risk, 2050 climate[14]

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2	–	–	–	–	–	**–**
Conde	1	–	–	–	–	–	**–**
Micoló	2	12,202	13,231	14,612	17,749	19,548	**7,693**
S. Amaro	2	–	–	–	–	–	**–**
Neves	1	–	1,081	2,749	3,240	3,576	**299**
S. Catarina	1	19,372	21,690	24,662	26,825	28,889	**12,275**
Trindade	4	12,548	13,943	11,999	13,245	15,402	**7,672**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	-	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	1,268	1,625	2,299	2,913	3,902	**895**
Pantufo	1	–	5,323	5,777	5,443	7,639	**853**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	7,689	8,543	6,940	8,916	10,400	**4,711**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S.António	2	56,229	65,565	70,443	78,296	84,376	**35,806**
Príncipe – Resto	9	11,828	12,214	11,963	12,577	12,907	**7,161**
TOTAL	**55**	**121,136**	**143,215**	**151,443**	**169,205**	**186,639**	**77,364**

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[14] According to the hazard dataset, in 2050 one secondary health facility in Trindade province is slighly less affected than in 2020 and 2080 scenarios due to lower water depths. Therefore, the AAL for Trindade province is lower in the 2050 climate scenario, while all other heathcare facilities show an increase in AAL.

Table 30: Healthcare facilities economic flood risk, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Facilities**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2	–	–	–	–	–	**–**
Conde	1	–	–	–	–	–	**–**
Micoló	2	22,352	23,326	20,765	29,342	31,394	**13,666**
S. Amaro	2	–	–	–	–	–	**–**
Neves	1	2,564	2,810	3,398	3,885	4,280	**1,637**
S. Catarina	1	21,728	24,722	27,897	30,444	33,544	**13,831**
Trindade	4	19,537	21,707	24,432	30,942	35,262	**12,498**
Bombom	1	–	–	–	–	–	**–**
Madalena	3	–	–	–	–	–	**–**
Caixão Grande	1	–	–	–	–	–	**–**
Almas	-	–	–	–	–	–	**–**
São Tomé – Norte	1	–	–	–	–	–	**–**
São Tomé – Centro	7	–	–	–	–	–	**–**
São Tomé – Sul	4	1,618	2,330	3,126	4,416	5,173	**1,183**
Pantufo	1	9,658	9,709	11,910	13,190	14,390	**6,013**
Santana	7	–	–	–	–	–	**–**
Ribeira Afonso	4	9,985	10,818	12,083	11,531	12,973	**6,210**
S.J. Dos Angolares	1	–	–	–	–	–	**–**
Malanza	1	–	–	–	–	–	**–**
Príncipe – S.António	2	86,351	93,289	92,051	92,544	91,656	**52,766**
Príncipe – Resto	9	13,534	14,580	15,801	16,857	18,052	**8,412**
TOTAL	**55**	**187,327**	**203,291**	**211,464**	**233,151**	**246,723**	**116,217**

EDUCATION SECTOR

Table 31: School building economic flood risk, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
Guadalupe	2,522	5,988	6,566	7,626	7,633	8,160	**3,762**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	–	–	–	–	–	**–**
S. Amaro	3,387	–	–	–	–	–	**–**
Neves	6,114	3,857	4,097	4,758	4,767	6,536	**2,423**
S. Catarina	1,481	3,869	3,492	4,722	5,489	3,688	**2,347**
Trindade	9,671	–	–	–	2,082	2,803	**73**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	–	–	17,569	17,472	20,421	**1,271**
São Tomé – Sul	6,918	–	–	–	–	–	**–**
Pantufo	1,338	4,315	4,853	5,916	6,592	5,599	**2,749**
Santana	4,705	–	–	–	–	–	**–**
Ribeira Afonso	3,191	–	–	–	–	9,969	**150**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	37,309	38,172	47,715	51,852	55,932	**23,368**
Príncipe – S.António	3,184	37,282	37,282	38,021	43,824	48,299	**22,662**
Príncipe – Resto	2,135	–	–	–	–	–	**–**
TOTAL	**81,303**	**92,620**	**94,461**	**126,328**	**139,711**	**161,407**	**58,806**

Table 32: School building economic flood risk, 2050 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	7,467	8,169	8,873	10,018	10,621	**4,678**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	–	–	–	–	13,134	**197**
S. Amaro	3,387	–	–	–	–	–	**–**
Neves	6,114	5,069	5,319	19,884	24,182	26,906	**4,268**
S. Catarina	1,481	4,414	3,356	2,566	3,041	2,838	**2,446**
Trindade	9,671	2,559	3,349	4,404	5,141	5,893	**1,761**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	–	–	27,927	104,098	131,750	**4,655**
São Tomé – Sul	6,918	–	–	4,049	5,680	7,269	**356**
Pantufo	1,338	6,285	6,591	7,758	8,405	9,042	**3,927**
Santana	4,705	–	–	–	2,119	3,188	**80**
Ribeira Afonso	3,191	–	–	10,029	12,826	17,941	**863**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	57,277	57,913	66,367	70,057	73,590	**35,217**
Príncipe – S.António	3,184	40,507	40,053	47,871	50,904	55,321	**24,941**
Príncipe – Resto	2,135	–	–	–	–	–	**–**
TOTAL	**81,303**	**123,578**	**124,750**	**199,729**	**296,471**	**357,493**	**83,389**

Table 33: School building economic flood risk, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	9,579	9,940	10,253	11,645	12,207	**5,874**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	22,847	25,119	18,706	37,277	41,662	**14,223**
S.Amaro	3,387	2,048	1,837	3,630	3,982	4,628	**1,343**
Neves	6,114	10,816	22,579	28,034	35,332	40,065	**8,926**
S. Catarina	1,481	–	–	–	–	–	**–**
Trindade	9,671	5,755	6,552	7,547	8,253	8,944	**3,674**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	43,838	50,543	182,388	225,541	273,387	**38,550**
São Tomé – Sul	6,918	6,925	8,748	11,026	27,241	35,077	**5,192**
Pantufo	1,338	5,070	5,307	6,630	7,325	8,009	**3,201**
Santana	4,705	–	–	–	2,148	2,062	**63**
Ribeira Afonso	3,191	–	17,906	27,565	36,895	46,570	**3,787**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	75,325	75,472	82,767	85,809	88,749	**45,863**
Príncipe – S. António	3,184	46,747	52,326	57,249	74,195	86,178	**29,918**
Príncipe – Resto	2,135	–	–	–	–	–	**–**
TOTAL	**81,303**	**228,951**	**276,329**	**435,794**	**555,642**	**647,538**	**160,614**

Table 34: Number of pupils affected, 2020 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	125	125	125	125	125	**75**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	–	–	–	–	125	**2**
S.Amaro	3,387	–	–	–	–	–	**–**
Neves	6,114	67	170	170	170	859	**66**
S. Catarina	1,481	125	125	125	125	125	**75**
Trindade	9,671	–	125	125	125	125	**19**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	1,216	1,216	4,068	4,068	4,068	**929**
São Tomé – Sul	6,918	125	125	125	270	270	**79**
Pantufo	1,338	125	125	125	125	125	**75**
Santana	4,705	–	–	–	–	–	**–**
Ribeira Afonso	3,191	1,138	1,138	1,138	1,138	682	**676**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	624	624	624	624	624	**374**
Príncipe – S. António	3,184	1,009	1,009	1,009	1,009	1,009	**605**
Príncipe – Resto	2,135	–	–	–	–	–	**–**
TOTAL	**81,303**	**4,554**	**4,782**	**7,634**	**7,779**	**8,137**	**2,976**

Table 35: Number of pupils affected, 2050 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	125	125	125	125	125	**75**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	–	–	125	1,019	1,019	**36**
S.Amaro	3,387	–	–	–	125	166	**4**
Neves	6,114	295	295	1,109	1,109	1,109	**234**
S. Catarina	1,481	125	125	125	125	125	**75**
Trindade	9,671	125	125	125	125	125	**75**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	1,341	4,193	4,193	5,379	5,379	**1,268**
São Tomé – Sul	6,918	395	395	270	270	270	**228**
Pantufo	1,338	125	125	125	125	125	**75**
Santana	4,705	–	–	125	125	125	**9**
Ribeira Afonso	3,191	682	682	682	682	1,138	**416**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	624	624	624	624	624	**374**
Príncipe – S. António	3,184	1,009	1,009	1,009	1,009	1,009	**605**
Príncipe – Resto	2,135	–	–	–	–	55	**1**
TOTAL	**81,303**	**4,846**	**7,698**	**8,637**	**10,842**	**11,394**	**3,476**

Table 36: Number of pupils affected, 2080 climate

		RETURN PERIOD (YEARS)					RISK
Subdistricts	**Pupils**	**5**	**10**	**25**	**50**	**100**	**AAL (#/year)**
Guadalupe	2,522	125	125	125	125	125	**75**
Conde	869	–	–	–	–	–	**–**
Micoló	1,019	1,019	1,019	1,019	1,019	1,019	**611**
S.Amaro	3,387	125	125	125	166	166	**76**
Neves	6,114	859	1,109	1,109	1,109	1,109	**553**
S. Catarina	1,481	125	125	125	125	125	**75**
Trindade	9,671	125	125	125	125	125	**75**
Bombom	2,628	–	–	–	–	–	**–**
Madalena	1,533	–	–	–	–	–	**–**
Caixão Grande	1,381	–	–	–	–	–	**–**
Almas	2,631	–	–	–	–	–	**–**
São Tomé – Norte	1,260	–	–	–	–	–	**–**
São Tomé – Centro	21,901	6,668	6,668	6,793	6,793	6,793	**4,010**
São Tomé – Sul	6,918	395	270	1,231	1,356	1,356	**289**
Pantufo	1,338	125	125	125	125	125	**75**
Santana	4,705	125	125	125	125	125	**75**
Ribeira Afonso	3,191	1,138	1,138	1,138	1,138	1,138	**683**
S.J. Dos Angolares	2,586	–	–	–	–	–	**–**
Malanza	849	624	624	624	624	624	**374**
Príncipe – S. António	3,184	1,009	1,009	1,878	2,934	2,934	**698**
Príncipe – Resto	2,135	–	–	55	305	247	**10**
TOTAL	**81,303**	**12,462**	**12,587**	**14,597**	**16,069**	**16,011**	**7,680**

TOURISM SECTOR

Table 37: Tourist buildings economic flood risk, 2020 climate

		RETURN PERIOD (YEARS)					RISK
No.	**Location**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
2	Praia Inhame	32,878	32,322	31,280	33,697	38,095	**19,709**
3	Gumbela Ecolodge	12,566	13,795	16,374	14,490	16,366	**7,876**
4	Jale Ecolodge	7,641	8,686	4,369	5,477	9,632	**4,535**
5	Domus Jalé Lodge	–	–	–	–	–	**–**
6	VANHA turismo rural	–	–	–	–	–	**–**
7	Ngembu rest & lodge	–	–	–	–	–	**–**
8	Mionga rest & Lodge	32,798	35,565	40,091	42,918	46,014	**20,542**
9	Tortue Ecolodge	6,159	10,000	9,846	10,455	12,913	**4,316**
10	Club Santana	81,768	85,302	102,247	111,210	120,535	**51,186**
11	Pestana hotel	154,411	159,282	170,229	159,969	138,474	**93,513**
12	Omali Lodge	–	–	–	–	–	**–**
13	Emoyeni Gardens	7,094	6,502	8,696	9,196	11,246	**4,367**
14	Hotel Miramar	–	–	19,057	26,175	32,780	**1,647**
15	Hotel Praia	290,916	313,860	401,480	419,536	451,860	**185,151**
16	Bigodes rest e hotel	86,191	86,480	92,489	96,285	92,153	**52,230**
17	Mucumbli ecolodge	–	–	–	–	–	**–**
18	Bom Bom resort	9,988	9,641	4,396	10,933	10,645	**5,765**
19	Sundi Eco-resort (HBD)	18,537	9,504	8,947	9,857	10,651	**9,768**
20	Sao Pedro Guesthouse	–	–	–	–	–	**–**
21	Hotel Central	11,542	13,130	15,953	15,973	16,995	**7,377**
22	Hotel Vitoria	–	–	–	–	–	**–**
	TOTAL	**752,491**	**784,069**	**925,455**	**966,171**	**1,008,359**	**467,983**

Table 38: Tourist buildings economic flood risk, 2050 climate

		RETURN PERIOD (YEARS)					RISK
No.	**Location**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
2	Praia Inhame	38,649	35,821	43,170	50,900	42,027	**23,378**
3	Gumbela Ecolodge	16,912	18,251	17,034	18,603	20,450	**10,338**
4	Jale Ecolodge	9,014	9,918	12,144	13,033	14,918	**5,755**
5	Domus Jalé Lodge	–	–	–	–	–	**–**
6	VANHA turismo rural	–	–	–	–	–	**–**
7	Ngembu rest & lodge	–	–	–	–	–	**–**
8	Mionga rest & Lodge	43,931	46,766	47,615	50,185	51,693	**26,943**
9	Tortue Ecolodge	11,681	13,357	15,565	16,651	19,016	**7,483**
10	Club Santana	121,822	130,081	136,234	143,976	152,678	**75,126**
11	Pestana hotel	176,613	180,222	224,949	247,112	275,141	**110,725**
12	Omali Lodge	14,542	13,846	31,580	46,712	55,351	**10,446**
13	Emoyeni Gardens	15,691	15,262	42,866	54,103	66,310	**11,803**
14	Hotel Miramar	40,329	41,792	51,301	57,137	62,742	**25,342**
15	Hotel Praia	446,655	463,985	544,112	581,380	618,853	**277,882**
16	Bigodes rest e hotel	99,092	97,899	83,467	86,432	81,379	**58,279**
17	Mucumbli ecolodge	–	–	–	–	–	**–**
18	Bom Bom resort	10,380	10,847	10,966	12,709	13,441	**6,369**
19	Sundi Eco-resort (HBD)	10,784	7,352	7,128	8,073	4,662	**5,917**
20	Sao Pedro Guesthouse	–	–	–	–	–	**–**
21	Hotel Central	14,112	15,741	19,834	22,416	24,951	**9,114**
22	Hotel Vitoria	–	–	–	2,437	2,557	**75**
	TOTAL	**1,070,209**	**1,101,140**	**1,287,966**	**1,411,859**	**1,506,170**	**664,974**

Table 39: Tourist buildings economic flood risk, 2080 climate

		RETURN PERIOD (YEARS)					RISK
No.	**Location**	**5**	**10**	**25**	**50**	**100**	**AAL (US$/year)**
2	Praia Inhame	45,855	49,758	54,956	46,890	50,869	**28,280**
3	Gumbela Ecolodge	21,013	18,829	17,747	17,255	18,859	**12,214**
4	Jale Ecolodge	14,710	16,101	19,350	19,193	19,952	**9,269**
5	Domus Jalé Lodge	–	–	–	–	–	**–**
6	VANHA turismo rural	–	–	–	–	–	**–**
7	Ngembu rest & lodge	–	–	–	–	–	**–**
8	Mionga rest & Lodge	51,476	51,606	55,570	56,802	58,037	**31,238**
9	Tortue Ecolodge	22,412	20,643	13,007	13,002	14,052	**12,663**
10	Club Santana	152,958	160,847	155,658	138,531	144,772	**92,175**
11	Pestana hotel	320,502	324,829	378,043	405,109	431,006	**197,876**
12	Omali Lodge	87,054	83,814	115,215	125,888	136,997	**54,431**
13	Emoyeni Gardens	83,777	90,013	120,244	137,352	152,304	**54,055**
14	Hotel Miramar	71,203	71,969	65,827	71,766	43,535	**42,161**
15	Hotel Praia	614,961	619,852	697,879	730,658	764,022	**376,656**
16	Bigodes rest e hotel	87,894	89,178	97,614	102,138	107,985	**53,743**
17	Mucumbli ecolodge	–	–	–	–	–	**–**
18	Bom Bom resort	13,712	15,552	14,668	17,450	16,955	**8,517**
19	Sundi Eco-resort (HBD)	6,442	5,771	6,352	6,516	6,957	**3,817**
20	Sao Pedro Guesthouse	–	–	–	–	–	**–**
21	Hotel Central	29,697	29,148	35,234	37,441	39,695	**18,262**
22	Hotel Vitoria	2,744	2,676	23,760	24,676	29,874	**3,217**
	TOTAL	**1,626,408**	**1,650,586**	**1,871,125**	**1,950,668**	**2,035,874**	**998,574**

Table 40: Average water depths within tourist property areas, 2020 climate

		RETURN PERIOD (YEARS)					RISK
No.	**Location**	**5**	**10**	**25**	**50**	**100**	**AAL (m)**
2	**Praia Inhame**	0,99	0,99	1,05	1,09	1,11	**0,60**
3	**Gumbela Ecolodge**	0,92	0,96	1,07	1,11	1,17	**0,57**
4	**Jale Ecolodge**	0,66	0,71	0,73	0,78	0,83	**0,41**
5	**Domus Jalé Lodge**	1,01	1,06	1,12	1,12	1,15	**0,62**
6	**VANHA turismo rural**	1,46	1,44	1,56	1,53	1,57	**0,88**
7	**Ngembu rest & lodge**	1,38	1,43	1,52	1,58	1,61	**0,84**
8	**Mionga rest & Lodg**	1,44	1,50	1,59	1,64	1,71	**0,88**
9	**Tortue Ecolodge**	0,72	0,77	0,79	0,80	0,86	**0,44**
10	**Club Santana**	0,88	0,90	0,94	0,99	1,02	**0,53**
11	**Pestana hotel**	0,98	1,00	1,05	1,07	1,09	**0,60**
12	**Omali Lodge**	0,33	0,33	0,39	0,42	0,45	**0,20**
13	**Emoyeni Gardens**	0,30	0,31	0,32	0,31	0,30	**0,18**
14	**Hotel Miramar**	0,48	0,50	0,62	0,68	0,75	**0,30**
15	**Hotel Praia**	0,61	0,64	0,75	0,78	0,82	**0,38**
16	**Bigodes rest e hotel**	1,26	1,26	1,32	1,35	1,37	**0,76**
17	**Mucumbli ecolodge**	0,40	0,44	0,44	0,44	0,46	**0,25**
18	**Bom Bom resort**	0,79	0,83	0,87	0,90	0,93	**0,48**
19	**Sundi Eco-resort (HBD)**	1,05	1,00	1,03	1,07	1,09	**0,63**
20	**Sao Pedro Guesthouse**	0,02	0,02	0,01	0,02	0,06	**0,01**
21	**Hotel Central**	0,43	0,46	0,52	0,52	0,54	**0,27**
22	**Hotel Vitoria**	0,21	0,21	0,27	0,24	0,27	**0,13**
	TOTAL	**0,74**	**0,76**	**0,82**	**0,84**	**0,87**	**0,45**

Table 41: Number of beds affected (threshold: 0.2m), 2020 climate

		RETURN PERIOD (YEARS)					RISK
No.	**Location**	**5**	**10**	**25**	**50**	**100**	**AAL (#/a)**
2	**Praia Inhame**	23	23	23	23	23	**14**
3	**Gumbela Ecolodge**	3	3	3	3	3	**2**
4	**Jale Ecolodge**	3	3	3	3	3	**2**
5	**Domus Jalé Lodge**	8	8	8	8	8	**5**
6	**VANHA turismo rural**	5	5	5	5	5	**3**
7	**Ngembu rest & lodge**	10	10	10	10	10	**6**
8	**Mionga rest & lodge**	4	4	4	4	4	**2**
9	**Tortue Ecolodge**	3	4	3	3	3	**2**
10	**Club Santana**	31	31	31	31	31	**19**
11	**Pestana hotel**	115	115	115	115	115	**69**
12	**Omali Lodge**	30	30	30	30	30	**18**
13	**Emoyeni Gardens**	20	20	20	20	20	**12**
14	**Hotel Miramar**	65	65	65	65	65	**39**
15	**Hotel Praia**	20	20	20	20	20	**12**
16	**Bigodes rest e hotel**	20	20	20	20	20	**12**
17	**Mucumbli ecolodge**	11	11	11	11	11	**7**
18	**Bom Bom resort**	19	19	19	19	19	**11**
19	**Sundi Eco-resort (HBD)**	15	15	15	15	15	**9**
20	**Sao Pedro Guesthouse**	–	–	–	–	–	**–**
21	**Hotel Central**	14	14	14	14	14	**8**
22	**Hotel Vitoria**	–	–	10	10	10	**1**
	TOTAL	**419**	**420**	**429**	**429**	**429**	**252**

(Note that a location is identified to be affected as soon as part of the property is flooded above threshold)

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