Small Islands – Large climate change challenges

Household resilience to climate change vulnerabilities - a case study of Bonaire

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Abstract

Small Islands (SIs) often have a small capacity to resist or recover from the increasing impacts of climate change and, therefore, increasing climate resilience is necessary. However, knowledge and research on climate resilience, especially in the context of (Caribbean) SIs are limited in number and quality, although imperative for increasing it. Additionally, research, while proven beneficial, often overlooks the household-level. Therefore, this study researched household climate resilience (HCR) in Caribbean SI-context – in this case Bonaire. Since the aspects determining HCR depend on geographic context, this context was first studied for Bonaire. Through 13 key-informant interviews, complemented by desk research, the main climate vulnerabilities, their impact on Bonaire and its households, and the aspects making Bonairean households resilient for these were identified. These aspects were used as indicators to form a composite score measuring HCR through online household surveys. Hereby, the barriers to HCR and differences in HCR between socio-demographic groups were identified. Results showed an average HCR-score for the sample (N=183) of .455 out of 1 (SD=.11) – indicating HCR is not low, but also not high. The following aspects negatively contributed to HCR: expected damage to homes, amount of savings, insurance covering damage from climate change (vulnerabilities), incomes, dependent income sources, vulnerable neighbourhoods, alternatives to electricity, water, and food, social resilience, community response, government response, awareness of climate change, information and education on climate change impacts, and steps to prepare for this. Furthermore, the following households are less inclined to be climate resilient: bigger households, households with high kid ratios, households with younger household heads, households speaking fewer languages, households not fluently speaking English, and households with a higher level of obtained education. This study knows limitations that possibly impacted these results, like the limited representativeness of the household sample. Although this study adds to the knowledge base of SI-context HCR, additional research is beneficial. Therefore, recommendations for further research are provided. The same goes for policy recommendations.

Keywords: *climate resilience, household climate resilience, Small Islands (SI), Caribbean Small Islands, Bonaire.*

Table of Contents

List of Figures and Tables

List of Abbreviations

ABC	Contraction of Aruba, Bonaire, and Curaçao
BES	Contraction of Bonaire, Sint Eustatius, and Saba
CAS	Contraction of Curaçao, Aruba, and Sint Maarten
CC	Climate Change
CBS	Central Bureau for Statistics
DCNA	Dutch Caribbean Nature Alliance
ER	Economic Resilience
HCR	Household Climate Resilience
HCRI	Household Climate Resilience Index
IPCC	Intergovernmental Panel on Climate Change
IR	Institutional Resilience
KI	Key Informant
PR	Physical Resilience
SDG	Sustainable Development Goals
SI	Small Island
SLR	Sea Level Rise
SR	Social Resilience
SSS	Contraction of Saba, Sint Eustatius, and Sint Maarten
UN	United Nations

Chapter 1 – Introduction

At the beginning of this year (2022), the United Nations' (UN) climate science research group – the Intergovernmental Panel on Climate Change (IPCC) – shared many worrisome conclusions in their newest report (IPCC, 2022). It states, for example, that in all scenarios the limit of a 1.5ºC global temperature rise will already be reached in ten years and that human influence has impacted this accelerated warming immensely. Furthermore, it states that global warming has already caused major changes around the world. However, these changes differ regionally; various impacts hit different regions and some areas are affected more than others (IPCC, 2021).

1.1. Small Islands (SIs)

Small Islands (SIs) are such regions. They have long been recognized as being particularly at risk for climate change and climate-related disasters (Thomas, Schleussner, & Kamur, 2018) and will likely be the first and most intensely affected by climate change impacts (Nurse et al., 2014). According to the IPCC (2022), these islands' natural and human systems are already increasingly affected by climate change and many of these islands report losses and damages due to these climate changes. Furthermore, projections expect these impacts to increase in the future. These SIs are therefore often referred to as the 'hotspots' of climate change (Thomas, Schleussner, & Kamur, 2018). Ironically, SIs experience what Füssel and Klein (2006) call 'double inequality'; where regions have barely contributed to the overall cause of climate change while showing a small capacity to resist or recover from its impacts. Although SIs are far from homogenous (IPCC, 2014a; Thomas & Lindo, 2019), they do share similar sustainable development challenges. Examples are a high susceptibility to natural hazards, limited physical size, limited natural resources, isolated nature, dominance of economic sectors that are reliant on the natural environment, remoteness, and limited economies of scale (e.g., McCarthy, Canziani, Leary, Dokken, & Whit, 2001). These challenges further complicate the environmental and socio-economic impacts of climate change these islands experience (Scandurra, Romano, Ronghi, & Carfora, 2018). The World Bank Group (2021) found that most SIs are not prepared for new challenges imposed by climate change.

1.2. Climate Resilience

The IPCC report (2022) states that if deep greenhouse gas reductions do not occur in the upcoming decades, global warming will increase and with every additional increment of global

warming, its impacts will increase as well. Thus, in this scenario, SIs will increasingly face environmental and socio-economic impacts of climate change without an increase in resources to fight these. Therefore, mitigation strategies are being designed and implemented. However, many of the changes caused by greenhouse gas emissions are irreversible for centuries to millennia (IPCC, 2014a). In this sense, mitigation strategies will not be enough to decrease climate change impacts.

Thus, to protect regions, especially SIs, from these effects and to safeguard development gains, it is of major importance to build resilience to climate change impacts (e.g., UN Climate Resilience Initiative, n.d.). Climate resilience – although defined differently in literature (elaborated on in Chapter 2) – is mostly seen as 'the ability to anticipate, prepare for, and respond to hazardous events, trends, or disturbances related to climate' (Centre for Climate and Energy Solutions, 2019, p. 1). Building climate resilience is part of the Sustainable Development Goals – SDGs – (United Nations, n.d.-a). Especially target 13.1 sees to this: "Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries". However, although many nations are starting (to think about) building climate resilience, considerably greater action is needed (United Nations, n.d.-b). Furthermore, even though the target aims at strengthening resilience for all countries, less action seems to be directed at vulnerable regions and people, such as SIs and their citizens (Thomas, & Lindo, 2019). The UN Climate Resilience Initiative (n.d., p. 3) states that "concrete, coherent and transformative action for climate resilience is required for the most vulnerable people and countries". Also, the IPCC (2022) concludes that the window of opportunity to enable climate-resilient development is rapidly narrowing. Thus, more action to build climate resilience is needed. To act, knowledge on how to build resilience and what is standing in the way to do so is necessary. As the IPCC (2022, p. 5) states: "Greater insights into which drivers weaken local and indigenous resilience […] can assist in identifying opportunities at all scales to enhance climate adaptation and enable action towards climate resilient development pathways". However, such knowledge is limited regarding its capacity, focus, and consensus.

1.3. Problem Statement

Although an extensive amount of scientific and grey literature on climate resilience exists, corresponding research knows many limitations, and the topic has many knowledge gaps that need to be filled to achieve a good understanding of climate resilience and how to build it.

Firstly, consensus regarding the topic – about its determinators, variables, and even its definition – is limited. Secondly, as Rhiney (2015, p. 3) concludes "A large portion of the climate impact studies conducted in the [Caribbean] region to date have tended to focus on the direct and potential biophysical and chemical effects of climate change […], as opposed to its human, economic, and societal consequences". This is acknowledged by Cooper (2020).

Thirdly, a major limitation of these latter studies is that they mainly address the regional, national, or community level while overlooking the household level (Quandt, 2018). However, studying climate resilience at the household-level is important for many reasons (e.g., Vinck et al., 2020; Jones, Samman, & Vinck, 2018). Differences between households are overlooked when studying climate resilience at the macro-level, therefore excluding certain households, often the most vulnerable ones (Jones & Tanner, 2017). Furthermore, many of the capital and functions needed to respond to climate shocks derive from household-level dynamics (Barret, Reardon, & Webb, 2001) and focusing on the household-level can add to capturing the interactions of individual choices and characteristics with wider norms, behaviours, and institutions that jointly affect response to climate change impacts (Adger, 2000). Fourthly, research about the equality, equity, or inclusivity of (household-level) climate resilience, is limited. However, this is important since, as the UN (UN, n.d.b) states "the poorest and most vulnerable people are being affected the most [by climate change]" and climate resilience should be increased for all.

Fifthly, the quality of some of these studies is questionable. Often frameworks and measures used to conceptualise climate resilience have limitations. These include incorporating too many factors and indicators (Al-Maruf, Jenkins, Bernzen, Braun, 2021), not incorporating contextual factors (Vinck, Fergusson, and Bollettino, 2020) and local knowledge (Backford, 2019), and merely taking objective measures into account, although subjective measures have proven to be beneficial (e.g., Jones & Tanner, 2018). Furthermore, many of the studies regarding climate resilience are conducted or commissioned by organizations working in the field and these studies are thereby mostly evaluating own projects. This raises questions about the positionality of researchers and the possibility of their (unconscious) influence on methods and outcomes. Also, the knowledge gained through these studies is very specific (for the region and project). Furthermore, the frameworks used by these organizations rarely integrate the local, subjective understanding of resilience (Pacoma & Delda, 2019).

Lastly, the focus of research around (household) climate resilience that does exist, is quite narrow. For example, it mostly focuses on either urban or rural households (e.g., Arouri, Nguyen, & Youssef, 2015; Oriangi et al., 2020; Rabbi, Rabbi, Karmakar, Kropp, 2021), which both do not reflect the characteristics of most SIs. This raises the question of whether insights gained in these studies apply to the context of SIs. For example, the bigger part of the encountered literature on household-level climate resilience is aimed at farmers and studies agricultural climate resilience to try and protect food security (e.g., Oriangi et al., 2019). Despite its relevance, this research is not applicable to this research's study region, since agriculture is often not big on SIs like Bonaire (Analistennetwerk Nationale Veiligheid, 2019). Furthermore, studies on (household) climate resilience are mostly focused on African and Asian countries (e.g., Asmamaw, Mereta, & Ambelu, 2019; Tan, Peng, & Guo, 2020; Gaisie, Adu-Gyamfi, & Owusu-Ansah, 2021). The very small numbers that do study the context of SIs, investigate the Pacific SIs while neglecting Caribbean ones. Also, literature specifically researching household-resilience to climate change on SIs does, as far as known, not exist, which is surprising since the urgency of research and initiatives in these regions. Often, knowledge on (household-level) climate resilience and the factors shaping it are treated as universal, although there is a common understanding that these are shaped by cultural, institutional, and social contexts (Noll, Filatova, Need, & Taberna, 2022), like the previously described specific characteristics of SIs. Therefore, findings on the nature and dynamics of household resilience in one context or geography cannot blindly be copied to another. Thus, since a dire need for action and research towards household climate resilience (HCR) on (Caribbean) SIs is needed and knowledge on HCR cannot blindly be copied due to contextuality, independent research for these SIs and specifically Caribbean SIs is needed.

1.4. Research Objective and Research Questions

Thus, location- and context-specific knowledge on HCR about (Caribbean) SIs lack, while imperative for necessary action. To add to the current literature and knowledge on HCR on Caribbeans SIs, this research will measure HCR and barriers to it, while attempting to limit the before mentioned limitations of previous studies. Thereby, this study will be based on a well-designed framework which considers contextual factors. Additionally, this study will research if and how HCR varies between different socio-demographic variables. Such insights may help target climate resilience action in a more inclusive direction to ensure climate resilience for all, as the UN (n.d.-n) calls for. Since researching all Caribbean SIs is not feasible for this study, this research will study one Caribbean SI: Bonaire. Of course, this island has its differences

from other Caribbean SIs – for example, its constitutional situation (explained in Section 4.3.). However, Bonaire shares many of the previous described characteristics with other Caribbean SIs. Therefore, knowledge about HCR on Bonaire may also provide insights for other (Caribbean) SIs.

To research household climate resilience, while taking contextual factors into account, the following research questions have been formulated.

Research Question 1: How resilient are households on Bonaire to climate change vulnerabilities?

1. a. What are the main climate change vulnerabilities on Bonaire?

1. b. How do these vulnerabilities impact Bonaire and her citizens?

1. c. How can Bonairean households be resilient to these impacts - and thus climate change vulnerabilities?

Research Question 2: What are the barriers to household climate resilience? I.e., what indicators of household climate resilience score the lowest?

Research Question 3: How does household resilience differ between various socio-demographic variables?

An overview of the structure of this thesis can be found in Figure 1.

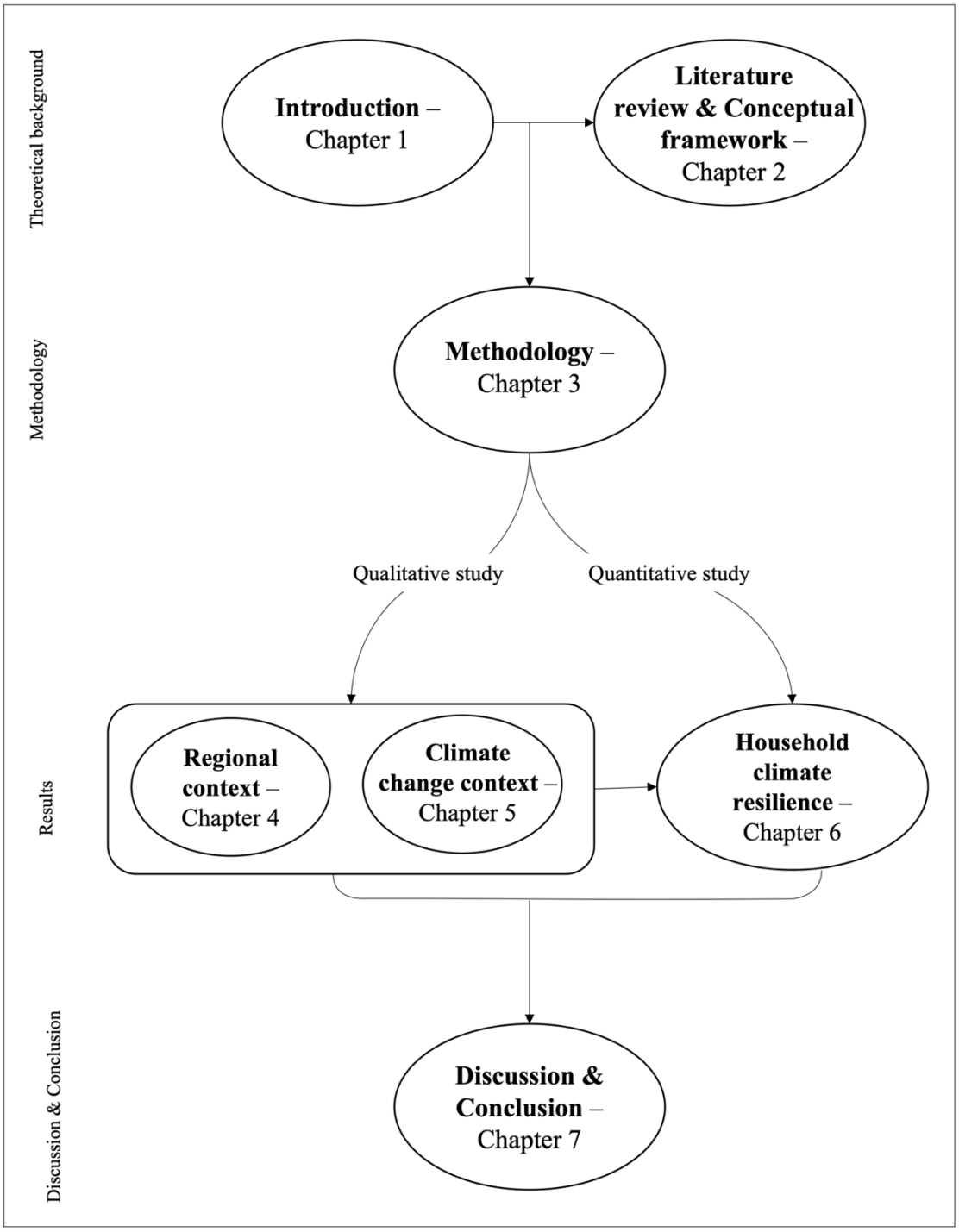


Figure 2. Flowchart of thesis layout.

1.5. Study Relevance

This research has both academic and societal relevance. By focusing on household-level climate resilience and SIs, it adds to the academic knowledge base since research on (Caribbean) SIs regarding HCR has, to current understanding, not yet been conducted while highly necessary.

Although knowledge of climate change vulnerabilities and resilience is contextual and cannot blindly be copied, SIs – especially those in the same region – share similar challenges and their vulnerability is partly driven by common characteristics (Scandurra et al., 2018). Therefore, through this study more insights into climate resilience in the context of SI's in general may be gained. Also, a study that was designed in a way that – attempts to – eliminate all previously mentioned limitations is, as far as known, non-existent. Such a study will add to the knowledge base of the topic and methodology around it. Additionally, the approach of studying HCR as used in this study might be of help to study the topic on other (Caribbean) SIs. Moreover, this study might contribute to debates around climate justice. This research also has practical relevance since Bonaire is in dire need of both research and action regarding climate change, climate change vulnerabilities, and climate change resilience. This research aims to provide recommendations on how to increase HCR by understanding where barriers to building it lie. These may be indicators of climate resilience (e.g., housing not being resilient to climate change impacts) or socio-demographic exclusions (e.g., female-headed households are less inclined to be climate resilient). In this sense, initiatives can directly target these barriers.

Chapter 2 – Literature Review and Theoretic Framework

This chapter elaborates on the available knowledge around climate resilience in general and household climate resilience specifically. It will describe some of the main concepts used in this research and how they are used within a scholarly perspective. Also, further descriptions of the gaps in (scientific) literature this research attempts to fill will be provided. This chapter concludes with the conceptual model this research is based on.

2.1. Climate Resilience

2.1.1. Definition

The term 'resilience' is used in a broad spectrum of disciplines (Laganda, 2015). Simplified, in the context of development studies 'resilience' refers to the "ability of a socio-ecological system to 'bounce back' and recover from the effects of a harmful event or disturbance" (Laganda, 2015). There are many lenses through which to look at resilience. Within this study, that is climate resilience. Climate describes the average weather over a long period in a particular area (NASA, 2005). Climate is unstable and has always changed over time due to natural influences (Verweij et al., 2020). However, according to the IPCC (2021) the fact that human activity has eminently contributed to Anthropocene climate change is unequivocal. Climate changes negatively impact natural and socio-economic systems directly (UN Climate Resilience Initiative, 2017). Cimate changes can also cause certain vulnerabilities that, in their place, have negative impacts on these systems. These climate change vulnerabilities are often categorized by making a distinction between climate change shocks and climate change stresses (Laganda, 2015). Climate change shocks – also known as sudden onset shocks – are sudden and rapid disturbances caused by extreme climate conditions (Oriangi et al., 2020). An example is a hurricane. Climate change stresses – also known as slow onset shocks – are long-term pressures on a system (Bujones, Jaskiewicz, Linakis, & McGirr, 2013). An example is a drought. The key focus of increasing climate resilience is to reduce the impact of climate change shocks and stresses – thus climate vulnerabilities (Venema & Temmer, 2017). A visualization of these relations can be found in Figure 2.

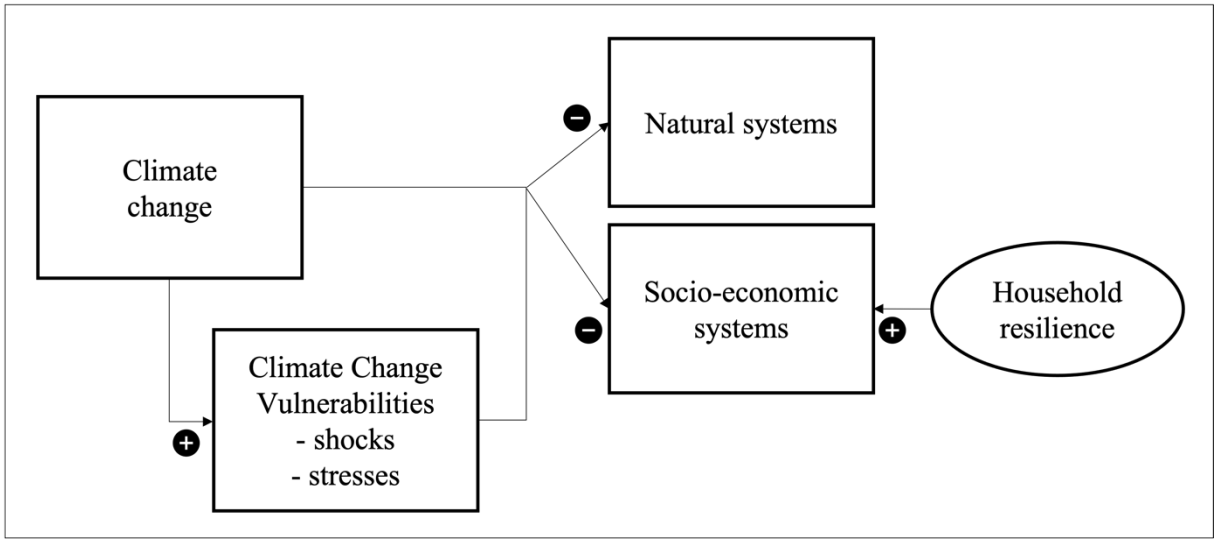


Figure 2. Simplified visualization of the relation between climate change, climate change vulnerabilities, natural and socio-economic systems, and household resilience.

There is no consensus on the exact definition of climate resilience, which causes researchers, policy advisors, and other parties to conceptualize and operationalize it differently. In this study IPCC's (2014b) definition will be used – "the ability of a social-ecological system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions". Despite the limited consensus on its exact definition, it is agreed upon that the concept of climate resilience fills a conceptual gap that other discourses related to climate change, like climate change vulnerability and adaptation, appear not to satisfy (Schipper & Langston, 2015). Therefore, over the last decade, (climate) resilience has emerged as a "key concept in the international development discourse" (Laganda, 2015, p. 3). The World Resource Institute (n.d.) states that "climate resilience saves lives, reduces poverty, addresses underlying inequalities and delivers strong economic returns". The concept has been embraced and used by numerous big donors like UKAID, USAIS, and the European Union (Laganda, 2015). Furthermore, building (climate resilience) is incorporated into multiple SDGs (UN, n.d.b). Despite this positive interest in the term climate resilience, others have criticized it for multiple reasons, like it being imprecise, fuzzy, and malleable (Laganda, 2015).

The lack of consensus about standard definitions is not only noticeable when talking about climate resilience, but also when talking about related concepts such as climate change

adaptation (Miola & Simonet, 2014). Since the definitions of these concepts are often overlapping and characterized by vagueness, the concepts are regularly described as rhetoric (Hinkel, 2011). However, adaptation is often described as "the capacity of a system to absorb disturbance and re-organize while undergoing change to still retain essentially the same function, structure, identity, and feedback" (Folke, 2004, p.3). Thus, in these commonly used definitions, adaptation includes two temporalities – absorption and adaptation – while resilience includes one more temporality: transformation (also referred to as reshaping). This addresses the "system's capacity to transform the stability landscape and to create new system pathways when ecological, economic, and social structures make the existing system untenable" (Pacoma & Delda, 2019).

2.1.2. Climate change vulnerabilities

Climate change vulnerability is another term that is closely related to climate resilience, although again there is no consensus on the relation between the two terms. Some scholars refer to it as the predecessor of resilience (e.g., Laganda, 2015), while others perceive it as the opposite pole of resilience (e.g., Brooks, Anderson, Burton, and Fisher, 2013). Either way, scholars seem to agree that vulnerability, together with threat, determines risks – to which one can be resilient (Centre for Climate and Energy Solutions, 2019). According to this approach, to increase resilience to a risk means to either decrease vulnerability or decrease threat. In the case of climate change, it is too late to eliminate short-term threats since they are already present and, according to the IPCC (2021) will only increase in the future. Therefore, it is important to address climate change vulnerabilities.

Vulnerability is regarded as a function of three variables (e.g., IPCC, 2007; Centre for Climate and Energy Solutions, 2019): 1) the exposure to a threat - determined by the physical proximity of a system to the threat; 2) the sensitivity to a threat – defined as the level to which a system is or might be impacted by the threat, which is determined by its economic, social, physical, and environmental characteristics; and 3) the adaptive capacity – defined as the ability of the system to adjust to, take advantage of, and cope with the threat. Figure 3a shows a formula that can be applied to establish a simple vulnerability index. Figure 3b shows how to use this in the example of sea level rises.

$$\text{Vulnerability}_{\text{Climate hazards}} = \frac{\textit{Exposure}_{\textit{Climate hazards}} \times \textit{Sensitivity}_{\textit{Climate hazards}}}{\textit{Adaptive capacity}}$$

Figure 3a. Formula to establish a vulnerability index. Reprinted from "How to do - Measuring climate resilience", by Laganda, G., 2015, IFAD, p. 13.

$$\text{Vulnerability}_{\text{Sea level rise}} = \frac{\textit{Seashore proximity}\ [\text{km}] \times \textit{Dependency on salt- or flood-sensitive crops}\ [\text{rating}]}{\textit{Access to submergence- or salinity-resistant crop or livestock varieties}\ [\text{rating}]}$$

Figure 3b. Example of how to use this formula in the case of sea level rises. Reprinted from "How to do - Measuring climate resilience", by Laganda, G., 2015, IFAD, p. 13.

As previously mentioned, climate vulnerabilities are often divided into climate change shocks and climate change stresses. Research and action toward climate resilience have mostly focused on climate change shocks while neglecting climate change stresses (UN Climate Resilience Initiative 2017). The same was concluded for the Caribbean – the international community has focused on climate change shocks but has largely overlooked many of the slow-onset changes and their impacts on livelihoods, while these are just as worrisome (Fuller, Kurnoth, & Mosello, 2020). Therefore, this study takes both climate change shocks and climate change stresses into account.

2.1.3. Main characteristics of climate resilience

Over the past decade, many researchers have attempted to establish the fundamental characteristics of a (climate) resilient system. Although there is no consensus on the exact elements, there is an agreement on some of the broader properties which are used by multiple big organizations like the IPCC (2014a) and the Overseas Development Institution (Mitchell & Harris, 2012). These properties will be briefly summarized. Firstly, resilient systems are said to have a strong asset base so they can respond to (climate) shocks and stresses. What is seen as 'a strong asset base' differs, but often include assets like social or human, financial, physical, natural, and productive ones. Another property is a high level of institutional connectivity including learning opportunities and access to information. Furthermore, resilient systems are said to be equal and inclusive. Also, resilient systems should create innovation and experimentation cultivating environments in which niche solutions can be explored. Another property is the possession of built-in functions to collect, analyse, and diffuse both scientific

and traditional information, which is an important element of risk management. Moreover, resilient systems are said to have strong social capital, which allows parts of the system to be supported. Lastly, resilient systems are redundant; in the face of distress, parts of the system may collapse without the whole system collapsing. It is important to stress that these listed properties are general characteristics of resilient systems, and more specific characteristics are context-dependent (e.g., Vinck, Fergusson, and Bollettino, 2020).

2.1.4. Building climate resilience

Efforts to increase climate resilience comprise technological, economic, political, and social strategies (World Bank Group, 2021). Strategies to build climate resilience include risk management (preparedness), mitigating the negative impacts of climate change (not to be confused with climate mitigation which refers to the reduction of greenhouse gasses), adapting to climate change and its impacts, and post-impact activities such as reconstruction and recovery (Solar, 2014). Examples of activities that increase climate resilience are building climate resilient infrastructure, designing climate resilient crops, strengthening crisis communication, increasing awareness, and redesigning business operations.

The three pillars used by the UN Climate Resilience Initiative to accelerate action in building the key aspects of climate resilience (UN Climate Resilience Initiative, n.d.), might provide the reader with some additional insights into what building climate resilience may look like. The first pillar – 'Anticipate' – seeks to strengthen early warning and early action to strengthen capacities to anticipate and act on climate change vulnerabilities. The second pillar – 'Absorb' – sees to increase access to climate risk insurance and other social protection systems to enhance capacities to absorb climate change vulnerabilities. The third pillar – 'Reshape' – sees to enforce capacities to reshape development pathways (UN Climate Resilience Initiative, n.d.). Action under the third pillar comprises long-term undertakings, which require changes in planning, investment (both private and public), policy, and behaviour. Furthermore, the World Resource Institute (n.d.) states that accelerating climate resilience means "making climate risks visible, factoring those risks and adaptation responses into government and business decisions, supporting locally led adaptation and mobilizing finance for climate-resilient solutions". Hereby, perspective is important; how individuals and institutions experience certain climate-related threats will impact their priorities of building climate resilience (Centre for Climate and Energy Solutions, 2019).

2.2. Household Resilience to Climate Change

2.2.1. Household-level resilience

A ‘resilient system’ can refer to many different entities and, therefore, there are different levels of looking at climate resilience, such as the regional, national, and community level (Laganda, 2015). Much of the discussion on climate resilience is aimed at these levels and thereby often overlooks the relevance of household-level climate resilience (Quandt, 2018), while, as was described in Section 1.3., studying climate resilience at the household-level is important. For example, while knowledge on community-level resilience is relevant, it may not reflect household-level resilience, especially for the most vulnerable households (Jones & Tanner, 2017). Most of the studies and frameworks focusing on community-level resilience, assume that all households in a community have equal access to elements of climate resilience (Berkes & Ross, 2013). However, communities are rarely homogenous and unified (Agrawal & Gobson, 1999). Therefore, in-between household variations of climate resilience might be missed (Jones & Tanner, 2017). Furthermore, assumed capacities and vulnerabilities by macro-scale assessments, have been proven to differ a lot when measured at the household-level (Toole, Klocker, & Head, 2016). Also, the capital and functions needed to respond to climate shocks derive from household-level dynamics (Barret, Reardon, & Webb, 2001) and studying climate resilience at the household-level can add to capturing the interactions of individual choices and characteristics with wider norms, behaviours, and institutions that jointly affect response to climate change impacts (Adger, 2000). Despite these reasons for researching climate resilience on household-level, the amount of research on household-levels of climate resilience is lower than those at other levels. This research aims to fill this gap; the household is the focus of this thesis. Therefore, the upcoming sections will be dedicated to a literature review on household-level climate resilience.

Just like the definition of resilience greatly differs over literature, the definition of ‘households’ does as well. This study uses a slight alteration of the Dutch Central Bureau of Statistics’ (CBS) definition of a private household – in opposition to an institutional household (CBS, n.d.). It treats a household as 'one or more persons who live in the same residential space and who jointly provide in daily basic needs'. In this thesis household resilience is defined as ‘the capacity of a household to deal with change by maintaining or transforming living standards in the face of climate change vulnerabilities without jeopardizing their long-term prospects’ (adapted from Jones & Tanner, 2015). Hereby, an increase in household resilience can manifest

itself in three ways: 1) an increase in the capacity to withstand the impact of a climate change vulnerability; 2) an increase in the rapidity to recover from the impact of a climate change vulnerability, and; 3) an increase in the extent of recovering from the impact of a climate change vulnerability. These three types of manifestations are visualized in Figure 4.

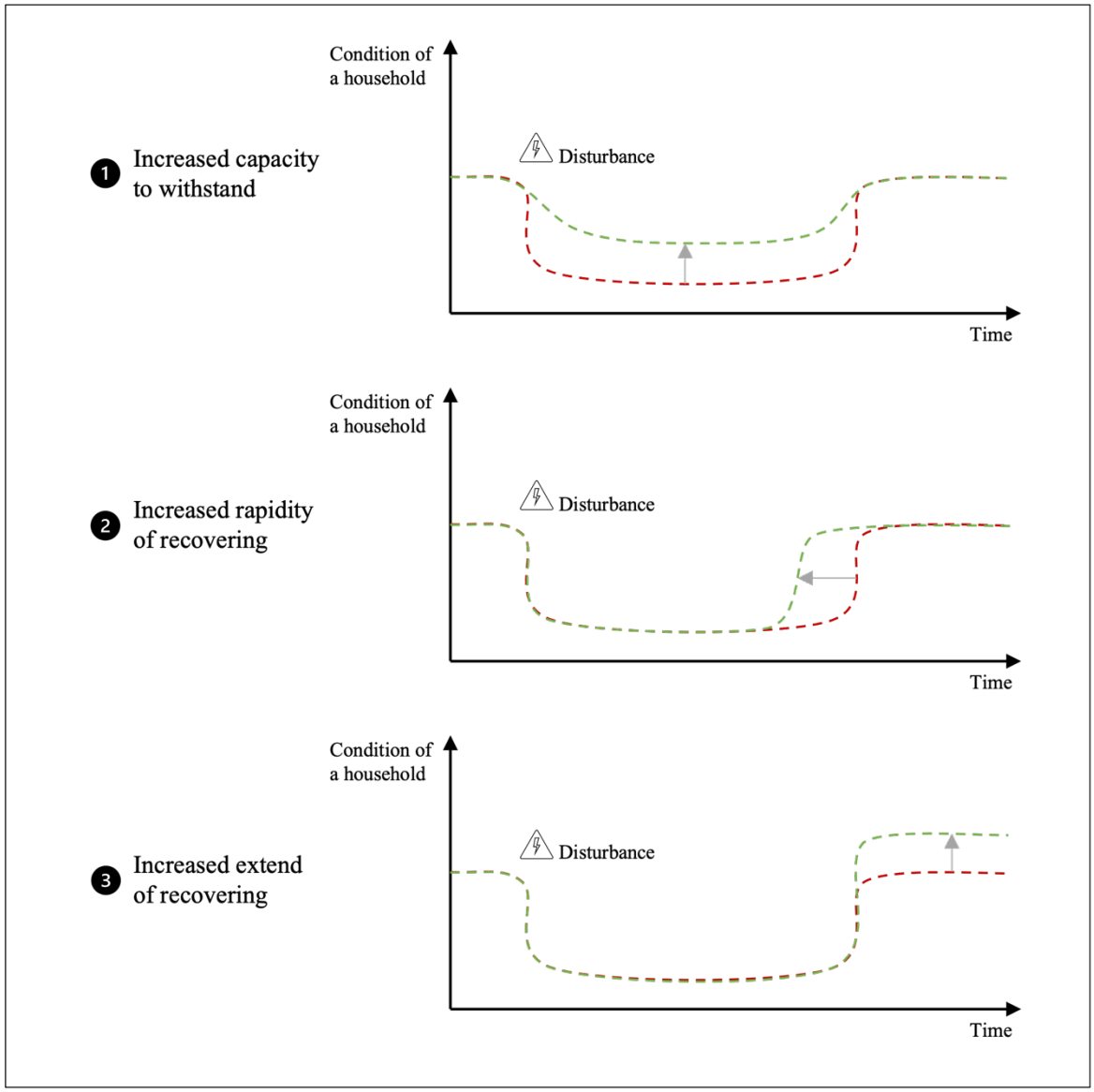


Figure 4. A visualization of the three ways an increase in household resilience can manifest itself. In each graph, the red lines represent the condition of a household without increased resilience, the green lines represent the condition of a household with increased resilience. Adapted from "Food system resilience: Defining the concept", by Tendall, D. M. et al., 2015, Global Food Security, 6, p.5.

As already mentioned in Section 1.3., what climate resilience means and how it is measured and built, is highly contextual and the same accounts for HCR (Cooper & Wheeler, 2015). This is due to, amongst others, the fact that climate change has different impacts on different localities (IPCC, 2014). Furthermore, resilience is highly dependent on social, institutional, and cultural context, which also differs between localities (Noll et all., 2022). Due to the contextuality of climate impacts and climate resilience, it is not possible to blindly copy frameworks, research methods, results, and projects regarding climate resilience from one context to another. Understanding local contexts is therefore imperative for building HCR (e.g., Hollis, 2017). The same applies to understanding what increases household resilience – because of the aspects making households resilient being context-specific, knowing what increases household resilience, does as well. Broadly speaking however, a household can increase resilience by increasing one of the three types of manifestations as shown in Figure 4. By answering Research sub-question 1.c (How can Bonairean households be resilient to climate change vulnerabilities?) this study will research how a Bonairean household can practice climate resilience (See Section 5.5.)

2.2.2. Measuring household climate resilience

Measuring climate resilience can be valuable for, amongst others, identifying vulnerable regions, understanding the determinants of resilience, and creating tools to infer the effectiveness of interventions (Jones, 2019). Therefore, the measurement of resilience is a new yet rapidly growing area of research and practice (Bahadur, Ibrahim, & Tanner, 2010) and more and more entities are developing measurement tools (Winderl, 2014). Since climate resiliency is not directly measurable, most of these tools make use of quantifiable indicators of resilience (Jones & Tanner, 2015). However, measuring climate resilience faces multiple challenges, like the contested definition of resilience (Jones, 2019), the dynamic and long-term nature of climate resilience (Lamhauge, Lanzi, & Agrawala, 2012), the multidimensional character of resilience, and the range of processes and characteristics and their intangibleness and difficulties in observing (Jones, 2019).

In the last few years, new measures attempting to avoid some of these challenges are arising. An example is the use of qualitative and process-based indicators in contrast to quantitative proxies (Lamhauge, Lanzi, & Agrawala, 2012). Furthermore, Jones and Tanner (2015) advocate for the use of subjective measures instead of, or in addition to, the use of subjective measures.

The justification for this is that people "generally have a good understanding of the factors that contribute to their ability to plan for and cope with disturbance and change" (Jones & Tanner, 2015). This ensures a more bottom-up approach, provides agency to people, and may help with the reduction of uncertainty in the selection of indicators (Quandt, 2018). However, there is still no agreed-upon methodology for measuring (climate) resilience (Al-Maruf et al., 2021).

2.2.3. Conceptualization of household climate resilience

Just like there are multiple methods to measure household (climate) resilience, there is also an overwhelming number of frameworks surrounding the assessment, understanding, evaluation, monitoring, and promotion of climate resilience in general. For household resilience, the number is lower, but multiple frameworks still exist. Most of these are built on either the sustainable livelihoods approach (e.g., Quandt, 2018; Rabi et al., 2021) or the capacity approach (e.g., Asmamaw et al., 2019; Tan, Peng, & Guo, 2020). Existing frameworks differ greatly regarding definitions and components used, the scale they operate on, and their function (Bahadur & Pichon, 2016). Furthermore, they depend on which vulnerability is studied. Also, they seem to be strongly influenced by the organizations creating and using the frameworks.

This is also one of the main limitations of most of the frameworks – they include indicators that are not applicable to the context they are designed for. Furthermore, many frameworks take too many factors and corresponding indicators into account (Al-Maruf et al., 2021). Also, local and traditional knowledge (LTK) is often not included in frameworks and measures on (household) climate resilience while literature shows that LTK can help with building climate resilience, especially when combined with scientific knowledge (Makondo, 2018; Khatibi, Dedekorkut-Howes, Howes, & Torabi, 2021). Also, the operationalization of climate resilience is often carried out without consulting people originating from the study region. However, locals often know better what resilience means for them (Pacoma & Delda, 2019).

Due to this contextuality and the other above-described limitations of existing frameworks, this study will not use an existing framework to assess HCR on Bonaire. To ensure context is considered, a framework applicable for the region regarding its climate change vulnerabilities and their environmental, social, institutional, and cultural context will be designed. The set of indicators used to measure HCR will be based on the following four components of household resilience: Economic Resilience (ER), Physical Resilience (PR); Social Resilience (SR); and

Institutional Resilience (IR). These components, in different forms, often reoccur in frameworks measuring household (climate) resilience. The indicators that make up these components differ depending on the study area (Mayunga, 2009). Context-appropriate indicators of household resilience will first be selected through a regional study – described in Chapter 4. To understand the above-mentioned components of household resilience that are used to base the final set of indicators on, these four components will be shortly described. A visualization of the relation between HCR and these components can be found in Figure 5.

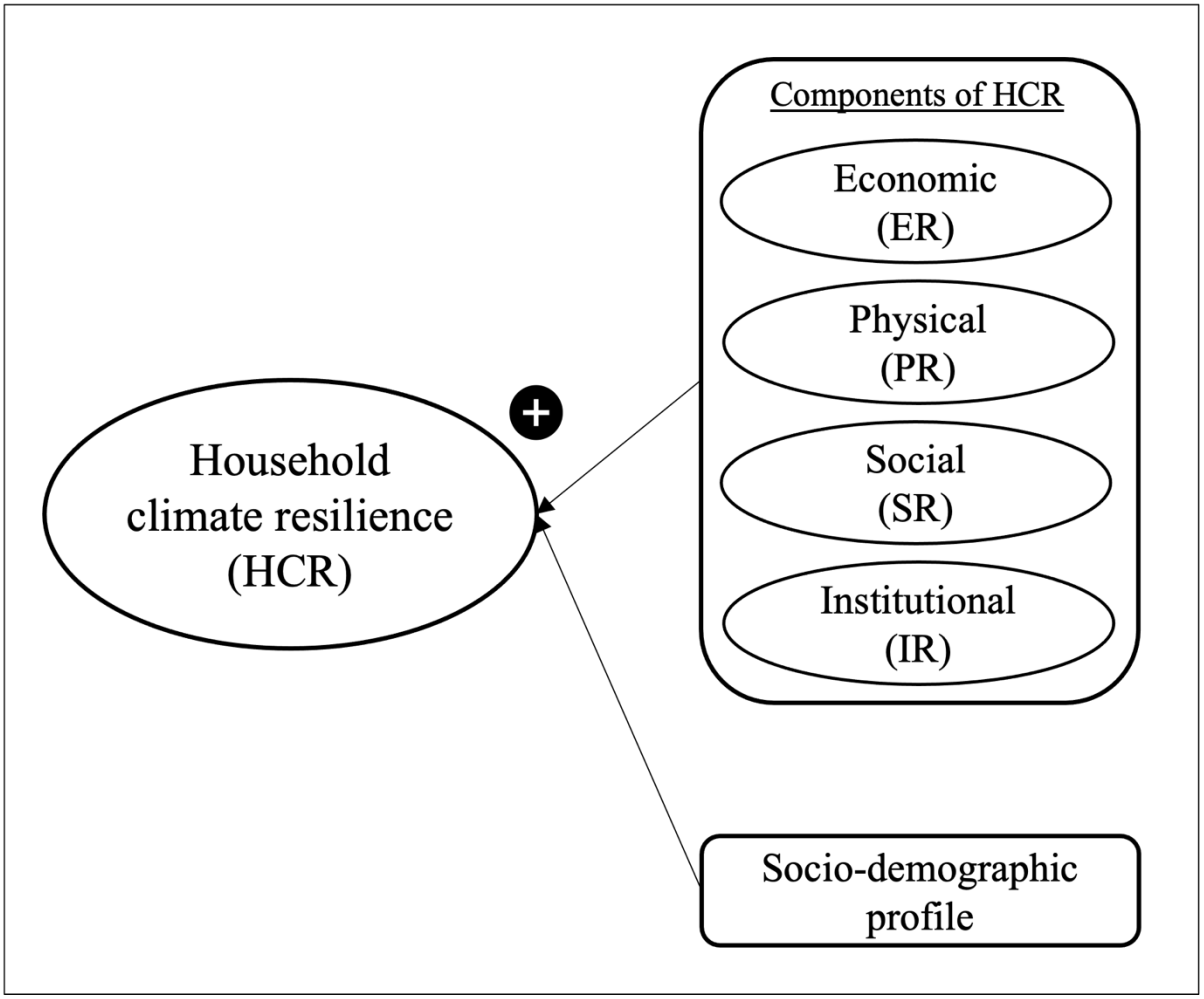


Figure 5. Visualization of the relation between household climate resilience and related components used in this study.

2.2.3.1. Economic Resilience (ER).

In different forms, this indicator is recognized as a crucial aspect of disaster resilience in multiple frameworks regarding HCR (e.g., Al-Maruf, 2017). It refers to a household's ability and pace of recovering from a severe shock by using economic assets to achieve a desired state

– mostly continued performance of key functions (e.g., Rose, 2007). It is aligned with the "efficient allocation of resources in response to disaster risks" (Rose, 2004). Overall, the main attribute of ER that is included in almost every framework is household income – which can be utilized to prepare for, adapt to, and transform after being exposed to a climate change vulnerability (e.g., Vinck et al., 2020). Other included attributes vary between the context of measurement. For example, in rural areas, the ability to sell excess produced food is one of the main attributes (Al-Maruf et al., 2021), while this would not be very applicable to SIs like Bonaire.

2.2.3.2. Physical Resilience (PR).

This component of resilience is called, defined, and operationalized differently in literature. In this study, it is referred to as 'physical resilience' (PR), which is defined by Joerin, Shaw, Takeuchi, and Krishnamurthy (2014) as the basic infrastructure which enhances households' ability to respond, absorb and recover when faced with shocks and stresses. This includes physical features of housing, property, and vital infrastructure (Shah et al., 2018), which may be resources or services (e.g., Vinck et al, 2020). There are multiple resources justifying the decision to include such indicators. For example, Al-Maruf et al. (2021) conclude that well-maintained and accessible infrastructure is critical to household ability to cope with and recover from cyclones and storm surges. Furthermore, Vinck et al. (2020) conclude that access to basic services has been linked to a quicker response and recovery.

2.2.3.3. Social Resilience (SR).

Social Resilience (SR), also defined differently in literature, is another key indicator of household resilience. In the face of shocks, locals are mostly the first in responding and safekeeping the community (Islam, & Walkerden, 2015). Also, at these times households mostly depend on assistance that they receive from relatives and institutions (Aldo, Savagodo, & Abdoul-Azize, 2019). Therefore, having strong social connections can assure a household of communal resources or help, thereby increasing their resilience (Zamboni, 2017, Stern et al., 2006; Hassan, Islam, Saifullah, & Islam, 2016). Also, SR is a useful tool for enhancing the capacity of households to collectively organize for and mitigate risks (Pelham, Clay, & Brunholz, 2011; Alinovi, Mani, & Romano, 2010) and may help with increasing early warning systems (Aldrich & Meyer, 2014).

2.2.3.4. Institutional Resilience (IR).

The content of this component differs in existing literature. For this study, it was decided to combine the content of multiple frameworks (e.g., Al-Maruf, 2017; Arbon, Steenkamp, Cornell, Cusack, & Gebbie; Oriangi, 2019; Shah et al., 2018) and perceive Institutional Resilience (IR) as a form of crisis management, including household awareness and learning, household preparedness and early warning and communications. Awareness, knowledge, and learning capacities have all proven to be key elements in household resilience to climate change impacts. Additionally, knowledge and agency to take steps to prepare for and adapt to the effects of climate change have positive effects on HCR (Arbon, Steenkamp, Cornell, Cusack, & Gebbie, 2016). Access to information adds to this (Thathsarani & Gunaratne, 2017). Lastly, the provision of proper communication, warning systems, and essential training by institutions, like the government, play a big role in these (e.g., Vinck et al., 2020).

2.2.3.5. Socio-demographic profile.

Sociodemographic variables have proven to affect both climate change vulnerabilities (e.g., Baptiste & Kinlocke) and climate resilience (Enarson, Fothgill, & Peek, 2018). An example of such a variable is the gender of the household head (e.g., Gaisie et al., 2021; Lykke et al., 2016). However, the results of such studies differ. Differences in findings might be explained by the earlier mentioned contextuality. To build inclusive and equal (household) climate resilience, it is important to include all population groups, especially the already marginalized ones. Therefore, an understanding of which demographic groups have lower HCR is crucial. Since these effects can be context specific, these relations should be studied for SI-contexts specifically. Therefore, socio-demographic variables that might be of interest in the context of this study, will also be included in this research.

2.3. Conceptual Framework

As mentioned in Chapter 1, to ensure contextuality is considered in this thesis, this study will be based on a conceptual model that is adjusted to the context of SIs in general and Bonaire specifically. This context-specific model will be based on a general conceptual model and will be adjusted to the context through a preliminary study. This general conceptual model can be found in Figure 6. It finds its grounds in the literature review discussed in this chapter and combines the relations shown in Figures 2 and 5. Although, in this study this general conceptual

model is used to create a model for Bonaire's context, it can also be used to map out the context of other geographical areas.

The general conceptual model mostly visualizes relations already explained in this chapter. Namely, climate change both directly and indirectly impacting natural and socio-economic systems (in this study: households). Furthermore, it shows that household resilience has a positive influence on these socio-economic systems and visualizes the components of household resilience. In addition, it visualizes the mutual relation between natural and socio-economic systems. Lastly, it shows that the negative impact of climate change on natural systems can reinforce this relation: climate change shocks can cause degradation of natural systems, which can result in natural systems being less able to protect themselves from the negative impacts of climate change (vulnerabilities).

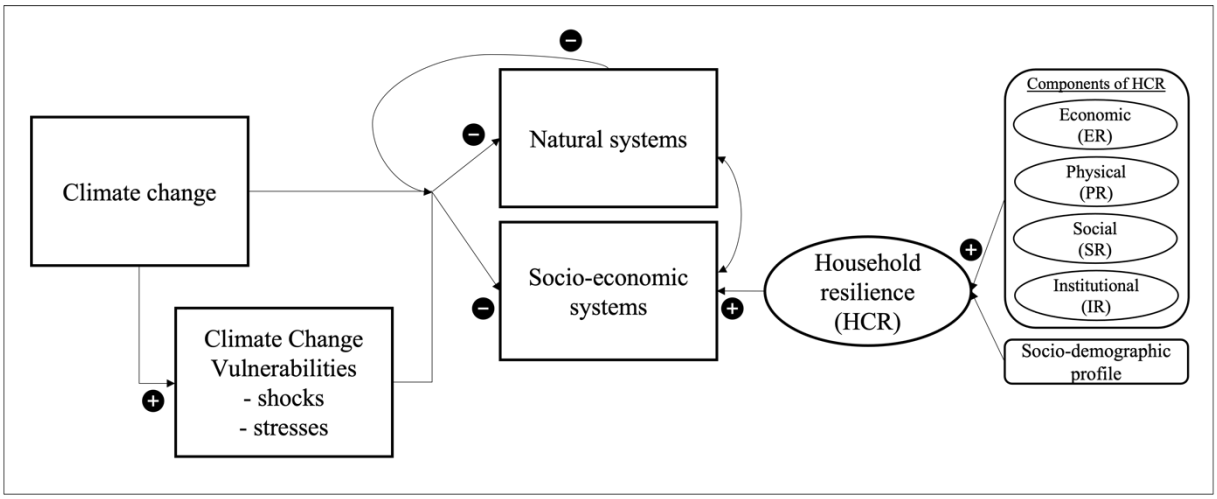


Figure 6. General conceptual model of this study.

Chapter 3 – Methodology

Different methods were used to answer this thesis's (sub-)research questions (as formulated in Section 1.4). This chapter will discuss those methods. A methodological flow chart for this study can be found in Figure 7.

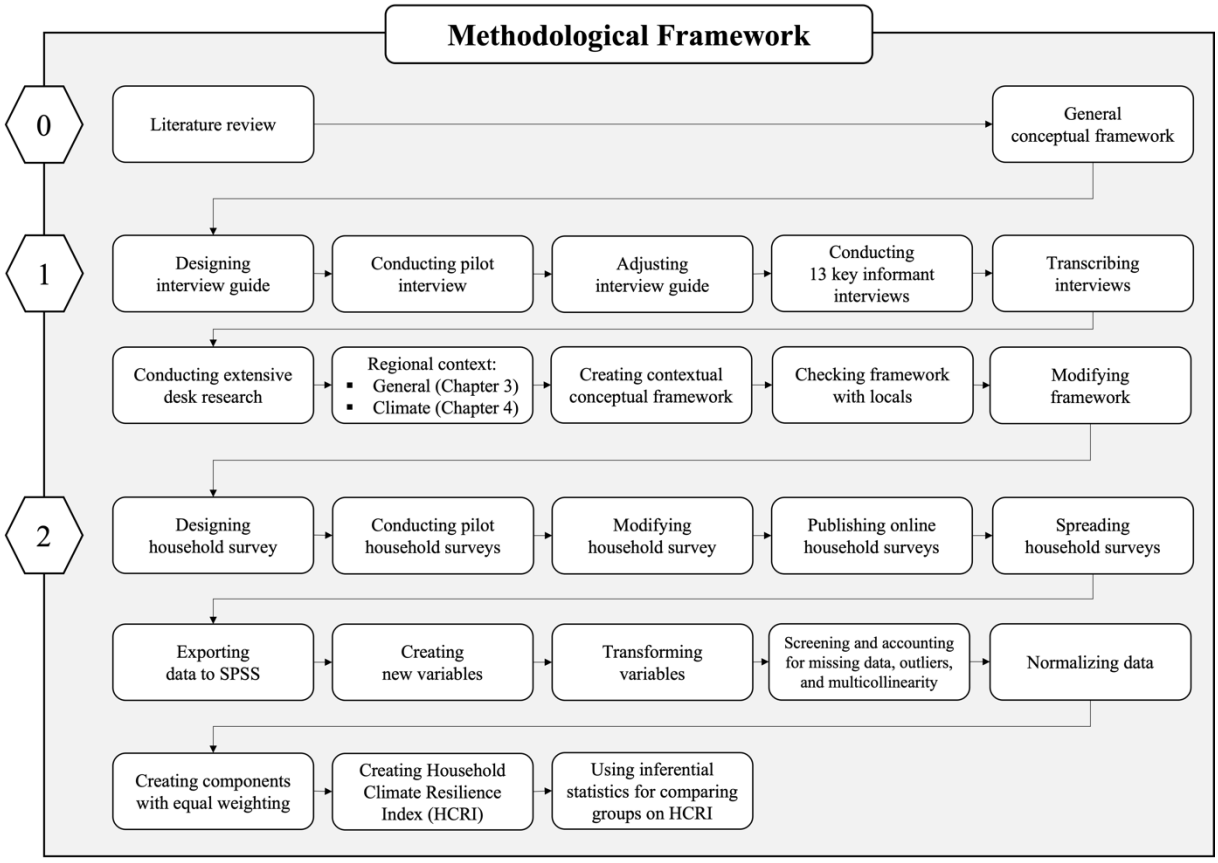


Figure 7. Methodological flow chart of this study.

This thesis was created in partnership with the Dutch Caribbean Nature Alliance (DCNA). The DCNA is a "non-profit organization created to safeguard nature in the Dutch Caribbean through supporting Protected Area Management Organizations" (DCNA, n.d.). Although the DCNA is active on all six Dutch Caribbean islands, its headquarter is located on Bonaire. The organization mainly focuses on nature preservation but wants to broaden its focus by taking both environmental and socioeconomic vulnerabilities of climate change into its scope. The DCNA offered both financial and logistic support throughout creating this thesis in exchange for the final version of this thesis and a policy brief and video containing the main findings of this research.

3.1. Qualitative Study – Developing a Contextual Framework

To answer Research sub-questions 1a to 1c key-informant (KI) interviews were conducted and supplemented by an extensive desk research of both scientific and grey literature. Combining these two methods ensured a broad and thorough understanding of the (climate change) context of Bonaire in which multiple perspectives and local knowledge got included. The general conceptual model was used to create an interview guide for the key-informant interviews (see Appendix A for the English version). This guide was the starting point for all interviews, although they often deviated from it. The guide was tested in a pilot interview with an employee of the DCNA. Changes were made accordingly. After this, 12 additional interviews were conducted. The selection of key-informants started through suggestions by the employees of the DCNA. Suggested participants were approached through e-mail. Later, snowballing was used. An overview of the job descriptions of these key-informants can be found in Appendix B. Interviews lasted approximately one hour. The participant chose the location of the interview (online was also a possibility).

After these interviews were conducted, they were transcribed. To ensure confidentiality, transcripts have not been attached to this thesis. References to these interviews will be made without information enabling to link certain statements to certain key-informants, since confidentiality was promised to those looking for this. Results from these interviews, in combination with results from the extensive desk research, led to a general contextualisation of Bonaire (presented in Chapter 4) and to a climate change contextualisation of Bonaire (answering research sub-questions 1a to 1c; presented in Chapter 5). The adapted conceptual framework can also be found in Chapter 5. This framework has subsequently been used as the basis for extensive desk research resulting in a final set of indicators used to measure household resilience to climate change that is appropriate for the context of Bonaire. To validate the comprehensiveness and appropriateness of this set for the context of Bonaire, it was discussed with multiple local people and stakeholders. Where needed, adjustments were made. The final set of the 21 selected indicators and a brief justification of them is discussed in section 4.6.

3.2. Quantitative Research – Measuring Household Climate Resilience

To answer research questions 1 to 3 (as formulated in Section 1.4) an online household survey was used. This survey is based on the set of indicators selected through the qualitative research. Data collection, processing, and analyses will be described in the upcoming sections.

3.2.1. Data collection

After operationalizing HCR through the set of 21 indicators, this set was transformed into a household survey. An effort was made to collect as much information without making the survey too long to make it more appealing for people finalize the survey. To honour the latest calls for including subjective questions when measuring household resilience (e.g., Jones & Tanner, 2015), the survey includes both objective and subjective questions. Since multiple languages are spoken on Bonaire, the survey was offered in the four languages mostly spoken: Papiamentu, Dutch, Spanish, and English. The Papiamentu and Spanish versions were translated by official translators. The English version of the survey can be found in Appendix C. Before they were published online, the surveys in all four languages were tested for understanding and appropriateness by local people. Adjustments were made where needed. Due to the cultural inappropriateness and possible safety issues of conducting door-to-door surveys on Bonaire, it was decided to conduct the survey online. Qualtrics – an online survey tool – was used.

The target population of the survey was Bonairean households. Therefore, people living on Bonaire who have a *sédula* (a certificate of registration on Bonaire, which is only issued to people living on Bonaire for longer than six months) have been asked to fill in the survey for their whole household. Therefore, it was stressed that only one person per household should respond to the survey. When mentioning the term 'household' to (possible) respondents, the definition of a household used by the CBS (as provided in Chapter 2) was shared. To attract respondents – also from different backgrounds – amongst respondents who left their e-mail address after filling in the survey, the following prizes were raffled: a two-night stay in a villa, a free guided dive including gear for two, and a free dancing class at a local dance school. These prices were offered by local businesses in exchange for exposure in the outreach about the survey. Since the survey was anonymous, these e-mail addresses were not connected to respondents' answers but were collected in a different file. An information sheet including background on the research, how data would be handled, and the contact information of the researcher was added to the survey. This information sheet can be found in Appendix D. To reach as many people as possible, an article about the survey including the links to the surveys in different languages was posted on the website of the DCNA. Subsequently, the DCNA and some other organizations in Bonaire shared information on social media by referring to this article. Also, articles were posted in local online newspapers. Furthermore, people in personal

networks were asked to fill in and spread the survey. The survey was online for 4 weeks and the deadline for filling in the survey was communicated.

3.2.2. Data processing

At the time the survey was closed, 262 people filled in the survey. Data was exported from Qualtrics to SPSS. Exported data was checked at random against the original completed surveys in Qualtrics and errors were investigated and corrected if necessary. Subsequently, the data was processed in the following manner.

1. With the available data, new variables were created.
2. Where needed, variables were transformed so that an increase in the value of the variable corresponded to an increase in HCR. Therefore, all variables with values yes or no were transformed so that 'no'=0 (being less resilient) and value 'yes'=1 (being more resilient). Also, where needed, variables were transformed, so their values showed the right direction.

A description of all the variables included in the analysis, with a description of all the alterations made to them, their labels, final levels of measurement, and categories (where applicable) can be found in Appendix E.

3.2.3. Development of Household Climate Resilience Index

After the data were processed, the Household Climate Resilience Index (HCRI) was developed. A composite indicator approach was favoured since it reflects the multidimensional nature and complexity of resilience and provides a clear monitoring tool (Al-Maruf et al., 2021). The HCRI was developed through the following steps:

1. Data was screened and accounted for missing cases and outliers. Also, multicollinearity among indicators was identified. Firstly, all cases with a completion rate lower than 97% (meaning that the answer to more than one question was missing) were deleted. It was decided that cases with just one question missing would still be included since a composite score could still be formed. However, for more missing variables, the composite score would be too distorted. After deleting these cases, a sample of N = 183 remained of which 6 cases missed the answer to one variable (a completion ratio of 97%). Subsequently, outliers and other outstanding data was checked and accounted for.

2. All indicators were normalized, which enables variables to a have common basis and avoids the problems of mixing measurement units (Nardo et al, 2008). This was done by transforming all values to scores from 0 to 1 with the following equation:

   $$I_a = \frac{X_a}{X_{max}}$$

   In which: I_a is the normalized value of the original value X_a of household *a,* and X_{max} is the maximum value of the original value.

3. Equal weighting was used to create each component of the HCRI, with the following equation (adapted from Mallick, Sultana, & Bennet, 2020):

   $$C_a = \frac{\sum_{a=1}^{n} I_{a^i}}{n}$$

   In which: C_a is one of the four components (ER, PR, SR, IR) for household *a*, I_{a^i} is the component's indicators by *i*, and *n* is the number of indicators of each component.

4. The HCRI was obtained by combining the four components using the following equation (adapted from Mallick et al., 2020):

   $$HCRI_a = \frac{w_{ER}CER_a + w_{PR}CPR_a + w_{SR}CSR_a + w_{IR}CIR_a}{w_{ER} + w_{PR} + w_{SR} + w_{IR}}$$

   In which: $HCRI_a$ is the *Household Climate Resilience Index* for household *a*, which equals the weighted average of the four components (21 indicators). W_{Ca} is the weight of each component given by the number of indicators making up the component (ER_a, PRa, SRa, and IR_a), which are used to guarantee that all indicators have an equal contribution to the $HCRI_a$.

   This results in an HCRI in which values can lay between 0 (least resilient) and 1 (most resilient).

3.2.4. Data Analysis

After exploring the descriptive statistics of the sample (which can be found in Section 6.1.), inferential statistical techniques were used to explore differences in HCRI and indicators between various groups. To compare groups with no more than two levels, independent sample t-tests were conducted. To compare groups with more than two levels, one-way between groups ANOVAs with posthoc tests (Tukey test) were used. Appendix F shows the used test per socio-demographic variable. The assumptions for all these tests were checked beforehand. These were all met, except for some of Levene's tests of homogeneity of variances – in which case the Welch Robust Tests of Equality of Means was used.

3.3. Research Limitations

In this section, the most important limitations of this study will be described and reflected upon. The first is the positionality of the researcher. The researcher coming from the European Netherlands may have had an impact on the results of this study, especially considering the sensitive relationship between Bonaire and the European Netherlands. An example of such an impact is that both key-informants and survey respondents might have responded differently to questions due to the associations they have with the researcher's Dutch background. Another example is that this background might have unconsciously influenced the researcher's questioning or responding in interviews, perhaps especially when speaking about the previously mentioned sensitive relationship. Also, this research attempts to include local context. However, one may wonder to what degree a researcher not originating from that location can understand that context, especially when never having visited that location before. Furthermore, the position of the researcher within the DCNA might have influenced this study. Although most research was conducted independently of the DCNA, both key-informants and survey respondents were aware of the connection of the research to the DCNA. This might have altered their responses. Also, although not consciously, this triple role of the researcher (as a student, researcher, and intern of the DCNA) might have influenced the researcher's actions.

Moreover, the limited representativeness of the household sample is the biggest methodological limitation. Attempts were made to create a sample that was representative of the Bonairean population. This was done by providing the household surveys in four languages, spreading the surveys through the social media of local institutions and newspapers, and by offering prizes. Nevertheless, when looking at the descriptive statistics of the sample (provided in Section 6.1.) it seems like the Spanish-speaking community has not been reached (only 3.3% of the sample used the Spanish version of the survey). The same goes for the Papiamentu-speaking community – only 15.8% of the sample used the Papiamentu version of the survey. These low percentages can also be explained by respondents from the Spanish and local community using other default languages. However, the percentages of households identifying as Mid/ Southern American or Bonairean (4.9% and 21.3%, respectively) indicate the same conclusion.

Furthermore, it was not possible to check whether cases within the data set belonged to the same household. Respondents were asked to make sure that only one person per household would respond to the survey and data was checked to see if any cases were similar and therefore indicated they were representing the same household. Nevertheless, there was no way of

making sure whether people filled in the survey more than once, for example, to have a bigger chance of winning the raffled prices. Furthermore, the survey included some subjective questions. Data collected for these questions might be difficult to compare, since, for example, some people interpret ‘many steps to prepare’ differently than others. Further possible limitations include that the survey was supposed to collect data on households but some questions (e.g., “To what extent are you aware of what climate change means and how it can impact your household?”) are directed at the respondent. Collected data on the question might therefore not represent the household. It was attempted to minimize this by emphasizing that either household heads should fill in the survey or the respondent should be able to consult with the household head.

Another limitation is that the researcher did not speak Papiamentu or Spanish and could therefore not check whether the questions of those versions of the household survey were internally consistent with those of the Dutch and English versions. However, the surveys were translated by professional translators and checked by multiple people speaking the language to see whether the surveys were clear in every language. Nevertheless, some questions might have been interpreted differently in different languages. The possibly further limited representativeness of the population is also something to consider. Conducting online surveys has one main downside: only people with internet access can respond. However, on Bonaire, most people have internet access. On the other hand, since social media was the main channel used to spread the surveys, people without access to social media – so mainly older people – may have been excluded from the sample population. However, since on Bonaire older people often live with their families and information was collected on a household-level, information on their households might have been collected when a household member fills in this survey. Furthermore, the survey has also been spread through the news and might therefore still have reached people without social media.

Chapter 4 – General Context of Bonaire

In this study and the framework used for it, much attention is paid to regional context. Also, the impact of climate change (vulnerabilities) cannot be separated from other challenges and dynamics in a region. For these two reasons, this chapter describes the regional context of Bonaire. Although this chapter is elaborate, all information is highly summarized and certain nuances and perceptions might have been left out.

4.1. Dutch Caribbean Islands

To get a better picture of Bonaire, it is important to understand its relationships to other (Dutch) Caribbean Islands. There are six Dutch Caribbean Islands: Aruba, Bonaire, Curacao, Saba, Sint Eustatius, and Sint Maarten. They are part of a group of islands named the 'Small Antilles'. Geographically speaking, the Dutch islands are divided into two groups of islands named after their position to the prevailing north-eastern trade winds: the Leeward Islands and the Windward Islands (Schmutz, Potter, & Modlin, 2017). Aruba, Bonaire, and Curacao are part of the Windward Islands and are jointly referred to as the ABC-islands. Saba, Sint-Eustatius, and Sint-Maarten are part of the Leeward Islands and are jointly referred to as the SSS-islands. Figure 8 (on the next page) shows the islands' positions and most important information.

The six Dutch Caribbean islands are also subdivided by their political statutory. Aruba, Curaçao, and Sint Maarten are autonomous – but not independent – countries within the Kingdom of the Netherlands and are jointly referred to as the CAS-islands (Rijksoverheid, n.d.-a). Bonaire, Saba, and Sint Eustatius are 'public bodies' of the Netherlands and are jointly referred to as the BES-islands. So, currently the Dutch Kingdom consists of Aruba, Curacao, Sint-Maarten, and the Netherlands and the latter consists of the European Netherlands, Bonaire, Sint-Eustatius, and Saba.

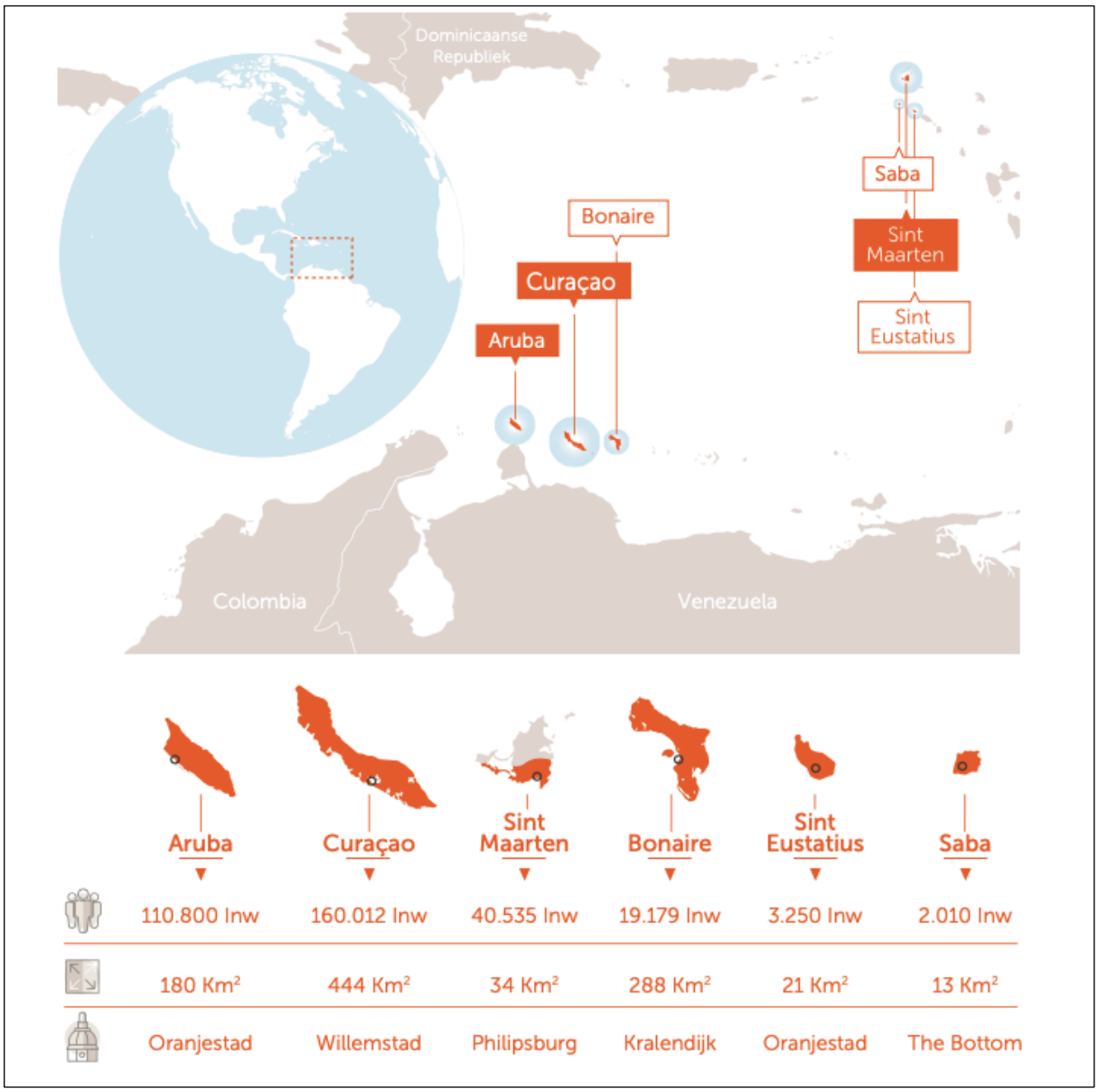


Figure 8. Map and main characteristics of the Dutch Caribbean islands. Reprinted from Adviesraad Internationale Vraagstukken (2020, September 10th). Veiligheid en rechtsorde in het Caribisch gebied: Noodzakelijke stappen voor een toekomstbestendig Koningsrijkverband. Retrieved on December 1st, 2022, from https://www.adviesraadinternationalevraagstukken.nl/documenten/publicaties/2020/09/10/veiligheid-en-rechtsorde-in-het-caribisch-gebied

4.2. History of Bonaire

To current knowledge, the earliest inhabitants of Bonaire date back to 3300 B.C. – and are now referred to as 'Archaic Indians' (Van Buurt, 2011). Bonaire got 'discovered' by the Spanish in

1499, who shipped away the biggest part of Bonaire's habitants (Schmutz, Potter, & Modlin, 2017). The English, Spanish, and Dutch took turns in occupying Bonaire until the Dutch officially (re)conquered Bonaire in 1815 (Dalhuisen, Donk, & Hoefte, 2019). From 1814 to 1845, Bonaire – in differing combinations with the other Dutch Caribbean islands – was part of the colony 'Curaçao and Dependencies' and got ruled from Curaçao (Van de Walle, 1975). After negotiating for eight years after the islands were promised autonomy, the colonial status of the islands ended in 1954: the islands together formed the Dutch Antilles, which together with the Netherlands formed the Kingdom of the Netherlands (Oostindie, 2011). Throughout the years, three of the islands – Aruba, Curaçao, and Sint Maarten received the status of 'country' within the Dutch Kingdom. In 2010 the Dutch Antilles was abolished as country (Het Koninklijk Huis, n.d.). Since then, Saba, Sint-Eustatius and Bonaire became 'public bodies' of the Netherlands. Section 3.3 explains what this means.

The West India Company - and later the Dutch government - exploited Bonaire from 1636 to 1868. This exploitation was dominated by stockbreeding – with livestock originally introduced by the Spanish (Dresscher, 2009) – and the export of brazilwood, aloe divi-divi pods, and salt (Klomp, 1986). Large-scale plantation agriculture was never developed on Bonaire. Enslaved people from Africa were shipped to Bonaire to – alongside Caiquetio Indians and European convicts - work in the salt mines (Hartog, 1957). Slavery was only abolished in 1868. As a result, the plantations and the salt industry were no longer profitable, and the ex-enslaved people were left empty-handed (Koolen, 2010).

Until around a hundred years ago, Bonaire's inhabitants were mostly self-sufficient in their food demand (Verweij et al., 2020). They nurtured plots of land – known as 'kunuku's' – and kept livestock. In these times – in contrast to many other Caribbean islands – only few people migrated to Bonaire and the other Dutch islands (Gastmann, 1996). This was mainly due to the weak economies of the islands. This changed with the discovery of oil in Venezuela and the emergence of the oil industry in Curaçao and Aruba and the growing tourism and banking sector. People living on Bonaire started leaving their kunuku's to find work abroad or in urban areas (Verweij et al., 2020). Nowadays, many kunuku owners have sold their land to foreigners, who mainly use this land to build houses or tourist attractions like resorts and restaurants.

4.3. Current Political Situation in Bonaire

As previously mentioned, Bonaire, Saba, and Sint Eustatius are 'public bodies' of the Netherlands since 10/10/2010 (often referred to as 'ten ten ten'). Being a 'public body' – a.k.a. 'special municipality' – practically means these islands are part of the Netherlands in the form of overseas municipalities. Where the CAS-islands have their own governments, the BES-islands fall under the government of the Netherlands. However, all three of the BES-islands have their own popular representation in the form of an island council and an executive council (Analistennetwerk Nationale Veiligheid, 2020). Bonaire also has a governor. Furthermore, there is a 'Rijksdienst Caribisch Nederland', a liaison of the Dutch government on Bonaire.

The 'Municipality Act' [translated from Dutch] present in the Netherlands serves as the basis for the administration on Bonaire, with some exceptions, for example in social security. However, although some of Bonaire's legislation has been adapted to the Dutch model, the former legislation of the Dutch Antilles still applies on many occasions as well (College voor de Rechten van de Mens, n.d.). An example is that the 'equal treatment legislation' [translated from Dutch] does not apply to Bonaire. Furthermore, the international human rights treaties from the UN and the Council of Europe and parts of the European Union law do not always apply to Bonaire (College voor de Rechten van de Mens, n.d.).

Bonaire becoming a public body of the Netherlands occurred after a series of events. Very briefly summarized, after the Dutch Antilles were dissolved, multiple referenda were planned to decide on the relation Bonaire would have with the Netherlands (ANP, 2010). Although the majority of the Bonairean population showed disagreement with Bonaire becoming and being a public body of the Netherlands (Caribisch Openbaar Lichaam, n.d.), this was still the outcome of the constitutional reform. This was due to, amongst others, one of the referenda being declared invalid due to a low turnout. KI-8 (March 29th, 2022) talked about the circulating stories of politicians paying people to stay at home on the day of the referendum. Furthermore, in the process before the referendum and the integration of Bonaire, many promises were made to the population; Bonaireans believed that integration would mean Bonaire would get a living standard similar to the European Netherlands (Spies et al, 2015). However, this promise has to date – more than 11 years later – not been fulfilled. Among a considerable part of the Bonairean population, dissatisfaction still exists about the way Bonaire is governed by the Netherlands and about the arrival of more and more Dutch people ('Makamba's in Papiamentu, the local language). An example of this sentiment can be seen in

Figure 9.

Figure 9. A sign along one of the main roads in Bonaire showing some Bonaireans sentiment towards Dutch people – Makamba's in Papiamentu (own photo).

Two evaluations from 2015 – more recent ones do not yet exist – conclude that Bonaire's statutory situation has both had positive and negative outcomes (Spies et al., 2015; SCP, 2015). On the one hand, the financial and personal investments of the Netherlands improved, among others, education and healthcare (Spies et al., 2015) and the police, airport, and water supply (SCP, 2015). On the other hand, these gains are being overshadowed by the disappointment of the population, mostly regarding the lack of progress in welfare levels – the concern for basic needs prevails. Many citizens state their living situation got worse after 10/10/10, which gets confirmed by social workers (SCP, 2015). This disappointment is reinforced by the high expectations Bonaireans had – and were given – about the new form of government. Bonaireans experience a lack of considered contextuality, arbitrariness, and double standard in legislation, policy, and implementation (SCP, 2015; Spies et al., 2015). There is no commonly supported vision for the future between European Netherlands and Bonaire, which often causes the Dutch

vision to become dominant (SCP, 2015). Furthermore, the many Dutch Ministries that are involved in the development of the Caribbean Netherlands all create their plans with limited alignment or collaboration (Spies et al., 2015). Both evaluations describe that a feeling of neo-colonialism is present among parts of the population.

On the other hand, feelings of disappointment exist in European Netherlands as well (Spies et al., 2015). It is felt that, partly due to a weak administration on Bonaire, the effectiveness of the taken measures lags behind the great financial and personal investments that have been made on the Dutch side (SCP, 2015). Differences in culture, language, and administration cause difficulties in understanding each other, which complicates the process. Furthermore, key-informants often mentioned that Bonaire is responsible for solving problems that it – as a municipality, which also misses support from a provincial government, like other Dutch municipalities do get – does not have the means for. Lastly, the great discrepancy in interests between the territories – their relationship is very important to Bonaire, while it is not for the European Netherlands – places Bonaire in a dependent and 'submissive' position.

The conclusions of these evaluations (SCP, 2015; Spies et al., 2015), although they were carried out some time ago, do not seem outdated. Similar observations came forward in the key-informant interviews. Multiple key-informants mentioned the difficult relationship between the European Netherlands and Bonaire and the different governments involved. One participant mentioned the following:

"What we see is that the lower policy framework in The Hague [where Dutch politics operates] changes so quickly that they often don't really know what to do [with policy on the BES-islands], so that creates frustration on the islands. And that is a clumsy way of handling and determining things. While at the higher level... well... if I may paraphrase the words of one correspondent, it sometimes comes across as rather neo-colonial. Like the white high official will come and tell you how it should be done." [translated from Dutch]

KI-5 (March 21st, 2022) said the following when they described the sensitivities around the collaboration between the Dutch and the local Bonairean government:

"[...] and what I also find resentful is that now, 12 years later [after 10/10/10] many of the pain points are clear and it is obvious that if you [the Netherlands] want to solve things, you actually have to approach it via a certain path, but that there are still enough people in The Hague who simply refuse to take that path and only want to do it their way [...]. And on the other hand, I think like what does it take to make the [BES-]islands more able to cope with the

way The Hague works [...]. Neo-colonialism is also something that both parties bring up again and again. So, one moment it's like 'ok you [the Netherlands] need to help us [Bonaire], because we cannot do things individually', but when you [the Netherlands] tell [Bonaire] how to do it, they don't want to hear it either. […]. That colonial past should really not be underestimated I think and how complicated and sensitive this makes the cooperation [between Bonaire and the Netherlands]." [translated from Dutch]

4.4. Geography and Demographics of Bonaire

Bonaire, located 80 km from the coast of Venezuela, comprises the island of Bonaire and the smaller inhabited island 'Klein Bonaire' (see Figure 10 on the next page for visualisation). Bonaire is 288 km^2 and its elevation ranges from sea-level to 240 meters but is mainly flat and especially the southern part of the island and the Kralendijk region lay low (Schmutz, Potter, & Modlin, 2017). Furthermore, Bonaire is characterized by a tropical steppe and a semi-arid, hot, tropical climate (Meteorological Department of Curaçao, 2016) and is exposed to consistent easterly trade winds (Schmutz, Potter, & Modlin, 2017). Bonaire has two national parks: the Bonaire National Marine Park – the oldest marine reserve worldwide, including the sea around Bonaire and Klein Bonaire – and Washington Slagbaai National Park – a terrestrial park that covers 5643 hectares of Bonaire (STINAPA, n.d.).

Figure 10. Map of Bonaire. Reprinted from Wikimedia Commons (n.d.). *File: Bonaire travel map.png.* Retrieved on May 4th, 2022, from https://commons.wikimedia.org/wiki/File:Bonaire_travel_map.png

In 2021, Bonaire's population officially counted 22,573 residents (CBS, 2022). Bonaire's population has been growing a lot in the last decades; in 1961 Bonaire only had a population of 5800 (CBS, 2019b). 'The Bonairean' is hard to define. The population of Bonaire is a mix of more than 80 nationalities and ethnic backgrounds (CBS, 2022). What is striking, is that only about 35% of the Bonairean population was born on the island – 16% is born in European Netherlands and 42,5% is born in Mid and South America (Bonaire not included) (CBS, 2022). Around 81% of the Bonaireans are said to be religious, mainly Roman-Catholic (CBS, 2019a, reference year: 2017). Because Bonaire is part of the Netherlands, its official language is Dutch, which is also the only language used in legal matters and administration (Rijksoverheid, n.d.-b). However, the working language is Papiamentu (CBS, 2019d). Other main languages that

are being spoken are Spanish and English. Since 10/10/10, school lessons are only provided in Dutch. This is disadvantageous for many locals who might speak Dutch but have more difficulties with writing and reading it (SCP, 2015).

Bonaire's GDP is 553 million US dollars (CBS, 2021a, reference year 2019). In the past years, the island showed economic growth (CBS, 2021a, reference year 2018) but economic inequality and poverty increased as well (CBS, 2019c, reference year 2018). Around 40% of Bonaire's GDP is direct tourism expenditure and Bonaire therefore relies heavily on tourism. Tourism provides many Bonaireans with jobs in accommodation, food serving, recreational and cultural activities, construction, wholesale, and retail (CBS, 2017). Besides tourism, salt mining and the service sector are of importance to its economy (Buiren & van Ernst, 2019). In a smaller amount, fishing and agriculture play a role in Bonaire's economy. Of the Bonairean population 69,8% is employed (CBS, 2021b). More men than women are employed (relatively 73.6% and 65.7%). The same goes for higher educated people in comparison to lower educated people (relatively 77,4% and 64.0%). The median annual disposable household income on Bonaire in 2019 was 24,000 US dollars, with a Gini coefficient of 0.39 (CBS, 2021b).

4.5. Challenges for Bonaire

Although this thesis focuses on climate change challenges (as described in Chapter 5), this section will briefly discuss the island's further challenges. Since both types of challenges are interlinked, it is important to understand the latter as well. According to scholars and most of the interviewed key-informants, poverty is the most pressing challenge for Bonaire. One of the reasons for Bonaire to become a public body of the Netherlands was the hope for better living conditions. However, the situation has only gotten worse since then (SCP, 2015). Research shows that 43% of the Bonairean households have an income that lies under the average budget needed to live on Bonaire (Straatmeijer, de Bruijn, & Mack, 2018). Despite the ambition of the Dutch government to decrease this percentage, the number of households living under the poverty line grew in the last years (Koolmees, 2021). One of the reasons for the high amount of poverty is that social benefits in Bonaire are relatively low. For example, the retirement pension in 2021 was 684 US Dollars (Rijksdienst Caribisch Nederland, n.d.), while the minimum costs of living amount to 1,363 US Dollars (Koolmees, 2021). Also, finding a job, especially one that can provide an income that meets basic needs, is difficult (College voor de Rechten van de Mens, 2018). Furthermore, according to social workers, there are only a few

families without debts (SCP, 2015). In February 2022 Unkobon, the Bonairean Consumers' Association, sued the Dutch government because "[…] the Dutch government does not do enough to fight poverty on Bonaire" (Drayer, 2022).

Another challenge is the fast-growing population on Bonaire; the population increased by a third in ten years (CBS, 2021b). This population growth is mainly caused by migration – only about 35% of the Bonairean population is born on the island (CBS, 2022). Many of the key-informants talked about how this causes a feeling of being 'overpowered' by others, especially Dutch people. The fast-growing population also causes other challenges, like a housing crisis. The shortage of houses drives the renting prices up, which, in combination with the shortage of social housing (College voor de Rechten van de Mens, 2019), makes it even more difficult for people living in poverty to rent, let alone buy a house (Briene, Bongenaar, & Bos, 2019).

The unilateral dependency on tourism poses another challenge for Bonaire; it makes the island's economy vulnerable to global health issues (as the COVID-pandemic has shown), fluctuations in the (global) market and climate change. The island is also highly dependent on nearby, bigger islands like Aruba and Curaçao (Analistennetwerk Nationale Veiligheid, 2020). Amongst others, it depends on them for more urgent or complex medical care. Furthermore, Bonaire is for 99% dependent on imported food (Verweij et al., 2020) and most other goods are imported as well (Spies et al., 2015). Therefore, the island is dependent on import countries and the supply through Aruba and/ or Curaçao (Kamer van Koophandel Bonaire, n.d.). A crisis on one of these islands or a situation in which Bonaire's (air)port is not accessible, can therefore have big impacts on Bonaire.

These dependencies, in combination with the small markets, low supermarket competition, and high shipping and refrigerating costs, result in high prices for goods (Verweij et al., 2020). For example, groceries are 40% more expensive than in European Netherlands. This is especially the case for fruits and vegetables – while around 40% of these could be produced locally (Van der Geest & Slijkerman, 2019). This particularly impacts the lower income group who end up buying cheaper, unhealthy food. This adds to the high obesities rates – currently, 30% of the population is obese (CBS, 2021b) – and health issues. The health of Bonaireans is further endangered by the infection diseases Dengue, Zika and Chikungunya, which are transferred by mosquitos. Outbreaks of these diseases can have immense consequences for the island (Analistennetwerk National Veiligheid, 2020).

One of the challenges receiving a lot of attention – mainly from foreign actors – is the loss of biodiversity on Bonaire. The 'State of the Nature of Caribbean Netherlands 2017'-report concluded that the Dutch Caribbean biodiversity is in a "moderate to very unfavourable state" (Debrot, Henkens, & Verweij, 2018). This accounts for both the ecosystems and the (groups of) species that depend on these. Bonaire's nature is extra vulnerable due to the island's small surface and small species populations, which makes the latter especially "vulnerable to habitat loss, fragmentation, and degradation" (Verweij et al., 2020). Invasive species, climate change, and tourism further threaten biodiversity (Analistennetwerk National Veiligheid, 2020). The necessity for conservation management is being emphasized (e.g., CBD, 2019).

Furthermore, there are high levels of subversive criminality, including the trafficking and smuggling of drugs, people, and weapons and high levels of money laundering (Analistennetwerk National Veiligheid, 2020). There are also indications that the integrity of civil servants and administrators is under pressure (Van der Zee & Hoebé, 2019). Additionally, there is a tradition of clientelism (Veenendaal, 2017). Lastly, the mass tourism, the rise in illegal migration (mainly from Venezuela), and the increasing Chinese involvement in, among others real estate, pose challenges for Bonaire (Verweij, 2020; WODC, 2018; Van der Zee & Hoebé, 2019).

Chapter 5 – Results: Climate Change Context of Bonaire

This chapter answers the sub-questions of Research question 1: a) What are the main climate change vulnerabilities on Bonaire? (Section 5.1 and 5.2); b) How do these vulnerabilities impact Bonaire and its citizens? (Section 5.3); and c) How can Bonairean households be resilient to these climate change vulnerabilities? (Section 5.5). Answering these questions will allow for the adaptation of the general framework (Figure 6) into a framework specific to the context of Bonaire including a set of indicators for measuring household resilience to climate change vulnerabilities. This adapted framework can be found in Figure 11. The relations within this figure are, for the sake of the length of this chapter, only briefly described and slightly simplified. A small description of the current situation of action towards climate change, climate change vulnerabilities, and (household) climate resilience can be found in Section 5.4.

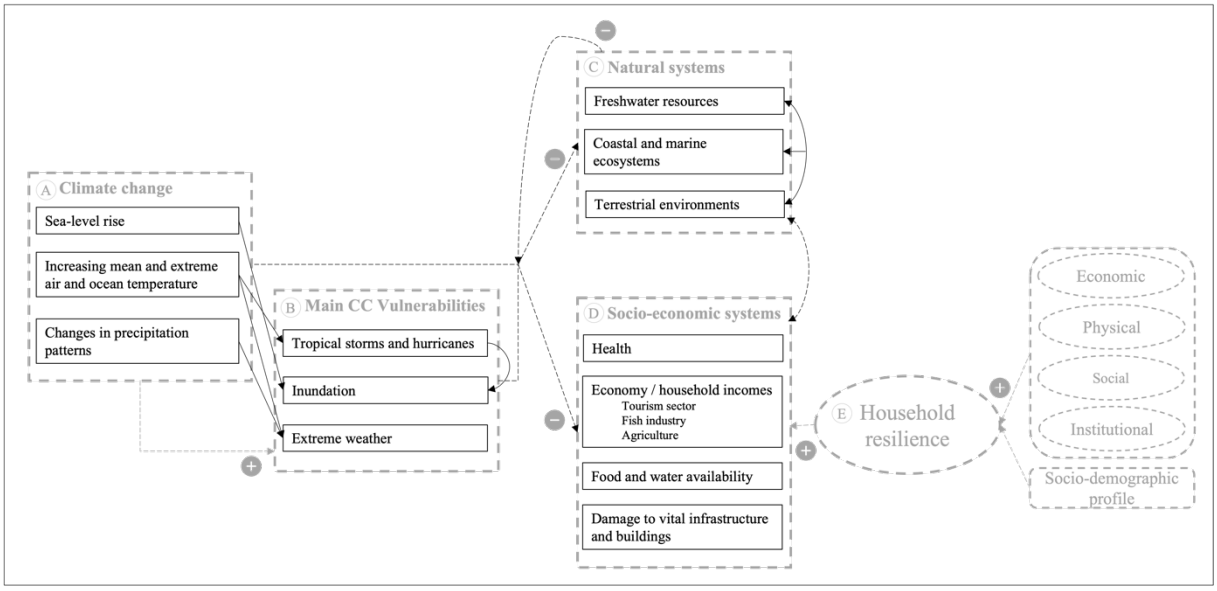


Figure 11. Conceptual model adjusted to the context of Bonaire. The grey letters and arrows show concepts and relations already explained in the general conceptual framework in Chapter 2. The black letters and arrows show concepts and relations that were found through the contextual study which will be explained throughout this chapter. The capital letters in circles relate to the sections within this chapter.

5.1. Climate Change on Bonaire

Long-term series of accurate measurements from weather stations are necessary to determine trends in changing climate. However, although nowadays data is being collected, long-term data is limited for Bonaire (KNMI, 2021). Therefore, data from Curaçao or Aruba is often used when describing changes for Bonaire (KNMI, 2021). For example, the annual average

temperature change on Bonaire is determined by that of Curaçao; which is an increase of 0.2 °C per ten years since 1961. However, exact conclusions or predictions for changes in Bonaire's climate cannot yet be drawn. Data collection specific for Bonaire is therefore essential. Nevertheless, by combining findings from key-informant interviews with results from desk research on the (Southern) Caribbean, some conclusions can be drawn about the main climate changes in Bonaire (visible in Box A in Figure 11).

A change in climate all key-informants mentioned is Sea Level Rise (SLR). Most mentioned that increases in sea level are already visible and further rise is expected. This is confirmed by Bars (2022): SLR in Bonaire occurs with 3.3. mm per year on average in the last three decades – which is higher than the global average – and this rise is expected to accelerate in the future (Bars, 2022). Debrot and Bugter (2010) argue that for Bonaire a maximum SLR of 1.6 metres by 2100 should be expected. Besides SLR, KI-3 (March 21st, 2022) mentioned that sea temperature has increased by 2°C for Bonaire in the last 10 years. Increase in air temperature is also a main climate change for Bonaire (KI-2, March 21st, 2022). These observations were recognized in conclusions from the IPCC (2021) stating that SIs are progressively affected by increases in air and ocean temperature that have already occurred. Furthermore, it is expected to become even hotter: a 1.2 °C rise between 2040-2060 and a 1.6 – 3.0 °C rise between 2060-2100 is expected for the Caribbean SIs (Bowden et al., 2020). Changes in weather patterns were also considered by all key-informants. Such mentioned changes include alterations in the amount of rainfall and the periods in which rain falls. For example, KI-12 (March 30th, 2022) mentioned that from 2015-2018 there was barely any rain (even in dry seasons) but this year a lot of rain fell in dry seasons. KI-7 (March 26, 2022) mentioned the tangible longer periods of droughts and decreases in rainfall. Long-term empirical data on Bonaire lacks but data on the Caribbean in general confirms these observations. The IPCC (2021) concluded with high confidence that SIs are increasingly affected by increases in aridity and changing precipitation patterns. Furthermore, it is expected to become dryer on Caribbean SIs: 9% less rain and up to 327% more dry days by 2080-2100 are expected (Bowden et al., 2020; Stennett-Brown, Jones, Stephenson, & Taylor, 2017). All these projections and the extent to which they might occur, are highly dependent on the global increase in temperature. The IPCC (2022) states that if countries do not sharpen current plans, the world is facing global warming of 3.2 °C in 2100. This would mean above-mentioned predictions will be even more extensive.

5.2. Main Climate Change Vulnerabilities

The observed and expected changes in the Bonairean climate impose multiple climate change vulnerabilities – both climate change shocks and climate change stresses. The main ones will be discussed beneath (and are shown in box B in Figure 11).

5.2.1. Tropical storms and hurricanes

When asked about the main climate change vulnerabilities of Bonaire, most key-informants discussed tropical storms and hurricanes. Two key-informants spoke about the fact that hurricanes and storms usually occur in the SSS-islands, which are located in the hurricane belt, and not on Bonaire. However, other key-informants did not agree. To quote KI-11 (March 30th, 2022):

"It is often said that we are located outside the hurricane belt, but that is nonsense because we lay in its the fringes. But people like realtors use the idea that we are not to sell houses"
[translated from Dutch]

Furthermore, most key-informants spoke about the expectation of either increased frequency or increased intensity of storms and hurricanes, partly caused by climate change.

It is true that the chances of being hit by a tropical storm or hurricane are lower for Bonaire than for the SSS-islands: 12-18% and 42-48 %, respectively (Molen, van der Berendsen, Gerardts, Haverkorts, & Torenvlied, 2017). Nevertheless, the chance still exists. Furthermore, changes in the frequency and an increase in the intensity of hurricanes in the area are expected (IPCC, 2019). The KNMI (2021) expects hurricanes in the Caribbean region to become 20% stronger due to the increase of available energy in a warmer climate. Also, it is expected that climate change causes a 20% increase in rainfall within 100 kilometres of the eye of the hurricane (Knutson et al., 2010). This would increase the chances of Bonaire being hit by a hurricane or, when it is not directly hit by a hurricane, being affected by the 'tail' of a hurricane, which can also have disastrous effects. Hurricane Lenny, which occurred in 1999, is an illustration of this; although being at a 900-kilometre distance from Bonaire, it caused significant damage to the island (Schmutz, Potter, & Modlin, 2017). Amongst others, it caused beach erosion and damage to coral reefs, houses, infrastructure, and historic structures. The occurrence of tropical storms in the region is also expected to increase (IPCC, 2022). Although not as strong as hurricanes, tropical storms can have a disastrous effect on Bonaire. KI-9 (March 27^{9h}, 2022) already noticed a (slow) increase in the occurrence of tropical storms in Bonaire.

Bonaire and her citizens are not at all well prepared for the occurrence of tropical storms and hurricanes or for the possible impact of the surrounding islands, which Bonaire depends on, being hit by a storm or hurricane (most Key-informants). Furthermore, "*people assume that when Bonaire is hit by a tropical storm or hurricane, support will come from Curaçao but whenever Bonaire was hit in the past, Curaçao was as well. Also, there is a high dependency on the Netherlands, but it will take them a few days to send help as well"* (quote of KI-4, March 21st, 2022). Thus, although – for now – Bonaire's exposure to tropical storms and hurricanes is not very high, its sensitivity, and therefore vulnerability is. Especially given the fact that Bonaire's exposure to them is very likely to increase.

5.2.2. Inundation

Following the perspective of key-informants, one of the biggest climate change vulnerabilities for Bonaire is inundation. Inundation occurs through SLR, which is accelerating for Bonaire (KI-5, March 22nd, 2022; IPCC, 2021). SLR also imposes changes in wave climate, which will "significantly increase coastal flooding and coastal and reef island erosion" (IPCC, 2021, p. 4). Inundation furthermore occurs through storm surges of which tropical storms and hurricanes are the drivers (Vitousek et al., 2017). Since, as previously described, for Bonaire both are expected to increase, this enlarges the chances of storm surges – and thus inundation – even more. Furthermore, Bonaire's whole coastline is at risk of a tsunami which can hit Bonaire at any time (KI-6, March 25th, 2022; Engel & Brückner, 2012; Schmutz, Potter, & Modlin, 2017).

Thus, it is expected that the number of flood events on Bonaire will increase (e.g., Debrot & Bugter, 2010). This would be of major concern for Bonaire. The island is relatively flat, and as is visible in Figure 12, roughly half of the island is low-lying (Brienne, Bongenaar, & Bos, 2019). Furthermore, big parts of Bonaire's vital infrastructure, urban area, economic assets, and population lay in the relatively low-lying coastal area (KNMI, 2021). This makes Bonaire especially vulnerable to floods and storm surges. As KI-5 (March 21st, 2022) states: "*Most important buildings are located along the shore. With flood events, maybe they are not entirely underwater, but it will at least be difficult to reach these buildings"*. Furthermore, the IPCC states with high confidence that from 2050 onwards the "frequency, extent, duration, and consequences of coastal flooding will significantly increase" (IPCC, 2021, p. 4). The bad shape of Bonaire's ecosystems that could protect the island from inundation, enlarges the risk (e.g.,

KI-1, March 19th, 2022). All interviewed key informants state that Bonaire and her citizens are not well prepared for this. For example, a tsunami risk analysis or measures to protect the low-lying areas are entirely missing (KI-5, March 22nd, 2022). Altogether, since both expected exposure and sensitivity to inundation are high, this is one of the main climate change vulnerabilities imposing Bonaire.

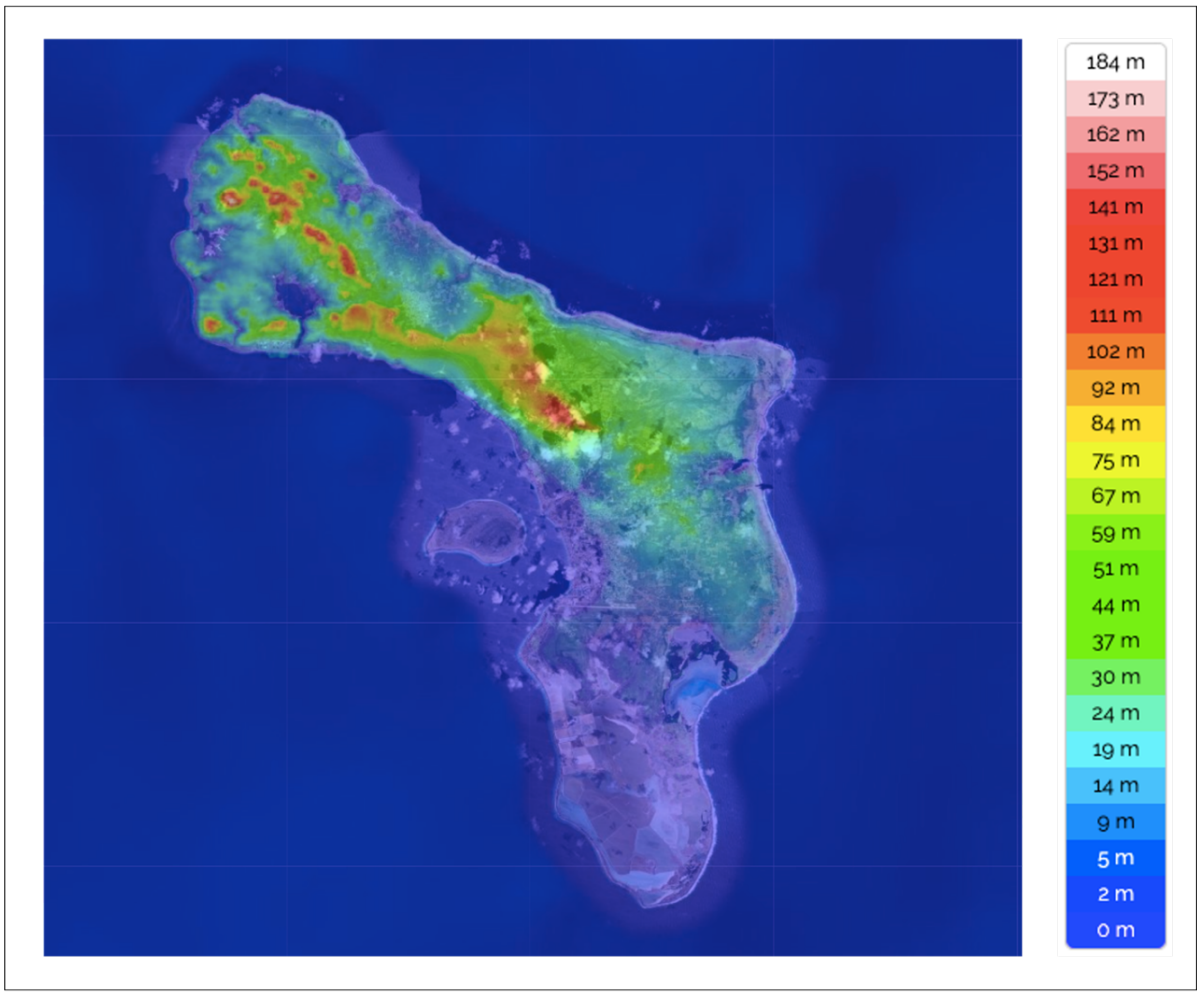


Figure 12. Elevation map of Bonaire. Adapted from Topographic-Map (n.d.). Bonaire. Retrieved on June 28th, 2022, from https://en-gb.topographic-map.com/maps/lp7g/Bonaire/

5.2.3. Extreme weather

As was described in section 5.1. many of the key-informants mentioned changes in drought and precipitation patterns already changing. Furthermore, an increase in the frequency, magnitude, durations, and extent of droughts is expected for Caribbean SIs (IPCC, 2019). For the Southern Caribbean – including Bonaire – the IPCC predicts a decrease in the average amount of rainfall and a lengthening of the dry season (IPCC, 2007). These patterns were already confirmed by some key-informants: many mentioned that it has been dryer in the last years and that the dry

seasons have been lasting longer. KI-7 (March 28th, 2022) mentioned that after the intense droughts in the period from 2015 to 2018, the last few years have known above-average amounts of rainfall. Among others, KI-8 (March 29th, 2022) mentioned that rain and dry seasons appear to be shifting.

Changes in precipitation patterns, in combination with increasing air temperatures, are expected to impose freshwater stress on SIs in the Caribbean (KI-1, March 19th, 2022; IPCC, 2021). Both these changes cause an increase in the frequency and intensity of droughts. Bonaire is, due to its location, very sensitive to increases in extreme weather (Brienne et al., 2019). Although data on precipitation on Bonaire is limited, it does show that both the years in which there is less rainfall and the decline in rainfall have grown (Verweij et al., 2017).

Although drought periods can be devastating on their own, multiple studies have shown that their impacts become more drastic in combination with other extreme weather events like storms and hurricanes (Rhiney, 2015). Also, long periods of droughts followed by sudden extreme rainfall can have disastrous effects like landslides (IPCC, 2007). Since the IPCC (2022) also expects an increase in the frequency and intensity of heavy participation on the Caribbean SIs, this imposes another vulnerability for Bonaire. Due to the fast growth of construction activities – both buildings and roads – in combination with the lack of inclusion of local knowledge in this process, cause an increase in the run-off of rainwater (KI-10 March 29th, 2022). This lowers the buffer of water in the ground and may cause dangerous landslides. Through both the interviews and the policy review no specific action for protecting Bonaire and its citizens from extreme weather could be recognized. Since both expected exposure and sensitivity to extreme weather are high, this is perceived as another main climate change vulnerabilities – a climate change stress – for Bonaire.

5.3. Impacts of Climate Change and Related Vulnerabilities on Bonaire

The following section will discuss how the main climate change vulnerabilities discussed in the previous section impact Bonaire and its citizens. These impacts are divided into those on natural systems (Box C in Figure 11) and socio-economic systems (Box D in Figure 11). The negative impacts on natural systems may also negatively affect socio-economic systems (IPCC, 2021). The opposite may also occur; when socio-economic systems are being threatened, people might further adversely affect natural systems (e.g., KI-6, March 25th, 2022). This explains the mutual

negative relation between the two systems visible in Figure 11. Furthermore, the impact of climate change and related vulnerabilities are expected to increase all existing challenges (as described in Section 4.5), including the structural problem of poverty (e.g., KI-11, March 30th, 2022). Since this thesis focuses on socio-economic systems, impacts on Bonaire's natural system will be discussed in less detail.

5.3.1. Natural system

As was mentioned in Section 4.5., Bonaire's natural systems are already in bad shape and climate change and related vulnerabilities only exacerbate this state (e.g., KI-2, March 20th, 2022; Debrot, Henkens, & Verweij, 2017). Following the division used by the IPCC (2014), this section will discuss the impacts of climate change (vulnerabilities) on natural systems.

5.3.1.1. Freshwater resources.

For Bonaire – and many of the other Caribbean islands – freshwater is a limited resource, even in the best conditions (DCNA, 2020). With the expected increases in the frequency, magnitude, durations, and extent of droughts and increases in temperature (IPCC, 2019), freshwater is becoming even more limited. The intrusion of seawater through sea level rise and storm surges imposes even more stress on freshwater resources, due to salinification (e.g., KI-8, March 28th, 2022). Freshwater resources serve as (nesting) habitats and resources for many plant and animal species and limited freshwater resources threaten these species (KI-6, March 25th, 2022).

5.3.1.2. Coastal and marine ecosystems

Bonaire's coastal and marine ecosystems provide crucial habitats for many marine species and protect the island from physical damage through, for example, climate change vulnerabilities (e.g., KI-6, March 25th, 2022). Ironically, these vulnerabilities impose extensive negative impacts on these ecosystems. For example, Bonaire's coral reefs have been and will further deteriorate due to climate changes (KI-8, March 28th, 2022) like ocean acidification and increases in water temperature (Steneck & Wilson, 2017). Mangroves and seagrass meadows are also negatively impacted by climate change (Simpson, Scott, & Trotz, 2011; Brodie & N'Yeurt, 2018). Additionally, storms, hurricanes, and floods may harm or destroy coral, mangroves, and seagrass (Debrot et al., 2017). However, all three of these provide a "variety of ecosystem services that are important to island communities" (IPCC, 2021, p. 4), among which the provision of a buffer between coastal waters and terrestrial environments, thus limiting

erosion and protecting against storms and surges (Frieler et al, 2013). Therefore, the destruction of these maintains a vicious circle.

Another example of the negative impact of climate change on marine ecosystems is the observed and expected increase in algal blooms (IUCN, 2017). On Bonaire, especially sargassum is growing fast. Big amounts of this macroalgae wash ashore daily and create hostile coastal environments – it outcompetes coral and creates conditions that are unsuitable for Bonaire's marine life. Furthermore, it releases toxins that can be a threat to small animals and can bioaccumulate up the food chain, threatening bigger animals (DCNA, 2020). One KI-1 (March 20th, 2022) referred to sargassum as the 'silent killer'. The influxes of sargassum require human intervention to have it removed (Buiter, 2022).

5.3.1.3. Terrestrial environments

Climate change vulnerabilities pose a significant threat to the terrestrial environments of Bonaire (e.g., DCNA, 2020). Floods and increased wave action cause beach erosion (e.g., Debrot et al., 2017) which is exacerbated by the loss of protective services from coral and mangroves. Furthermore, droughts, storms and hurricanes cause terrestrial erosion and surface runoff (KI-10, March 29th, 2022; Debrot, 2010), which is enforced by past deforestation, overgrazing, and urbanization (e.g., Koster, 2013). This has many negative effects such as a degradation of foundation from houses (KI-13, April 2nd, 2022), a decrease in nutrients for plants, and a decrease in the ocean's water quality (Debrot & Bugter, 2010). Healthy vegetation retains fresh water and holds soil and therefore plays a role in preventing this erosion (Debrot et al., 2017). Unfortunately, increases in temperature and droughts will affect the health of vegetation on Bonaire and thus increase erosion and soil runoffs (e.g., Debrot et al., 2017). All these impacts on Bonaire's natural systems put extra pressure on Bonairean species, which are endemic or already at risk of becoming extinct (IPCC, 2021) and decrease biodiversity (e.g., Pörtner, et al., 2021).

5.3.2. Socio-economic systems

Next to the impact on natural systems, climate change and the vulnerabilities it imposes on Bonaire also affects the island's socio-economic systems. This section will briefly describe these impacts.

5.3.2.1. Health

Possibly the most direct effect of climate change vulnerabilities on households is the casualties and injuries it can cause (e.g., Annalistennetwerk Nationale Veiligheid, 2020). Psychological distress is also often experienced after exposure to great natural hazards (Schultz et al., 2019). Furthermore, climate change impacts human health through an increase in the occurrence of infectious diseases, foodborne infections, and animal infections (EPA, 2014). For example, on Bonaire mosquitos can carry vector-borne diseases like Dengue, Chikungunya, and Zika. A warmer and more humid climate offers perfect conditions for mosquito populations (Debrot et al., 2017), which can thus cause a boom in these diseases. Increases in air temperature can also lead to a rise in respiratory and cardiovascular diseases, which may be worsened by the increase of pollutants and aeroallergens caused by climate change (WHO, 2018). KI-1 (March 18th, 2022) also mentioned that Bonaireans suffer from dust caused by aridity. Lastly, limited freshwater resources may cause hygiene and sanitation issues – which in its place can cause health risks and communicable diseases (IPCC, 2014a).

5.3.2.2. Economy and household incomes

The main climate change vulnerabilities will negatively affect the Bonairean economy in general and the tourism, fishery, and agriculture sectors specifically (e.g., KI-3, March 21st, 2022; KI-7, March 28th, 2022). First, tourism is expected to decrease. Increases in temperature and decreases in precipitation decrease tourism demand (ECLAC, 2011). Degradation of coastal and marine ecosystems – both significant drivers for tourism (Maning, 2016) – has the same effect. For example, 70% of Bonaire's tourists visit to dive (Dutch Ministries of LNV, I&W, and BZK, 2020) and only 20% of them are willing to return if the coral reefs are affected (Uyarra et al., 2005). Furthermore, the increasing chances of floods, storm surges, extreme droughts, storms, and hurricanes may cause tourism to decrease (e.g., KI-4, March 21st, 2022). To illustrate: tourism in the SSS-islands has been steadily decreasing since Hurricane Irma hit in 2017 (Buiren & van Ernst, 2019). Also, most of the infrastructure and housing – including resorts – used by tourists on Bonaire are located in low-lying areas and near the coast (KI-5, March 21st, 2022). This means they are extremely vulnerable to SLR, inundations, storms, and hurricanes. If tourists feel at risk when on holiday, or when there is no place for them to stay, tourists might be less inclined to visit Bonaire (KI-12, March 30th, 2022). The impact of climate change is not considered in the creation of policy around tourism by the local government (KI-13, April 2nd, 2022).

Secondly, the fishing industry already is, and will further be affected by climate change (e.g., KI-2, March 20th, 2022). The overall marine ecosystem and fish species distribution and migration patterns of underwater life specifically are impacted by climate change vulnerabilities (IPCC, 2014). Groups of fishers have already noticed these migration patterns changing (KI-2, March 20th, 2022). This harms fisheries, especially those in low latitudes – like the ones in Bonaire. Altogether this can cause decreasing numbers or a total collapse of commercial fish species (e.g., Bari & Cochrane, 2011). Furthermore, fishing boats are vulnerable to SLR and storms. This can affect food availability since fish is an important part of local diets. Furthermore, it will impact the Bonairean economy since multiple fishermen depend on fisheries to make a living. Also, fishing is a big part of the Bonairean culture, and part of its cultural heritage might therefore get lost (KI-2, March 20th, 2022).

Thirdly, the agricultural sector will be affected (e.g., KI-3, March 21st, 2022). Although currently, commercial agriculture is not big in Bonaire, there are multiple (government) plans aimed at enforcing it. According to KI-5 (March 22nd, 2022), these initiatives do not (sufficiently) take climate change into account. Furthermore, many local people cultivate crops on their kunuku's. Increases in temperatures, droughts, erosion, and salinification of groundwater, and decreases in land and water for watering crops negatively impact agriculture (KI-3 and KI-4, March 21st, 2022). Furthermore, Reyer and colleagues (2017) suggest that agricultural areas are one of the Caribbean areas most affected by hurricanes.

The impacts on these three sectors significantly influence the Bonairean economy and the many people and households depending on incomes or revenues from them (e.g., KI-9, March 29th, 2022). In the absence of economic alternatives, this may increase unemployment, poverty, criminality, uncontrolled migration, and social unrest (van Buiren, Gerritsen, & Ernst, 2020). In turn, this can scare tourism – creating a downward spiral – and can create increased tension on government structures (AIV, 2020). Furthermore, climate change has extensive impacts on the economy in general. The average annual GDP in Caribbean SIs is expected to decrease by 5% by 2025 due to climate change – compared to .5% globally (Thomas, Baptiste, Martyr-Koller, Pringle, & Rhiney, 2020). For the Caribbean SIs, this escalates to 20% by 2100. Additionally, climate change impacts erode fiscal cushions (Ötker & Srinivasan, 2018). Also, climate change vulnerabilities can seriously affect the economy due to related costs (e.g., Analistennetwerk Nationale Veiligheid, 2020). For example, annual hurricane costs range between 11 to 17% of the current GDP of Caribbean islands (Reyer, 2015, reference year:

2015). Additionally, the (financial) resources of a household may also be affected due to climate change shocks. For example, household savings may be depleted when a house needs to be rebuilt after being damaged by flooding.

5.3.2.3. Food and water availability

The negative impacts on the fishing and agriculture industry do not only affect the economy but can also cause problems with food supplies and thus affect food availability (e.g., KI-11, March 30th, 2022). Food scarcity will very likely become more acute (IPCC, 2021). According to the Planetary Security Initiative (2019), this may increase competition over space and resources. Furthermore, when a sudden onset climate change shock reaches Bonaire – and creates a crisis - food availability may drop. Also, the fact that Bonaire is highly dependent on food imports, makes the island vulnerable to disruptions in the food chain (FAO, 2020). So, even when Bonaire is not directly hit by such a shock, but neighbouring territories are, food availability might decrease (KI-5, March 22nd, 2022). The same problem occurs when a climate change shock damages the (air)port.

Climate change vulnerabilities may also decrease water availability for people and flora and fauna. For example, alterations in precipitation patterns may cause freshwater stress on Bonaire (KI-6, March 25th, 2022). Bonaire creates its drinking water by converting ocean water through reverse osmosis (WEB, n.d.). This makes the island less vulnerable to scarcity of drinking water. However, parts of the population are dependent on rainwater that is being collected in cisterns (Annalistennetwerk Nationale Veiligheid, 2020). KI-10 (March 29th, 2022) mentioned that droughts can threaten water collection and distribution through this process. Also, SLR and ocean acidification causes saltwater intrusion (Schmutz et al., 2017). This impacts soil but can also impact the water in cisterns.

5.3.2.4. Buildings and vital infrastructure

Climate change vulnerabilities can also damage Bonaire's vital infrastructure, which may further affect the socio-economic systems of the island. Vital infrastructure includes the processes that are so essential to society that failure or disruption would result in serious social disturbance and pose a threat to national security (Analistennetwerk Nationale Veiligheid, 2019). Examples of such infrastructure in Bonaire are roads, electricity grids, telecommunication, water supply networks, sewers, and the (air)port. All forms of Bonaire's vital infrastructure are vulnerable to climate change vulnerabilities like inundation and storms

(e.g., KI-7, March 28th, 2022). The outdated – in some cases neglected – state of some increases their vulnerability (KI-3, March 21st, 2022; Planet Security Initiative, 2018). Furthermore, disruption of one form of vital infrastructure may cause disruption of others which enlarges the impact on society (Annalistennetwerk Nationale Veiligheid, 2020). For example, due to its location near the coast and deferred maintenance, the island's oil terminal is vulnerable to climate change vulnerabilities. Since it is this oil that is mainly used to generate electricity, this makes the electricity network even more vulnerable to climate change shocks. Subsequently, electricity is necessary for Bonaire's water supply reverse osmosis needs electricity (WEB, n.d.). Furthermore, when roads are impacted, parts of the island can become unusable or inaccessible, impacting the livelihoods of the community (Analistennetwerk Nationale Veiligheid, 2019). Also, during crises it can cause ambulances and fire trucks to not reach people in time (KI-4, March 21st, 2022).

Climate change vulnerabilities like storms and hurricanes may also severely damage buildings that are important for households on Bonaire. Furthermore, flooding and storm surges, in combination with the deteriorating coastal stability caused by erosion, will likely damage or destroy buildings along the coastline and other low-lying areas (e.g., IPCC, 2014). Buildings in these areas include resorts and houses, buildings that are parts of cultural heritage, and the hospital, police station, and some schools and day-cares (KI-9, March 29th, 2022). Next to the risk of damage, these places may become poorly accessible. Workplaces may also be affected. Many of these buildings cannot withstand floods and storms – partly due to the backlog of renovation of these buildings (Brienne et al., 2019). Partly due to bad urban planning, Bonaire's urban area is not prepared for these described impacts (KI-10, March 29th, 2022). These impacts can pose a significant threat to the livelihoods of Bonaireans and can cause major disruptions in society through, amongst others, financial damage, people losing their homes, jobs, and access to education (Planetary Security Initiative, UN, 2018). A Key-informant in a high government position stated that only few people are insured against damage caused by climate change (vulnerabilities).

5.4. Current Climate Change Policies and Initiatives

As described in the previous sections, climate change and related vulnerabilities are expected to increase. To study how to increase climate resilience, it is important to understand what

action to it is currently taken, how the topic is perceived on the island and who are the main actors operating in this field. This section describes this information.

None of the known government policy documents for Bonaire, like the 2018-2022 governance agreement (Rijksdienst Caribisch Nederland, 2018) and the Policy plan Nature and Environment [translated from Dutch] (Dutch Ministries of LNV, I&W, and BZK, 2020), mention specific action towards climate or climate resilience. Also, initiatives on increasing climate resilience on Bonaire are, as far as known, non-existent (e.g., KI-7, March 28th, 2022). These findings are confirmed by Debrot and collegues' (2018) conclusion that the effects and future effects of climate change are very unfavourable for the Dutch Caribbean due to the lack of an effective strategy for facing climate change-related threats.

The IPCC (2021) states that for SIs constraints in government arrangements, financial resources, and human resource capacity are often the main barriers to the implementation of climate change responses. This seems to be the case for Bonaire as well. The difficult relationship between the Dutch and local governments, as described in Chapter 4, is one of those barriers. Due to Bonaire being a part of the Netherlands, its access to bilateral and multilateral aid and grants is significantly reduced (van Buiren et al., 2020). Also, it cannot be a part of certain regional partnerships, such as the Small Island Development States (SIDS), while regional cooperation can contribute to policymaking and overcoming common challenges (e.g., Fuller et al., 2020). Bonaire does however qualify for European funds and EU-wide cooperation agreements but as far as known, no use of these have been made (KI-3, March 21st, 2022). Furthermore, the Dutch government oversees achieving climate goals like the SDGs which are also applicable on Bonaire since 10/10/10. However, Bonaire is not part of the Paris climate agreement and resulting European emission reductions. Therefore, action and information on, for example, CO2 emissions are lacking (Brienne et al., 2019). Many Key-informants conclude that the Dutch government is not fulfilling its role in helping Bonaire become prepared for climate change.

On the other hand, the Bonairean government has the task of prioritising action and creating policy and implementation plans which can subsequently be realised with the support of the Dutch government. However, as mentioned, the Bonairean government is not planning any action toward climate change (resilience) nor includes it in other policies. One reason for this, is that many citizens, policymakers, and governors experience other challenges, like poverty,

education, and housing, as more pressing (e.g., KI-8, March 28th, 2022). Therefore, action is mostly focused on these issues. Also, as KI-2 (March 20th, 2022) states: "*There is a fear among local politicians that if the Dutch government provides money for climate action (or proposes to do so), Bonaireans will react with indignation because they feel there are more important problems for which no or less money is given*" [Translated from Dutch]. Furthermore, the Bonairean government experiences a big human capacity problem (KI-3, March 21st, 2022).

Furthermore, KI-4 (March 21st, 2022) mentioned that there is a "problem with awareness". All participants stated that awareness of what climate change is, its impacts, or what can be done to become more climate resilient, is very low amongst the Bonairean population. Education or information campaigns aimed at the topic are non-existent. Also, the average Bonairean does not feel empowered to act on climate change (KI-5, March 22nd, 2022). As KI-12 (March 30th, 2022) concluded: "*If people do not understand the topic, they cannot have a voice in it either. This causes them to be mad when certain climate policy restricts them or when money is invested in action on this [climate change adaptation/resilience] and they do not understand why this is important".* Additionally, the idea that climate change is a problem of the future prevails for many people, including policymakers and governors on the island (e.g., KI-4, March 21st, 2022), leading to policy prioritising other problems, hiding the fact that climate change (vulnerabilities) contributes to worsening these problems (Fuller et al., 2020). In conclusion, it is difficult to know who has the span of control and the budget to deal with these issues and no one seems to take responsibility (KI-13, April 2nd, 2022). When asking Key-informants who should be responsible, both the Dutch and local governments are mentioned.

5.5. Household Resilience to Climate Change Vulnerabilities

This section describes the justification of the indicators selected to measure household climate resilience based on the earlier described climate change vulnerabilities and related impacts and thereby attempts to answer sub-research question 1c. This Section is thus also part of the analytical process. The 21 selected indicators cover the different manifestations of household resilience as described in Figure 4. The selection of these indicators has proceeded through the methods described in Chapter 3 and is the result of key-informant interviews and extensive desk research. Some indicators that are often included in household (climate) resiliency frameworks were not selected due to them not being relevant to the context of Bonaire. An example of such an indicator is the material of housing since in Bonaire almost all houses are built from bricks.

The indicators are divided into the four components of HCR as described in Chapter 2 and visible in Figure 5. An overall visualization of the selected indicators can be found in Figure 13.

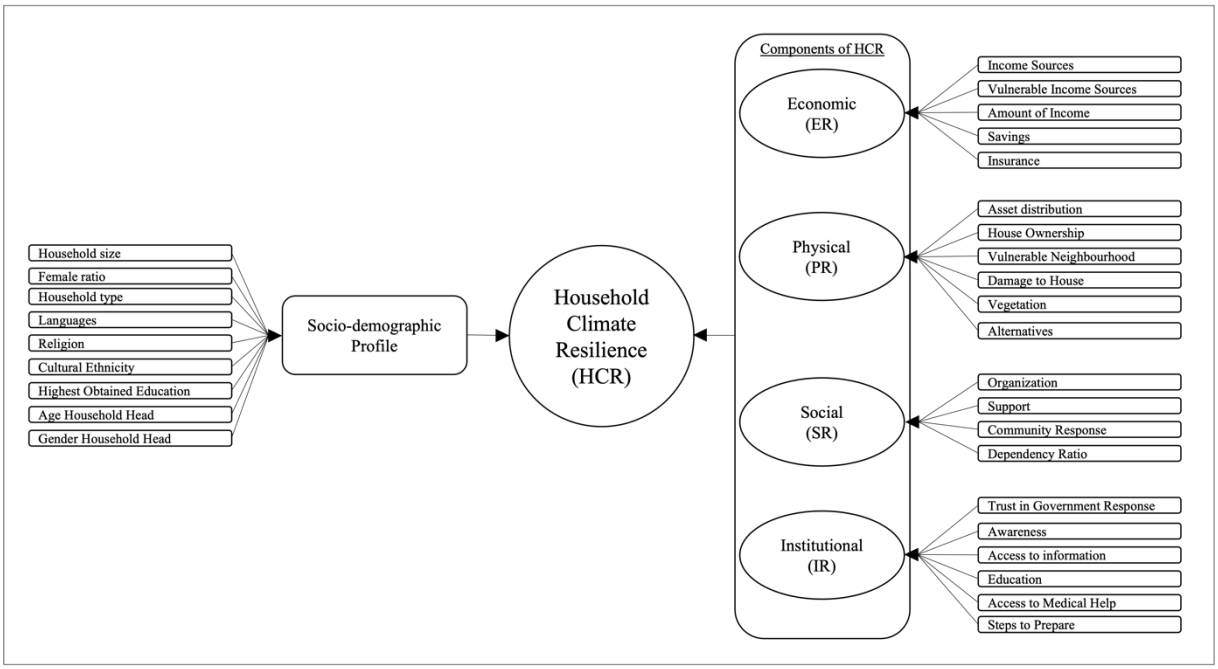


Figure 13. Visualization of selected components for measuring household climate resilience.

5.5.1. Economic Resilience (ER) indicators

Five indicators were selected for the ER component. The first selected indicator is 'Income sources' – referring to a household's amount of income sources. As Choptiany, Graub, Philips, Colozza, & Dixon (2015) describe it, the more sources of income a household has, the less dependent it is on one source of income, which makes the household more resilient in the case one source is lost. This is supported by, for example, the conclusion of Qasim et al. (2016) that households with a secondary income source are less vulnerable to floods and cyclones. Since, as described in Section 4.4.2.2., incomes in Bonaire that are dependent on either tourism, fishery, or agriculture are vulnerable to climate change and climate change vulnerabilities, the second selected indicator is 'Vulnerable income sources'. This refers to the number of income sources that are dependent on any of these vulnerable sectors. The third selected indicator is 'Amount of income' since poorer households are less resilient to climate change and related vulnerabilities (Lo, Xu, Chan, & Su, 2016). Furthermore, poverty is seen as a threat multiplier when households are faced with climate change-driven phenomena (Olsson, Tschakert, Agrawal, & Opondo, 2014). As Al-Maruf, Jenkins, Bernzen, and Braun (2021, p.3) sum up: "The higher the household income, the lower the risk of losing the basis of the household's

livelihood during a crisis and having savings that tide people through a bad period". Furthermore, since savings decrease the chances of losing the base of a household's livelihood during a crisis, like a climate change shock (Al-Maruf, Jenkins, Bernzen, & Braun, 2021), having savings is considered a factor increasing HCR. Therefore, 'Savings' was also selected as an indicator. Lastly, house and household content insurance are considered important risk mitigation tools, which serve as economic back-ups for a wide range of possible shocks, including climate change shocks (Naidoo & Motsomi, 2016). Thus, 'Insurance' referring to whether a household is insured to damage from climate change (vulnerabilities) was also selected as a variable.

5.5.2. Physical Resilience (PR) indicators

Six indicators were selected for the PR-component. Since a household's climate resilience may be enhanced when the household (or one of its members) has assets in other locations than Bonaire (Vinck et al., 2020), the indicator 'Asset distribution' was selected. Furthermore, owning a house is considered a factor that decreases vulnerability to (climate change) shocks and thus increases HCR (Shah, Dulal, Johnson, & Baptiste, 2013; Henly-Shepard et al., 2015; Cutter, Boruff, & Shirley, 2003). This might especially be the case for Bonaire since most of the houses that are being rented are in bad shape and more expensive (KI-7, March 28th, 2022). Thus, 'House ownership' was considered. The same applies to the indicator 'Vulnerable neighbourhood' – referring to whether a household is located in a neighbourhood that is vulnerable to climate change vulnerabilities. As was previously mentioned, the Southern part of Bonaire and the coastal areas are vulnerable to flooding and all coastal areas are more vulnerable to tsunamis. Therefore, households located in these areas are considered more vulnerable and thus less resilient. Furthermore, secure housing is important for surviving the forces of climate change shocks and serves as a place to stay during recovery (e.g., Al-Maruf et al., 2021). Also, damage to housing may put (financial) pressure on a household. Therefore, a house that can survive climate change shocks increases a household's climate resilience, thus 'Damage to house' – referring to the extent a house can do so – is considered. The fifth selected indicator is 'Vegetation' – referring to the amount of vegetation around a household's house – since this helps retain topsoil and therefore helps with preventing damage due to landslides, increases soil fertility, and helps with retaining water (e.g., IPCC, 2022). Lastly, 'Alternatives to electricity, water, and food supplies' – referring to whether a household has alternative access to these resources in case regular supply is inaccessible – is selected. The availability of

electricity is often included as one of the factors that are crucial in protecting life and property after the occurrence of climate change shocks (e.g., Hossain, 2015) and in responding, absorbing, and recovering more easily from climate change shocks and stresses (Joerin et al., 2014). As mentioned, Bonaire's electricity network is very vulnerable, especially to the impact of climate change vulnerabilities. Also, as mentioned by multiple key-informants, its energy security in crisis events is not properly regulated. Therefore, households are more resilient when they have an alternative way of generating electricity. The availability of water is also crucial in protecting life and property after a climate change shock (e.g., Hossain, 2015). Since drinking water may be inaccessible after the occurrence of a climate change vulnerability, households are more resilient to climate change vulnerabilities if they have access to alternative forms of drinking water. Lastly, access to food is often mentioned as one of the key elements of the physical resilience of households (e.g., Asmamaw et al., 2019). Therefore, when food in supermarkets is not available to households because of, for example, roadblocks, damage, or lootings due to climate change shocks, a household is more resilient when it has access to alternative supplies of food.

5.5.3. Social Resilience (SR) indicators

Four indicators were selected for the SR component. The first one is 'Organization', referring to households' membership in community groups, which is suggested to increase household resilience (e.g., Aldrich & Meyer, 2015). Vinck et al. (2020) found that in the Philippines, membership in a community organization was the biggest predictor of preparedness for climate change vulnerabilities. They explain this by the fact that "when households engage in a community group, they not only build social capital but can also gain access to resources and services they may not otherwise have had" (Vinck et al., 2020, p. 36). Furthermore, Lo et al. (2016, p. 5) state that "weak engagement in the community, including residential committees and other organisations, is related to a lower capacity to cope with the economic consequences of extreme weather events". Secondly, 'Support system' referring to the expected support from neighbours, family, and friends is considered since this has shown to be an important indicator for household resilience in the face of (climate change) shocks (e.g., Quandt, 2018). Furthermore, community disaster preparedness has proven to have a positive effect on household resilience, especially if a household is aware of and confident in this plan (e.g., Vinck et al., 2020). Therefore, 'Community response' – referring to a household's extent of trust in the community response after a shock – is included. Lastly, the 'Dependency ratio' – referring

to the number of household members with an age under 15 or over 65 and/ or a disability or chronic disease relative to the household size – was included. The reason for this is that these persons can hinder the mobility process during emergencies (Hamidi, Zhen, Khan, 2020; Qasim et al., 2018). Furthermore, they are likely to be less able to contribute to the recovery and transformation of the household (Cutter, Burton, & Enrich, 2010). Since it is quite common for Bonairean households to take in older and/ or disabled or sick family members and to have multiple children, this variable seems of importance.

5.5.4. Institutional Resilience (IR) indicators

Six indicators were selected for the IR component. Firstly, 'Trust in government response to climate change vulnerabilities' was selected since the chance that people take action to protect themselves is higher when they trust government sources (Paton & Johnston, 2006). Furthermore, households' perceptions of the quality of local government support have proven to be indicative of household resilience in the case of crisis (Paton, Sagala, Okada, Lang, Bürgelt, & Gregg, 2010). The second selected indicator is 'Awareness of climate change impacts'. In most studies on HCR, knowledge or awareness of climate change and its impact is included as an indicator (e.g., Rabbi et al., 2021). Although being aware of climate change and its impacts does not automatically guarantee increased resilience, it is a crucial first step into assessing and understanding the risk of one's household and into taking steps to prepare, adapt and transform (Mercado, 2016). In addition, knowledge and agency to take steps to prepare for and adapt to the effects of climate change have positive effects on HCR (Arbon, Steenkamp, Cornell, Cusack, & Gebbie, 2016). Access to information on the topic and how to respond to it, adds to this (Thathsarani & Gunaratne, 2017). Therefore, 'Access to information regarding climate change vulnerabilities' impact and steps to prepare' was included. Furthermore, household self-organization and learning is an important indicator in many household resiliency frameworks (e.g., Al-Maruf, Jenkins, Bernzen, and Braun, 2021; Vinck et al., 2020). Examples thereof include disaster risk reduction and climate change capacity adaptation learning (Boke, 2017), received livelihood training (Rabbi et al., 2021), first aid training (Shah et al., 2018), and basic disaster-management training (Islam, Paull, Griffin, & Murshed, 2021). Thus, the indicator 'education', referring to the amount of such education household members had – was selected. Since, in case of (climate change) shocks, access to healthcare has proven to be a key element in household resilience (e.g., Rose, 2007), 'Access to medical help' was also included. Lastly, the impact of (climate) shocks on a household's health and livelihoods is likely smaller

when the household has taken steps to protect themselves from these shocks. In this way, they also increase their capacity to recover (e.g., Vinck et al., 2020). Therefore, 'Steps to prepare' was included as an indicator.

5.5.5. Socio-demographic variables

To compare household resilience between different groups, the following socio-demographic variables were selected. Since household size was found to be a significant determinant of preparedness, recovery, and adaptation to droughts and erratic rainfall events (Oriangi, 2019) and relatively larger family sizes were found to negatively impact a household's capacity to prepare, cope, and recover from the impacts of flooding, 'household size' was included. The household's 'Female ratio' has proven to significantly affect HCR in multiple studies (e.g., Vinck et al., 2020). However, the direction of this relation is not unequivocally found and seems to be dependent on the context of the study region. Although no study including the type of household has been encountered, the variable was included since it might affect HCR. The same applies to 'languages spoken by (members of) the household'. However, since many different languages are spoken on Bonaire, and not everyone speaks the languages in which, for example, the government communicates, it can be assumed that this might influence household resilience. For example, if information about a climate shock is only provided in Papiamentu and Dutch, the Spanish-speaking community is left out. Since information can reach a household through all members (also children), it was decided to ask about all the languages fluently spoken by members in the household instead of just by the household head.

The household's dominant religion may also influence HCR in different ways. For example, Ahmad & Afzal (2018) found that almost all households in their study area considered flood hazards an act of God and were, therefore, less likely to adopt preventive measures. Since 81% of the Bonairean population is religious (CBS, 2018, reference year: 2017), this might also be applicable to Bonaire. Furthermore, cultural ethnicity may influence awareness and adaptation, and thus resilience, to climate change (e.g., Ado, Leshan, Savadogo, Bo, & Shah, 2019). Education has also shown to have a positive impact on HCR (e.g., Vinck et al., 2020; Tan, Peng, & Guo, 2020). However, most studies take the education of household heads into account. Since it is common for Bonairean households to include multiple adult members, it was decided to ask about the highest level of education among all household members, instead of just the household head. Also, multiple studies have found an effect of the age of the household head

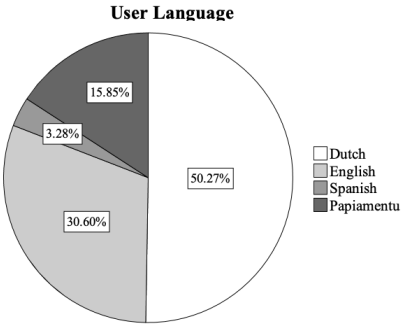
on household resilience (e.g., Jones & Samman, 2016). However, whether it affects resilience positively or negatively, seems to differ between studies. Gender of the household head was found to also influence household climate vulnerability (e.g., Lykke et al., 2016; Shah et al., 2013) and HCR (e.g., Gaisie et al., 2016). However, results from all these studies differ between male- and female-headed households.

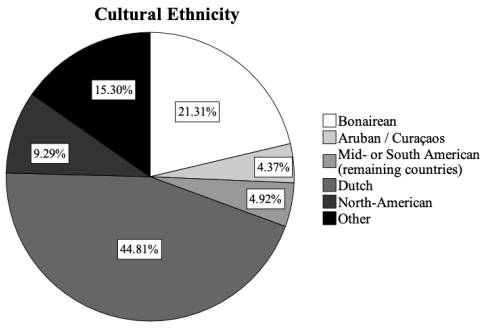
Chapter 6 – Results on Household Climate Resilience

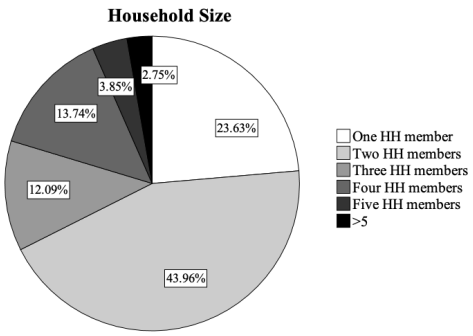
6.1. Household demographics

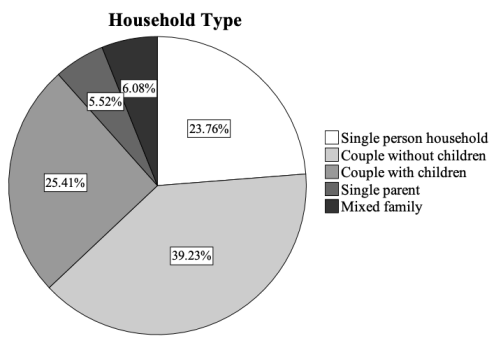
The sociodemographic variables of the study sample (N = 183) are shown in the pie charts in Figure 14. An overview of the descriptive statistics of these variables can also be found in Table G in Appendix G This section will discuss the most notable descriptive statistics to provide an overview of this study sample. Most respondents filled in the survey in either Dutch (50.3%) or English (30.6%), while only 15.8% and 3.3% used the Papiamentu and Spanish version, respectively. Furthermore, 44.8% of the households identified as Dutch, while only 21.3% of the households identified as Bonairean.

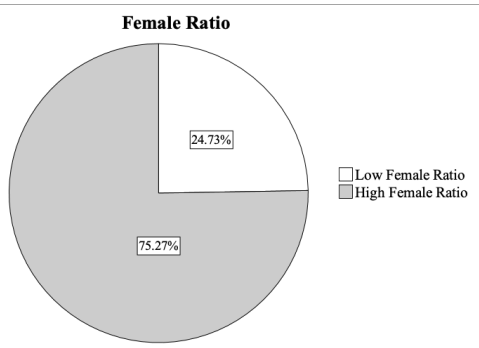
Most households were either single-person households (23.8%) or households consisting of couples without (39.2%) or with children (25.4%) children. The number of household members varied from 1 to 7, with an average of 2.39 (SD = .26) and a mode of 2. On average, the households had a kid ratio of .135 (SD = .217) – meaning 13.5% of the household members was younger than 18 years old – and 82.3% of the households had a kid ratio lower than .5 – meaning less than half of the household members were children. Furthermore, on average, the households had a female ratio of .527 (SD =.298) – meaning 52.7% of the household members was female – and 75.3% of the households had a female ratio above .5 – meaning more than half of the household members were female. 111 households had only one household head, of which 58.6% were female. The minimum and maximum age of household heads were 24 and 81, respectively, with an average of 46.8 years (SD = 14.24). Most (74.1%) household heads fall within the adult age category (30-64 years old). Only 5 (4.5%) of the household heads had a disability. Furthermore, in most households, one, two or three languages were fluently spoken by one or more members (respectively 24.6%, 28.4%, and 25.1%). Papiamentu (55.7%) and Spanish (73.8%) were not fluently spoken in most households, but Dutch (80.3%) and English (8.7%) were. Most of the households stated not to be religious (68.9%). Of those that were (31.1%), most were Roman Catholic (57.9%). Lastly, most of the households included a household member with a high obtained education level (76.0%) – meaning bachelor, master, or PhD-level – while 24.0% of the households did not – meaning the highest level of education within the household being primary, high, or trade school.

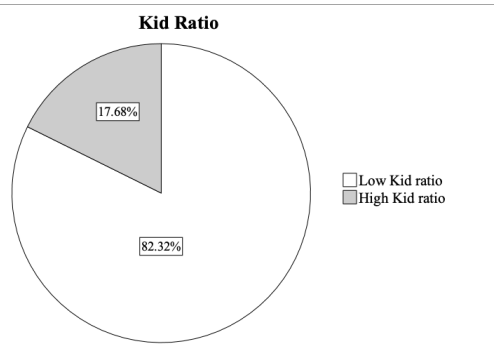

User Language
15.85%
3.28%
50.27%
30.60%
Dutch
English
Spanish
Papiamentu

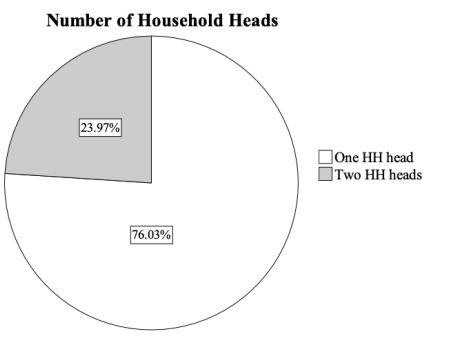

Cultural Ethnicity
15.30%
21.31%
9.29%
4.37%
4.92%
44.81%
Bonairean
Aruban / Curaçaos
Mid- or South American (remaining countries)
Dutch
North-American
Other

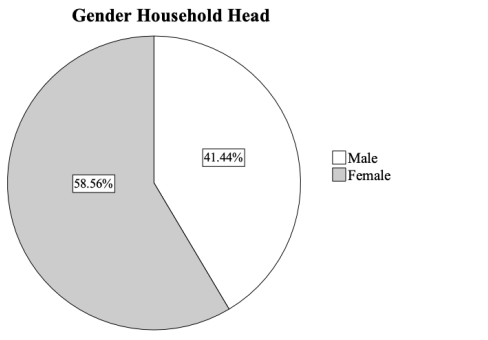

Household Size
2.75%
3.85%
13.74%
23.63%
12.09%
43.96%
One HH member
Two HH members
Three HH members
Four HH members
Five HH members
>5

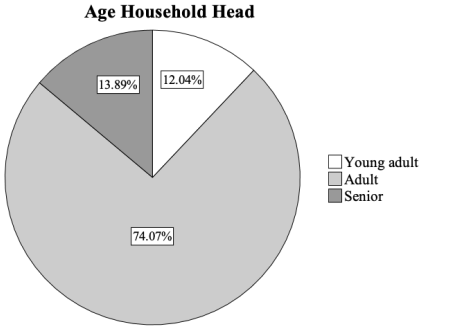

Household Type
6.08%
5.52%
23.76%
25.41%
39.23%
Single person household
Couple without children
Couple with children
Single parent
Mixed family

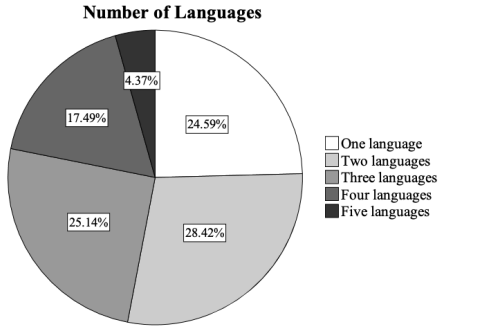

Female Ratio
24.73%
75.27%
Low Female Ratio
High Female Ratio


Kid Ratio
17.68%
82.32%
Low Kid ratio
High Kid ratio


Number of Household Heads
23.97%
76.03%
One HH head
Two HH heads


Gender Household Head
41.44%
58.56%
Male
Female


Age Household Head
13.89%
12.04%
74.07%
Young adult
Adult
Senior


Number of Languages
4.37%
17.49%
24.59%
25.14%
28.42%
One language
Two languages
Three languages
Four languages
Five languages

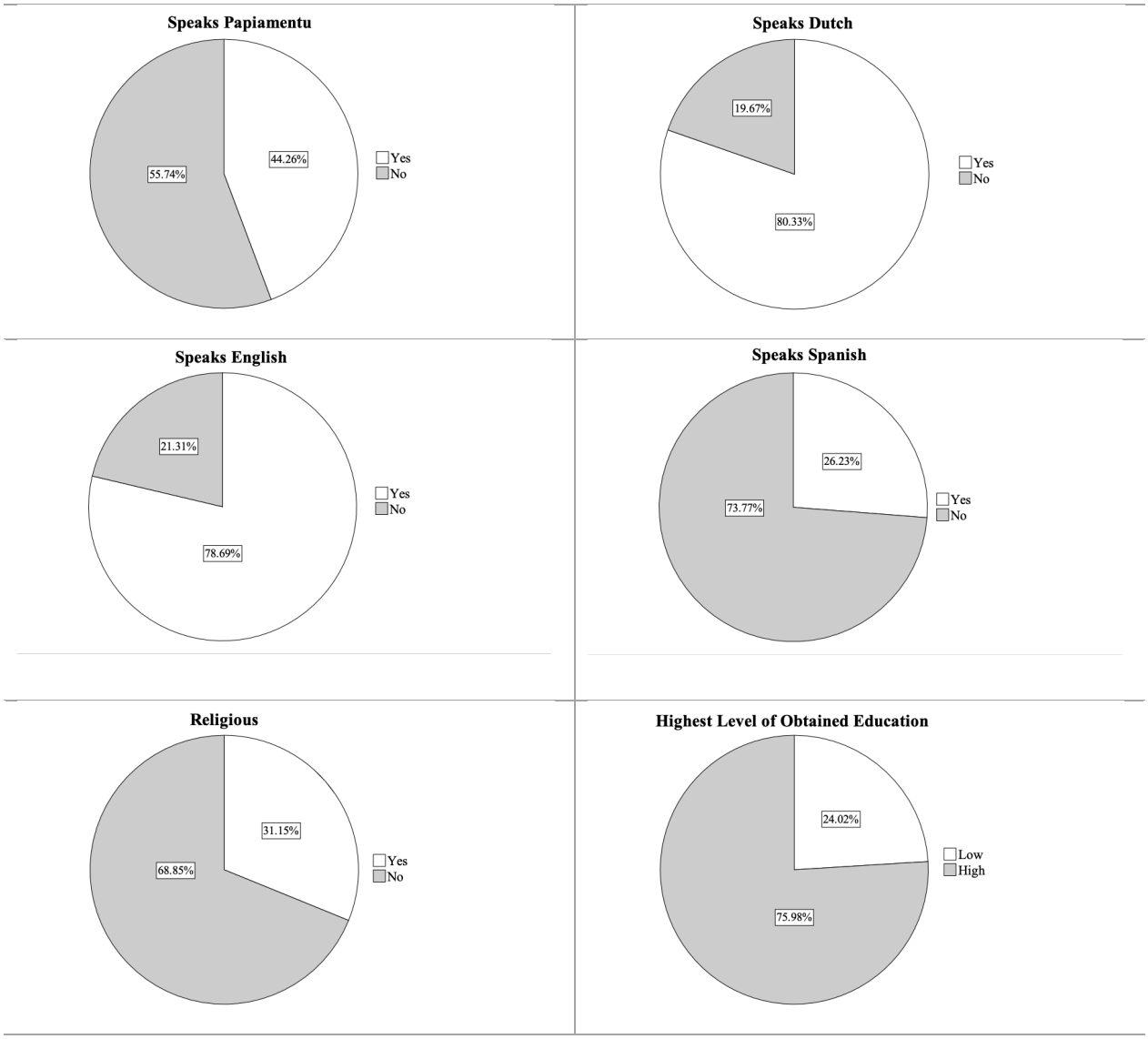


Figure 14. Pie charts showing the socio-demographics of the study sample.

6.2. Descriptive Statistics of HCRI and Components

This section will discuss the most notable descriptive statistics for the Household Climate Resilience Index (HCRI) and its components (Economic Resilience, Physical Resilience, Social Resilience, and Institutional Resilience). An overview of the descriptive statistics of related indicators can also be found in Table G2 in Appendix G. In this study, scores of these components and indicators were scaled from 0 (least resilient) to 1 (most resilient).

6.2.1. HCRI

The average of all 183 HCRI-scores was .455 (SD=.11). The minimum HCRI score was .212 – belonging to the least climate resilient household – and the maximum score was .7367 –

belonging to the most climate resilient household. The results of the Shapiro-Wilk test of normality indicated a normal distribution (p=.175). Figure 15 shows the distribution of the HCRI scores.

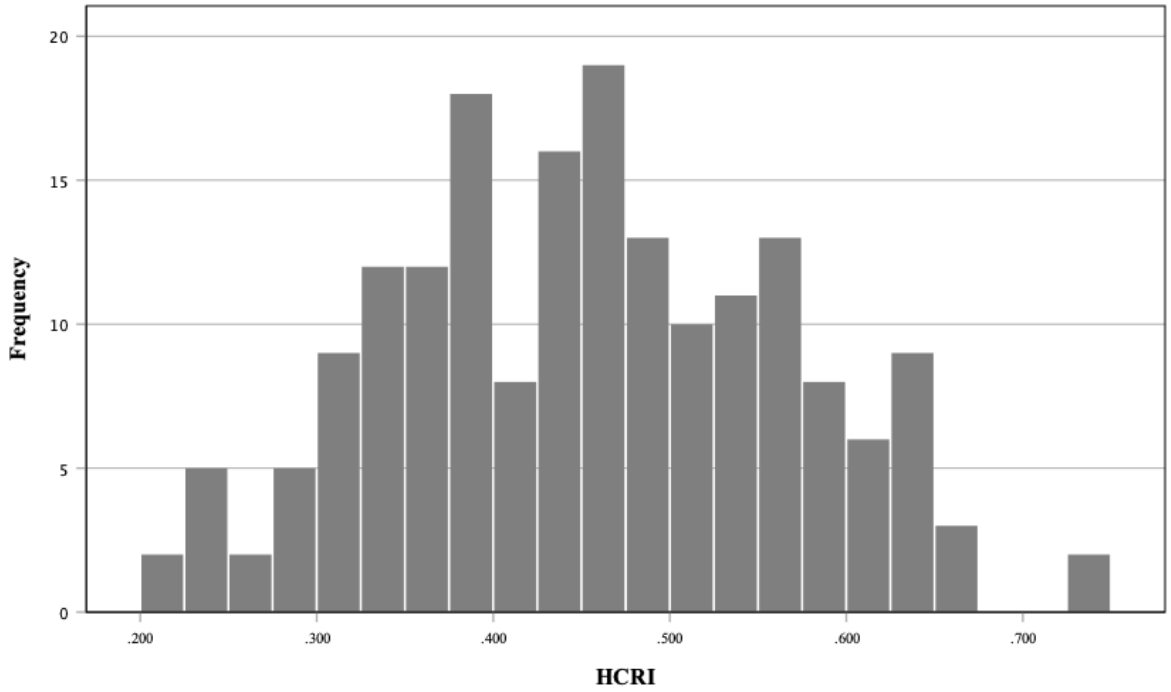


Figure 15. The distribution of HCRI scores.

6.2.2. Economic Resilience (ER)

The Economic Resilience (ER) component had a minimum and maximum score of .000 and .950, respectively, and an average score of .438 (SD=.21). The results of the Kolmogorov-Smirnov test of normality indicated a normal distribution (p = .087). The average score for the income sources ratio was .21 (SD = .13) – meaning that on average households had .21 income source per household member. The average score of the independent source's ratio was .63 (SD = .41) – meaning that on average 63% of a household's income sources were independent and 37% were dependent. Furthermore, more than half of the households (52.2%) had at least one dependent income source. Figure 16 shows the distribution of households over the income categories – as shown, 34.5% of the households fell within the 'low' or 'very low' income category. The savings of 80 households (43,7%) would insufficiently help the household recover from a climate change vulnerability. Lasty 24.6% did not know whether they are insured for damage caused by climate change and/ or natural disasters. Of the households which did know, 60.1 % were not insured in such a manner.

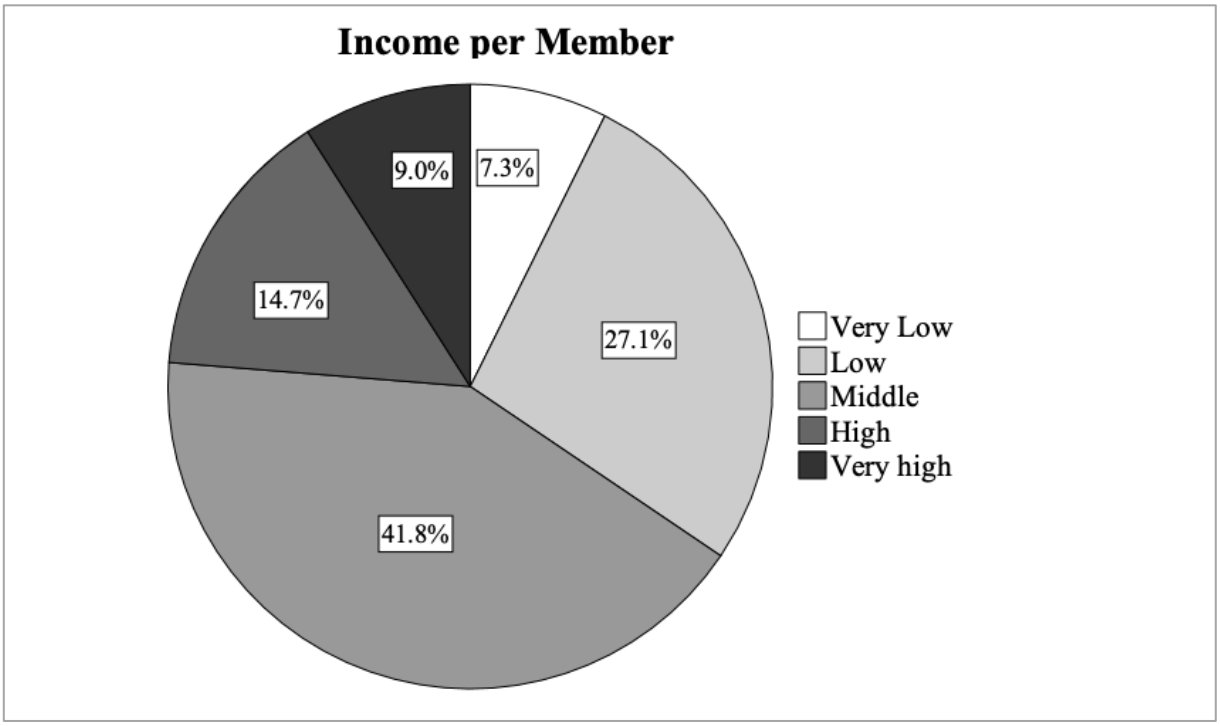


Figure 16. The distribution of households over the income categories.

6.2.3. Physical Resilience (PR)

The Physical Resilience (PR) component had a minimum score of .083 and a maximum score of .819. The average score was .420 (SD = .16). The results of the Kolmogorov-Smirnov test of normality indicated a normal distribution (p = .089). 143 households (78.1%) did not have any valuable assets in other places than Bonaire. Furthermore, 77 (42.1%) of the households did not own the house they live in. Also, 77 (43.3%) of the households lived in a neighbourhood that is highly susceptible to climate change vulnerabilities; 90 (50.6%) in one that is medium susceptible; and only 11 (6.2%) lived in one with low susceptibility. 43 (24.9%) of the households expected their houses to be totally or severely damaged by natural hazards. Also, 41 (22.4%) households stated they have no or almost no vegetation around the house they live in. Lastly, 8 households (4.4%) had alternatives to electricity, water, and food in case of need, while 90 (49.2%) had alternatives to none of these, 53 (31.1%) had alternatives to one, and 30 (16.4%) for two. Figure 17 shows the percentages of households that did and did not have alternatives for electricity, water, or food.

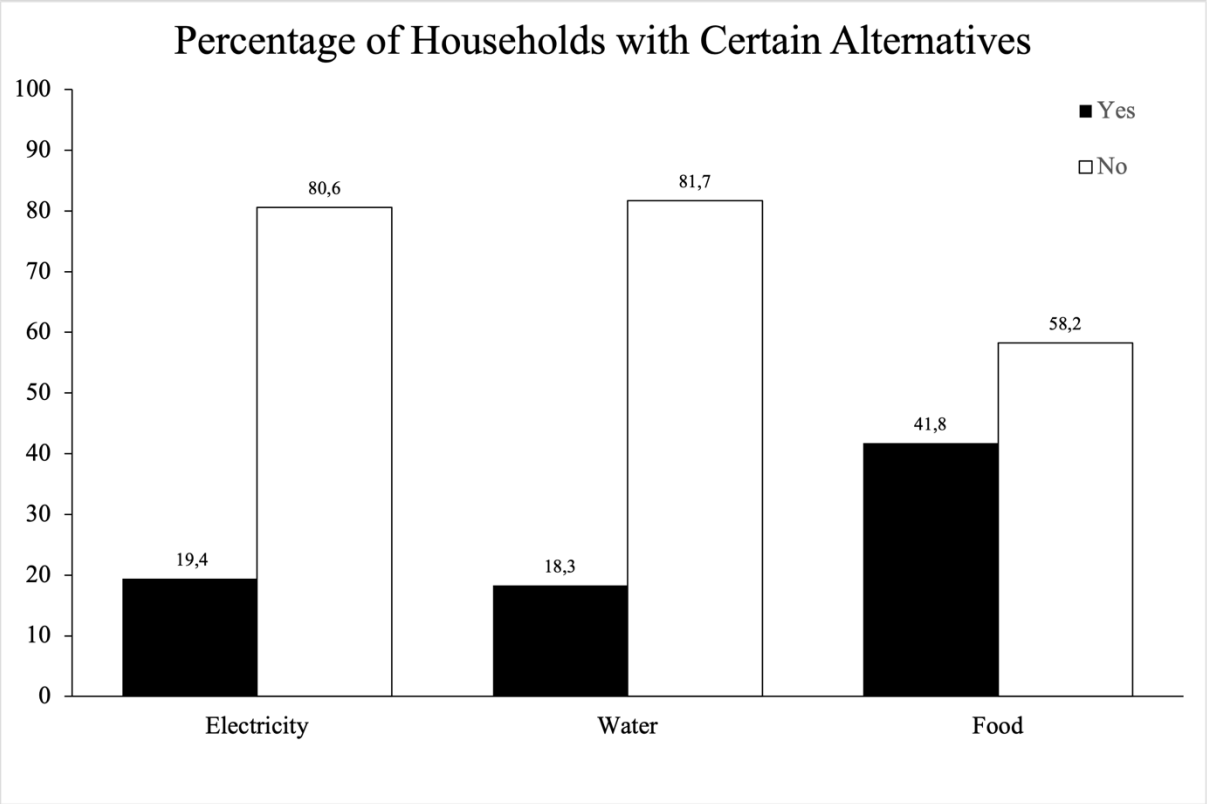


Figure 17. Percentage of households having and not having alternatives to electricity, water, and food.

6.2.4. Social Resilience (SR)

The Social Resilience (SR) component had a minimum and maximum score of .000 and .875, respectively, and an average score of .474 (SD = .19). The results of the Shapiro-Wilk test of normality indicated a normal distribution (p = .068). Of the households, 120 (65.5%) had no members that are part of a (community) organization or association. Also, 39.3% of the households expected no or little support from people near their household in case of need. Furthermore, 112 households (61.2%) stated they think their community response to natural hazards is not at all or only little effective. Lastly, the average independency ratio of households was .735 – meaning that on average 26.5% of the household members were dependent. Furthermore, 31.6% of the households had a ratio of .5 or less, meaning that 50% or more of their household members were dependent.

6.2.5. Institutional Resilience (IR)

The Institutional Resilience (IR) component had a minimum and maximum score of .055 and .820, respectively. The average score was .491 (SD = .16). The results of the Shapiro-Wilk test of normality indicated a non-normal distribution (p = .003) with a slight skew to the left (skewness = -.321). Of the households, 65.6% had no or little trust in the government's preparations for natural hazards and only 12.6% had good or full trust. Also, 13.1% of the households were not at all aware of what climate change means and how it can impact them; 21.9% had mediocre awareness. Besides, 36.1% of the households did not know where to find more information about the impact climate change and natural hazards can have on their household or information on how to prepare for it. Furthermore, 50.8% of the households received no or little education about climate change and its impacts or how to prepare for it. Most of the households (106; 59.9%) could reach medical care in between 5 to 15 minutes, 18 households could reach it in less than 5 minutes (10.2%); 36 households (20.3%) in 15-30 minutes, and 9 take longer than 30 minutes (5.1%). Lastly, 68.0% of the households had taken no or little steps to prepare for climate change and related hazards. Only 11.8% of the households took a lot of steps.

6.3. Comparing HCRI for Socio-demographic Variables

Groups within the sample have subsequently been compared regarding HCRI-scores and scores on other, possibly deviating indicators with inferential statistical techniques described in Chapter 3. Table 1 to Table 4 show the test statistics, degrees of freedom, p-values, mean differences, confidence intervals, and effect sizes of tests. For ANOVA's the results of the significant posthoc tests are also provided. For T-tests Table 1 shows results regarding HCRI-scores and Table 2 shows the significant relations on other scores. For ANOVA's, Table 3 shows results regarding HCRI-scores and Table 4 shows the significant relations on scores of other variables. This section will briefly describe these results, while only mentioning the most important statistics. Tables 1 to 4 can be consulted for more detailed statistics.

There was a statistically significant difference in HCRI-score according to household size (F(5, 176) = [2.67], p = .024). Tukey's posthoc test found that the mean value of HCRI-score was significantly different between households with one member and households with 5 members. The same accounts for households with two members and five members, households with two members and more than five members, and households with four members and five members. Furthermore, both households with one and two members had significantly higher scores on

the ER-component than households with five members. Differences in HCRI-scores according to household type did not reach statistical significance (F(4, 176) = [1.00], p = .024). However, statistically significant differences in ER-scores according to household type were found; both single-person households and couples without children scored higher than single-parent households. Following Cohen's (1988) guidelines for interpreting effect sizes, the magnitude of all these differences in means were either medium or high.

The difference in HCRI-scores between households with high and low female ratios was found to be statistically non-significant. Households with low kid ratio's on the other hand were significantly more resilient (M = .46, SD = .11) than those with high kid ratios (M = .41, SD = .12); t(179) = 2.52, p <.05 (two-tailed). Cohen's d (= .49) indicates a medium effect size. Furthermore, households with low kid ratios had significantly higher ER-scores than those with high kid ratios. For the number of household heads, no statistically significant differences in HCRI- scores or other scores were found. The same applies to the gender and age group of the household head (in those cases where there was only one household head). Nevertheless, senior household heads score higher on the ER-, PR-, and SR-component and on the alternatives ratio than (young) adult household heads (see Table 4 for exact comparisons). All these relations show a medium to high effect size.

A statistically significant difference in HCRI-scores was found for the number of languages spoken within a household (F(4, 176) = [3.23], p = .014). Tukey's HSD test found that the mean value of HCRI-score was significantly different between households speaking two and households speaking three languages. Also, scores on the SR- and IR-component, organization, information, and education variable significantly differed according to the number of languages spoken (see Table 4 for exact comparisons). Furthermore, HCRI-scores significantly differed between households fluently or not fluently speaking English (t(57.8) = -.03, p <.050), but not between households fluently or not fluently speaking Papiamentu, Dutch, and Spanish. Nevertheless, households fluently speaking Papiamentu score higher on the SR-component and the organization variable, but lower on the sources per member and savings variable, than households who do not. Furthermore, households fluently speaking English score higher on the IR-component and resource ratio, income per member, awareness, information, and education variable than those who do not. Also, HCRI-scores differed significantly according to user language (F(3, 179) = [4.93], p = .003); the mean value of HCRI-scores was significantly different between English and Spanish and between English and Papiamentu. Furthermore,

households using English scored higher on the ER component than those using all other languages and higher on the awareness variable than those using Dutch and Papiamentu. Those using English and Dutch also score higher on the income per member and savings variable than those using Spanish or Papiamentu.

No statistically significant differences in HCRI-scores were found according to cultural ethnicity. However, households identifying as North American scored higher on the sources per member variable than those identifying as Bonairean and Mid or Southern American and higher on income per member than those identifying as Mid or Southern American. Furthermore, those identifying as Dutch scored higher on the savings variable than those identifying as Bonairean. Lastly, households identifying as Mid or Southern American scored higher on asset distribution than households identifying as all other ethnicities. Moreover, differences in HCRI-scores between religious households and non-religious households were not significant. However, religious households score lower on the income per member and savings variables than non-religious households. Lastly, significant differences in HCRI-scores according to educational level were found ($t(77.6) = -2.81$, $p < .050$), showing that households with low education levels are less resilient than those with high education levels. The same applies to scores on income and insurance.

Table 1

Statistics for T-tests comparing groups for HCRI-scores

Variable	*t*	*df*	Mean difference	95% CI [*LL, UL*]	*Cohen's d*
Female ratio (Low x High)	- .12	63.3	-.003	[.04, .04]	-.02
Kid ratio (Low x High)	2.52 *	179	.054	[.01, .10]	.49
Number of household heads (1 x 2)	-.48	57.5	-.010	[- .05, .03]	-.09
Gender of household head (Male x Female)	.07	91.5	.002	[-.04, .05]	-.36
Speaks Papiamentu (Yes x No)	.73	163.9	.012	[-.02, .05]	.11
Speaks Dutch (Yes x No)	-.79	51.3	-.017	[-.06, .03]	-.15
Speaks English (Yes x No)	2.25 *	57.8	.046	[.01, .09]	.42
Speaks Spanish (Yes x No)	-.03	83.1	-.001	[-.04, .04]	.01
Religious (No x Yes)	-.81	110.3	-.014	[-.05, .02]	-.13
Education level (Low x High)	-2.81 **	77.6	-.051	[-.09, -.01]	-.46

Note. df indicates degree of freedom. * indicates $p < .05$. ** indicates $p < .01$. *** indicates $p < .001$. *LL* and *UL* indicate the lower and upper limits of a confidence interval, respectively. *Cohen's d* indicates the estimated effect size.

Table 2

Statistics for significant T-tests comparing groups for component and indicator scores

Variable	*t*	df	Mean difference	95% CI [LL, UL]	*Cohen's d*
Kid ratio x ER-component	3.64 ***	46.6	.137	[.06, .21]	.69
Speaks Papiamentu x SR-component	3.49 ***	162.7	.096	[.04, .15]	.53
Speaks Papiamentu x Savings	-2.53 **	172.4	-.120	[-.21, .03]	-.38
Speaks Papiamentu x Sources/ member	-2.56 **	179	-0.048	[-.08, .01]	-.38
Speaks Papiamentu x Organization	3.93 **	181	.268	[.13, .40]	.59
Speaks English x IR-component	2.98 **	55.5	.092	[.03, .15]	.58
Speaks English x Resource ratio	2.45 **	71.6	.049	[.00, .09]	.39
Speaks English x Income/ member	2.73 **	60.8	.120	[.03, .21]	.47
Speaks English x CC Awareness	2.25 **	58.5	.113	[.01, .21]	.42
Speaks English x CC Information	3.70 ***	56.9	.324	[.15, .50]	.70
Speaks English x CC Education	2.39 **	68.9	.120	[.01, .22]	.40
Religious x Income/ member	-3.01 **	95.4	-.127	[.21, .04]	-.50
Religious x Savings	-2.48 *	111.2	-.125	[-.23, .03]	-.39
Education x Income	-.28 **	76.8	-.122	[-.21, -.03]	-.48
Education x Insurance	-2.33 *	135	-.217	[-.40, -.04]	-.45

Note. df indicates degree of freedom. * indicates $p < .05$. ** indicates $p < .01$. *** indicates $p < .001$. *LL* and *UL* indicate the lower and upper limits of a confidence interval, respectively. *Cohen's d* indicates the estimated effect size.

Table *3*

Statistics for T-tests comparing groups for HCRI-scores

Variable	*F*	df [BG, WG]	*η2*	Groups that differ	Mean difference
Household size	2.67 *	(5, 176)	.071	1 vs 5 •	.12 **
				2 vs 5 •	.12 **
				2 vs >5 •	.10 *
				4 vs 5 •	.12 *
Household type	1.00	(4, 176)	.061		
Age of household head	2.00	(2,105)	.036		
Number of languages	3.23 *	(4, 176)	.067	2 vs 3	-.07 *
User language	4.93 **	(3, 179)	.076	English vs Spanish	.14 *
				English vs Papiamentu	.07 *
Cultural ethnicity	.85	(5, 177)	.023		

Note. df indicates degree of freedom with BG and WG indicating between groups and withing groups, respectively. * indicates $p < .05$. ** indicates $p < .01$. *** indicates $p < .001$. *η2* indicates partial eta squared. • indicates an LSD post hoc test was used instead of the Tukey's HSD test.

Table 4

Statistics for significant T-tests x groups for component and indicator scores

Variable	*F*	df (BG, WG)	*η2*	Groups that differ	Mean difference
Household size x ER-component	9.59 *** (Welch)	(5, 26,7)	.122	1 vs 5 2 vs 5	.29 ** .27 **
Household type x ER-component	2.52 *	(4, 176)	.054	Single person vs Single parent • Couple without vs Single parent •	.17 * .18 **
Age of household head x ER-component	4.00 *	(2, 105)	.071	Young adult vs Senior	-.22 *
Age of household head x PR-component	8.15 ***	(2, 105)	.134	Young adult vs Senior Adult vs Senior	-.21 *** -.12 *
Age of household head x SR-component	12.84 ***	(2, 105)	.197	Young adult vs Senior Adult vs Senior	.29 *** .23 ***
Age of household head x Alternatives ratio	3.81 *	(2, 105)	.068	Adult vs Senior	-.23 *
Number of languages x SR-component	.35 *	(4, 178)	.054	1 vs 4 • 2 vs 4 • 2 vs 5 •	-.09 * -.11 ** -.14 *
Number of languages x IR-component	8.45 *** (Welch)	(4, 49.6)	.090	1 vs 5 2 vs 5	-.18 * -.19 *
Number of languages x Organization	3.51 * (Welch)	(4, 41.7)	.081	1 vs 4 2 vs 4	-.37 ** -.34 *
Number of languages x Information	4.81 ** (Welch)	(3, 98.5)	.076	1 vs 3 1 vs >3	-.31 ** -.33 **
Number of languages x Education	3.56 **	(4, 178)	.074	1 vs 5 2 vs 5 3 vs 5	-.39 ** -.38 ** -.32 *
User language x ER-component	6.78 ***	(3, 179)	.102	English vs Dutch English vs Spanish English vs Papiamentu	.09 * .30 ** .15 **
User language x Income/ member	7.68 ** (Welch)	(3, 22.8)	.114	Dutch vs Spanish English vs Spanish English vs Papiamentu	.27 * .36 ** .22 **
User language x Savings	7.02 ***	(3,179)	.105	Dutch vs Spanish Dutch vs Papiamentu English vs Spanish English vs Papiamentu	.38 * .22 ** .40 * .25 **
User language x Awareness	6.25 ** (Welch)	(3, 25.8)	.079	English vs Dutch English vs Papiamentu	.14 * .20 **
Cultural ethnicity x Sources/ member	3.25 **	(5, 175)	.085	North American vs Bonairean North American vs Middle or South American	.12 * .16 *
Cultural ethnicity x Income/ member	3.00 *	(5, 171)	.081	North American vs Mid or South American	.32 *
Cultural ethnicity x Savings	3.75 ** (Welch)	(5, 32.2)	.093	Bonairean vs Dutch	-.21 *
Cultural ethnicity x Asset distribution	3.63 ** (Welch)	(5, 34.0)	.116	Mid or South American vs Bonairean Mid or South American vs Aruban/Curaçaos Mid or South American vs Dutch Mid or South American vs North American Mid or South American vs Other	.65 *** .65 * .60 *** .60 ** .46 *

Note. df indicates degree of freedom with BG and WG indicating between groups and withing groups, respectively. * indicates $p < .05$. ** indicates $p < .01$. *** indicates $p < .001$. *η2* indicates partial eta squared. • indicates an LSD post hoc test was used instead of the Tukey's HSD test.

Chapter 7 – Discussion and Conclusion

This chapter aims to add depth to this study's results as discussed in Chapters 5 and 6. Section 7.1 summarizes these results by answering the (sub-) research questions of this study while reflecting on and interpreting them. Section 7.2 provides both recommendations for additional research and policy recommendations. The chapter closes with a conclusion in Section 7.3.

7.1. Summary and Interpretation of Results

This section describes the conclusions that can be drawn from this study's results. These conclusions are structured following this study's (sub-) research questions. Simultaneously, these results will be interpreted, reflected on, and compared with results from comparable studies. It is important, however, to note that all comparable studies into HCR differ in geographical context, therefore possibly explaining any differences.

7.1.1. Sub-question 1a and 1b – *What are the main climate change vulnerabilities on Bonaire and how do these impact Bonaire and its citizens?*

From the results of the qualitative study (as described in Chapter 5), it can be concluded that the observed and expected climate changes mainly affecting Bonaire are sea level rise, increases in mean and extreme air and ocean temperature, and changes in precipitation patterns. These changes cause the following climate change vulnerabilities. First, changes in the frequency and an increase in the intensity of hurricanes and tropical storms are expected, including an increase in rainfall related to these. Secondly, the number and extent of flood events are expected to increase through sea level rise, changes in wave climate, and storms – all expected to extend due to climate change. Thirdly, the occurrence of extreme weather – including more frequent and intense droughts, sudden extreme rainfall, and shifting seasons – and related impacts like landslides are expected to increase. These imposed climate change vulnerabilities already impact – and may further impact – both Bonaire's natural and socio-economic systems. Impacts on the previous include stress on freshwater resources, coastal and marine ecosystems, and terrestrial environments, all highly important for the island, because of, for example, the protection it provides to the island's flora and fauna and socio-economic systems. Impacts on Bonaire's socio-economic system include negative impacts on citizens' health, Bonaire's economy, household incomes (especially those dependent on the tourism, agriculture, or fishery sector), food and water availability, buildings, and vital infrastructure. Results from key-

informant interviews also indicated that action on climate change (resilience) has not yet been initiated by either the Dutch or local government.

It must be noted that these conclusions are based on expectations, which cannot be regarded as exact facts. Furthermore, although conclusions on the expected climate changes, climate change vulnerabilities, and their impacts on Bonaire from the key-informant interviews correspond to those from the desk research, it must be mentioned that these results are based on observations and regional models. Specific empirical data for Bonaire is mostly missing, although crucial for understanding and increasing climate resilience. This decreases the certainty of expectations on climate change – and thus climate change vulnerabilities – in Bonaire. Nevertheless, by combining knowledge from multiple sources and by using data on nearby islands, there is confidence in the relative strength of the built framework.

7.1.2. Sub-question 1c – *How can Bonairean households be resilient to these climate change vulnerabilities?*

Furthermore, results from the qualitative research indicated that the following aspects increase a Bonairean household's climate resilience. A household's economic resilience is expected to increase with high levels of income sources, independent income sources, income, savings, and insurance covering damage from climate change (vulnerabilities). Physical resilience is expected to increase through asset distribution, living in a non-vulnerable neighbourhood, lower expected damage to housing, higher levels of vegetation surrounding the house, and high levels of alternatives to electricity, water, and food. Furthermore, social resilience is expected to increase with household members being part of social organizations, expected social support, effective community response, and a low dependency ratio. Lastly, institutional resilience is expected to increase with high levels of trust in government crisis-response, awareness of climate change (vulnerabilities, related impacts, and manners to prepare), access to information to the previous, education on climate change and resilience building, access to medical help, and steps taken to prepare the household for climate change vulnerabilities.

These 21 aspects were used as indicators for measuring HCR. Considerations were made on how many – and which – indicators to include. There are also frameworks for measuring HCR which include more indicators, like Tan and colleagues' (2020) one, which includes 38 indicators. Using more indicators may reveal nuances and retrieve more information. However, in this study, a trade-off has been made between retrieving as much information as possible and

keeping the questionnaire as short as possible - to invite more respondents to complete the survey. Nevertheless, using fewer indicators – and using proxy indicators at all – places question marks on the validity of the HCRI. By basing the selection of indicators on existing frameworks and by having the selection repeatedly checked, attempts were made to increase this validity.

7.1.3. Research question 1 – *How resilient are households on Bonaire to climate change vulnerabilities?*

The answers to the sub-questions allowed for the creation of a context-specific framework (shown in Figure 11) that was used to measure household climate resilience in Bonaire through surveys. Following the order of the main research questions, the following conclusions can be drawn. Considering the score's possible range reaching from 0 to 1, it may be concluded that the average HCRI-score of .455 does not indicate a low resilience, but also not a high one. However, answering this first research question is complicated since the HCRI-score is difficult to interpret. It would be easier to interpret if comparable scores existed. Examples are HCRI-scores in Bonaire at a different moment in time or HCRI-scores in other (Caribbean) SIs.

7.1.4. Research question 2 - *What are the barriers to household climate resilience in Bonaire?*

When comparing the average scores of the four components of the HCRI to answer Research Question 2, it can be concluded that – on average – Bonairean households score similarly on all components (between .438 and .491). Therefore, it can be concluded that there is not one resiliency component that specifically is a barrier to HCR. However, when looking at the descriptive statistics for the component's indicators, such barriers do become visible. For the ER-component, the high percentage of households whose savings are not sufficient to help recover from damage from a climate change vulnerability, especially in combination with the high percentage of households not being insured for such damage seems to be a barrier to HCR. The scores on income sources and vulnerable income sources are difficult to interpret because comparable scores are non-existent. Nevertheless, it shows that more than half of the sampled households have one or more incomes that are dependent on the tourism, fishery, or agriculture sector. Since these sectors are highly vulnerable to the expected climate changes and related vulnerabilities on Bonaire, this decreases HCR. The results of the income variable showing that a third of the Bonairean households fall in the 'low' or 'very low' income group, matches the concerns of Bonairean citizens, politicians, and activists about the high poverty levels on the

island. Since poverty is seen as a threat multiplier when households are faced with climate change-driven phenomena (Olsson et al., 2014), this is alarming for the HCR-level.

For the PR-component, especially the low number of households having alternatives to electricity, water, and/ or food in case of need stands out – especially alternatives to electricity and water lack. This matches many key-informants' statements about the Bonairean population not being prepared for climate change vulnerabilities. Furthermore, the fact that more than a quarter of the households expected their homes to be totally or severely damaged by climate change vulnerabilities – especially in combination with the above-mentioned barriers to recovering from such damage through savings or insurance – indicates a barrier to Bonairean HCR. This result might implicate the bad state of repair of houses, also mentioned by KI-8 (March 29th, 2022). Also, the small number of people living in a neighbourhood that is not vulnerable to climate change and the low average asset distribution, indicate barriers. A lack of vegetation – which for example protects from landslides – did not seem to be a barrier to HCR. This is slightly surprising since Bonairean gardens are known for their lack of vegetation. This result might be explained by the limited representativeness of the sample – from observations it can for example be concluded that Dutch households often have more vegetation in their gardens. House ownership did not specifically seem to be a barrier.

For the SR-component, the high number of households thinking their communities' response to natural hazards is not or little effective, also indicates a barrier to HCR – as Vinck and colleagues (2020, p.34) state: "when community disaster preparedness is not strong, or when households are not aware of these plans, they may not be able to take advantage of community knowledge and resources before, during, and after a disaster". Also, both the high number of households not having a member being part of a (community) organization or association and the semi-high number of households expecting no or little support from people near their household in case of need, indicate a low social resilience, therefore decreasing HCR. Furthermore, although difficult to compare due to the lack of studies including this variable in the same way, the high dependency ratio levels indicate a barrier to Bonairean HCR.

Lastly, for the IR-component, the low trust of households in government preparations for natural crises stands out. This result matches the statements of key-informants about the seemingly low preparedness of the government. Since the chance that people take action to protect themselves is higher when they trust government sources (Paton & Johnston, 2006), this

indicates a barrier to HCR. The slightly low percentage of households stating they have no or only little awareness of what climate change means, how it might impact them, and how to prepare for it, is surprising considering almost all key-informants mentioned the low climate change awareness of the Bonairean population. This surprising result can have a few alternative explanations like the sample not being representative of the whole population and a possible respondent bias such as a social desirability bias. Furthermore, although the percentage is not high, there are still many households non-aware of the topic. Similar conclusions can be drawn about the access to information about the topic and how to prepare for it – two-thirds of the sample stated they knew where to find more information. However, after looking into it, specific information for Bonaire is non-existent. Households knowing where to find it, is therefore surprising. These conclusions, together with the fact that more than half of the sample did not receive any form of education contributing to HCR, indicate increasing these indicators might be helpful when attempting to increase HCR. The high number of households which did not take any or only few steps to prepare also indicates a barrier to HCR – a result confirmed by statements of many key-informants. Medical help is quickly accessible for almost all households – therefore not indicating a barrier.

Thus, taken together, the results of the household survey indicate the following variables as barriers to HCR in Bonaire: expected damage to homes, amount of savings, insurance that covers damage from climate change (vulnerabilities), dependent income sources, incomes, vulnerable neighbourhoods, alternatives to electricity, water, and food, social resilience, community response, government response, awareness of climate change, information and education to increase HCR, and steps taken to prepare for this. However, some of these conclusions may have been influenced by this study's limitations.

7.1.5. Research question 3 - *How does household resilience differ between various socio-demographic variables?*

When comparing HCRI-scores and indicator scores for different socio-demographic variables to answer the third research question, the following conclusions can be drawn. Households with 1 or 2 members are more climate resilient than households with five or more members. The same accounts for their economic resilience. This might confirm Oriangi's (2019) and Arouri and colleagues' (2015) conclusion that smaller households are less resilient than bigger ones, but a similar conclusion cannot be drawn without further research. Furthermore, overall climate resilience does not differ significantly between household types, however, economic resilience

does – single-parent households are less economic resilient than single-person households or couples with children. As far as known, no study on HCR has included this variable, although insights into the differences between various household types can add to targeting specific interventions.

Although studies have found that women are less climate resilient (e.g., Kadir et al., 2021) and that households with high female ratios are less climate resilient (e.g., Vinck et al., 2020), this study did not find such an effect. The cultural context of this study may explain this difference – Bonairean women are said to be highly resilient due to, amongst others, their experiences with running the household alone when male members were out fishing or working in other localities (e.g., KI-9, March 27^{9h}, 2022). On the other hand, households with low kid ratios (the number of household members younger than 18 in relation to all household members) were significantly more climate and economically resilient than households with high kid ratios. This confirms results from Tan and colleagues (2020) that households with more children are less climate resilient. However, this result might (partly) be explained by the fact that the number of household members under 15 years old was included in the 'dependency ratio' variable, which negatively impacts HCR.

Climate resilience did not significantly differ between households with one or two household heads. The age and gender of the household head (in case there was only one) also did not significantly impact HCR. This result does not correspond with the results of most studies researching this relation – which did find an effect of household age and gender on household resilience (e.g., Jones & Samman, 2016; Gaisie et al., 2016). This discrepancy in gender may be explained by the same cultural context as described above. Moreover, senior household heads (≥65 years) are economically more resilient than young household heads (<30 years) and more physically and socially resilient than young and adult (30-65 years) household heads. Also, on average they have more alternatives to electricity, water, and food than adult household heads.

One goal of this study was to understand whether 'local' households (those consisting of local Bonairean people) differ from 'migrant' households (those consisting of people who migrated to Bonaire from, mostly, the Netherlands or South America) regarding their HCR. However, due to the complexity of retrieving information to distinguish these households, it was difficult to achieve this goal. An example of why collecting this information is complicated, is that

variables normally making this distinction possible do not apply in Bonaire. For example, asking the nationality of a household does not provide this information since all locals are Dutch due to Bonaire's statutory situation and all Dutch respondents can identify as Bonairean due to their residence permit. Nevertheless, in an attempt to contribute to achieving this goal, HCR was compared for some socio-demographic variables that might indicate the distinction between 'local' and 'migrant' households. The first is the cultural ethnicity of the household – for which no statistically significant differences in HCR were found. However, North American households have a higher income ratio than Bonairean and other South- or Mid-American households and have a higher income source ratio than other South- or Mid-American households. South- and Mid-American households have a higher asset distribution than households with all other ethnicities. Furthermore, Bonairean households are less inclined to have sufficient savings to recover their homes than Dutch households. Mid or Southern American households have higher asset distributions than households with all other ethnic backgrounds. The difference in cultural ethnicity, however, does not equal the difference between 'local' and 'migrant' households, since, for example, a Dutch household living on Bonaire for years or a mixed household might have described themselves as Bonairean while not necessarily a 'local' household. Therefore, this variable does not expose possible differences between 'local' and 'migrant' households.

Furthermore, the type of language that is or is not fluently spoken within a household might impact HCR and might indicate a difference between 'local' and 'migrant' households – since most Dutch households for example do not fluently speak Papiamentu. However, only households fluently speaking English are more climate resilient than those which do not – this difference was not found regarding Dutch, Papiamentu, and Spanish. Furthermore, households fluently speaking English are more institutionally resilient, have a higher resource and income ratio, are more aware about climate change and its impact on them, know better where to find additional information about this, and received more education contributing to HCR. Also, households using the English version of the household survey are more climate resilient than those using the Spanish or Papiamentu version. These are also more economically resilient and have a higher income ratio and awareness than those using Spanish, Papiamentu, or Dutch. Those households using Dutch or English are also more inclined to have sufficient savings to recover their homes than those using Papiamentu or Spanish. On the other hand, households fluently speaking Papiamentu are more socially resilient and are more often part of a social organization than those who do not. Nevertheless, they have fewer income sources per member

and less sufficient savings to recover their homes. These differences between households speaking and not speaking certain languages fluently are manifold and will, for the sake of the length of this chapter, not all be discussed. However, the fact that households fluently speaking English are more climate resilient and score higher on multiple HCRI-indicators, stands out. This relationship can also have multiple explanations, such as that information on climate change, its impacts and how to prepare for it is easier to find in English, therefore increasing these indicators to HCR. Another explanation is that there are structural differences between the four different survey versions, although attempts were made to limit these. Also, the households speaking English fluently might be better educated or might be 'migrant' households, which may influence their HCR. Altogether, the differences in HCR for cultural ethnicity, speaking Papiamentu, and the language used to fill in the survey, might indicate differences between 'local' and 'migrant' households. However, they do not entirely correspond to it. Therefore, there is no direct evidence for any differences in HCR between 'local' and 'migrant' households. Additional research is needed to explore any possible differences.

Furthermore, households speaking two languages were less climate resilient than those speaking three. Also, those speaking one or two languages are less socially and institutionally resilient, are less often part of an organization, had less education on climate change, and were less likely to know where to find information than those speaking four or more. It is slightly difficult to interpret these findings, since there is not enough proof to recognize a trend, like 'households speaking more languages are more resilient'. However, such a relation could be explained by the fact that on Bonaire multiple languages are spoken and different institutions communicate in different languages. Therefore, information important for HCR might reach households speaking multiple languages better. Additional research might add to the understanding of this relationship.

Moreover, climate resilience did not significantly differ between religious and non-religious households, although the latter group has higher income ratios and more sufficient savings to recover their homes. This does not correspond with other studies including this variable – which did find a significant difference (e.g., Ahmad & Afzal, 2018; Shah et al., 2018). Lastly, households with a high level of obtained education are more climate resilient than those with a low level of obtained education. Also, those with high education levels have higher incomes per member and are more inclined to have insurance covering damage from climate change

(vulnerabilities) than households with low levels of obtained education. This matches the results from multiple studies concluding that higher educated households are more climate resilient (e.g., Vinck et al., 2020; Tan, Peng, & Guo, 2020; Arouri et al., 2015).

In conclusion, households that are less inclined to be climate resilient, are: (possibly) bigger households, households with high kid ratios, households with younger household heads, (possibly) households speaking fewer languages, households not fluently speaking English, and households with a higher level of obtained education. However, as discussed, there are a few sidenotes to these conclusions. Additional research trying to limitations, like including a more representative sample, is necessary to understand the difference to a fuller extent.

7.2. Recommendations

This section will provide multiple recommendations for additional research and policy.

7.2.1. Additional research

As mentioned in Section 7.1.1, empirical data on climate change for Bonaire specific misses, although imperative as a fundament to base research and action on HCR on. This applies to many Caribbean SIs: "more remains to be known about the specific local scale differences in impacts vulnerability, and resilience to these climatic changes" (Rhiney, 2015, p.7). Therefore, it is recommended to increase the availability and quality of data on climate change (vulnerabilities) and its impacts for Bonaire – and other SIs – specifically. Monitoring activities can be used to analyse how observed changes are related to climate change and other environmental and socio-economic development (Verweij, Meesters, & Debrot, 2015). Also, models specific to the island can be created and risk-analyses can be conducted.

Considering the benefits but also limitations of this study, it is recommended to repeat this study with a more representative sample – meaning it includes more respondents from the local and Spanish community – and ensuring households are included in the sample only once – for example by conducting the surveys offline. Also, the internal consistency between the different survey versions may be checked by someone speaking all languages. Additionally, researching the (possible) differences in HCR between 'local' and 'migrant' households may provide valuable insights. Furthermore, the HCRI as designed in this study may be used as a tool monitoring HCR after implementing initiatives aimed at increasing it. Lastly, considering the limited number of studies researching climate resilience at the household-level, especially on

(Caribbean) SIs, it is recommended to focus more studies on this theme and these geographies. This may also expose differences between SIs, providing further insights into the barriers and requirements of (household) climate resilience in the 'hot-spots of climate change'.

7.2.2. Policy recommendations

From the analysis of this study's results (as discussed in section 7.1.), it can be concluded that HCR in Bonaire is not at the desired level and that there are multiple barriers to it, including the fact that households with certain socio-demographic characteristics are less inclined to be climate resilient. The following recommendation may contribute to increasing HCR and decreasing these barriers. These recommendations are aimed at the household-level, but also include other levels – such as the community and 'national' level – which may also positively affect HCR.

First, a more integrated approach to addressing climate change (vulnerabilities) and resilience should be adapted by, for example, coordinating responses to interconnected threats (e.g., poverty and HCR, as explained in Chapter 2). As Fuller and colleagues (2020, p.18) state "governments in the [Caribbean] region have tended to approach climate change and its impacts more as an 'environmental issue', without necessarily considering it in relation to the economic, political, social and security issues it raises". This trend can also be recognized for Bonaire. Therefore, it is important to ensure climate change (resiliency) is also incorporated, or at least considered, in the design of policy on other themes.

Secondly, the policy directly aimed at increasing (household) climate resilience should be formulated. The last paragraph of this section describes aspects that are recommended to at least include therein. The responsibility for creating this policy plan should lay with the local Bonairean government. Hereby a direction – or at least one or more policy officers – should be appointed for the responsibility of climate (change, resiliency) policy. The Dutch government has an important role in encouraging and supporting the Bonairean government in this process and increasing both the financial and human capacity within the Bonairean government. Furthermore, it is recommended to increase regional cooperation. Benefits of this include learning from each other, standing stronger together, and (increased) independence from (knowledge from) the global North (e.g., Fuller et al., 2020; Fraser & Kirbyshire, 2017).

Moreover, it is recommended that the creation and implementation of this plan will be executed in cooperation with local (nature) organizations – since they often hold the relevant knowledge – and local (educational) institutions such as schools and sport clubs – since they stand closes to the population. Hereby the devolved responsibilities should be set out clearly (Fraser & Kirbyshire, 2017). To ensure proper management – while keeping the uncertainty of future climate change impacts, its multi-sectoral nature, and the necessity for inclusive responses in mind – stakeholder participation (in the form of stakeholder meetings and/or the creation of a working group) is suggested. Also, since households and communities often have the best understanding of what increases their resilience (Jones & Tanner, 2017; Smith & Frankenberger, 2018), community engagement in the creation and implementation of climate resiliency policy is recommended. This engagement may also institutionalize local and traditional knowledge (LTK) (Fraser et al., 2020). Including LTK can help with building climate resilience, especially when combined with scientific knowledge (e.g., Makondo, 2018; Khatibi, Dedekorkut-Howes, Howes, & Torabi, 2021). While formulating climate change (resiliency) policy, it is important to keep the most vulnerable groups (as described in Section 7.1.5.) in mind. Targeted support for these groups should be mobilized. Including these groups in the creation and implementation of policy, might therefore be beneficial.

It is recommended that the above-mentioned climate policy at least includes the following aspects:

- Because of the high expected damage to housing from climate change vulnerabilities, in combination with the barriers to recover from this damage, it is recommended to increase the availability of insurance covering damage from climate change (vulnerabilities). Furthermore, financial assistance to help households prepare for climate change (vulnerabilities), such as using hazard-resistant material in construction or realizing off-grid electricity supply, could be considered.
- The government should provide income-generating opportunities to Bonaire's citizens – while increasing equal income distribution – as this reduces poverty and thus enhances HCR (Qasim et al., 2016). Hereby, both household income and the economy should be diversified. This would decrease the dependent income ratio, therefore making households less dependent on sectors that are vulnerable to climate change (vulnerabilities). As Verweij and colleagues (2020, p.13) conclude, "diversification [in Bonaire] could take place through further development of financial and IT services, bio-

pharmaceutical industries (algae and aloe), increased local vegetable and fruit production, and goat meat and brine shrimp production".

- It is recommended to keep focusing on the protection and recovery of Bonaire's natural systems, partly because of its protective and resource properties for socio-economic systems – thus households. Examples of initiatives are reforestation and beach cleaning projects. Such initiatives can also create employment which contributes to increased household income and income diversification.
- Since public responses are likely to be more effective when build on programs and mechanisms that are in place before a disaster occurs (Skoufias, 2003), it is recommended to create a community response plan.
- Other protection measures, including hard protection measures, securing vital infrastructure, and guidelines/requirements for construction – such as restricting residential building along the coast – can be considered.
- It is recommended to increase awareness around climate change (impacts) and the ways to and importance of enlarging resiliency, both among citizens and governors. This will enable them to access, understand, and apply the knowledge that is needed to inform their decision-making process (Cvitanovic et al., 2016). This might also increase community empowerment and engagement regarding efforts to increase climate resilience. Examples of ways to increase awareness are education programs and information campaigns. Residents should also be made aware of where to find information on climate change impacts and how to prepare for it. It is highly important to ensure this information (campaigns) is provided in the multiple languages spoken on Bonaire to ensure households not fluently speaking English are also included. Lastly, capacity-building activities, such as first aid training, should be promoted. Providing training, workshops, and information campaigns also generate employment – thus contributing to increased household income and income diversification.

7.3. Conclusion

This research has studied household climate resilience (HCR) within a (Caribbean) Small Island context – with Bonaire as a case study. To do so, quantitative research in the form of online household surveys was conducted. To study HCR in Bonaire, first, the climate change and resiliency context was studied through key-informant interviews, complemented with desk research. Results of these show the following observed and expected climate changes mainly affecting Bonaire: sea level rise, increases in mean and extreme air and ocean temperature, and

changes in precipitation patterns. These cause the following climate change vulnerabilities: changes in the frequency and an increase in the intensity of hurricanes and tropical storms, an increase in the number and extent of flood events, and an increase in the occurrence of extreme weather – including more frequent and intense droughts, sudden extreme rainfall, and shifting seasons. These climate change vulnerabilities have and can further have disastrous effects on Bonaire's natural and socio-economic systems – and thus negatively impact households.

The aspects increasing the climate resilience of Bonairean households – and thus limiting the negative impacts of climate change vulnerabilities – were retrieved and subsequently used to measure HCR through an online household survey. The average score of the household sample indicates that HCR in Bonaire is not particularly low, but also not high. Especially the following aspects of HCR seem to be limited in Bonaire: expected damage to homes, amount of savings, insurance covering damage from climate change (vulnerabilities), dependent income sources, incomes, vulnerable neighbourhoods, alternatives to electricity, water, and food, social resilience, community response, government response, awareness of climate change, information and education on climate change impacts and steps to prepare for this, and steps taken to prepare for this. Furthermore, the following households are less inclined to be climate resilient: (possibly) bigger households, households with high kid ratios, households with younger household heads, (possibly) households speaking fewer languages, households not fluently speaking English, and households with a higher level of obtained education.

Research on household-level climate resilience on (Caribbean) Small Islands, although imperative for action on the theme, is limited. Therefore, by studying HCR in (Caribbean) SI-context, this study has contributed to the understanding of this topic and gave ammunition to initiatives attempting to increase (household-level) climate resilience on (Caribbean) SIs in general and Bonaire specifically. Nevertheless, this study knows limitations, among which the limited Bonaire-specific data on the expected climate changes, related vulnerabilities, and impacts and the limited representativeness of the household sample. These might have impacted the results of this study. Therefore, it is recommended to conduct further research leading to Bonaire-specific climate data and to conduct household surveys including a more representative sample. Policy recommendations have also been provided. Altogether, it can be stated that a Small Island, like in this case Bonaire, and its households have large climate change challenges but also still have large numbers of opportunities to increase household climate resilience.

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Appendix A

Interview guide

Text between brackets was not mentioned to the participants but served as help for the interviewer. Even though most interviews were conducted in Dutch, for the reader's understanding the guide is shown in English.

[Introduction]

First of all, I would like to thank you again for agreeing to be interviewed by me. Before we start the interview, I think it's important that you know a little bit about who I am and about what the research I'm doing is broadly speaking about. Much of this was already in the email Tineke or me sent to you in which you were invited for the interview. However, I can imagine that in a busy schedule, you do not read every e-mail in detail. So, shall I tell you a little bit more about me and the research I am conducting? Please tell me if I repeat things. [If the respondent tells he/she remembers everything from the e-mail, ask whether they have any questions].

So, I'm Nina Zander, a student in the master 'International Development Studies' at the University of Utrecht. To graduate, I am conducting research on Bonaire. This research focuses on measuring the resilience [‘Veerkracht in Dutch’] of households to the impact of climate change. I say 'resilience' in English, because I don't think there is a Dutch translation that covers the same meaning (yet). But to not keep using English terms throughout the interview, I will refer to it as 'resilience' [‘Veerkracht in Dutch’] from now on. For this research, I'm going to conduct household questionnaires and see how resilient households are to climate change vulnerabilities. Because I want to avoid researching Bonaire without understanding the context of the region and basing my study solely on (academic) papers and in order to get a clear picture of what climate change and resilience to it means for Bonairean households specifically, I want to first speak to people and hear how they perceive it. And this is why we are here.

I have written down some of the questions I want to ask you, which is why you might catch me looking at this sheet sometimes. Some of the questions are quite complicated, so it would not be weird if you do not know the answer to a question. Please just tell me if you wish not

to answer a question. On the other hand, feel free to add things that I am not specifically asking about, if you think they might be interesting.

The interview takes approximately one hour. If you want to take a break, please let me know. You may also state at any time that you wish to stop the interview. Furthermore, with your permission, I would like to record this conversation so that I can relisten everything you have shared with me later. This recording will not be listened to by anyone but me. Furthermore, your name and what you say will remain confidential. If I want to use a quote by you in my thesis, I will always ask you for permission first. However, with your permission, I would like to include a description of your profession. You may always come back on your permission to do so.

Finally, I would like to say that there are no right or wrong answers to the questions I ask you; I am just curious about how you perceive certain things. Also know that you do not have to answer any questions you do not want to answer.

Before we start: are there things that are not clear, or do you have questions?
Then we will start! Do you give permission to start recording?

[Introductory questions]

- How long have you lived on Bonaire for?
- What is your education background?
- What is your current profession?

[Knowledge about climate change]

- How would you describe your existing knowledge on climate change?
- Does the theme ‘climate change’ or any related concepts play any role in your profession? In what way?

[Climate change on Bonaire]

Now a few questions about the role that climate change plays on Bonaire will follow. I have studied these topics through desk research but am also very interested in your perspective on these themes.

- First, I would like to ask you about what, in your perspective, the biggest changes in climate on Bonaire are. An example of a change in climate you could think of is rising air temperatures. And I would like to divide this question into changes that are already visible on Bonaire and changes you expect to occur in the future.
- If you look at the climate changes you have just listed, what kind of impacts could they have or are they already having on Bonaire and her citizens?
  [if needed, mention some possible impacts, people might then loosen up. Also make sure to ask about the impacts on households if the participant does not mention this themselves].
- Which people do you expect to be most affected by these impacts?
- Do you think Bonaireans are aware of climate change and the impact it has on Bonaire and her citizens?

[Resilience]

[Depending on the participant's background, you might not have to share this information]. Resilience is a term often used when talking about the impact of climate change. However, people do not yet agree on its definition. To give you a bit of an idea of what we are talking about, I am sharing a definition from the IPCC that is often used. Resilience is the capacity of a system (in this case the households of Bonaire) to cope with dangerous disturbances (in this case the impact of climate change) in a way that preserves the function, identity, and structure of the system (households) as well as its adaptive and learning capacity.

Do you feel like this description made the concept a bit clearer? Do you have any questions?

Research shows that the resilience of households to the impacts of climate change can depend on several things. Examples include the type of house a person lives in, their economic capacity, access to services, infrastructure and knowledge, but also, for example, social support. These are just a few general examples; many more can be thought of. It turns out that these things are very dependent on the context of both the type of impact of climate change and the culture of a place. Therefore, I would like to understand how this works for Bonaire. I have already studied possible important components of resilience specific for Bonaire, but I would like to supplement what I have found with the knowledge of people who know Bonaire

well. So, the following questions are specifically about aspects that make a Bonairean household resilient.

- You have just listed some of the biggest impacts of climate change on Bonaire. I would like to take a separate look at these and ask what you think is important for a household to be resilient to these impacts.
  [if needed, specifically ask about floods, droughts, and storms]

[Local and traditional knowledge]

Literature argues that local and traditional knowledge (LTK) in the Caribbean, combined with modern scientific knowledge, can play a major role in adaptation and mitigation strategies to cope with climate change. Examples of LTK include people using local materials or structures to prevent or reduce danger, but also nature-related rituals or ceremonies or specific ways of observing the environment.

- Do you know of such knowledge specifically on Bonaire?

[Governance]

Lastly, I would like to ask you some questions about governance around climate change and resilience.

- To your knowledge, what action is already being taken to reduce the risks of climate change on Bonaire?
- Who is responsible for this action? Who do you think should be responsible?
- To your knowledge, is there any education on climate change and the risks it poses to Bonaire?

[Closing]

These were all the questions I have for now. Are there things you would like to come back to or add? Do you have any comments or questions?

I would like to tell you briefly what my next steps are and ask if you have any tips. Also, is there someone you can think of that might be worthwhile asking to also be interviewed?

If you would like to be involved in my research, please let me know.

Appendix B

Overview of the interviewed key-informants' job descriptions

This Annex provides an overview of the job descriptions of all the key-informant that were interviewed. The order of these does not correspond to the numbers used to indicate the key-informants (e.g., "KI-1" does not correspond to the first key-informant in this list). Before starting the interview, participants were asked for their job descriptions and for approval for sharing these descriptions. Therefore, participants were in control over how much of their personal (traceable) information gets shared in this thesis.

Description	Organization
Director	**Echo** – *A local NGO protecting the future of Parrots & people through nature conservation, awareness building, and monitor programs. This participant is also a representative for farmers in Rincon [town on Bonaire] and works together with businesses and other groups on nature conservation and cultural and heritage preservation.*
Advisor	**'Commission for nature conservation Bonaire'** [Freely translated from Dutch]
Researcher	**WUR research project** *studying climate change and governance in, amongst others, Bonaire.*
Biologist	**STINAPA** – *an NGO responsible for the conservation of Bonaire's national parks.*
Employee	**WWF (Bonaire) –** *World Wide Fund for Nature*
Social psychologist	**Promoted** with research on Bonaire
Policy officer	**Nature and environment department** at the local government (OLB)
Advisor	**'Commission for nature conservation Bonaire'** [Freely translated from Dutch]
Geologist	

Former director	**STINAPA** – *an NGO responsible for the conservation of Bonaire's national parks.* Rich background in climate and nature activism.
Director	**Mangazina di Rei** – *a cultural park and learning centre on Bonaire.*
Employee	**Fuhikubo** – *a foundation collecting, archiving, documenting, and spreading Bonairean cultural heritage.*
Politician	**Local government (OLB)** – *member of the Executive Council of Bonaire, with a portfolio relevant to topics of this study*.
Policy officer	**Tourism and economy department** at the municipal government (OLB).
Government representative	**Rijksdienst Caribisch Nederland** (RCN)
Research Communication Liaison	**Dutch Caribbean Nature Alliance** (DCNA)

Appendix C

Online Household Survey

Dear,

First of all I would like to **thank you** for filling in this survey!

The survey consists of **26 questions** and takes about **10 minutes** to fill in. You can do this on your **computer, telephone, or tablet**. You will be asked for your consent to start this survey. Please read the Information sheet for more detailed information on the survey and what will be done with the collected data.

In this survey you will be asked about your **household**. In this study 'household' is defined as 'one or more persons who live in the same residential space and who jointly provide in daily basic needs'. So, a household can also consist of **one person**.

It might be easiest if the **person who makes the (most) decisions in your household** fills in this survey. Or is nearby when you fill it in, so you can ask questions. Please, make sure only one person in your household fills in this survey.

If you would like to have the chance to win one of the **prizes**, please leave your email-address at the end of the survey (you will specifically be asked for it). Note that this email-address will **not** be linked to the answers you filled in during the survey.

If you have any questions, comments, or concerns about this study, you may contact me through nina.p.zander@gmail.com

Pasa un felis dia!

With kind regards,
Nina

By clicking the button below, you acknowledge that:
- You are aware that participation in the study is voluntary.
- You are aware that you may choose to terminate your participation at any time for any reason.
- You are aware of how your data is treated (as described in the information sheet).

☐ I consent. Begin the survey.

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1. Please, **for every person** in your household:
- fill in their age
- fill in their gender
- thick the box if this person is the person who makes the (most) decisions within your household (in the table this is called the 'household head').
- thick the box if this person has a mental or physical disability or disease.

This means that if, for example, there is only two people in your household, you only fill this in for two people. If your household, for example, consists of 15 people, you fill this in for all 15 people.

	Age	Gender			Household head?	Disability?
	Fill in age	Male	Female	Other	Yes	Yes

Person 1		○	○	○	○	○
Person 2		○	○	○	○	○
Person 3		○	○	○	○	○
Person 4		○	○	○	○	○
Person 5		○	○	○	○	○
Person 6		○	○	○	○	○
Person 7		○	○	○	○	○

Person 8		○	○	○	○	○
Person 9		○	○	○	○	○
Person 10		○	○	○	○	○
Person 11		○	○	○	○	○
Person 12		○	○	○	○	○
Person 13		○	○	○	○	○
Person 14		○	○	○	○	○

Person 15		○	○	○	○	○

2. What describes the composition of your household best?

- ○ Single person household
- ○ Couple without children
- ○ Couple with children
- ○ Single parent with children
- ○ Mixed family
- ○ Friends
- ○ Colleagues
- ○ Other: _____

3. Which languages are fluently spoken by one or more people in your household?

- ☐ Papiamentu / o
- ☐ Dutch
- ☐ English
- ☐ Spanish
- ☐ Other: _____

4. Is your household religious? If so, what religion is dominant?

- ○ The household is not religious
- ○ Roman Catholict
- ○ Pentecostal church
- ○ Protestant
- ○ Evangelical
- ○ Jehovah
- ○ Adventist
- ○ Jewish
- ○ Muslim
- ○ Other: _____

5. In your opinion, which cultural ethnicity describes your household best?

- ○ Bonairean
- ○ Aruban or Curacaoan
- ○ Statian, Saban, or Sint-Maartens
- ○ Mid-or South-American (other countries)
- ○ Dutch
- ○ North-American
- ○ Other

---

6. What is the highest achieved level of education by anyone in your household? It does not matter who this person is, as long as he or she is a part of your household.

- ○ Primary school
- ○ High school
- ○ Trade school / Lower secondary education (in Dutch system: Mbo)
- ○ Bachelor's degree (in Dutch system: Hbo or WO)
- ○ Master's degree (in Dutch system: Hbo or WO)
- ○ PhD
- ○ I do not know

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7. How many sources of income are there in your household?

This includes side jobs, income from property and income from social security (like state

pension or sickness benefit).
In case this question is not entirely clear to you, an example is given below.

For example: a household consists of 3 adults and 2 children. One person has one job for which they get paid (1x). One person has a main job and works a side job in the evening hours (2x). The third person receives retirement funding (1x). Also, they receive an income through renting out a studio in their garden (1x). This means the household has 5 sources of income.

_____

8. How many of these incomes depend on one of the following sectors: tourism, agriculture, fishery?

_____

9. What is the monthly income of your household?
You can calculate this by adding up the amounts of USD income of all the different resources of income from the previous question. I am curious about your gross income (so before any charges or taxes are deducted).

If this amount differs per month, note the amount of last month.
When you do not know the exact number, please give an estimation.

_____

10. On a scale from 1-5, to what extent could your household's savings help your household recover from a crisis like a hurricane or flooding?

Not at all		Totally		I don't know
1	2	3	4	5

7	

11. Does your household have insurance (either house or household content) that covers damage from climate change and/ or natural disasters?

For example, if your house is damaged by a hurricane, would your insurance cover any of that?

- ○ Yes
- ○ No
- ○ I do not know

12. Does (someone in) your household have any valuable assets in other places than Bonaire?

Examples are residential properties or vehicles.

- ○ Yes
- ○ No
- ○ I do not know

13. In what neighbourhood is your household located?

- ○ Amboina
- ○ Belnem
- ○ Antriol Pabou
- ○ Antriol Pariba
- ○ Guatemala
- ○ Hato
- ○ Lagun Hill
- ○ Lima
- ○ Mexico
- ○ Nawati North
- ○ Nawati South
- ○ Nikiboko
- ○ Noord Saliña
- ○ Playa (Kralendijk)
- ○ Playa Pabou
- ○ Playa Pariba
- ○ Rincon North
- ○ Rincon South

- ○ Sabadeco
- ○ Sabana
- ○ Santa Barbara
- ○ Tera Kora
- ○ I am not sure

14. Is the house your household lives in owned by your household or someone in your household?

- ○ Yes
- ○ No
- ○ I do not know

15. On a scale from 1-5, how much do you think your house would be damaged by natural hazards, like hurricanes, floods, or landslides?

While answering this question think about the material the house (walls and roof) is made of and about the state of repair of the house.

	Not at all damaged				Totally damaged
	1	2	3	4	5
26					

16. On a scale from 1-5, how many plants and trees are planted in the ground (so not pots) around your house?

You can think about your garden but also about nearby streets and gardens of neighbours.

	Non at all				Many
	1	2	3	4	5
1					

17. In case WEB or supermarkets can no longer provide the following resources to your household, does your household have an alternative way to access these resources for at least four days?

	Yes	No	I am not sure
Electricity (for example, a generator, solar panel, or windmill)	○	○	○
Water (for example, a water tank or stocked water supplies)	○	○	○
Food (for example, homegrown food or stocked food supplies)	○	○	○

18. In case of emergency, how long would it take you to reach medical care?

0-5 minutes

5-15 minutes

15-30 minutes

More than 30 minutes

I do not know

19. Does one or more household member(s) belong to any (community) organization or associations on Bonaire?
Examples you can think of are a(n): NGO, fisherman group, religious group, union perished, youth group or club, political party, volunteer committee, finance group, farmer group, educational institute.

Yes

No

I do not know

20. On a scale from 1-5, to what extent are there people near your household that would support your household in case of need? *Examples are: neighbours, family or friends.*

	Non at all			Many
1	2	3	4	5

1	

21. On a scale from 1-5, to what extent do you think your community can react effectively during natural hazards, like floods and hurricanes?

Not at all Very well

1 2 3 4 5

1	

22. On a scale from 1-5, to what extent do you have trust in the preparations of the government (both local and Dutch) for any natural hazards, like floods or hurricanes?

Not trust at all Full trust

1 2 3 4 5

1	

Page Break

23. On a scale from 1-5, to what extent are you aware of what climate change means and how it can impact your household?

Not at all aware Totally aware

1 2 3 4 5

1 

24. Would you know where to find more information about the impact climate change and natural hazards can have on your household or information on how to prepare for it?

- ○ Yes
- ○ No

25. On a scale from 1-5, to what extent did people in your household receive any form of education about climate change or its impacts on your household or how to prepare for it?

Examples of such education is first aid training, hazard mitigation training, water sanitation and hygiene training, disaster risk reduction education, or climate change capacity adaptation training.

No education at all A lot of education

1 2 3 4 5

1 

26. On a scale from 1-5, to what extent has your household taken any steps to prepare for climate change and/or related hazards (like floods, storms, hurricanes, tsunami's,

droughts)?

Examples are, stocking food/ water, creating an emergency plan, diversifying your incomes.

	No steps at all			A lot of steps
	1	2	3	4	5
1					

Page Break

This is the end of the survey. Thank you again for filling it in.

If you would like to have the chance of winning one of the prizes, please fill in your email-address below. Again, this email-address will not be linked to the answers you filled in during the survey. The winners of the prizes will be announced somewhere in July through e-mail.

This research can help Bonaire and Bonaire's households best if as many people as possible fill in this survey. So, if you know of people who could fill in this survey too, please forward it to them. Thank you!

Appendix D

Survey Respondent Information sheet

SURVEY RESPONDENT INFORMATION SHEET

Household resilience to climate change vulnerabilities on Bonaire

Researcher: Nina Zander (Master student University of Utrecht) in cooperation with the Dutch Caribbean Nature Alliance (DCNA).

Objectives of the study: More knowledge on how households, and thus nations, can become more resilient to climate change and the vulnerabilities it imposes, is needed. Therefore, this study has three goals: (1) measure household resilience to climate change vulnerabilities on Bonaire; (2) understand which barriers to household climate resilience exist on Bonaire; and (3) if and how household climate resilience differs between socio-demographic profiles.

Methodology and participation: You will be asked a total of 26 questions about your household through this online survey. You can answer these questions on your computer, phone, or tablet.

Duration: This survey will take around 10 minutes to fill in.

Voluntary nature of participation: Your participation in this study is completely voluntary and you can stop the survey at any time without giving any justification.

Data privacy: To protect your privacy, this survey will not ask any contact details. The only exception is that people who would like to have the chance of winning one of the prices, will be asked to share their e-mail address. This email-address will not be linked to the answers you filled in during the survey.
Data collected through this survey will be analyzed by the researcher of this study. Additionally, the data will be published on the Dutch Caribbean Biodiversity Database (https://www.dcbd.nl/). Before publishing, all identifying information will be deleted. For example, in this survey you will be asked for the number of people in your household and for their ages. Information like this will be deleted, so no-one can identify you through your response to this survey.

Benefits: when participating in this study you have the chance to win a price. The following prices will be raffled:

- 1x two night stay for two at Casa Calexico
- 1x guided dive for two with FPA sports including dive gear from Wannadive
- 1x dance lesson at Dance & More Bonaire

If you would like to have the chance to win one of these prices, please leave your email-address at the end of the survey when asked for it. Again, this email-address will not be linked to the answers you filled in during the survey. Note that you only have a chance at winning one of these prices when you fill in the whole survey before the 3rd of June. The winners of these prizes will be announced somewhere in July through e-mail.

You have the right to:

- Be fully informed about the study and about how your data is processed.
- Request access to your data
- Request deletion of your data
- Restrict how your data is used

Since the research data is not linked to your name, we may be unable to identify which data within the dataset comes from you. Unless you can give us additional information that may help us to identify your responses, we may be unable to comply with (some of) the rights above.

Contact information:

If you have any questions, comments, or concerns about this study, you may contact Nina Zander, nina.p.zander@gmail.com

Appendix E

Table with a description of the variables included in the analysis of this study

Variable ***Description variable***	**Label.** *Please see Appendix C for full questions.*	**Creation / Alterations of data**	**Final measurement level** ***Categories (if applicable)***
User language *The language in which the respondent filled in the survey*	Dependent on which survey language was chosen.	-	Nominal, with the following categories: *1 = Dutch* *2 = English* *3 = Spanish* *4 = Papiamentu*
Household size *The amount of people within the household*	*	Sum of the amount of people for whom age and gender was filled in. To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 1 = One household member 2 = Two household members 3 = Three household members 4 = Four household members 5 = Five household members 6 = Six household members 7 = Seven household members
Kids Ratio *The number of household members with an age lower than 18 in relation to household size.*	*	The number of children (age < 18 years) within the household was counted. This number was divided by the number of people within the household (household size). To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 1 = Low (ratio <.5, meaning that less than half of the household members are children). 2 = High (ratio ≥ .5, meaning that half or more of the

			household members are children).
Female ratio *The number of female household members in relation to household size.*	*	The number of female household members within the household was counted. This number was divided by the number of people within the household (household size). To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 1 = Low (ratio <.5, meaning that less than half of the household members are female). 2 = High (ratio ≥ .5, meaning that half or more of the household members are female).
Amount of household heads. *The number of household members within the household.*	*	The number of household head within the household was counted. Some respondents did not fill in who was the household head, so no data is available. For these cases the data on this variable was marked s missing. To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 0 = Missing 1 = One household head 2 = Two household heads
Age household head *The* age of the household head when one household head.	*	To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 1 = Young adult (age <30) 2 = Adult (30>age<65) 3 = Senior (age≥65).
Gender household head	*	-	Nominal, with the following categories: 0 = Missing

The household head's gender when one household head.			1 = Male 2 = Female 3 = Other
Disability household head *Whether the household head has disability when one household head.*	*	-	Nominal, with the following categories: 0 = Missing 1 = Disability 2 = No disability
Neighbourhood *The neighbourhood the household lives in.*	"In what neighbourhood is your household located?"	-	Nominal, with the following categories: 1 = Amboina; 2 = Belnem; 3 = Antriol Pabo; 4 = Antriol Pariba; 5 = Guatemala; 6 = Hato; 7 = Lagun Hill; 8 = Lima; 9 = Mexico; 10 = Nawati Noord; 11 = Nawati Zuid; 12 = Nikiboko; 13 = Noord saliña; 14 = Playa (Kralendijk); 15 = Playa Pabou; 16 = Playa Pariba; 17 = Rincon Noord; 18 = Rincon Zuid; 19 = Sabadeco; 20 = Sabana; 21 = Santa Barbara; 22 = Tera Kora; 23 = I don't know.
Type of household *Composition of household*	"What describes the composition of your household best?"	-	Nominal, with the following categories: 1 = Single person household 2 = Couple without children 3 = Couple with children 4 = Single parent

			5 = Mixed family 6 = Friends 7 = Colleagues 8 = Other
Number of Languages *The number of languages fluently spoken by household members*	"Which languages are fluently spoken by one or more people in your household?"	The number of languages was counted. To allow an easier demographic analysis, the variable was altered into a categorical variable.	Ordinal, with the following categories: 1 = One language 2 = Two languages 3 = Three languages 4 = Four languages 5 = Five languages 6 = > five languages
Speaks Papiamentu *Whether someone within the household speaks fluent Papiamentu*	*	-	Nominal, with the following categories: 1 = Yes 2 = No
Speaks Dutch *Whether someone within the household speaks fluent Dutch*	*	-	Nominal, with the following categories: 1 = Yes 2 = No
Speaks Spanish *Whether someone within the household speaks fluent Spanish*	*	-	Nominal, with the following categories: 1 = Yes 2 = No
Speaks English *Whether someone within the household speaks fluent English*	*	-	Nominal, with the following categories: 1 = Yes 2 = No

Religious *Whether household is religious*	"Is your household religious? If so, what religion is dominant?"	-	Nominal, with the following categories: 1 = Yes 2 = No
Type of religion *Dominant religion if household is religious*	*	-	Nominal, with the following categories: 1 = Roman Catholic 2 = Pentecostal church 3 = Protestant 4 = Evangelical 5 = Jehovah 6 = Adventist 7 = Muslim 8 = Other 9 = Agnostic
Cultural Ethnicity *The cultural ethnicity best describing the household*	'In your opinion, which cultural ethnicity describes your household best?"	-	Nominal, with the following categories: 1 = Bonairean 2 =Aruban/ Curaçaos 3 = Station, Saban, St-Marten 4 = Mid or South American (remaining countries) 5 = Dutch 6 = North American 7 = Other
Education *Highest level of education obtained within the household*	"What is the highest achieved level of education by anyone in your household?" *Examples are provided.*	-	Nominal, with the following categories: 1 = Primary school 2 = High school 3 = Trade school / Lower secondary school (vmbo in Dutch)

			4 = Bachelor's degree (HBO or WO in Dutch) 5 = Master's degree (HBO or WO in Dutch) 6 = PhD 7 = I don't know Later altered in: 1 = Low (1 to 3) 2 = High (4 to 6)
Income sources *The amount of income sources per household member*	"How many sources of income are there in your household?" *Examples are provided.*	The amount of income sources was divided by the household size. After this, the min-max method was used.	Ratio.
Independent sources *The proportion of income sources that are independent of vulnerable sectors.*	"How many of these incomes depend on one of the following sectors: tourism, agriculture, fishery?" *Examples are provided.*	The amount of dependent income sources was subtracted from the amount of income sources. After this, the min-max method was used.	Ratio.
Income per capita *The household income per household member*	"What is the monthly income of your household?" *Examples are provided.*	The income per household was divided by the household size. Subsequently, categories were created based on the minimum needed income of 1363 USD (as described in chapter 4).	Ordinal, with the following categories: 1 = Very low (lower than half of the minimum needed income: <681.5 USD). 2 = Low (lower than the minimum needed income, higher than half: 681.5> and <1363).

			3 = Middle (between one and two times minimum needed income: 1363 – 2726 USD). 4 = High (between two and three times minimum needed income: 2726-4089 USD) 5 = Very high (higher than twice the minimum needed income: >4089 USD).
Savings *Subjective measure of the extend in which savings can help the household recover from a crisis*	"On a scale from 1-5, to what extent could your household's savings help your household recover from a crisis like a hurricane or flooding?" *Examples are provided.*	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous
Insurance *Whether insurance covers climate change damage*	"Does your household have insurance (either house or household content) that covers damage from climate change and/ or natural disasters?"	Recoded in which no = 0 and yes = 1.	Continuous
Asset distribution *Whether the household has*	"Does (someone in) your household have	Recoded in which no = 0 and yes = 1.	Continuous

assets in other places than Bonaire	any valuable assets in other places than Bonaire?" *Examples are provided.*		
Vulnerable neighbourhood *Whether the household is located in a vulnerable neighbourhood*	*	Recoded, in which: High vulnerability (Belnem, Hato, Playa, Playa Pabou, Playa Pariba, Sabadeco) receives value 0; Medium Vulnerability (Santa Barbara; amboina; Antriol Pabou; Antriol Pariba; Guatemala; lima; nawati Noord; Nawati zuid; Noord salina, Nikiboko; Tera kora, Sabana) receive value .5; Low vulnerability (Rincon Noord, Rincon Zuid, Lagun Hill) receive value 1.	Continuous
Ownership of house *Whether the household owns the house they live in*	"Is the house your household lives in owned by your household or someone in your household?"	Recoded in which no = 0 and yes = 1.	Continuous
Damage to house *The extend in which the house would be damaged by a natural hazard*	"On a scale from 1-5, how much do you think your house would be damaged by natural hazards,	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous

	like hurricanes, floods, or landslides?" *Examples are provided.*		
Vegetation *The extent in which the house is surrounded by vegetation*	"On a scale from 1-5, how many plants and trees are planted in the ground (so not pots) around your house?". *Examples are provided.*	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous
Alternatives ratio The ratio of alternatives for electricity, water, and food in case of need.	*	The amount of present alternatives was divided by 3.	Continuous
Organization *Whether one or more household members are part of an organization*	"Does one or more household member(s) belong to any (community) organization or associations on Bonaire?". *Examples are provided.*	Recoded in which no = 0 and yes = 1.	Continuous
Support system *Extent in which the household can*	"On a scale from 1-5, to what extent are there	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous

expect support from people nearby	people near your household that would support your household in case of need?". *Examples are provided.*		
Response from community Extend of expected effectiveness of community during natural hazards	On a scale from 1-5, to what extent do you think your community can react effectively during natural hazards, like floods and hurricanes?	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous
Independency ratio *The number of household members with a disability and/or an age lower than 15 years old or older than 64 years old in relation to household size.*	*	The number of dependent people (15 years < age > 64 years and/or a disability) within the household was counted. This number was divided by the number of people within the household (household size).	Ratio.
Climate change awareness	"On a scale from 1-5, to what extent are you aware of what climate change	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous

	means and how it can impact your household?"		
Information on climate change	"Would you know where to find more information about the impact climate change and natural hazards can have on your household or information on how to prepare for it?"	Recoded in which no = 0 and yes = 1.	Continuous
Education on climate change	"On a scale from 1-5, to what extent did people in your household receive any form of education about climate change or its impacts on your household or how to prepare for it?". *Examples are provided.*	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous
Response government	"On a scale from 1-5, to what extent do you	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous

	have trust in the preparations of the government (both local and Dutch) for any natural hazards, like floods or hurricanes?"		
Medical help	"In case of emergency, how long would it take you to reach medical care?"	Rescaled, so that: 0-5 minutes = 1 5-15 minutes =.33 15-30 minutes = .67 More than 30 minutes = 0 I do not know = missing	Continuous
Steps to prepare	"On a scale from 1-5, to what extent has your household taken any steps to prepare for climate change and/or related hazards (like floods, storms, hurricanes, tsunami's, droughts)?" *Examples are provided.*	5-point Likert scale recoded into a scale from 0-1 (with in between steps of .25).	Continuous

* Derived from other variables.

Appendix F

Table listing the used test per variable

Socio-demographic variable	Level	Test
User language	Categorical (Nominal; >2 levels)	ANOVA
Household size	Categorical (Nominal; >2 levels)	ANOVA
Kids ratio	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Female ratio	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Number of H-Head	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Age of H-Head	Categorical (Nominal; >2 levels)	ANOVA
Gender of H-Head	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Type of household	Categorical (Nominal; >2 levels)	ANOVA
Number of languages	Categorical (Nominal; >2 levels)	ANOVA
Speaks Papiamentu	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Speaks Dutch	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Speaks English	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Speaks Spanish	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Religious	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided
Type of religion	Categorical (Nominal; >2 levels)	ANOVA
Cultural Ethnicity	Categorical (Nominal; >2 levels)	ANOVA
Education level	Categorical (Nominal; 2-levels)	Independent sample t-test, two-sided

Appendix G

Tables Showing Statistic Descriptives of Independent and Dependent Variables

Table G1

Descriptive statistics of Independent Variables

Independent variable	**Descriptives**
User Language	N=183, of which: 92 Dutch (30.3%) 56 English (30.6%) 6 Spanish (3.3 %) 29 Papiamentu (15.8%)
Household Size	N = 182, of which: M=2.39; SD=1.264; Min=1; Max=7; Mode=2.
Household Size (categorical)	N = 182, of which: 43 One household member (23.6%) 80 Two household members (43.6%) 22 Three household members (12.1%) 25 Four household members (19.5%) 7 Six household members (3.8%) 1 Seven household members (.0%)
Kids Ratio	N =181, of which: M=.135; SD=.217; Min=.00; Max=.75.
Kids Ratio (categorical)	N =181, of which: 149 Low ratio (82.3%) 32 High ratio (17.7%)
Female Ratio	N =182, of which: M=.527; SD=.289; Min=.00; Max=1.00; Mode=.50.
Female ratio (categorical)	N = 182, of which: 45 Low ratio (24.7%) 137 High ratio (75.3%)
Amount of Household Heads	N =182, of which: 36 No Household Heads (19.8%) 111 One Household Head (60.1%)

	35 Two Household Heads (19.2%)
Age of Household Head ('Amount of household heads' = 1)	N =108, of which: M=46.81; SD=14.241; Min=24; Max=81; Median=45.
Age of Household Head ('Amount of household heads' = 1) (categorical)	N = 108, of which: 13 Young adult (12.0%) 80 Adult (74.1%) 15 Senior (13.9%)
Gender of Household Head ('Amount of household heads' = 1)	N=111, of which: 46 Male (41.4%) 65 Female (58.6%)
Disability of Household Head ('Amount of household heads' = 1)	N=111, of which: 106 No Disability (4.5%) 5 Disability (95.5%)
Type of Household	N=181, of which: 43 Single person household (23.8%) 71 Couple without children (39.2%) 46 Couple with children (25.4%) 10 Single parent (5.5%) 11 Mixed family (6.1%) 0 Friends (0%) 0 Colleagues (0%)
Number of Languages	N = 183, of which: 45 One language (24.6%) 52 Two languages (28.4%) 46 Three languages (25.1%) 32 Four languages (17.5%) 8 Five languages (4.4%)

	0 > Five languages (.0%)
Of which:	
Papiamentu	81 Yes (44.3%)
	102 No (55.7%)
Dutch	147 Yes (80.3%)
	36 No (19.7%)
Spanish	48 Yes (26.2%)
	135 No (73.8%)
English	144 Yes (78.7%)
	39 No (21.3%)
Religious	N=183, of which:
	126 No (68.9%)
	57 Yes (31.1%), of which:
	33 Roman Catholic (57.9%)
	2 Pentecostal church (3.5%)
	5 Protestant (8.8%)
	6 Evangelical (10.5%)
	2 Jehovah (3.5%)
	3 Adventist (5.3%)
	1 Muslim (1.8%)
	2 Agnostic (3.5%)
	3 Other (5.3%)
Cultural Ethnicity	N=183, of which:
	39 Bonairean (21.3%)
	8 Aruban/ Curaçaos (4.4%)
	9 Mid or South American (4.9%)
	82 Dutch (82%)
	17 North American (9.3%)
	28 Other (15.3%)
Education Level	N=183, of which:
	43 Low education (24.0%)
	136 High education (76.0%)
	Of which:

15	High school (8.2%)
28	Trade school/ Lower secondary school (15.3%)
72	Bachelor's degree (39.3%)
54	Master's degree (29.5%)
10	PhD (5.5%)
4	I don't know (2.2%)

Table G2

Descriptive statistics of Indicators and HCRI (components)

Dependent variable	**Descriptive statistics**
Income sources	N = 181, with values ranging from .03 to 1.00. M = .210 (SD = .13).
Independent sources	N = 181, with values ranging from .00 to 1.00. M = .63 (SD = .41).
Income per capita	N = 177, with: 13 Verry low [value = 0] (7.3%) 48 Low [value = .25] (27.1%) 74 Middle [value= .5] (41.8%) 26 High [value = .75] (14.7%) 16 Very high [value = 1.0] (9.1%)
Savings	N = 183, with: 34 [value = .00] (18.6%) 46 [value = .25] (25.1%) 42 [value = .50] (23.0%) 38 [value = .75] (20.8%) 23 [value = 1.00] (12.6%)
Insurance	N = 138, with: 83 No [value = .00] (60.1%) 55 Yes [value = 1.00] (39.9%)
Asset distribution	N = 183, with: 143 No [value = .00] (78.1%)

	40 Yes [value = 1.00] (21.9%)
Vulnerable neighbourhood	N = 178, with: 77 High Vulnerability (43.3%) 90 Medium Vulnerability (50.6%) 11 Low Vulnerability (6.1%)
Ownership of house	N = 183, with: 77 No [value = .00] (42.1%) 106 Yes [value = 1.00] (57.9%)
Damage to house	N = 178, with: 17 [value = .00] (9.6%) 26 [value = .25] (14.6%) 71 [value = .50] (39.9%) 54 [value = .75] (30.3%) 10 [value = 1.00] (5.6%)
Vegetation	N = 183, with: 12 [value = .00] (6.6%) 29 [value = .25] (15.8%) 44 [value = .50] (24.0%) 44 [value = .75] (24.0%) 54 [value = 1.00] (29.5%)
Alternatives ratio	N = 183, with: 90 [value = .00] (49.2%) 55 [value = .33] (30.0%) 30 [value = .67] (16.4%) 8 [value = 1.00] (4.4%)
Organization	N = 183, with: 120 No [value = .00] (65.5%) 63 Yes [value = 1.00] (34.4%)
Support system	N = 183, with: 20 [value = .00] (10.9%) 52 [value = .25] (28.4%) 50 [value = .50] (17.3%) 43 [value = .75] (23.5%)

	18 [value = 1.00] (9.8%)
Response from community	N = 183, with: 30 [value = .00] (16.4%) 82 [value = .25] (44.8%) 52 [value = .50] (28.4%) 16 [value = .75] (8.7%) 3 [value = 1.00] (1.6%)
Independency ratio	N = 183, with with values ranging from .00 to 1.00. M = .74 (SD = .35).
Awareness on climate change	N = 183, with: 8 [value = .00] (4.4%) 16 [value = .25] (13.1%) 40 [value = .50] (21.9%) 66 [value = .75] (36.1%) 53 [value = 1.00] (29.0%)
Information on climate change	N = 183, with: 66 No [value = .00] (36.1%) 117 Yes [value = 1.00] (63.9%)
Education on climate change	N = 183, with: 36 [value = .00] (19.7%) 57 [value = .25] (31.1%) 38 [value = .50] (20.8%) 37 [value = .75] (20.2%) 15 [value = 1.00] (8.2%)
Response government	N = 183, with: 45 [value = .00] (24.6%) 75 [value = .25] (41.0%) 40 [value = .50] (21.9%) 21 [value = .75] (11.5%) 2 [value = 1.00] (1.1%)
Medical help	N = 177, with: 9 More than 30 minutes [value = .00] (5.1%) 36 15 to 30 minutes [value = .33] (20.3%)

	30 5 to 15 minutes	[value = .67] (59.9%)
	26 0 to 5 minutes	[value = 1.00] (14.7%)
Steps to prepare	N = 178, with:	
	64 [value = .00] (36.0%)	
	57 [value = .25] (32.0%)	
	36 [value = .50] (20.2%)	
	18 [value = .75] (10.1%)	
	2 [value = 1.00] (1.7%)	
ER	N = 183, with with values ranging from .000 to .950. M = .448 (SD = .21).	
PR	N = 183, with with values ranging from .000 to .820. M = .240 (SD = .16).	
SR	N = 183, with with values ranging from .000 to .875. M = .74 (SD = .19).	
IR	N = 183, with with values ranging from .000 to .820. M = .74 (SD = .16).	
HCRI	N = 183, with with values ranging from .000 to .737. M = .74 (SD = .11).	