30/06/2023

Assessing the climate resilience of Small Island Developing States

An analysis of future climate change scenarios and stakeholder involvement in Sint Maarten

Francesco Paolo Giarratana

Wordcount:11977 / Student ID: 2733183

MSc Environment and resource management

Supervisor: Dr. Paolo Scussolini - External supervisor: Ms. Ildiko Gilders

IVM Institute for Environmental Studies

VU

MINISTRY OF V.R.O.M.I

EPIC – Environmental Protection in the Caribbean – Sint Maarten

Abstract

Building resilience against climate change is a field of study which as grown exponentially in recent times. Small Island developing states are among the countries that will suffer more damages from climate change globally.

The small island state of Sint Maarten has had a number of natural disasters which have brought hardships on local residents and slowed down the development of the nation. Sint Maarten is now looking for avenues from which to improve not only its natural disaster preparedness but also the resilience of the island itself against these events. This research employs a mixed method approach which combines scenario and stakeholder analysis in order to envision possible future climate change scenarios at different resilience levels, and possible policy pathways that can help in efficiently improve the island's resilience against climate change.

The data used for the scenario analysis was taken from the most recent local census and statistical yearbook, while stakeholder interviews have been set up with local key players in community, economic, and ecological resilience. The data gained from both analyses has provided a comprehensive picture of future possible developments on the island in terms of resilience building. From the analysis of stakeholder interviews and scenario creation a strong vision for policy development was suggested. This vision takes into account the necessity for all actors to collaborate among each other and it is based on the importance of building climate awareness and improving monitoring of environmentally friendly behavior at the public and private levels. Policy recommendations were formulated accordingly to the vision resulting from the analysis.

Acknowledgments

This research was conducted as part of a research project and internship in collaboration with the Ministry of public housing, spatial planning, environment, and infrastructure of the state of Sint Maarten. I want to thank the organization for the support during my research and for providing the workspace and facilities. I also want to thank the NGO Environmental Protection in the Caribbean for providing the accommodation for my stay on the island and also for stimulating interesting discussions which have helped me in my research. I want to thank all the stakeholders who have given me some of their time in order to be interviewed and provide their expertise, without them the thesis would have not been possible. The interviews were always stimulating and have allowed me to explore points of view that I would have not thought of otherwise.

I want to thank my university supervisor Paolo Scussolini for always being available to nudge me in the right direction during the writing process and for giving me many tips on how to properly structure my research. A special thank you goes to my external supervisor Ildiko Gilders for not only always supporting throughout the stressing time of writing my thesis and researching data, but also for having made sure that I got to experience as much of Sint Maarten as possible and for being a good friend other than a good tutor.

Lastly, I want to thank my parents for having supported me throughout my academic journey. Every time during this master's when I needed someone to vent to, a shoulder to cry on, or simply company and reassurance I knew that my parents would be there, I would not be where I am right now without them. You helped me make my aspirations come true, thank you.

Ringraziamenti

Questa ricerca è stata condotta nell'ambito di un progetto di ricerca e tirocinio in collaborazione con il Ministero dell'edilizia pubblica, della pianificazione territoriale, dell'ambiente e delle infrastrutture dello Stato di Sint Maarten. Desidero ringraziare l'organizzazione per il supporto durante la mia ricerca e per aver messo a disposizione lo spazio di lavoro. Desidero inoltre ringraziare l'ONG Environmental Protection in the Caribbean per avermi fornito l'alloggio per il mio soggiorno sull'isola e per aver stimolato interessanti discussioni che mi hanno aiutato nella ricerca. Desidero ringraziare tutte le parti interessate per avermi concesso un po' del loro tempo per essere intervistate e per aver condiviso la loro esperienza, senza di loro la tesi non sarebbe stata possibile. Le interviste sono state sempre stimolanti e mi hanno permesso di esplorare punti di vista a cui altrimenti non avrei pensato.

Voglio ringraziare il mio supervisore universitario Paolo Scussolini per essere stato sempre disponibile e per avermi dato una spinta nella giusta direzione quando ne ho avuto bisogno. Un ringraziamento speciale va alla mia tutor Ildiko Gilders, non solo per avermi sempre sostenuto durante il periodo stressante della stesura della tesi e della ricerca dei dati, ma anche per aver fatto in modo che potessi fare il più possibile esperienza di ogni angolo di Sint Maarten e per essere stata una buona amica oltre che una buona tutor.

Infine, voglio ringraziare i miei genitori per avermi sostenuto durante tutto il mio percorso accademico. Ogni volta che durante questo master ho avuto bisogno di qualcuno con cui sfogarmi, o semplicemente di compagnia e rassicurazione, sapevo che i miei genitori ci sarebbero stati, non sarei dove sono ora senza di loro. Mi avete aiutato a realizzare i miei sogni, grazie

Contents

List of figures and tables

1. Introduction

1.1 Societal and scientific relevance

Climate change is one of the most concerning issues of the last century (W.H.O. 2018). The Intergovernmental Panel on Climate Change (IPCC) has released a number of reports on the dangers of Climate Change (CC) for the future of humanity. The latest report published by the IPCC in 2022 proposes several Representative Concentration Pathways (RCPs) which represent different potential futures for greenhouse gas emissions. Moreover the IPCC has also developed a set of scenarios called Shared Socioeconomic Pathways (SSPs) to envision future economic and societal developments depending on different levels of climate change (Kikstra, 2022).

By combining specific RCPs with specific SSPs, researchers can create integrated scenarios that describe how different socioeconomic pathways can influence greenhouse gas emissions and subsequent climate outcomes. For instance, the combination of RCP 2.6, representing a pathway with significant emissions reductions, with SSP1, depicting a future of sustainable development, may illustrate a future where ambitious mitigation efforts and sustainable practices lead to more favourable climate outcomes. These integrated scenarios help policymakers and scientists understand the potential consequences of different policy choices, and emission pathways on future climate change. They provide a more specific exploration of the multiple dimensions and complexities of climate change, highlighting the importance of addressing both emission trajectories and societal developments in tackling the climate crisis.

The accuracy of such scenarios when describing CC depend widely on the geographic location and on which systems we decide to focus on. One particular geographic reality which, according to the IPCC, will experience some of the worst consequences of climate change is that of Small Island Developing States (SIDSs) (Kikstra, 2022). One of the vulnerabilities of SIDSs to climate change is mainly given by the fact that their elevation does not protect them from rising sea levels, moreover, their long coastlines, making up a significant amount of the nations' land area, make them more prone to suffer from extreme weather events such as hurricanes (Robinson, 2020; Petzold, 2019). Additionally, the risks that SIDS encounter are also outside the field of geography, one example, is the dependency that these nations have on outside actors for different necessities that are not immediately available to islands, like great food resources and abundant energy production which then need to be imported. Lastly, the economies of SIDSs are dependent on tourism which oftentimes is connected to various types of biodiversity hotspots on the islands, decreasing biodiversity in such areas like coral reefs has then a detrimental effect on the tourism sector of SIDSs (Christ, 2003).

This research is going to be focused on one specific small island developing nation, Sint Maarten. The island is home to a variety of endemic species of flora and fauna, both terrestrial and marine, typical to the Caribbean (Nature foundation St. Maarten, 2023). The unique biodiversity of the island is under extreme pressure due to climate-change-related drivers but also due to habitat fragmentation and overexploitation of resources (Nature foundation St. Maarten, 2023). The relationship between the island's ecosystems and the socio-economic wellbeing of its inhabitants can be classified as an example of socio-ecological system (SES). It is then important to assess the resilience of the SESs of the island in order to understand future changes in the relationship between the environment and social systems due to climate change.

In the field of environmental science, the ability of ecosystems, communities, or socio-ecological systems to tolerate disruptions, adapt to changes, and maintain their core functions and structural integrity is referred to as "resilience". It places emphasis on a system's capacity to withstand shocks or stresses without losing integrity or its ability to maintain and serve the needs of people. This research is going to focus on resilience of the island to climate change shocks, and their effects on the economy and life of residents of the island through the lenses of the SES framework.

1.2 Problem statement

There is a growing amount of research being done on SIDSs and their relation with sustainability and climate change issues. This research can be used as a basis from which one can delve deeper into the reality of SIDSs and their ecosystems. There is a need for studies that focus on the effects of climate change led effect on the resilience of Sint Maarten. This is due to the fact that, in general, there is a lack of scientific literature based on the effect of climate change on Sint Maarten. To further explain, the main cause of the lack of literature can be attributed to the lack of fundings for research on the island and the general lack of a solid research base to start with (Dana, 1990).

Small Island Developing States (SIDSs) face considerable socioeconomic hardships as a result of their susceptibility to the effects of climate change, including rising sea levels, extreme weather, and biodiversity loss. The small Caribbean island nation of Sint Maarten is under threat from climate change, endangering its distinctive biodiversity and the benefits it offers to its residents, particularly through the tourism industry. To comprehend the potential future changes in the interaction between the environment and social systems brought on by climate change, it is essential to understand the resilience of Sint Maarten's socio-ecological system (SES). The issue being investigated in this study is how resilient Sint Maarten's SES will be to biodiversity loss brought on by climate change, as well as how this will affect the island's economy and citizens' quality of life. This study intends to inform strategies and policies that strengthen the island's resilience and support sustainable development by examining the SES's capacity to adapt to and withstand climate change shocks. This research contributes to the body of literature intended for policy makers and future researchers to explore the reality of climate change on the island and make decisions on mitigation policies based on previous literature. As said by Carl Folke "If we are concerned beyond the present and with sustainability, the interplay of temporal and spatial scales of the social and the ecological, from history into the future, from local to global, clearly have to become part of the analysis" (Folke, 2016).

1.3 Thesis structure and research (sub)question

The focus of this research is to explore the different levels of relation between varying climate change scenarios and resilience of SES on the island. Moreover, the expertise of stakeholders involved at various levels and in different realities of community, economic, and ecosystem resilience on the island will be analyzed. The aim of this research is to expand the body of literature present on climate change impacts on SIDSs while also offering information for future policy making on the island.

Based on the background given in the introduction, the research question will be the following:

"What effects will future climate change, in line with the IPCC scenarios, have on the level of resilience of socio-ecological systems in Sint Maarten?"

The thesis will be structured in the following way: after the introduction the first chapter focuses on giving a literature review based on the study and research of the essential concepts needed to proceed with the thesis work. Secondly, in the literature review section the theoretical framework will be explored, this framework is the basis that connects the different concepts presented in the thesis to a wider academic discourse. Moreover, in this section, the focus of the research on Sint Maarten will be showcased and the connection between literature and the island study will be made clear. The second chapter will focus on the explanation of the methodology applied in the context of this research particularly how and why a specific methodological approach was chosen in place of others. The methodological framework will be explained and how it is connected to the theoretical framework explained in the earlier sections. The third chapter will be based on results of the analyses conducted during this research, tables and data will be discussed as a starting point to jump into the discussion of results. After discussing the main findings, future policy solutions will be presented and limitations to the research discussed. Lastly, conclusions will be drawn.

The sub-questions are supposed to expand on the research question's scope.

1. How do we define resilience of socio-ecological systems in this research?
2. How do we construct resilience through policy in Sint Maarten?

These questions will be answered in the literature review chapter of the thesis.

3. How is resilience measured in this research?

This second step will be explored in the methodology section.

4. How do future scenarios of climate change on the island change depending on resilience?

This question will be answered in the results chapter in the context of performing scenario analysis.

5. What are possible policies avenues to explore in the future to improve resilience on the island?

This question will also be answered in the results chapter as part of a broader analysis based on stakeholders on the island.

2. Literature review / theoretical framework

2.1 Socio-ecological systems (SESs)

When assessing the relationship between nature and society we talk about socio-ecological systems. This concept has been popularized since the Millennium Ecosystem Assessment (MEA) in turn brought under public light the concept of Ecosystem Services (ES) (Lee, 2009). Ecosystem services refer to “The benefits that human societies gain from the environment” (Daily, 2008). The realization of the interrelatedness of natural systems and socio-economic systems brought to the forefront an interest in studying these systems not as separate entities but as complex systems with high levels of coordination between them (Ostrom, 2009).

These systems have the particular characteristics of being connected by various feedback loops that might impact their resilience and sustainability. Socio ecological systems (SESs) are defined as such because they are composed by multiple parts that are interdependent and create a joint outcome. Moreover, these systems are complex, that is, they are composed of many parts which act in ways that are hard to predict. Lastly, they are adaptive, such that each component of the system evolves in response to the state of other connected components (Ostrom, 2009). Understanding Sint Maarten's socio-ecological systems is essential to assess the effects of climate change on the island's biodiversity and economy and proposing practical tactics to foster sustainability and create resilience.

Elinor Ostrom offers a way in which to conceptualize SESs in a framework, her approach to the framework is mainly composed by four parts: resource systems, resource units, governance systems, and users. The author states that the interactions between these four components shape the functioning of SESs in correlation with various feedback loops (Ostrom, 2009). When applying Ostrom’s framework, four main steps characterize the process. Firstly, the boundaries of the system have to be well confined and recognized. In the case of this research, the boundaries of the system are defined by the geography and political autonomy of the island. Specifically, the study of the SESs will focus on the ecological system of Sint Maarten with a lower degree of focus on the interactions of the surrounding areas with the island system. Moreover, the social boundary of the system consists of considering the island political and social reality with less focus on external actors and interactions with political-social players outside the island. Secondly, one of the most important steps is to recognize the components of such systems. In the case of this research the socio-ecological system components are highlighted by figure 1 and are further discussed in section 3.3 and in figure 6.

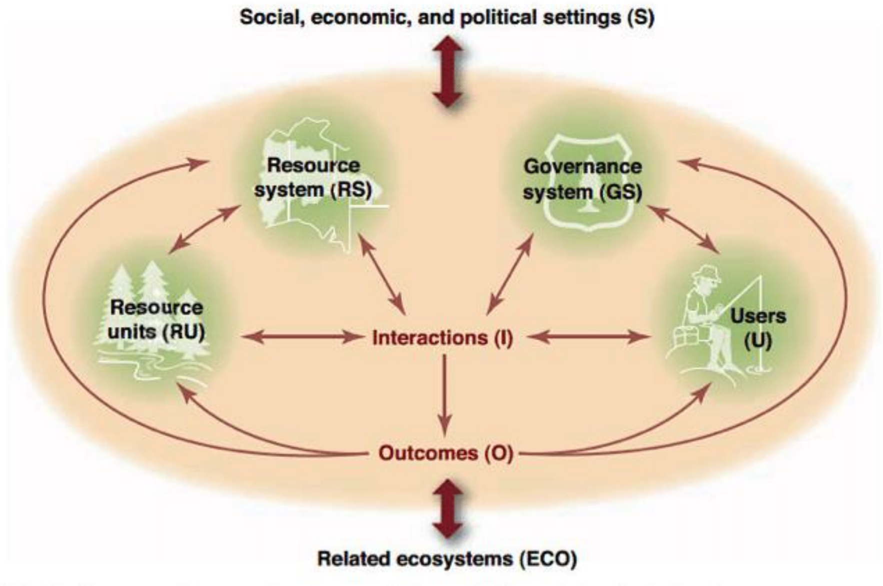

Figure 1: Socio-ecological systems framework by Elinor Ostrom (2009)

The third step is to identify the connections between various components. Some connections that appear clear in the context of the research are those between climate change and resilience loss, or the effect that tourism revenues have on enhancing interest towards environmental protection. In the methodology section a casual loop diagram will be provided showing the connections between each component.

The fourth step would be to recognize possible feedback loops in the system. Recognizing feedback loops is essential in order to understand the functioning of SESs, one example related to the research would be that of a negative feedback loop between climate change increase and tourism sector earnings: An increase in climate change will lead to lower biodiversity loss and thus a loss in earnings for the tourism sector because of loss of tourist attraction to natural areas, this will also be explored more in depth in the methodology section. The last step would be to identify the resilience of the system or how it might survive certain shocks and come back to normal functioning.

While the framework has received general praise over the years, some critiques have also been proposed by other experts in the field. One of the main critiques to this framework relates to the last concept of resilience. Brian Walker argues that Ostrom's framework does not give enough attention to the effect of external drivers for the loss of SESs functioning such as climate change (Folke, 2010). Thus he argues that Resilience in the context of SESs has to be expanded upon in order to better understand their functioning.

2.2 Resilience

The concept of resilience was originally proposed by Holling in 1973 and it was defined as "The capacity of system with different attractors (drivers) to return to their original state after perturbance" (Holling, 1973). This definition was key in the development of the field of resilience of ecosystems due to the stress it puts on the multilateral and various nature of ecosystems and their drivers. Brian Walker in his paper "Resilience Thinking: Integrating Resilience, Adaptability and Transformability" argues that when studying SESs it is key to look at them through the lenses of varied levels of interrelation, thus not pushing for a single outcome but account for uncertainty of complex systems. The solution proposed by the author is that of “Resilience thinking” which accounts for the ability of ecosystems to maintain their original functions while adapting and learning to take care of disturbances (Walker, 2010). According to the author “Resilience thinking explicitly focuses on understanding how periods of gradual change interplay with periods of rapid change in intertwined social-ecological systems confronted with true uncertainty and what that means for people and the planet.”. The author proposes three key components that make up resilience thinking: Resilience, Adaptability, and Transformability. Resilience, as explained, refers to the ability of a system to absorb shocks and maintain its functions. Adaptability refers to the ability of systems to modify their functioning and evolving depending on possible external changes. Transformability refers to the case in which resilience and adaptability fail to work and the system needs to revolutionize its own functioning in order to react to shocks (Folke, 2016).

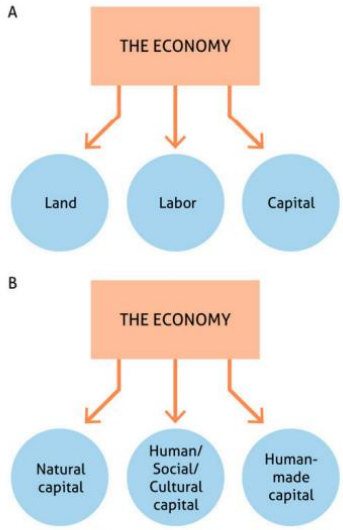

Figure 2 factors of production of an economy, A = classical factors, B = factors included under resilience thinking. Folke, 2016

Different indicators have been proposed by various authors to assess the state of resilience in SESs. Some of these indicators are:

- Diversity, The amount of species and services offered by different systems.
- Flexible governance structures that are responsive to changes in the natural and social spheres.
- Efficient management of resources of systems that allows for more shocks to be absorbed.
- Economic and cultural diversity that enhance knowledge about systems and preservation.

This abundance of indicators for resilience makes it difficult to focus research in one particular way and to set down proper methodologies that use resilience as a framework.

Thus, even if the concept of resilience has been explored more in depth by different authors, the author Marjolen Sterk argues that it lacks conceptualization and does not add to Ostrom earlier framework. The author states that the concept of Resilience has to be clearly defined and that there should be a standardization on how to assess the level of resilience of certain ecosystems. A successful analysis of resilience of systems can lead to a better understanding of tipping points of ecosystems and how they react to anthropogenic pressures (Sterk, 2017).

Recent resilience literature has moved from the impression that resilience has one definitive breaking point to the understanding of complexity of system and how resilience scales depending on how many factors interact with various systems (figure 3). According to the author the fifth step in Ostrom's framework should be divided in an additional three steps which are: Defining resilience, finding indicators, assessing methods. In this research the definition of resilience used is the original one by Holling mentioned earlier. Then indicators used in this research are based on the "Resilience index score" developed by Sanaz Moghim and the "Economic resilience index" developed by Briguglio. The indicators used in the analysis are then a mix of different indexes which allow for a wider exploration of the components of resilience on the island. The indicators used in the research are: Climate risks, Greenhouse Gasses emissions, Air pollution, Energy consumption, Access to clean water, Access to sanitation, Macroeconomic stability, and flooding exposure.

Lastly the methods used will involve a mix of scenario and stakeholder analyses that will allow for an optimal and all-encompassing picture to be formed about the state of resilience of the socio-ecological / socio-economic systems of Sint Maarten.

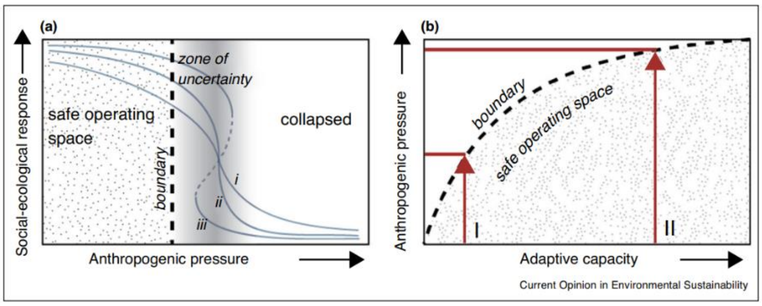

Figure 3 change in opinions on resilience in systems. Sterk, 2017.

2.3 Constructing resilience

Resilience as a concept, can be quite useful in assessing the state of society and the environment together. However, in order to improve resilience of systems, the institutional environment that surrounds decision making has to understand the tools that are needed to improve such resilience to an optimal extent. According to the book "Principles for building resilience; sustaining ecosystem services in socio-ecological systems" by Biggs, Schluter, and Schoon, there are seven principles to follow in order to optimally build resilience. These principles focus on socio-ecological systems at every level, from within the mechanism that maintain the systems, to the outside forces that affect them (Biggs, 2015). Each principle will be shortly summarized in the next paragraphs.

Principle One: Maintain Diversity and Redundancy: Sint Maarten possesses rich biodiversity, including unique coastal ecosystems, mangroves, and coral reefs. However, urbanization and tourism development have led to habitat fragmentation and loss. Preserving and restoring ecological diversity is crucial for enhancing resilience (Biggs, 2015).

Principle Two: Manage Connectivity: Sint Maarten's socio-ecological systems are closely interconnected, with strong linkages between coastal and marine ecosystems, tourism, and the local economy. Effective governance should prioritize managing these connections to ensure sustainable development and resilience (Biggs, 2015).

Principle Three: Foster a Sense of Place and Stewardship: Sint Maarten's cultural diversity and history contribute to a unique sense of place and attachment to the island. Promoting stewardship requires engaging the community in sustainable practices and decision-making processes. Recognizing and valuing local knowledge systems, including traditional ecological knowledge and practices, is crucial for effective governance.

Principle Four: Foster Complex Adaptive Systems Thinking: Sint Maarten's socio-ecological systems are characterized by complex interdependencies and nonlinear dynamics. Applying a complex adaptive systems approach to governance can help navigate uncertainty and facilitate adaptive management.

Principle Five: Encourage Learning: Continuous learning and experimentation are critical for building social-ecological resilience on Sint Maarten. Establishing long-term monitoring programs for key ecological and social indicators will provide essential data for adaptive management.

Principle Six: Broaden Participation: Promoting broad participation in governance processes is vital for building social-ecological resilience on Sint Maarten. Engaging diverse stakeholders, including local communities, businesses, NGOs, and government agencies, fosters a sense of ownership and facilitates the integration of different perspectives.

Principle Seven: Promote Polycentric Governance: Polycentric governance approaches hold promise for enhancing social-ecological resilience on Sint Maarten. Establishing effective coordination mechanisms among multiple governing bodies, including local, regional, and national entities, can enable swift responses to environmental challenges.

Incorporating the seven principles of building social-ecological resilience into governance approaches on the island of Sint Maarten holds significant potential for enhancing sustainability and adaptability. By maintaining diversity, managing connectivity, fostering a sense of place and stewardship, embracing complex adaptive systems thinking, encouraging learning, broadening participation, and promoting polycentric governance, Sint Maarten can address its unique socio-ecological challenges (Biggs, 2015). However, it is crucial to tailor these principles to the island's specific context and actively engage stakeholders in their implementation. By doing so, Sint Maarten can pave the way for a resilient and sustainable future.

2.4 Study area

Sint Maarten is a small island in the northeast Caribbean sea. The total land area of the island is 87 square kilometers which are divided on two sides one French and one Dutch. The French side is 53 square kilometers in area and the Dutch side is 34 square kilometers. The population of the entire island is 84795 inhabitants as of 2023 with a slight majority of the population living on the Dutch side. The two parts of the island are administered by two separate governmental entities. The French side is an oversea territory of the republic of France and thus part of the European Union. The Dutch side has obtained independence from the kingdom of the Netherlands in 2010 and is thus an autonomous republic although still a constituent country of the kingdom. According to the system of Koppen, the climate of the island is a mix of savanna and monsoon type (Rojer, 1997). During the months of June to November the island experiences hurricane season which is characterized by strong tropical storms that vary in intensity. The last event of this nature that has caused a significant amount of damage to the infrastructures and people of the island was Hurricane Irma in 2017.

The islands boasts at least 552 species of plants, on the other hand, land fauna is limited due to the dimensions of the island and to habitat destruction. The main ecosystems of the island comprise coral reefs, mangroves, coastal ecosystems, and seasonal forests. The biodiversity of St. Maarten is under danger due to habitat loss, development-related deterioration, and tourist-related pollution. Complete surveys and research of uncommon and endangered species are required in order to successfully manage St. Maarten's natural resources (Rojer, 1997).

Figure 4: Map of Sint Maarten showing main neighborhoods, border between French and Dutch part and airports.

3. Methodology

3.1 Justification

This chapter will discuss the different methods used in this thesis to answer the research question and sub-questions. The methods used in this research are based on two main types of analysis: scenario analysis and stakeholder analysis. The former is aimed at estimating the amount of resilience of the socio-ecological system of Sint Maarten's nature and economy, this is achieved by using the IPCC's RPCs scenarios of medium-high climate change and scenarios of low-high resilience. Secondly, the scenario analysis goal is to project future variation in impacts of climate change on the island and consequences to the resilience of the island. The approach to the stakeholder analysis will be explored more in depth in the following parts of this chapter.

Following the scenario analysis, a stakeholder analysis approach was performed to better explore and give details to the possible future scenario visions. . The stakeholders involved in this research were specifically selected to have a variety of perspectives, influence on the future of the island, and interests. Four stakeholders were then chosen, these were:

- Government agencies in particular the ministry of Ministry of public housing, spatial planning, environment, and infrastructure of the island (VROMI).
- Non-governmental organizations like Environmental Protection in the Caribbean (EPIC) which works on protecting Caribbean ecosystems from degradation.
- Representative for private businesses and the tourism sector, for this research the Sint Maarten Hospitality and Trade association (SHTA) was taken as a representative.
- Lastly, a representative for one of the big faith-based congregations present on the island was chosen as a stakeholder to discuss community resilience.

The rationale and reasoning behind the selection of these stakeholders and the specific categories they represent will be further explored in the following chapters. The mix of methodologies that this research is composed of can help better asses the reality of resilience of Socio-ecological systems. According to Tompkins, a multilayered approach to the study of SESs is essential in order to grasp the various interaction of the human systems and nature-system (Tompkins, 2004). Moreover, the possibility to involve stakeholders and their

Research question
What effects will future climate change, in line with the IPCC scenarios, have on the construction of resilience of socio-ecological systems in Sint Maarten?

Sub-questions				
How do we define resilience of socio-ecological systems?	How do we construct resilience through policy?	How do we measure resilience?	How do future scenarios of CC on the island change depending on resilience?	What are possible policies avenues to to improve resilience on the island?

Methods used to answer				
Answer in literature review	Answer in literature review	Answer in methodology	Answer in results of scenario analysis	Answer in results of stakeholder analysis

Table 1 showing approach to answering research question.

expertise can grant a further understanding of the reality of creating policy on the island and the implications that this can have on resilience. The approach used to answer the research question and sub-questions provided in this thesis is based on multiple parts that comprise the research. The literature review is used to shape the knowledge of the essential concepts used in this research and support the methodology and result chapters.

3.2 Methodological framework

The methodological framework that will be applied for this research is based on the one used by Verwej et.all in their paper "Bonaire 2050". This method is also based on the method called "Foresight" which is useful when researching about uncertain futures and possible avenues for nature inclusiveness in spatial planning. Foresight as explained by Verweij is an approach to sustainable development that seeks to find a balance among different sustainability issues related to various sectors, for example, social well-being, clean energy, and clean water and sanitation (Verwej, 2022).

The reasoning behind choosing this specific methodological approach in this research lies in the fact that the core of the research based in the scenario analysis is concerned with highly uncertain futures. Moreover, with this approach the policy section resulting from the various analysis can be supplied with different pathways and higher involvement of stakeholders. The methodology will be roughly based following the structure shown in figure 5, however, section 1 "Motivation and purpose" will be omitted because its contents have already been explored in the introduction. Moreover, sections 2 "Identify stakeholders" will be moved to the results session and thus come after other sections because its contents are part of the results involving this research.

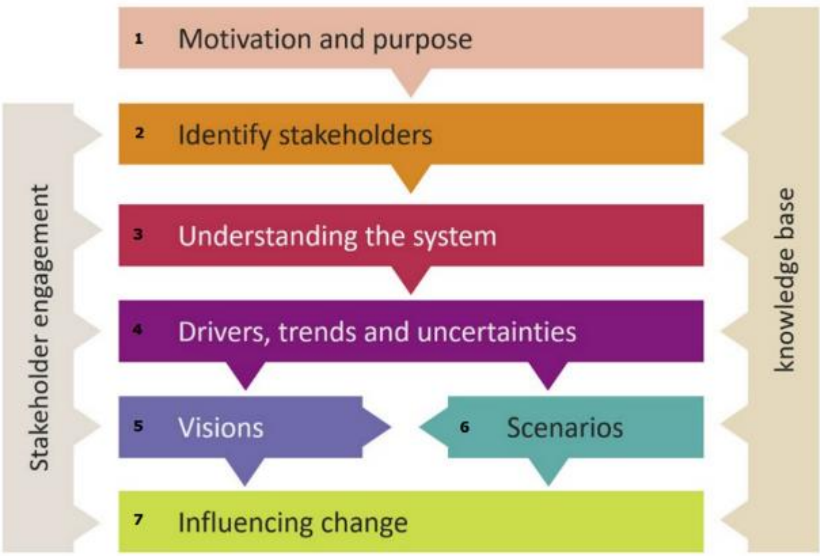

Figure 5: methodological framework by Verwej et.all 2022

3.3 Understanding the system

To understand the SES in Sint Maarten this research takes the approach used by Ostrom on dividing SESs in components and studying their interactions and their outcomes. Figure 6 shows a diagram visualizing the different components of Sint Maarten's SES and their potential relations. The interactions are explored both in a negative and positive direction depending on the potential for change that each component brings on the others. In turn this visualization helps in the imagination and drafting of possible interrelations between components. For example, the research by Molenaar shows how demographic changes on Sint Maarten are related to an increase in over-development and destruction of mangroves in the Simpson Bay Lagoon, in turn the functions of the lagoon are then limited and support less life and resources compared to unaltered states (Molenaar, 2019). This example can be directly connected to the diagram in figure six, following the red arrow stemming from the users box and going towards resource systems we see that "More users can increase stress on resource systems", moreover, starting from governance systems and following the red arrow to resource systems we also see that "Inefficient governance systems might tend to overexploit resource systems. These two connections on the diagram are directly associated to the processes at work in the lagoon.

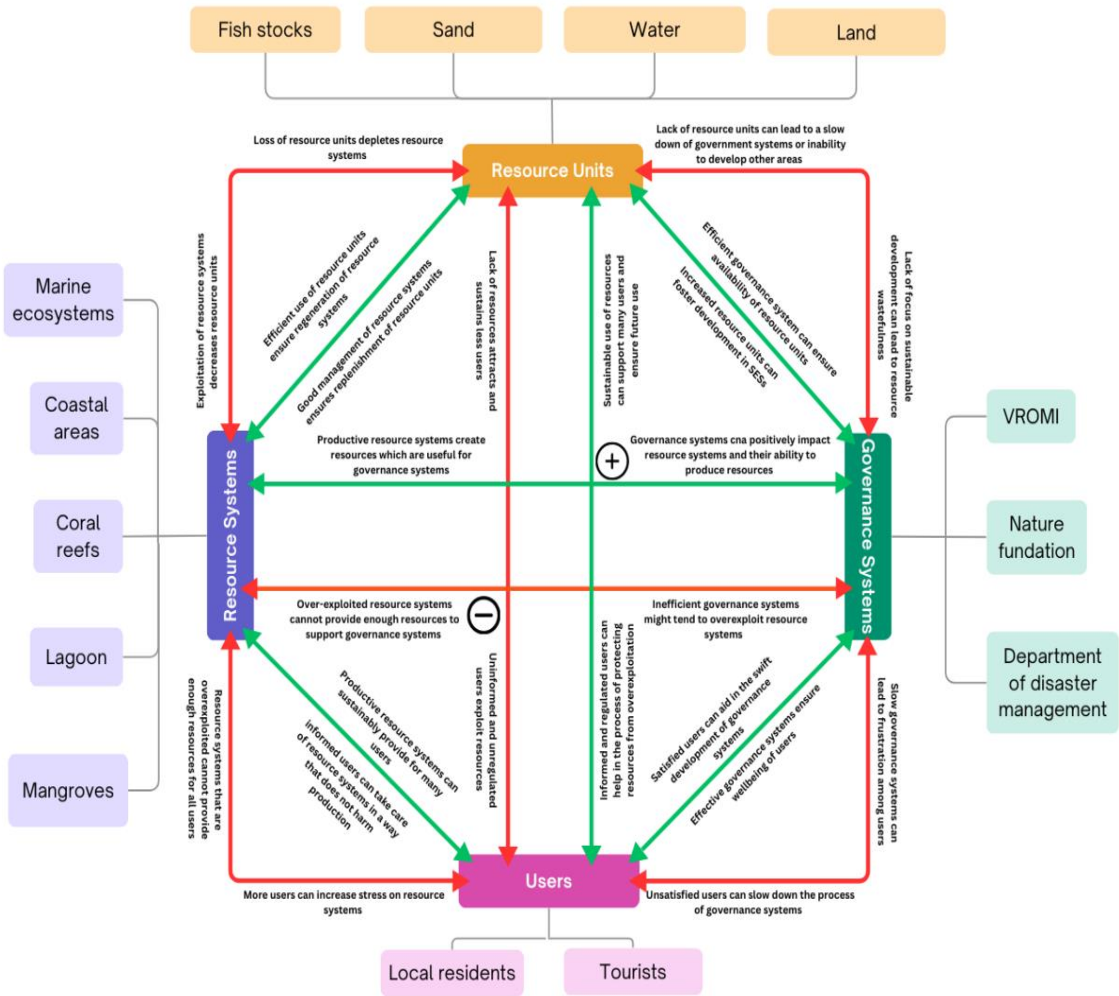

Figure 6: diagram showing the relations between components of the socio-ecological system in Sint Maarten.

By using the diagram in figure six created for this research, we then understand that the socio-ecological system at work on the island is complex and made up of different elements all interconnected and with multiple positive and negative interactions among each-other. The next step required to further understand the system at work on the island is that of analyzing the outcomes of these interactions. In order to do so the next paragraphs will study the drivers of the system and show the steps taken in the research to perform a scenario and stakeholder analysis. These next sections will show the outcomes of various interaction between different components of the island SESs by analyzing the change of indicators of resilience in the future as a result of changes in the state of the socio-ecological system particularly from climate change.

3.4 Drivers, trends, and uncertainties

This paragraph of the methodological framework coincides with the first steps taken to perform the scenario analysis. Firstly drivers were identified, those were selected as the 8 components of resilience taken from Moghim and Briguglio (Moghim, 2019; Briguglio, 2009). Secondly, expected changes and the impact they have on the case study were assessed. Lastly, the level of uncertainty and the importance of each driver in the context of the study was assessed (Borjeson, 2006). Table 2 showing the explanation of each driver, their uncertainty and their trends can be found in Annex 1.

The data used to determine the state of the drivers was collected through online resources. Most data comes from the statistical yearbook published in 2017 from the department of statistics of Sint Maarten. The data for hurricane frequency and their impacts on the island has been taken from the website of the USA's Atlantic Oceanographic and meteorological laboratory, lastly, some of the data was taken from the island census performed in 2011, particularly when data needed was missing from the yearbook.

3.5 Scenarios and visions

This paragraph will be focused on explaining the steps taken after the identification of drivers to perform the scenario analysis and the main components of said analysis.

The scenario analysis was based on a 2x2 matrix with two main components resilience and climate change (figure 7) (Ramirez, 2013). The component of resilience is built using a modified version of the index on the resilience of socio ecological systems developed by Moghim with added points from the index for economic resilience developed by Briguglio. The last indicator of flooding risk has been chosen because of the importance that this specific issue has in the agendas of SIDS (Zari, 2019) . To reiterate, the indicators chosen are: Climate risks, Greenhouse Gasses emissions, Air pollution, Energy consumption, Access to clean water, Access to sanitation, Macroeconomic stability, and flooding exposure.

The component of climate change was based on the climate change scenarios proposed by the IPCC, in particular, the scenarios that this research will focus on are the intermediate, and very high emissions scenario or SSP 2 -4.5, and SSP 5 – 8.5. These two scenarios have been selected because of the consequences to resilience that both scenarios would have compared to lower ones that would end up being more , consequentially the intermediate scenario will be considered as low climate change and the very high scenario will be considered as the high climate change. The matrix will then be divided into four scenarios:

- Low resilience, medium climate change = minimum effort scenario.
- Low resilience, high climate change = worst case scenario.
- High resilience, medium climate change = best case scenario.
- High resilience, high climate change = strong resilience basis.

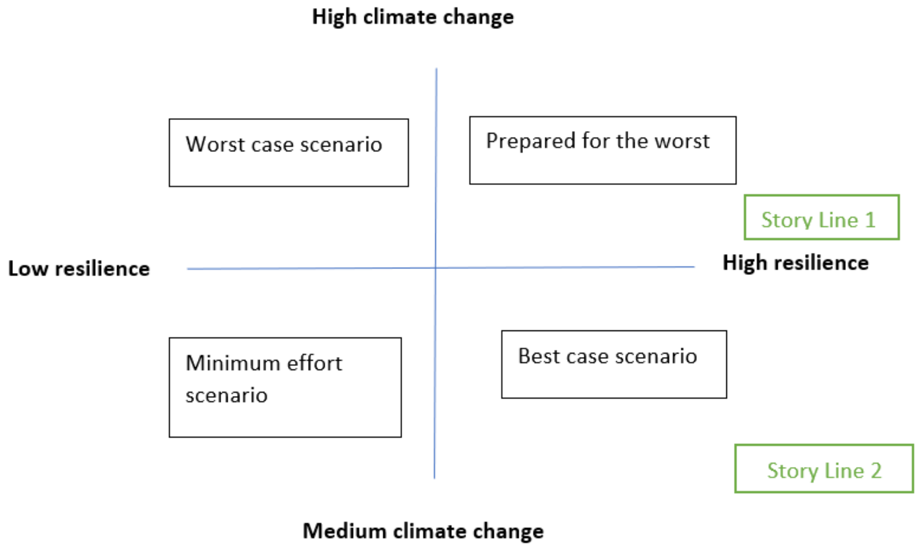

Figure 7: 2x2 matrix used in the creation of scenarios for the island.

Following changes in the two main drivers listed above here a definition of the four scenarios is provided. The timing for the changes is expected in concordance with the timing of IPCC scenarios, that is between 2050 and 2100 with a particular focus on the short term future and thus towards the 2050 end of the spectrum (Robinson, 2020).

Best case scenario:

This scenario is based on the assumption that global climate change does not increase drastically over the upcoming years and that countries all across the globe manage to keep their emissions low enough to maintain global temperatures between 2 and 3 degrees. This scenario is based on the RCP 4.5 which according to the IPPC is the most likely to happen (Allen, 2014). Damages to biodiversity and sea level rise would still happen but in this scenario the island has worked towards building up their resilience and achieved higher resistance to environmental shocks.

Minimum effort scenario:

In this scenario global change is still assumed to not be too high and thus causing a bearable amount of damage to the island. However, what makes this scenario different from the best case scenario is the application of policies in favor of more resilience on the island. While in the former case policies have been enacted and have increase the resilience of the island, in the latter case, which is the one for this scenario few policies if any have been proposed and passed in order to increase the resilience of the island thus leaving the country subject to the lower but still damaging effects of the intermediate climate change scenario.

Worst case scenario:

In the case of this scenario the global community has not managed to come to an agreement on climate change reduction thus not really enacting any successful policies on GHGs emissions reduction and exacerbating the damage done to the environment. Temperature rise is projected to increase between three and five degrees Celsius thus really increasing sea level and habitat destruction (Allen, 2014). Moreover, in this scenario resilience improvement on the island has not been deemed a priority, thus spreading easily the great amount of devastation that climate change brings about in the form of floods, droughts, air pollution and so on.

Strong resilience basis:

In this last scenario climate change has had the same course as in the worst case scenario. What change is the policy preparation and attitude towards resilience construction on the island. While the amount of damages that CC might bring is great, the resilience construction on the island helps reducing these damages to a minimum and thus maintain the stability of the socio-ecological systems on the island to a good level.

Visions:

In addition to the scenarios presented, the analysis will also focus on creating two visions of possible pathways towards better resilience. These visions will be based on the scenarios imagined with high resilience, the reasons behind this choice is because the aim of the analysis is also to provide with policy recommendations, thus it is more coherent to focus on possible futures that can ensure increased resilience. Moreover, Once the two visions have been created a s a result of different scenarios, the data gathered from the stakeholder analysis will be cross analyzed with the resulting visions in order to point out which vision is more in line with stakeholders' expectations.

3.6 Influencing change

In order to study how the future scenarios can be selected to improve the resilience of the island and what steps have to be taken to ensure that certain scenarios happen this research also focused on interviewing stakeholders on the island. Stakeholder interviewing and the following analysis of interviews allow for a further understanding of the dynamics at play to enact change on the island.

The interviews took place between the 1st of May 2023 and the 7th of June 2023. The questions asked during the interviews were focused on assessing three types of resilience on the island: Community, economic, and ecological resilience. In order to do so an array of stakeholders was selected as explained in paragraph 3.2 based on their knowledge of these concepts. The process of the interview followed a standard schedule: firstly each stakeholder was given information about the project. Secondly, a paragraph on comfort and trust during the interview was repeated in order to ensure each stakeholder was comfortable in taking part in the interview. Lastly, the interview started with an explanation of what this research considers resilience using the definition by Holling, that is: “The capacity of system with different attractors (drivers) to return to their original state after perturbance” (Holling, 1973).

The questions used in the interview were drafted to be as similar as possible to each other and for each stakeholder while also allowing the latter to showcase their knowledge in their own specific area of expertise (Golafshani, 2003). The reason why the questions were made similar was to ensure that in the analysis of the interviews no or minimum bias was present towards one stakeholder. Moreover, the use of similar questions was beneficial in ensuring that the analysis did not have to engage with putting together sets of data with high degrees of difference (Golafshani, 2003). A list of the questions used during the interview together with the steps taken before the interviews can be found in annex 1. Once the interviews were transcribed the process of coding such interviews began, in the following paragraph the theory used to code the interviews will be explained.

3.7 Coding the interviews

Once the registration and transcription of the interviews was completed, I applied a systematic coding method in order to study the qualitative data gathered in the earlier stages of the stakeholder analysis. This coding method is comprised of different stages and techniques associated to coding, in turn, the specific techniques applied in the analysis were chosen because I deemed them to be the most fitting ones to apply in a future policy context.

The first type of coding technique utilized was open coding (Saldana 2006). This involved a meticulous examination of the collected data, which included interviews in order to identify initial codes or labels that represented different aspects of the stakeholders' perspectives. The data was thoroughly reviewed, and initial codes were generated to capture a wide range of ideas expressed by the stakeholders. This open coding approach allowed for the emergence of the first coding components of the analysis and ensured that no important insights were overlooked. The codes that emerged are shown in annex 1.

After the initial open coding phase, the data was further analysed using axial coding (Saldana, 2006). This technique involved making connections between the initial codes and categories identified in the open coding phase. Axial coding provided a more structured framework for analysis, enabling a deeper understanding of the interrelationships between various stakeholders' perspectives and the factors influencing them. The grouping of different themes is shown in annex 1.

The next coding technique employed was selective coding (DeCuir-Gunbi, 2011). In this phase, the focus was on selecting the most significant and representative codes from the previous stages. The themes and sub-themes identified in the open and axial coding phases were refined and consolidated to capture the key factors or issues that were most salient to the stakeholder analysis. This process involved careful consideration and evaluation of the codes to ensure that the analysis accurately represented the stakeholders' viewpoints and priorities. By selecting the most relevant codes, a clear picture of the stakeholders' perspectives emerged, contributing to the overall understanding of the stakeholder landscape. The most relevant codes ended up creating the four main themes of the analysis shown in annex 1.

4. Results

4.1 Resulting scenarios with changing drivers

After having set the scenario analysis drivers and main scenarios as explained in the methods chapter, the following step was to set up a table with each driver and the changes expected under each scenario. This table is available in annex 1 and offers an overview of the main characteristics in terms of data for each scenario. In the next paragraphs the resulting scenarios complete with data will be showcased in order to understand the possible futures state of resilience on the island. Moreover, once each scenario has been set, this chapter will explore the resulting two visions created from the scenario analysis. The visions are based on high resilience futures and the possible avenues for policy making.

Scenario 1: Best-case scenario

In this scenario, the island nation's future is based on a mix of low climate change and high resilience preparedness. This entails moderate environmental risks and high resilience measures. Under RPC 4.5, the island experiences no increase in hurricane frequency, then, the average of 0.11 destructive hurricanes per year is maintained (Jing, 2021).. The increase of resilience infrastructure keeps the island safe against the destructive impacts of these hurricanes, The government pays limited attention to energy consumption. While global efforts to stabilize CO2 particles improve air pollution levels, local air quality may stagnate due to the low focus on resilience measures (McMillen, 2014). The island's greenhouse gas emissions decrease in line with the RPC 4.5, but without significant emphasis on resilience, the island's ability to adapt to the adverse impacts of climate change is limited (Allen, 2014).

Access to clean water remains relatively stable. Similarly, access to sanitation remains unchanged, with a lower risk of reduced access during extreme events. Macroeconomic stability follows the RPC 4.5 projections, with potential increases in government spending on disaster relief and adaptation measures (Allen, 2014). Unemployment and inflation rates may rise due to climate change's impacts on economic activity, particularly in vulnerable regions which on the island comprise the regions next to the coast and thus the majority of the economically developed areas (Briguglio, 2009). However, the focus on resilience ensures that the damages made to the economy are at a lower level than otherwise. Flooding exposure 5.32% of the island which is the lowest level compared to other scenarios (Sikking, 2022).

Scenario 2: "Minimum Effort Scenario"

In this scenario, the island nation follows the RPC 4.5, with no significant improvements in resilience measures. Hurricane frequency remains unchanged, resulting in an average of 8 major hurricanes over 70 years, causing an average of 5 deaths and $500 million in damages per event (Jing, 2021).. While energy consumption is primarily focused on reducing emissions, the low emphasis on resilience limits improvements in energy efficiency and infrastructure. Similarly, air pollution levels improve globally due to efforts to stabilize CO2 particles, but local air quality may stay at a low level due to the low focus on resilience measures (McMillen, 2014).

GHG emissions decrease in line with the RPC 4.5 projections, but without significant investment in resilience, the island remains vulnerable to the impacts of climate change (Allen, 2014). Access to clean water and sanitation remains relatively stable, but the lack of resilience measures prevents improvements in these areas, leaving the island susceptible to climate-related risks. Macroeconomic stability follows the same trajectory as the RPC 4.5 projections, with limited focus on utilizing the advantages of lower climate change impacts. Flooding exposure remains at 9.14% of the island, with no resilience measures in place to reduce this figure by 50% (Sikking, 2022).

Scenario 3: "Worst-Case Scenario"

In this scenario, the island nation faces the most severe risks under the RPC 8.5. Hurricane frequency increases by 14%, resulting in one additional destructive hurricane added to the span of 70 years (Jing, 2021).. The lack of resilience measures leaves the island fully unprepared to the shocks of climate change. On the other hand, Energy consumption relies heavily on fossil fuels, with no significant efforts to reduce emissions or improve energy efficiency. Air pollution levels worsen due to increased global activities, including maritime traffic. The lack of resilience measures exacerbates the negative effects of air pollution on the island (McMillen, 2014). GHGs emissions increase by far under the RPC 8.5, leading to severe consequences for the island, moreover, limited resilience efforts prevent the island from effectively addressing the drivers of GHGs emissions, resulting in significant environmental challenges (Allen, 2014).

Access to clean water faces difficulties due to rising costs of desalination and limited access to alternative freshwater sources. The lack of resilience measures increases the problem, leaving many without access to clean drinking water (Domptail, 2010). Similarly, access to sanitation is compromised by extreme events, with limited resilience efforts to mitigate the risks. Macroeconomic stability is affected by increased government spending on disaster relief and adaptation measures (Briguglio, 2009). Unemployment and inflation rates rise due to the impacts of climate change on economic activity, and the external debt to GDP ratio increases due to decreased economic activity and investment. Flooding exposure affects 10.65% of the island, primarily impacting developed areas which tend to be the most lucrative (Sikking, 2022). The lack of resilience measures exacerbates the catastrophic scenario, with severe consequences for the island's infrastructure and economy.

Scenario 4: "Strong resilience basis"

In this scenario, the island nation faces increased hurricane frequency under the RPC 8.5, but with high resilience measures in place. The government invests in infrastructure such as sea walls and elevated relocation of key facilities, significantly reducing the damages caused by hurricanes. The focus on resilience extends to the energy sector, with investments in energy-efficient solutions and improved climate change protection infrastructure. The government promotes clean energy projects and incentivizes sustainable practices to enhance energy resilience and reduce emissions. Additionally, the efforts to mitigate air pollution include sustainable transportation initiatives and sustainable waste management practices (McMillen, 2014). The government focuses on improving air quality standards and promotes eco-friendly alternatives to reduce the negative impact of air pollution on the island.

Despite the challenges posed by the RPC 8.5, high resilience measures help protect the island from severe damages and ensure low-emission recovery plans. Access to clean water is improved through stable water supply connections, and sanitation facilities are resilient against extreme events (Domptail, 2010). Macroeconomic stability is maintained through the government's focus on strengthening the tourism industry and infrastructure (Briguglio, 2009). The high resilience measures protect the island's tourism sector, which is vital for its economy. Although some economic damage is inevitable, resilience efforts minimize the negative impacts of climate change on the island's economy. Flooding exposure affects a reduced area of 5.32% of the island due to the high resilience measures (Sikking, 2022). The government's investments in resilience infrastructure significantly mitigate the damages caused by flooding events.

4.2 Defining visions

The next paragraphs will focus on describing two possible visions with policy suggestion to increase resilience on the island. These visions are based on the information gathered by the analysis of these four future scenarios and by focusing on high resilience futures. The two visions are based on two approaches, the first is focused on infrastructure and how to improve it in order to avoid the majority of damages from climate change. The second vision focuses on improving soft approaches to resilience and increasing awareness of green practices. The two visions are not mutually exclusive of each other but just two ways of looking at approaches to improve the resilience on the island.

4.3 Vision 1: Resilience through Energy and Climate Infrastructure

This vision focuses on the possibility of high climate change and also of an increase in climate disaster outside of control for the island. The government in this case focuses on two main points to improve and create policies in order to improve resilience. The two points are improved disaster infrastructure, improved energy infrastructure.

The first point for improvement is the disaster infrastructure. As gathered from the future scenarios projections, we can expect that with high climate change futures there is also going to be an increase of at least 14% of hurricane incidence and a likely impact of floods on at risks areas comprising of 10,65% of the island area. In order to improve the disaster infrastructure and take this damages down to a minimum a set of policies focused on building resilience have to be considered.

In the aftermath of Irma, the government of Sint Maarten created a National recovery and resilience plan (NRRP, 2018). The focus of the document was on the immediate recovery of the island and, while it made some effort to include future planning, it focused less on building resilience. In order to improve legislation on resilience the focus should be on future thinking. Building resilience after a disaster and planning for the future are both crucial aspects of disaster management, but they differ in terms of timing and emphasis (Folke, 2010). When it comes to building resilience after a disaster, the immediate focus is on recovering and rebuilding communities, infrastructure, and systems that have been severely impacted. On the other hand, this vision's focus is on planning for the future and building resilience in advance, which involves proactive measures taken before a disaster strikes. In order to do so it encompasses comprehensive risk assessments, designing resilient infrastructure and policies, implementing early warning systems, educating communities on preparedness, and fostering a culture of resilience (Burnside, 2016). This forward-thinking approach aims to reduce vulnerabilities, enhance adaptive capacity, and minimize the impact of future disasters.

The main focus on building resilience should focus on disaster infrastructure particularly this vision suggestion is based on: Flood control systems, coastal protection measures, and resilient buildings and infrastructure (Karamouz, 2017). The first suggestion can be improved by building or improving flood control systems, such as levees, flood walls, and dikes, to prevent floodwaters from inundating low-lying areas and critical infrastructure present around the coast (Karamouz, 2017). For coastal protection measures one should focus on construing or enhancing coastal defences, such as seawalls, and breakwaters to protect vulnerable coastal areas from storm surge and erosion. Lastly for resilient buildings and infrastructure the focus should be on establishing or updating building codes and regulations to ensure new constructions and renovations comply with resilient design principles, including wind-resistant structures and elevated foundations (Shapiro, 2016). This is a project that is ongoing at the government level on the island. Moreover another good idea would be to install hurricane shutters or impact-resistant windows on existing buildings to protect against wind-borne debris.

When talking about energy infrastructure, the focus should be on avoiding loss in energy efficiency and increasing energy input from renewables. The government of Sint Maarten focuses on this aspect in the national energy policy. In this vision, the avenues suggested to improve this aspect are two. For energy efficiency there should be the creation of energy standards for buildings that miss it and a clear way to enforce them. For renewables the focus of this vision is on two project already mentioned in the national energy policy. The creation of an offshore windfarm with funding from the world bank and the implementation of solar farms to use the high amount of sunlight that the island gets.

4.4 Vision 2: Resilience through Sustainable Tourism and Ecotourism

This scenario revolves around the promotion of sustainable tourism and ecotourism, as well as improved awareness about environmental conservation on the island of Sint Maarten. The government recognizes the importance of preserving the natural beauty and biodiversity of the island while harnessing the potential of tourism for economic growth and development (Burnside, 2016). The three main points of focus in this vision are sustainable tourism practices, ecotourism initiatives, and increased environmental awareness among visitors and locals alike. To promote sustainable tourism practices, the government should introduce policies and regulations that encourage tourism operators and accommodations to adopt environmentally friendly practices. This includes implementing waste reduction and recycling programs, promoting water and energy conservation measures, and supporting sustainable transportation options for tourists, such as public transit and cycling (Pan, 2018).

In line with ecotourism principles, the government should collaborate with local communities and conservation organizations to develop and promote nature-based tourism activities (Fennel, 2020). This involves establishing protected areas, nature reserves, and eco-parks that showcase the island's unique ecosystems and wildlife. This particular aspect of interest for the vision has not been developed presently on the island with the presence of only one marine protected area off the coast of the island, not counting the additional one off the coast of the French side. The government also must encourage tour operators to offer guided tours and activities that focus on environmental education, biodiversity conservation, and responsible wildlife viewing. Examples of this can be found in the work of local NGOs that promote hikes in nature and educational visits to natural areas. Furthermore, the government interest should be in investing in infrastructure and facilities that support sustainable tourism and ecotourism. This includes the development of nature trails, birdwatching platforms, and interpretation centres that provide visitors with opportunities to explore and learn about the island's natural wonders (Pan, 2018).

To increase environmental awareness among visitors and locals, educational campaigns and initiatives should be launched. Partnering with schools, community organizations, and tourism associations to promote environmental stewardship and responsible tourism practices are examples of such initiatives (Burnside, 2016). Informational materials, such as brochures and signage, can be distributed at key tourist locations to raise awareness about the importance of conserving natural resources, respecting wildlife, and minimizing waste.

Funding for these initiatives can be obtained through various sources. The government can allocate a portion of the tourism budget specifically for sustainable tourism projects and initiatives. Additionally, partnerships with international organizations focused on sustainable development and tourism, such as the United Nations World Tourism Organization (UNWTO) or regional development banks, can provide financial support and expertise (Wong,2012). Engaging in public-private partnerships with tourism businesses and seeking investments from eco-conscious investors interested in supporting sustainable tourism can also be explored (Wong, 2012). By focusing on sustainable tourism practices, promoting ecotourism initiatives, and fostering environmental awareness, Sint Maarten can position itself as a destination that values its natural heritage, attracts environmentally conscious tourists, and contributes to the preservation of its ecosystems for future generations.

4.5 Identify stakeholders

To identify the stakeholders for the following stakeholder analysis a prioritization matrix was created. The first step towards the selection of the most coherent stakeholders was to create a list of different stakeholders involved in various activities that affect resilience on the island. The list of stakeholders on the island is shown in annex1 which also shows the main role these stakeholders have in the socio-economic system of Sint Maarten.

Subsequently after having created a comprehensive list of stakeholders a prioritization matrix was created. This matrix is based on two main axes, high-low interest and high-low influence. Depending on the level of interest and influence that each stakeholder has on the system they were given an alignment on the matrix dependent on the two axes. After, this process the four quadrants of the matrix divided the stakeholders in four categories, nominally: Context setter, crowd, subjects, and key players. Each category of stakeholder has a role in the system and a unique perspective on how to enact change (Pichler, 2021).

Context setters are highly influential but have little interest in the issues at play. They may be a significant risk to the enactment of future policies focused on change and should be monitored and managed throughout the research progress in order to ensure the efficient functioning of the system (Pichler, 2021).

The crowd is defined as those stakeholders that have little influence or interest over desired outcomes, while it might seems counterintuitive to engage with the crowd because of their low level of importance in the system, it might still be beneficial to assess their interests in regards to the issue in order to gain knowledge from different points of interest and perspectives that might not try to push a specific agenda (Pichler, 2021).

Subjects are stakeholders that possess a high level of interests in the issue but low influence on the system. In general they have a lack the capacity for impact, however, they can be influential by forming alliances with other stakeholders. Their perspective can be used to find common ground among those stakeholders that have high influence in the system especially when the interests of context setters and key players diverge (Pichler, 2021).

Lastly, key players should be actively involved in the process of future planning because they have high interest in and influence over a particular phenomenon. In general, key players tend to have higher sway over decisions made in a system, in order to avoid this fallacy and ensure that a majority of parties are satisfied the collaboration of different stakeholders should be studied carefully (Pichler, 2021).

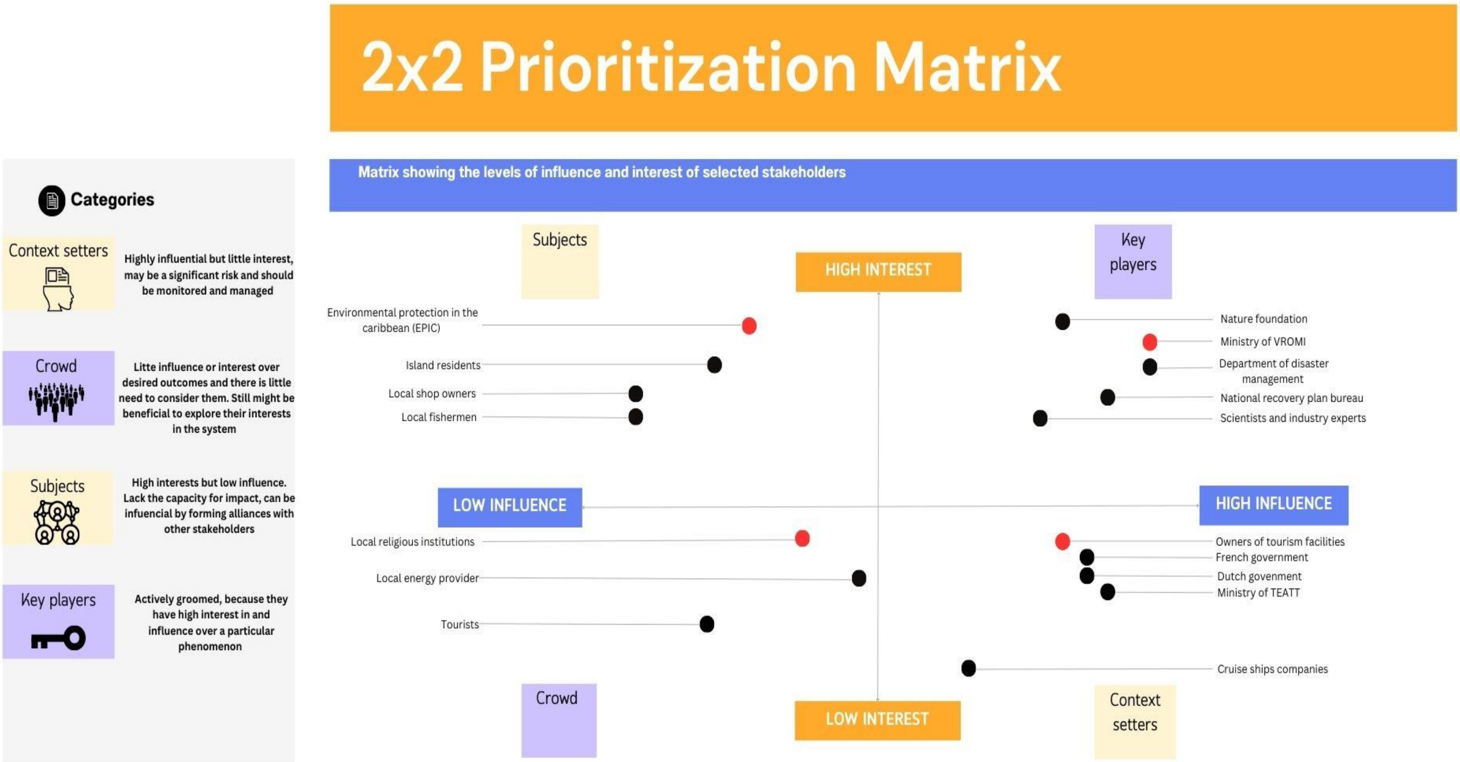

Figure 8: prioritization matrix employed in the stakeholder mapping process.

After having divided the stakeholders in groups a stakeholder from each group was selected in order to ensure the representation of each perspective on the system while also ensuring that different levels of decision making, cultural backgrounds and involvedness in the system were represented. The decision to not select only stakeholders form the key players group was taken to ensure that the research could be based on a variety of perspectives that was possible only when different actors in the system are involved. The stakeholders selected are shown in figure six and they are: the local government (ministry of the environment VROMI), local representative for the private sector and tourism (SHTA), representative for the local faith-based institutions, and lastly NGOS involved in environmental protection on the island particularly EPIC.

4.6 Results of interviews

The interviews, as explained in the methods section, were coded following a variety of approaches which then gave as a result the division of the interviews' codes into four main thematic groups. The thematic groups are:

- Thematic Group 1: Resilience Building and Disaster Effects
- Thematic Group 2: Infrastructure and Intervention
- Thematic Group 3: Collaboration and Awareness
- Thematic Group 4: Policies, Governance, and Sustainability

These groups emerged from an analysis of the codes which showed two main viewpoints of stakeholder on the issue of building resilience on the island: one focused on building infrastructure and the elements needed to ensure that resilience is achieved, the other point instead more focused on the importance of awareness at multiple levels, local, inter-institutional and between public and private sector. The remaining two groups, which are group 1 and 4, were selected because they represent respectively the approaches and concepts related to resilience on the island, and the actors and action needed to improve the situation. The resulting subdivision and the frequency of appearance of each code is shown in table 2.

Group 1 (yellow) Group 2 (orange) Group 3 (green) Group 4 (blue)	Interview EPIC	Interview SHTA	Interview VROMI	Interview faith-based institution	Total
Presence of various approaches to resilience building (yellow)	1	1	2	0	4
Varied nature of resilience issues (yellow)	1	0	0	0	1
Negative effects of disasters on ecosystems (yellow)	1	0	2	0	3
Appearance of disasters also increases awareness about sustainability (yellow)	1	0	1	0	2
Disasters also lead to a "Survivor mentality" which is detrimental to sustainability (yellow)	1	0	0	1	2
Dependency on tourism (yellow)	1	2	0	0	3
Need for policies that take into consideration climate change (yellow)	0	1	2	4	6
Difficulty in promoting sustainability compared to economic development (yellow)	0	2	2	0	4
Importance of collaboration between private and public sectors (yellow)	0	5	0	1	6
Presence of enough projects (yellow)	1	0	0	0	1
Higher effect of disasters on low income communities (yellow)	0	0	0	1	1
General lack of infrastructure, especially after disasters (orange)	1	0	0	2	3
Lack of sufficient intervention in the event of disasters (orange)	2	0	0	0	2

Uncertainty on the continuation of projects because of natural disasters	2	0	0	0	2
Uncertainty due to the instability of government / shifts in political power	1	0	1	0	2
Uncertainty due to population swings	2	0	0	1	3
Lack of funds	2	2	1	2	7
Lack of manpower	4	3	0	1	8
Lack of resources	1	0	0	1	2
Improve building code, build better	1	0	3	0	4
Little focus on tourism sector in recovery plans	0	2	0	1	3
Lack of incentives for local businesses and communities to change	0	2	0	2	4
Need for focus on building better	2	0	3	0	5
Misallocation of resources	1	1	0	0	2
Need for a diverse approach	3	0	0	1	4
Need to think future-forward	2	0	0	0	2
Various opportunities for collaboration	1	0	0	1	2
Example of collaboration: plastic bag ban	2	0	0	0	2
Slow decision-making processes	0	0	1	0	1
Need to update current legislation	0	1	1	1	3
Importance of awareness	4	4	1	1	10
Importance of community building	0	0	0	4	4
Need to build knowledge on environmental and other issues	0	2	3	1	6
Insufficient scale of enforcement	0	1	1	0	2
Sufficient presence of legislation	1	0	0	0	1
Lack of enforcement	3	3	1	1	8
Lack of government intervention	2	0	1	0	3
Involvement of external actors like the Dutch government	0	1	2	1	4
Need for policies that connect nature and economic development	1	1	3	4	9
Challenge to gain political will to enact change	0	0	3	0	3
Importance of civil society actors	0	0	1	0	3
Importance of networks	0	3	0	0	3
Need for better emergency systems	0	1	1	0	2
Need to incorporate natural disasters into local decision-making	0	2	1	0	3
TOTALS	45	40	36	33	

Table 2: results of coding of stakeholder interviews.

The resulting analysis shows that in terms of frequency of codes belonging to each group we get a classification that follows the following order: Group 3 and 4 with a frequency of 41 codes, followed by group 2 with 40 codes and group 1 with 33. The relative even frequency of each group shows an interest in all the subjects exposed by each theme. The code with the highest frequency of appearance is “Importance of awareness”, followed by “Need for policies that connect nature and economic development” and “Lack of manpower” – “Lack of enforcement”. From this results one can get a firsthand impression of what are the most important aspects for a future scenario involving resilience building in the eyes of local stakeholders. Particularly, the stakeholders seem to value awareness in the public and private spheres together with an approach that takes into consideration the development of the island, moreover, the other high frequency codes give us an overview of what the stakeholders believe is missing to achieve the goals of better policies and increased awareness. These codes are lack of enforcement and lack of manpower, the former shows that at the local level there is a struggle apparent to all stakeholders to make sure that local provisions are respected. Moreover the latter shows that there is a need for specialized professionals that can help in achieving the goals proposed at all levels. Future policy making should take into consideration these needs showcased.

5. Discussion and contingencies

5.1 Policy recommendations: putting together the results of scenarios and interviews.

The two visions that resulted from the scenario analysis and the results of the stakeholder analysis have various convergence points which shows the that the analysis of possible futures proposed in the scenario analysis is also what is in the interests of local stakeholders. Particularly both visions offer solutions that have been discussed with local stakeholders. To put the results side by side thematic group 2 can be associate with vision 1 and thematic group 3 can be associated with vision 2. The additional knowledge we have gained from performing the stakeholder analysis can be applied by the use of thematic groups 1 and 4 to better understand the local and institutional frameworks and actors at play that influence resilience. With this understanding and the result of the stakeholder analysis being skewed towards an interest for improving awareness of climate change, the policy recommendation proposed is based on vision 2 with improvements gained from stakeholder intervention.

To improve sustainable tourism practices on the island of Sint Maarten and ensure effective enforcement of green practices, the government should implement several key strategies. Firstly, the government should establish clear policies and regulations that outline the required sustainable practices for tourism operators and accommodations (Pan,2018). These guidelines should cover areas such as waste management, energy and water conservation, and responsible resource usage. Additionally, it should create an independent regulatory body or task force responsible for monitoring and enforcing compliance with these green practices (Green, 2012). This body can conduct regular inspections, provide training and support to businesses, and impose penalties for non-compliance.

Furthermore, institutions should foster collaboration between relevant stakeholders, including tourism businesses, local communities, and environmental organizations, to create a culture of environmental responsibility and encourage self-regulation within the tourism industry. This can be achieved through the establishment of industry-wide certifications or accreditation programs that recognize and reward businesses that demonstrate exceptional sustainability practices (Blackman, 2010). By encouraging businesses to voluntarily participate in these programs, the government can incentivize ongoing improvement and create a competitive environment that promotes sustainable tourism.

In addition to these measures, the government should invest in education and awareness initiatives targeting both tourists and locals (Burnside, 2016). Educational campaigns can highlight the importance of sustainable tourism practices, the value of the island's natural resources, and the potential impact of individual actions on the environment. By partnering with schools, community organizations, and tourism associations, the government can ensure that these messages reach a wide audience and are incorporated into educational curricula and tourism promotional materials.

To strengthen the enforcement of green practices, it should be a priority for the local government to allocate adequate resources and personnel to the regulatory body responsible for monitoring compliance (Green,2012). This may involve hiring and training environmental inspectors and providing them with the necessary tools and authority to carry out their duties effectively. Additionally, another priority should be to establish a transparent and accessible system for reporting and addressing violations. This can include a dedicated hotline or online platform where individuals can submit complaints or provide information on non-compliant businesses. Prompt investigation and enforcement actions should be taken in response to these reports to demonstrate the government's commitment to upholding sustainable tourism practices.

By combining robust policies, stakeholder collaboration, educational initiatives, and strong enforcement measures, Sint Maarten can enhance its sustainable tourism practices and ensure the effective implementation and enforcement of green practices. This will not only protect the island's natural beauty and biodiversity but also contribute to its long-term economic growth and development.

5.2 Limitations

While the combination of different methodological approaches was chosen with the goal of analyzing resilience on the island as comprehensively as possible, some contingencies and limitations are inevitable and will be discussed in this paragraph.

Firstly, when talking about scenario analysis there are some key limitations that apply to the use of this methodology. In general, scenarios are not accurate representations of the future, they are models we use to get a sense of all possible future directions and situations we might encounter when studying something. Moreover, scenarios are instruments that have to deal with a high degree of uncertainty. This uncertainty is most often addressed by creating assumptions about the current state of certain systems and about how we can predict future scenarios. In the case of this scenario analysis some key assumptions involve the use of IPCC scenarios as trusted inferences about future climate change, moreover, other assumptions involve the selection of the set of drivers used in this research as good indicators of future resilience. Lastly, one further limitation was the amount of data available in order to calculate the various changes in drivers, the sources used were to various extents all outdated (public census 2011, statistical yearbook 2017), this factor might create a skewed image of the future because it is based on data that has probably changed since it was released but that is not available at the current moment.

Secondly, stakeholder analysis also works with certain limitations that have to be addressed. The opinions, statements and concepts used by various stakeholder are all limited by varying degrees of stakeholder bias which might influence on the impartiality of how they see the case study and thus on how their knowledge translates in the research. Moreover, the stakeholders' influence, interest, and opinion on the study is subjected to variation that is not controllable. Lastly, This particular stakeholder analysis is not comprehensive enough to get he full picture of all possible stakeholders involved in the resilience on the island. The small pool of stakeholders used for this research was used mainly in support of the data already gathered in the scenario analysis and thus not intended to e used by itself or to be comprehensive.

6. Conclusion

In conclusion, the focus of this study was on examining the resilience of socio-ecological systems on the island of Sint Maarten. This study was built upon the overarching theme of the negative effects of climate change on small-island developing nations. The research employed a mix methodological approach of scenario analysis and stakeholder analysis which provided insights that were useful when trying to construct future policy plans.

The research question that started the whole research was "*"What effects will future climate change, in line with the IPCC scenarios, have on the level of resilience of socio-ecological systems in Sint Maarten?"*. This was answered with the use of the scenario analysis which showed the presence of four main possible future scenarios based on a matrix of high-low climate change and high-low resilience. The four scenarios also showed the changes in different drivers used to assess resilience which have helped create a more realistic picture of the change that can happen at different levels of resilience.

The sub-question "How do we define resilience of socio-ecological systems in this research?" was answered in the literature review giving the definition used by Holling and thus describing it as the capacity of a system to anticipate, adapt to, and recover from external disturbances while maintaining essential functions (Holling 1973). Furthermore, the question of "How do we construct resilience through policy in Sint Maarten?" was addressed by explaining in the literature review how previous research defines optimal when developing policies to enhance resilience, moreover, this question was completed in the policy recommendations paragraph which used a mix of the knowledge gained in the literature review and that gained in the results section in order to come up with policies for the island.

Regarding the question of "How is resilience measured in this research?", the analysis focused on 8 indicators taken from the resilience index developed by Moghim and additionally one indicator used by Briguglio, these indicators are: Environmental risks, Energy consumption, Air pollution, Access to clean water, Access to sanitation facilities, Greenhouse gasses emissions, Macroeconomic stability, and Exposure to flooding . These drivers provided a comprehensive framework for assessing the resilience of Sint Maarten's socio-ecological system. The exploration of "How do future scenarios of climate change on the island change depending on resilience?" revealed two visions. Vision one was focused on building infrastructure resilience while vision two was focused on building resilience through awareness policies. Using stakeholder interviews, vision 2 was chosen as the preferred target and thus indicating a future where resilience-building efforts result in a more sustainable and resilient Sint Maarten.

Finally, the sub-question "What are possible policy avenues to explore in the future to improve resilience on the island?" was answered by proposing policy recommendations aligned with vision 2 and informed by stakeholder interventions. These recommendations include establishing clear policies and regulations, fostering collaboration among stakeholders, investing in education and awareness, and strengthening enforcement measures. These policies aim to enhance sustainable tourism practices, ensure effective implementation of green practices, and contribute to the long-term economic growth and development of Sint Maarten as a responsible and desirable tourist destination.

While this research tried to give a comprehensive picture of the situation of resilience on the island, future avenues for research could focus on exploring in depth each small part that influences resilience. For example, a study about the role of community engagement in effecting the resilience of the island would add important concepts to the body of research. Another possible study could see the economic implications of building resilience infrastructure on the island.

The conclusions drawn from this study are supported by the findings obtained through scenario analysis and stakeholder engagement. The study provides useful recommendations for both societal and scientific stakeholders, addressing the need for coordinated efforts to build resilience in Sint Maarten. In summary, the research contributes to our understanding of resilience and offers practical guidance for policymakers and stakeholders. The key take-home message is that by embracing sustainable practices such as the creation awareness programs in schools, collaboration with key players, and monitoring programs, Sint Maarten can enhance its resilience to climate change impacts and foster a sustainable and prosperous future.

Bibliography

Allen, M. R., Barros, V. R., Broome, J., Cramer, W., Christ, R., Church, J. A., Clarke, L., Dahe, Q., Dasgupta, Yohe, G. W. (2014). IPCC Fifth Assessment Synthesis Report-Climate Change 2014 Synthesis Report. *IPCC*, 116. http://www.mfkp.org/INRMM/article/13416115

Billgren, C., & Holmén, H. (2008). Approaching reality: Comparing stakeholder analysis and cultural theory in the context of natural resource management. *Land Use Policy*, *25*(4), 550–562. https://doi.org/10.1016/j.landusepol.2007.11.004

Blackman, A., & Rivera, J. (2010). The Evidence Base for Environmental and Socioeconomic Impacts of 'Sustainable' Certification. *EfD Discussion Paper Series*. https://doi.org/10.2139/ssrn.1579083

Börjeson, L., Höjer, M., Dreborg, K. H., Ekvall, T., & Finnveden, G. (2006). Scenario types and techniques: towards a user's guide. *Futures*, *38*(7), 723-739.

Briguglio, L., Cordina, G., Farrugia, N., & Vella, S. (2009). Economic Vulnerability and Resilience: Concepts and Measurements. *Oxford Development Studies*, *37*(3), 229–247. https://doi.org/10.1080/13600810903089893

Chapin III, F. S., Carpenter, S. R., Kofinas, G. P., Folke, C., Abel, N., Clark, W. C., ... & Swanson, F. J. (2010). Ecosystem stewardship: sustainability strategies for a rapidly changing planet. *Trends in ecology & evolution*, *25*(4), 241-249.

Christ, C., Hillel, O., Matus, S., & Sweeting, J. (2003). Tourism and biodiversity. *Conservation International, Washinghton, DC*.

Daily, G. C., & Matson, P. A. (2008). Ecosystem services: From theory to implementation. *Proceedings of the national academy of sciences*, *105*(28), 9455-9456.

Dana, L. P. (1990). Saint Martin/Sint Maarten: a case study of the effects of culture on economic development. *Journal of small business management*, *28*(4), 91.

DeCuir-Gunby, J. T., Marshall, P. A., & McCulloch, A. W. (2010). Developing and Using a Codebook for the Analysis of Interview Data: An Example from a Professional Development Research Project. *Field Methods*, *23*(2), 136–155. https://doi.org/10.1177/1525822x10388468

DeVerteuil, G., & Golubchikov, O. (2016). Can resilience be redeemed? *City*, *20*(1), 143–151. https://doi.org/10.1080/13604813.2015.1125714

Domptail, S., Easdale, M. H., Yuerlita, Darnhofer, I., & Grötzer, M. (2010). Managing socio-ecological systems to achieve sustainability: a study of resilience and robustness. *Building Sustainable Rural Futures: The Added Value of Systems Approaches in Times of Change and Uncertainty. 9th European IFSA Symposium, Vienna, Austria, 4-7 July 2010.*, 953–964. https://www.cabdirect.org/abstracts/20133409866.html

Encontre, P. (1999). The vulnerability and resilience of small island developing states in the context of globalization. *Natural Resources Forum*, *23*(3), 261–270. https://doi.org/10.1111/j.1477-8947.1999.tb00914.x

Folke, C., Biggs, R., Norström, A. V., Reyers, B., & Rockström, J. (2016). Social-ecological resilience and biosphere-based sustainability science. *Ecology and Society*, *21*(3).

Folke, C., Carpenter, S. R., Walker, B., Scheffer, M., Chapin, T., & Rockström, J. (2010). Resilience thinking: integrating resilience, adaptability and transformability. *Ecology and society*, *15*(4).

Golafshani, N. (2015). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report*. https://doi.org/10.46743/2160-3715/2003.1870

Goodin, R. E., Moran, M., & Rein, M. (2008). The Oxford Handbook of Public Policy. In *Oxford University Press eBooks*. https://doi.org/10.1093/oxfordhb/9780199548453.001.0001

Lee, M., & Diop, S. (2009). Millennium ecosystem assessment. *An Assessment of Assessments: Findings of the Group of Experts Pursuant to UNGA Resolution 60/30*, *1*, 361.

Kikstra, J. S., Nicholls, Z. R., Smith, C. J., Lewis, J., Lamboll, R. D., Byers, E., ... & Riahi, K. (2022). The IPCC Sixth Assessment Report WGIII climate assessment of mitigation pathways: from emissions to global temperatures. *Geoscientific Model Development*, *15*(24), 9075-9109.

Herrman, H., & Kieling, C. (2021). Symptoms of depression and anxiety during the COVID-19 pandemic: implications for mental health. *The Medical Journal of Australia*, *214*(10), 460–461. https://doi.org/10.5694/mja2.51080

Holling, C. S. (1973). Resilience and stability of ecological systems. *Annual review of ecology and systematics*, *4*(1), 1-23.

MacKinnon, D., & Derickson, K. D. (2012). From resilience to resourcefulness. *Progress in Human Geography*, *37*(2), 253–270. https://doi.org/10.1177/0309132512454775

Malek, Ž., & Boerboom, L. (2015). Participatory Scenario Development to Address Potential Impacts of Land Use Change: An Example from the Italian Alps. *Mountain Research and Development*, *35*(2), 126. https://doi.org/10.1659/mrd-journal-d-14-00082.1

McMillen, H., Ticktin, T., Friedlander, A. M., Jupiter, S. D., Thaman, R. R., Campbell, J., Veitayaki, J., Giambelluca, T. W., Nihmei, S., Rupeni, E., Apis-Overhoff, L., Aalbersberg, W. G., & Orcherton, D. F. (2014). Small islands, valuable insights: systems of customary resource use and resilience to climate change in the Pacific. *Ecology and Society*, *19*(4). https://doi.org/10.5751/es-06937-190444

Medina, N., Abebe, Y. A., Sanchez, A., Vojinovic, Z., & Nikolic, I. (2019). Surveying After a Disaster: Capturing Elements of Vulnerability, Risk and Lessons Learned from a Household Survey in the Case Study of Hurricane Irma in Sint Maarten. *Journal of Extreme Events*, *06*(02), 1950001. https://doi.org/10.1142/s2345737619500015

Medina, N., Abebe, Y. A., Sanchez, A., & Vojinovic, Z. (2020). Assessing Socioeconomic Vulnerability after a Hurricane: A Combined Use of an Index-Based approach and Principal Components Analysis. *Sustainability*, *12*(4), 1452. https://doi.org/10.3390/su12041452

Moghim, S., & Garna, R. K. (2019). Countries' classification by environmental resilience. *Journal of Environmental Management*, *230*, 345–354. https://doi.org/10.1016/j.jenvman.2018.09.090

Nyaupane, G. P., & Poudel, S. (2011). Linkages among biodiversity, livelihood, and tourism. *Annals of tourism research*, *38*(4), 1344-1366.

Ostrom, E. (2009). A general framework for analyzing sustainability of social-ecological systems. *Science*, *325*(5939), 419-422.

Pereira, E., & Steenge, A. E. (2021). Vulnerability and Resilience in the Caribbean Island States; the Role of Connectivity. *Networks and Spatial Economics*, *22*(3), 515–540. https://doi.org/10.1007/s11067-021-09533-w

Petzold, J., & Magnan, A. K. (2019). Climate change: thinking small islands beyond Small Island Developing States (SIDS). *Climatic Change*, *152*(1), 145-165.

Pichler, R. (2021, December 21). Getting Stakeholder Engagement Right. *Roman Pichler*. https://www.romanpichler.com/blog/stakeholder-engagement-analysis-power-interest-grid/

Ramirez, R., & Wilkinson, A. (2014). Rethinking the 2×2 scenario method: Grid or frames? *Technological Forecasting and Social Change*, *86*, 254–264. https://doi.org/10.1016/j.techfore.2013.10.020

Reed, M., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C. H., & Stringer, L. C. (2009). Who's in and why? A typology of stakeholder analysis methods for natural resource management. *Journal of Environmental Management*, *90*(5), 1933–1949. https://doi.org/10.1016/j.jenvman.2009.01.001

Rhiney, K. (2018). Recipe for Resilience? Tracing the Biopolitics of Sint Maarten's Recovery Efforts After Irma. *Journal of Extreme Events*, *05*(04), 1840002. https://doi.org/10.1142/s234573761840002x

Riahi, K., Van Vuuren, D. P., Kriegler, E., Edmonds, J. A., O'Neill, B. C., Fujimori, S., (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. *Global Environmental Change-human and Policy Dimensions*, *42*, 153–168. https://doi.org/10.1016/j.gloenvcha.2016.05.009

Robinson, S. A. (2020). Climate change adaptation in SIDS: A systematic review of the literature pre and post the IPCC Fifth Assessment Report. *Wiley Interdisciplinary Reviews: Climate Change*, *11*(4), e653.

Rojer, A., Carmabi, S., & Curaçao, N. A. (1997). Biological Inventory of St. Maarten. *CARMABI Report (KNAP project 96-10).*, 55.

Saldaña, J. (2009). *The Coding Manual for Qualitative Researchers*. http://ci.nii.ac.jp/ncid/BB20067005

Sikking Wessel (2022). *Climate change impacts for a small island nation* [Unpublished bachelor's thesis]. Vrije Universiteit Amsterdam.

Sterk, M., van de Leemput, I. A., & Peeters, E. T. (2017). How to conceptualize and operationalize resilience in socio-ecological systems?. *Current opinion in environmental sustainability*, *28*, 108-113.

Stürck, J., Levers, C., Van Der Zanden, E. H., Schulp, C. J., Verkerk, P. J., Kuemmerle, T., Helming, J., Lotze-Campen, H., Tabeau, A., Popp, A., Schrammeijer, E., & Verburg, P. H. (2015). Simulating and delineating future land change trajectories across Europe. *Regional Environmental Change*, *18*(3), 733–749. https://doi.org/10.1007/s10113-015-0876-0

Talubo, J. P. P., Morse, S., & Saroj, D. P. (2022). Whose resilience matters? A socio-ecological systems approach to defining and assessing disaster resilience for small islands. *Environmental Challenges*, *7*, 100511. https://doi.org/10.1016/j.envc.2022.100511

Teelucksingh, S. S., Nunes, P. A., & Perrings, C. (2013). Biodiversity-based development in Small Island Developing States. *Environment and Development Economics*, *18*(4), 381–391. https://doi.org/10.1017/s1355770x13000260

Tompkins, E. L., & Adger, W. N. (2004). Does adaptive management of natural resources enhance resilience to climate change?. *Ecology and society*, *9*(2).

Verweij, P., Cormont, A., Nel, J., De Rooij, B., Jones-Walters, L., Slijkerman, D., Soma, K., Van Eurpen, M., Pourier, S., Coolen, Q., Mone, G., Bervoets, T., Clarenda, J., Van Slobbe, F., Christiaan, D., De Meyer, K., De Vries, Y., Eleana, R., Hoetjes, P., . . . Teles, I. D. (2020). *A nature inclusive vision for Bonaire in 2050*. https://doi.org/10.18174/526467

Verweij, P., Lazebnik, J., van Eupen, M., Cormont, A., Panteleon, P., & Winograd, M. (2022). Bonaire 2050: Putting the vision into numbers.

World Health Organization. (2018). COP24 special report: health and climate change.

Zari, M. P., Kiddle, G. L., Blaschke, P. M., Gawler, S., & Loubser, D. (2019). Utilising nature-based solutions to increase resilience in Pacific Ocean Cities. *Ecosystem Services*, *38*, 100968. https://doi.org/10.1016/j.ecoser.2019.100968

7. Annex 1

Table with drivers for scenario analysis

Driver ID	Driver Name	Explanation of driver	Expected Changes	Impact on case study	Uncertainty	Importance
1	Environmental risk	Represented as the vulnerability of local communities to extreme weather events. Vulnerability is “the propensity or predisposition to be adversely affected, and it encompasses a variety of three dimensions susceptibility to harm, lack of capacity to cope and lack of capacity to adapt” (Medina, 2022).	Hurricanes are among the most common extreme weather event that takes place in the Caribbean. Even though every year Sint Maarten experiences an hurricane season from august to November, the intensity and destructiveness of these events will increase with climate change scenarios and has already increased in recent years with the years 2016-2017-2018-2019-2020 having above average hurricane intensity.	Very high, since the resilience of socio-ecological systems is mostly linked to the vulnerability that these systems have against external shocks	High: the uncertainty of future climate change scenarios makes it hard to understand how frequency of extreme weather events will be impacted. Moreover, being a meteorological phenomenon it is hard to estimate with certainty the drivers that influence the occurrence of such events.	Very high, understanding vulnerability is not only one of the most important steps when assessing resilience of SESs but also considered to be the closest indicator to influence resilience.
2	Energy consumption	Energy consumption is the total amount of energy that the economy of the island requires. One of the way to use this as an indicator is through energy efficiency, that is the ratio of	Energy efficiency is forecasted to decrease or remain stagnant with an increase in climate change related warming of the globe. This is mainly due to higher use of resources and electronic devices such as air conditioning in	Medium-high. Energy consumption has big impacts in the economic and political cycles of the island which in turn can be a big driver behind resilience of political	Uncertainty very high. The relationship between a rise in temperatures and an increase in energy consumption is depending on many factors that are very hard to predict	Medium. Understanding the relationship that consumption of energy has with the decision making that influences resilience is a good indicator but there are other indicators that have a more direct connection to the issue.

		unit of energy per unit of GDP. This indicator was chosen as it gives an overview of the resilience of the social system and its production sector (Moghim, 2019)	zones near the equator which would take priority over an improvement of efficiency of the electric grid (Moghim, 2019).	systems and or decision making apparatuses.	and put into one indicator.	
3	Air pollution	Air pollution is the quantity of particles of certain element that persists in the atmosphere. In this case we focus on CO2 concentrations on the island from an average taken by a report from the dutch ministry of public health.	Quantity of primary and secondary air pollutants is forecasted to increase with an increase in climate change scenarios. Particularly, each scenario also includes a change in GHG's emissions which has an effect on air pollution.	High. The quality of the air in socio ecological systems is associated with the well-functioning not only of human societies but also of ecosystems that tend to have certain equilibria when it comes to CO2 levels in their environments.	Uncertainty high. Uncertainty in the case of air pollution is high because it not only depends on wind patterns but also on secondary pollution which can be created by the interaction of particles and the environment around them.	High. To calculate resilience of socio ecological systems it is necessary to understanding resilience. Particularly more air pollution goes in tandem with other indicators of resilience such as greenhouse gasses emissions.
4	Greenhouse gasses emissions	Greenhouse gasses emissions in this case focuses on one of the main components of GHGs in the atmosphere,	Currently, CO2 on the island of sint maarten, according to Our World In Data, increase every year by 0.64% excluding land use change.	Medium-Low. Local emission in the scheme of global emissions are negligible but are still useful in	Low. Emissions emitted form production of goods and the industry sector are relatively easy to predict	Medium. Local GHGs emissions do not influence other indicators in an extreme way but they are useful once put next global emissions to assess the

		CO2. In this scenario analysis the focus will be at the global level when talking about the RCPs scenarios while it will be more at the local level when talking about resilience.		determining an index of resilience for the island.	once there is data available	resilience of the island.
5	Access to clean water	Access to water is an important social issue which can impact the political sphere and influence decision making. For these reasons it is a key concept in the resilience of SESs systems.	With an increase in extreme weather events such as hurricanes or droughts more people could be exposed to lack of clean water either through loss of current infrastructure or through loss of reserves.	Medium. Decrease in clean water access even if possible is unlikely because of the presence of desalinization implants on the island. However, a higher reliance on these implants could have big impacts on the energy consumption and costs of maintaining the island.	Medium. The possibility of clean water access decreasing has a high uncertainty due to the high uncertainty of future extreme climate events. However, the presence of desalinization implants ensures a safety net against such unpredictable events.	High. Resilience is based on the capacity of a system to bounce back from shocks and to have the resources it needs to recover. Clean water is one of these resources which are necessary for optimal resilience.
6	Access to sanitation facilities	Access to sanitation facilities goes hand in hand with access to	Access to sanitation is predicted to increase in the future unless an	Low. Currently almost 99% of the population	Low uncertainty.	Medium. Access to sanitation is also a fundamental factor in community resilience mainly

		clean water and thus shares its importance on a community scale.	extreme event such as a very destructive hurricane happens and destroys current facilities.	has access to sanitation facilities and in the case in which the number was to decrease it would not be difficult to improve the situation again.		due to the essential role it plays in ensuring wellbeing of the local population.
7	Macroeconomic stability	Macroeconomic stability refers to the aggregate demand and supply in an economic system, if the two elements are in equilibrium then an economy is less prone to shocks and more resilient. It is calculated by adding up three variables the fiscal deficit to GDP ratio, the sum of the unemployment and inflation rates, and the external debt to GDP ratio.	Future climate change is projected to lead the economy of small island developing states down. Particularly GDP and employment would suffer as a consequence of loss of tourism reliant on natural hotspots that would be lost due to habitat degradation.	High. Macroeconomic stability is a general indicator of the economy of an island and how resistant it is to shocks and thus resilient.	Very High uncertainty since he indicator is based on a series of different elements which are difficult to predict considering the uncertain futures that climate change prospects. The uncertainty of this driver is mainly connected with the future of the tourism industry which will in turn is connected to the condition of the natural environment of the island.	Very high. There is a need to understand also the economic resilience of a system in order to ensure that all the possible options are weighted in terms of possible futures for the resilience of the island.
8	Exposure to flooding	Particularly important for the case of	An increase in areas affected by flooding is	Very high. Building resilience on	Low. Scenarios have been built to	Very high. This factor is very important when

		SIDS is exposure to flooding. It is not included in the environmental risks because of the unique nature of this issue when it comes to SIDS. A complete evaluation of the flooding risks for the island of sint maarten has been completed in past years and the data from that study will be used for this indicator.	expected with higher climate change scenarios.	the island is also depending on understanding all its various vulnerabilitie s. Flooding risks pose such a big threat to the existence of the SESs on the island that it is necessary to include this vulnerability in the assessment	understand the impact of climate change on flooding on the island. While these scenarios are based on solid scientific evidence there is a margin of interpretation of how severe flooding will be depending on the climate change scenario involved.	assessing resilience particularly in the case of an island like Sint Maarten. In other cases it might have been added to environmental risks but as mentioned because of the specific and urgent threat that flooding poses to the island it is necessary to look at it individually

Steps taken before stakeholder analysis and questions used

Information about the project

I am a student from the Vrije University of Amsterdam. I am currently enrolled in a Master's in environment and resource management and also I am currently writing my thesis. The topic of the thesis is based on the resilience of the island to shocks caused by climate change. The definition of resilience that I will use is the following by Holling, an expert in the field of resilience studies, "The capacity of system with different attractors (drivers) to return to their original state after perturbance" (Holling, 1973). The interview will be useful in the context of my research because it will allow me to study the opinions of important stakeholders that have an influence on the resilience of the island.

Comfort and trust

I want to make sure that you understand that there are no right and wrong answers. I am curious about your opinion and feeling on the issue and there is no pressure for you to answer a certain type of way.

Informed consent

I will use this interview's content in the context of a stakeholder analysis, particularly a thematic analysis of the themes that surface from each interview. Your identity will not be shared, is it okay by you if I record the interview?

Questions

1. Local religious institutions:

- How have recent events (e.g. hurricanes, pandemics, economic crises) affected your congregation and the wider community?
- In your opinion, what are the most important factors that contribute to community resilience on Sint Maarten?
- How can religious institutions play a role in promoting resilience in the community, and what resources do they need to do so effectively?
- What challenges and opportunities exist for the introduction of sustainability and resilience thinking into local communities.
- What partnerships or collaborations between religious institutions and other stakeholders could help to strengthen resilience on Sint Maarten?

2. Environmental Protection in the Caribbean (EPIC):

- How have recent events (e.g. hurricanes, pandemics, economic crises) affected the local ecosystems on Sint Maarten, and what steps have been taken to mitigate these impacts?
- What are the most significant threats to ecological resilience on Sint Maarten, and what actions are needed to address these threats?
- How can NGOs play a role in promoting ecological resilience on the island, and what resources do they need to do so effectively?
- What challenges and opportunities exist for the introduction of sustainability and resilience thinking into local communities.
- What partnerships or collaborations between this NGO and other stakeholders could help to strengthen resilience on Sint Maarten?

3. Representative from the tourism sector:

- How have recent events (e.g. hurricanes, pandemics, economic crises) affected the tourism industry on Sint Maarten, and what steps have been taken to mitigate these impacts?
- In your opinion, what are the most important factors that contribute to the resilience of the tourism industry on Sint Maarten?
- How can the tourism sector and private businesses play a role in promoting ecological and economic resilience on the island, and what resources do they need to do so effectively?
- What challenges and opportunities exist for the introduction of sustainability and resilience thinking into private sector decision making.
- What partnerships or collaborations between the tourism sector and other stakeholders could help to strengthen resilience on Sint Maarten?

4. Ministry of Environment and Infrastructure (VROMI):

- How have recent events (e.g. hurricanes, pandemics, economic crises) affected the work of the public sector on Sint Maarten, and what steps have been taken to mitigate these impacts?
- In your opinion, what are the most important institutional factors that contribute to resilience on Sint Maarten?
- How can the government play a role in promoting ecological and economic resilience on the island, and what resources does it need to do so effectively?
- What challenges and opportunities exist for the introduction of sustainability and resilience thinking into government decision making.
- What partnerships or collaborations between the government and other stakeholders could help to strengthen resilience on Sint Maarten?

Conclusion

Thanks for answering all the questions and for reserving your time for the interview. If you are interested, at the end of the writing process I can send you a copy of the thesis. All I need is your contact details. In case you are not interested I still want to thank you for your availability, your contribution will be of great help for the research. Have a good day!

Thematic groupings per code used in stakeholder analysis

Resilience building and disaster effects	**Infrastructure and need for intervention**	**Collaboration and awareness**	**Policies, governance, and sustainability**
• Presence of various approaches to resilience building • Varied nature of resilience issues • Negative effects of disasters on ecosystems • Appearance of disasters also increases awareness about sustainability • Disasters also lead to a "Survivor mentality" which is detrimental to sustainability • Dependency on tourism • Need for policies that take into consideration climate change • Difficulty in promoting sustainability compared to economic development	• General lack of infrastructure, especially after disasters • Lack of sufficient intervention in the event of disasters • Uncertainty on the continuation of projects because of natural disasters • Uncertainty due to the instability of government • Uncertainty due to population swings • Lack of funds • Lack of manpower • Lack of resources • Improve building code, build better	• Need for focus on building better • Misallocation of resources • Need for a diverse approach to policy making • Need to think future-forward • Various opportunities for collaboration • Example of collaboration: plastic bag ban: • Slow decision-making process • Need to update current legislation • Importance of awareness	• Insufficient scale of enforcement • Sufficient presence of legislation • Lack of enforcement • Lack of government intervention • Need to update current legislation • Involvement of external actors like the Dutch government • Need for policies that connect nature and economic development • Challenge to gain political will to enact change • Importance of civil society actors

• Importance of collaboration between private and public sectors • Presence of enough projects • Higher effect of disasters on low income communities	• Little focus on tourism sector in recovery plans • Lack of incentives for local businesses and communities to change	• Disasters increase climate awareness • Importance of community building • Need to build knowledge on environmental and other issues	• Importance of networks • Need for better emergency systems • Need to incorporate natural disasters into local decision-making

Table showing stakeholders on the island and their roles

Stakeholder	Role
Tourists	Affect ecosystems, are interested in the area
Local energy providers	Monopoly on the island, knowledge of the electrical grid
Local faith-based institutions	High religious society, key community player
Local fishermen	Affect ecosystems, local sustenance
Shop owners	Interested in protecting their activities, local sustenance
Residents	Interested in improving their built environment
Scientists and experts	Knowledge of resilience, capacity to collaborate
Local NGOs	Wants to protect ecosystems, social player
Cruise ships companies	Business oriented, affect ecosystems
National recovery plan bureau	Allocates funds for projects, assess the proper continuation of projects
External actors like governments	Interested in maintaining the island for social and historical links
Owners of tourism facilities	Business oriented interested in improving hurricane resilience
Ministry of TEATT	Energy component, interested in improving current system
Department of disaster management	Sponsors and creates projects for extreme weather resilience
Ministry of VROMI	Interested in infrastructure and environmental resilience
Nature foundation	Interested in ecosystem preservation

Table showing changes for drivers in different scenarios

Driver ID	Driver name	Behavior in each scenario			
		"Best Case scenario" Optimal resilience high damages from CC	**"Minimum effort scenario"**	**"Worst case scenario"** No resilience high risks	**"Prepared for the worst scenario"** Optimal resilience low damages from CC
1	Environmental risks	According to the paper by Renzi Jing the frequency and intensity of hurricanes under RPC 4.5 will not have any major changes (Jing, 2021). We can expect then that in this scenario the frequency of hurricanes will be the same as in current times. The scenario also includes high resilience solutions which promote resistance against hurricanes even with current levels. According to previous literature on the island high resilience against hurricanes can be achieved through investment in resistant building materials and funding hurricane	In this scenario climate change is still at RPC 4.5 and thus hurricanes frequency does not change. However, resilience is not built on the island and thus we can expect the death rate and damage done by hurricanes to remain more of less the same. The latest data available shows an incurrence of 8 major hurricanes that caused deaths over the past 70 years. The death rate of these hurricanes is on average around 5 deaths and around 500 million dollars in damages per event, which could be avoided with higher resilience projects which would not take place in this instance thus leaving the island to	In the worst case scenario we follow the RPC 8.5 which projects an increase in hurricanes in the region of 14% (Jing,2021). Thus the frequency of current hurricanes would go from 0,11 destructive hurricanes every year to 0,125 thus increasing the chances of around 1 additional destructive hurricane every 70 years[1]. In this scenario resilience is lacking and thus the island would be completely subject to the destruction brought upon it by the additional	In this scenario hurricanes would still hit and increase in frequency by 14% however the changing factor in this scenario is that resilience would be expanded and built in response to the increase in hurricanes on the island. Some of the measures taken from literature on disaster management in Caribbean islands is the construction of sea walls or relocating key infrastructure such as airports to areas of higher elevation(Lewsey, 2003). According to Lewsey investing in resilience of the electrical supply in case of hurricanes can help reducing the amount of damages done to the electrical grid up to 99% while in the case of water supply facilities, resilience improvement

		recovery budgets (Maas,2022)	experience these impacts.	and stronger hurricanes that would hit it.	can save up to 80% of the structures.
2	Energy consumption	It is hard to estimate energy consumption especially when using energy efficiency in relation to climate change as an indicator for it. In the context of the RPC 4.5 global emissions would be cut down to a certain extent and thus it is plausible that energy efficiency would be improved worldwide in order to reduce emissions from the energy sector. In the case of this scenario which also includes high resilience energy efficiency would be one of the criteria to increase even with no push from climate change in order to increase the resilience.	In this minimum effort scenario we can assume that if energy efficiency were to change it would only be as a result of trying to reduce emission in the energy sector and thus keep up with the goals of RPC 4.5, resilience in this scenario is not calculated as an important factor.	In the case of RPC 8.5 we assume that there are going to be no efforts towards a reduction of emissions from countries globally. This in turn takes a toll on energy efficiency which would be reliant on the fossil fuel industry and receive less incentives to be improved. Moreover, resilience in this scenario is not an important factor thus there would not be a political push towards improved energy resilience.	Lastly, in this scenario we can imagine that there would still be little push from the energy sector to promote energy resilience. However, with high resilience policies put in place by the local government we expect there to be higher energy efficiency in order to improve the resilience of the island particularly in order to avoid loss of resources and improve air quality.
3	Air pollution	As per energy efficiency, the proper measurement of air pollution under specific IPCC scenarios is not easy to calculate. Air quality is dependent on a variety of factors, however, under scenario RPC	In this scenario we still assume a reduction in air pollution on the island as a result of a more global effort to achieve the RCP 4.5 target of a stabilization of CO2 particles in the atmosphere at 550	In this scenario we assume that there are no efforts globally for reduction of emissions and thus also no positive relation with air pollution reduction.	In this scenario we imagine that air pollution due to global activities is still going to rise, however, the high focus on resilience on the island might help mitigate the effects of such pollution by focusing on how to improve air

		4.5 we can expect that the reduction in global emissions dictated by the scenario would be a result of a change in polluting practices that also have an effect on air pollution. Moreover, the focus on high resilience would bring about better air quality over the island by focusing on proper waste management possibly reducing car use.	ppm by 2100. However, the low focus on resilience does not ensure that local air quality will improve or stagnate.	Moreover, because of the location of Sint Maarten on major shipping lanes in the Caribbean the result of an increase in trade related activities that the scenario brings might also increase air pollution as a result of maritime traffic (Geels, 2021). In this scenario resilience is also low thus the possible increase in air pollution would not be opposed by an increase in air quality focus on the island.	quality standards across the island. As mentioned, some solutions might involve tackling car use and invest in public transport, or focus on more sustainable waste management.
4	GHGs emissions	Global emissions in RPC 4.5 are expected to peak around 2040 and then go down. We can expect with this scenario that a decrease in GHGs emissions globally will be beneficial on the island because of the connection that this specific driver has to the other drivers of the analysis. Resilience on the island in this	GHGs emissions would still follow the RPC 4.5 and thus decrease after 2040. Focus on resilience would be low thus not improving the emissions on the island, however this driver is not extremely important for the safety of the island because of the mentioned little contribution of emissions that the	In this scenario climate change follows the RPC 8.5 and thus projects no reduction in GHGs emissions. This would bring a about a serious problem for the island concerning the drivers used in this analysis. Moreover, low effort on	In this last scenario climate change would still be as damaging to the island as in the worst case scenario. However, resilience would be high thus protecting the island from high damages while also ensuring that eventual recovery plans have the lowest emissions possible.

		scenario would be high, even though Sint Maarten is not a big contributor of emissions globally it resilience ca be increase by trying to take down emissions on the island.	Sint Maarten has globally.	resilience building on the island would leave it unable to defend itself against the various risk that increase GHGs emissions would bring. Focusing only on the emissions quantity on the island, it would probably increase exponentially especially when considering the various high emissions solutions that are necessary to recover from natural disasters.	
5	Access to clean water	Access to clean water under scenario 4.5 of the RPCs will probably go through various challenges because of the possible changes in the freshwater cycle and weather patterns. However, the change in availability of clean water should be bearable compared to other climate change scenarios. Moreover, on the island the presence of desalinization	In this scenario access to water supply would not change drastically and neither would the costs of producing fresh water. The low resilience assumed with this scenario would not change the amount of people with access to drinking water but would also not improve the number thus leaving the island vulnerable to	Under scenario 8.5 we assume that the costs of producing clean water through desalinization implants will rise by a good amount due to a rise in energy prices caused by more demand for fossils fuels, also, lower access to others resources of fresh water such as rainwater would	In this scenario we assume the same results under scenario 8.5 of the RPCs. High resilience in this case would make it possible to have less people that are at risk of water scarcity on the island by having made sure that more people were connected to a stable water supply line.

		implants makes it so that access to clean water is not really put into question but actually focuses on the costs of this access. The scenario's high resilience will make so that the totality of the population has access to clean water, the figures on the island are already optimistic with 91.6% of the population being connected to a stable water supply line while the remaining 8.4% being dependent on other forms of water supply like trucks or bottles.	shocks in the water supply.	exacerbate the problem. Low resilience in this case would have caused for a lower focus on making sure that more people were connected to a stable water supply line thus creating high numbers of people with little or no access to drinking water.	
6	Access to sanitation	Access to sanitation is an issue that goes hand in hand with the issue of clean water accessibility. In general under the RPC scenario 4.5 access to sanitation would only be put to risk in the occurrence of an extreme climate event such as flooding or hurricanes that would disrupt sewage implants, in this scenario however these	Access to sanitation remains the same under RPC 4.5. Low resilience does not focus on more access for a higher percentage of the population thus leaving more people susceptible to climate change risks and extreme weather events.	In this scenario there is a higher risk of extreme events lowering access to sanitation. Low resilience would not help in tackling this issue	Same risks as in the worst case scenario but high resilience built in order to ensure little damage to sanitation facilities.

		events are less likely to occur than in the high climate change scenarios. High resilience on the other hand would focus on ensuring everyone has access to sanitation on the island. At this moment 0.64% of the population does not have access to it.			
7	Macroeconomic stability	Under scenario 4.5: Fiscal deficit to GDP ratio: It is expected that global economic growth will continue, and this could lead to increased government revenues and a decrease in the fiscal deficit to GDP ratio in some regions. Unemployment and inflation rates: it is possible that global economic growth could lead to a decrease in unemployment rates, while inflation rates remain stable. External debt : it is expected that global economic growth will continue, which could lead to increased investment and economic	Under this scenario the same assumptions on the unfolding of the global economy would follow. Low resilience would not focus on improving the advantages that could be taken from lower climate change.	Under scenario 8.5: Fiscal deficit to GDP ratio: Under scenario 8.5, the projected impacts of climate change, including more frequent and severe natural disasters and increased social and economic disruption, could lead to increased government spending on disaster relief and adaptation measures. This could lead to an increase in the fiscal deficit to GDP ratio in some regions. Unemployment and inflation	In this scenario the same the same expectations on climate change and its relation with the economy would unfold as in RPC 8.5. High resilience however would dampen the economic effects of climate change by strengthening the tourism industry and infrastructure so as to a void a bulk of the damage done to the economy on the island which is very reliant on its tourism revenues. Some damage to the economy would be inevitable.

		activity in many regions. This could help to decrease the external debt to GDP ratio in some countries. High resilience would focus on these points to strengthen the economic system of the island.		rates: the impacts of climate change on economic activity, particularly in vulnerable regions, could lead to increased unemployment rates and inflation. External debt to GDP ratio: The impacts of climate change under scenario 8.5 could also lead to decreased economic activity and investment in some regions, which could lead to an increase in the external debt to GDP ratio.	

8	Exposure to flooding	We base this scenario on the data on flooding gathered by Sikking, we get that the increase in flooding will be of 9.14% with RPC 4.5 (Sikking, 2022). This scenario however promotes high resilience and thus assumes that mangroves restoration practices and green infrastructure have been promoted over the years to reduce flooding by 50% (Sikking,2022)	In this scenario the flooding still reaches 9.14% of the island but no resilience measures have been put in place thus losing the opportunity to reduce flooding by 50%	In the most extreme scenario of RPC 8.5 Sikking estimates a total area flooded on the island of 10.65%. with no resilience measure in place this would be an extremely catastrophic scenario for the island considering that most of the flooded areas would also be among the most developed and lucrative on the island.	In this case the flooding damage could still amount to 10.65% percent of the area but with high resilience this figure could go down by 50%.