IVM Institute for Environmental Studies

Impacts of Climate Change on Cultural Heritage on Bonaire

An assessment of the impacts of climate change on Bonairians' Cultural Heritage

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Summary

Climate change causes many problems, including non-economic loss and damage. However, non-economic damages are often overlooked as they are hard to measure and not felt by the wider society. The Caribbean region is especially vulnerable to the impacts of climate change. This project investigates the impacts of climate change on cultural heritage on Bonaire.

Expert interviews, participatory mapping, and social media analysis were applied to identify Bonaire's most important cultural heritage. Overlaying the resulting cultural heritage maps with inundation and flood maps from the different climate change scenarios for 2150 showed the predicted impacts of climate change on tangible cultural heritage. The inundation maps show that the southern tip of the island, with its lighthouse, slave huts, and salt pans, will most likely be flooded in 2150, as well parts of Kralendijk under climate scenarios SSP5-8.5 and SSP5-8.5 LC. The climate change impacts on intangible cultural heritage was predicted by means of expert interviews. Climate change is predicted to impact fisheries, agricultural practices, art, and festivities on Bonaire, even though these results are more exploratory and uncertain. Bonaire's cultural heritage is at risk and the island will be disproportionately affected by climate change. Decision-makers should take their responsibility to support Bonaire's adaptation to the expected impacts accordingly.

1 Introduction

Climate change (CC) is the defining concern of our time (UN, n.d.). Small islands are disproportionately affected by climate change, especially considering their minor contribution to global greenhouse gas emissions (IPCC, 2021; PAHO, 2019). Small islands are particularly vulnerable because of their small economies and often low-lying, large coastal areas which foster their lifestyles (Carabine & Dupar, 2014; Macpherson & Akpinar-Elci, 2013). The Intergovernmental Panel on Climate Change (IPCC) (2022) is confident that small islands will suffer from temperature increases, changes in precipitation patterns, sea level rise (SLR), coral bleaching, and extreme weather events, such as tropical cyclones, droughts, and storms, as a result of climate change.

Climate change will also disproportionately affect the Caribbean small island region (Nurse *et al.*, 2014). Small island states in the Caribbean and their inhabitants are already being affected, through SLR and weather changes, and indirect climate change effects, such as impacted fisheries and reduced food security (Alliance of Small Island States, 2009). The IPCC predicts higher temperatures, less precipitation, and SLR in the future (Akpinar-Elci & Sealy, 2014; Nurse *et al.*, 2014). These projected changes will produce environmental, economic, and social damage and put further pressure on the small islands (Akpinar-Elci & Sealy, 2014; Dutch Caribbean Nature Alliance, 2019).

To minimise the pressures associated with climate change, the impacts need to be managed with care (Dutch Caribbean Nature Alliance, 2019). However, non-economic loss and damage, (NELD) from climate change, including damage to cultural heritage, is often overlooked because non-economic impacts are difficult to quantify and are often not noticed by the wider society (Serdeczny *et al.*, 2016). Research on Caribbean islands mostly overlooks climate change damage to culture, as many studies investigate the climate change impacts on tourism demand, the economy, and nature (Akpinar-Elci & Sealy, 2014; Moore, 2010; Toba, 2009; Wilson, 2017).

Climate change is expected to affect culture on small islands in the Caribbean, through SLR and the increased occurrence of tropical cyclones, storm surges, and heavy precipitation (IPCC, 2021). More specifically, extratropical cyclones, SLR, and consequent flooding can damage low-lying tangible cultural heritage on the coast and exceptional heat can disturb intangible cultural heritage such as festivities.

UNESCO defines cultural heritage as tangible monuments, artifacts, and sites that have historical, symbolic, and social values, and the intangible cultural heritage (ICH) that is "embedded" within this tangible cultural heritage (TCH) (UNESCO Institute for Statistics, 2009, para 1). However, Intangible Cultural Heritage Bonaire (n.d.) include additional intangible heritage, such as traditions, festive events, and traditional craftsmanship into their definition.

Bonaire is a small, low-lying island in the Caribbean, which means that it will be heavily affected by climate change (IPCC, 2021). SIDS often lead the way in international climate negotiations (WHO, 2021a). However, upon signing the Paris Agreement, the Netherlands declared that the Paris Agreement would only apply for the European part of the Kingdom. As such, the Paris agreement does not apply to the islands in the Dutch Caribbean.

Research on the Bonairian cultural heritage is scarce. Information on Bonairian cultural ecosystem services (ES) is also limited, as research has focused on coastal and recreational ES, and the total economic value of nature (van Beek, 2011; Cado van der Lely *et al.*, 2013, van Zanten & van Beukering, 2012). Aubertin and colleagues (2012) have identified cultural ES, and van Beek (2011) has analysed the cultural ES provided by coral reefs. Lacle and colleagues (2012) have collected the traditional and historical locations most visited by Bonairians. However, research on the climate change impacts on culture does not exist for Bonaire (Adger *et al.*, 2012; Harkin *et al.*, 2020; Sesana *et al.*, 2021), reinforcing the need for research on the climate change impacts on culture on Bonaire.

Therefore, this study aims to examine how climate change is predicted to impact Bonairian cultural heritage in 2150. In order to understand the impact on Bonairians' cultural heritage, we first identify Bonaire's tangible and intangible cultural heritage. Secondly, we analyse the spatial allocation of cultural heritage on Bonaire. Finally, three different climate change scenarios have been applied to analyse the effects of climate change on Boniarians' cultural heritage.

2 Literature review

2.1 Study site

Bonaire is a small island (288 km2) located in the Caribbean Sea, 80 km north off the coast of Venezuela (figure 1), and has been a public entity within the Netherlands since the Netherlands Antilles dissolved in 2010. Bonaire's terrain is predominantly low-lying and covered by low thorny vegetation (Uyarra et al., 2005).

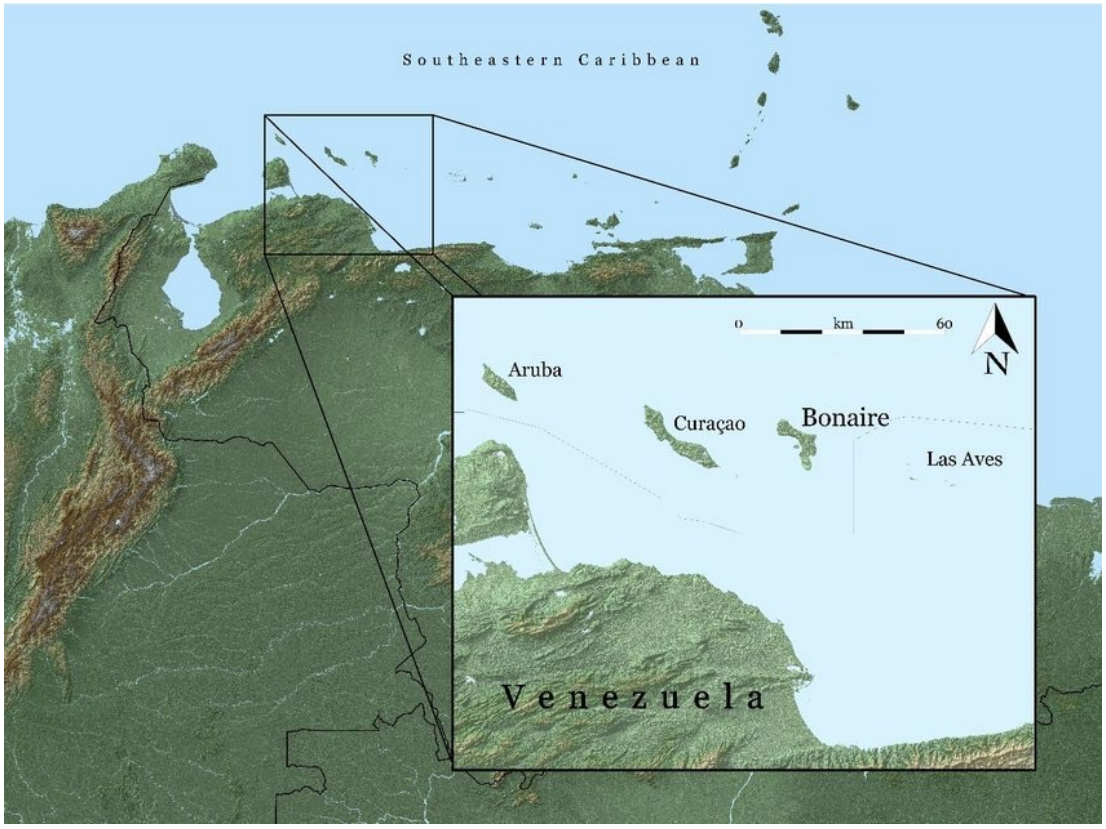


Figure 1 The ABC islands (Antczak, 2019, p.14)

Between 2010 and 2022, the population of Bonaire has grown from 15,500 to 22,600 people (CBS, 2022). This growth was mainly attributable to migration and is expected to continue (CBS, 2022). The population is diverse, with residents from the Caribbean Netherlands, Southern, Central, and North America, and the European Netherlands. Figure 2 shows the population by region of birth as of 1 January 2021.

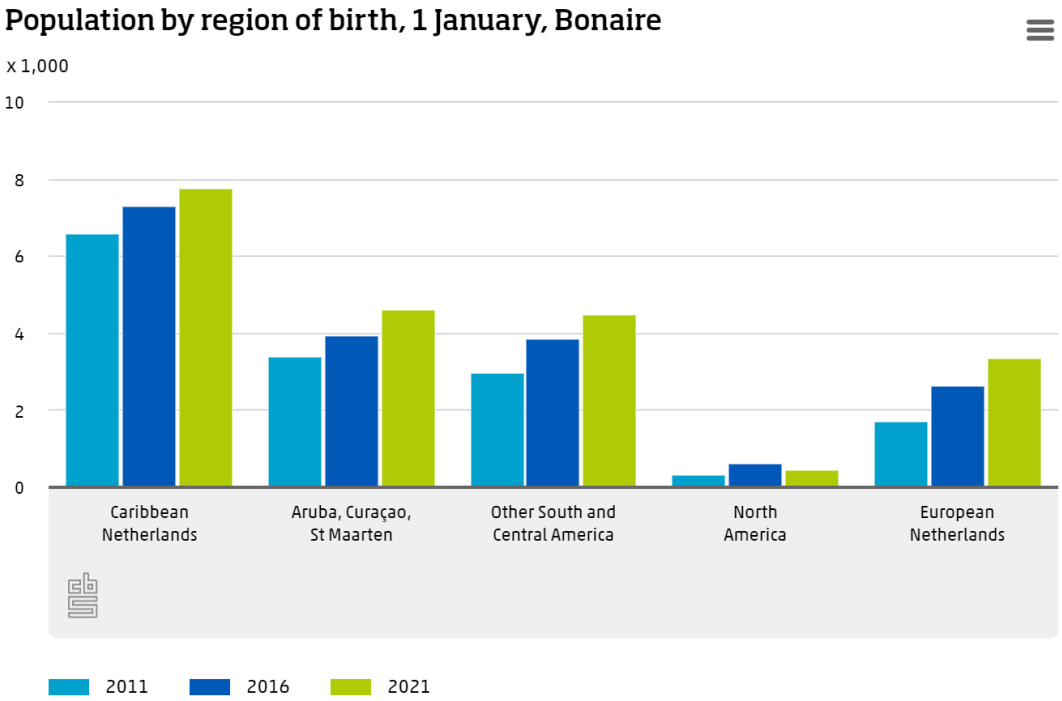


Figure 2 Bonaire population by region of birth (Statistics Netherlands, 2021)

Bonaire exhibits a semi-arid steppe, but also tropical climate with alternating wet and dry seasons ranging from October to January and February to May respectively. As Bonaire is located in the Southern Caribbean Dry Zone, its climate is drier compared to the rest of the Caribbean (Meteorological Department Curaçao, n.d.; Verweij *et al*., 2021). The tropical climate exhibits small temperature differences between seasons with seasonal mean temperatures between 26℃ and 29℃ (Meteorological Department Curaçao, n.d.; Schmutz *et al*., 2017). The fairly constant temperatures and distinct wet and dry seasons are presented in figure 3.

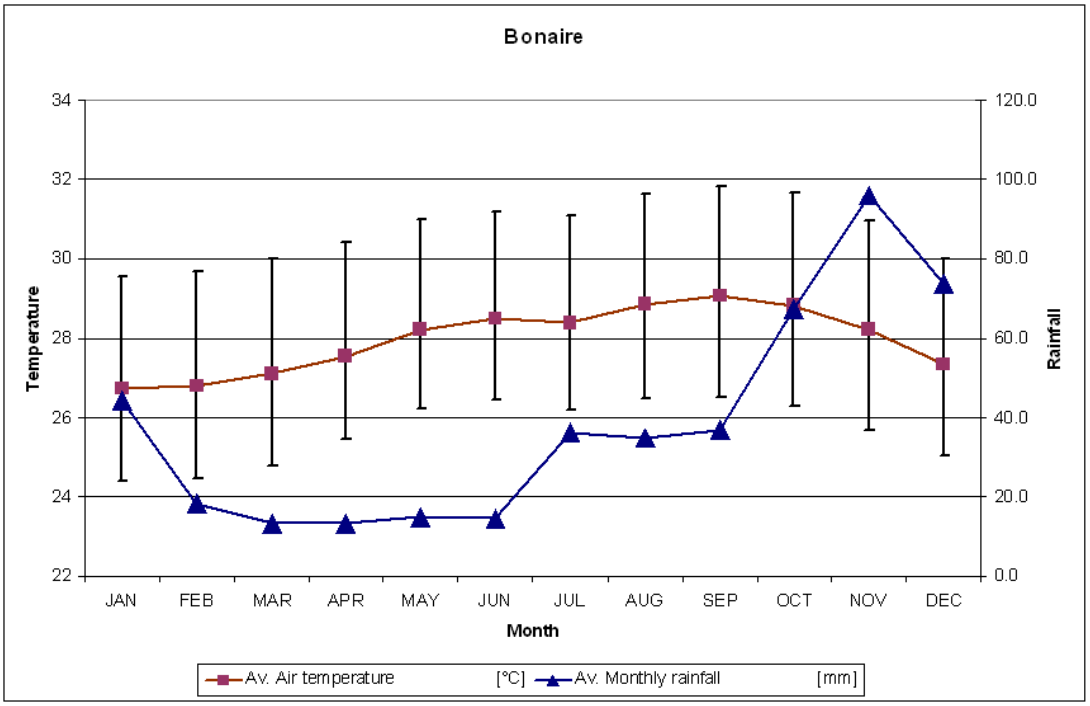


Figure 3 Climate summary for Bonaire (Meteorological Department Curaçao, n.d.)

2.2 Climate change on Bonaire

This section summarizes the physical changes that are expected to occur in Bonaire's climate as a result of climate change. More detailed information is presented in the study from Dullaart & van Manen (2022) and in Annex A.

2.2.1 Climate change scenarios

Climate change impacts are most often projected through scenarios that are regularly updated by the IPCC. Each Shared Socioeconomic Pathway (SSP) or Representative Concentration Pathway (RCP) is described by a global temperature increase (table 1).

2.2.2 Temperature

In the Caribbean, extreme temperatures are already occurring at an increased frequency due to climate change (Taylor *et al*., 2020; Stephenson *et al*., 2014). Due to the lack of a multi-year time series of temperature on Bonaire, no trends in temperature change can be assessed with island specific data (Dullaart & van Manen, 2022). However, on Curaçao, Bonaire's neighbouring island, mean temperature has increased by 0.6℃ since 1980 (KNMI, 2021). Furthermore, in all IPCC scenarios by 2100, a temperature increase is expected (Taylor *et al*., 2020). This increase is ranging from 0.83℃ to 3.05℃ for the least to most extreme scenario with respect to the baseline period 1986-2005 (Taylor *et al*., 2020).

Table 1 Physical changes projected for the Caribbean and Bonaire in the different climate change scenarios (Angeles-Malasapina et al., 2018; Taylor et al., 2020; NASA, 2022)

			2050	2100	2150
		SSP1/RCP1.9	NA	NA	
	Projected **mean temperature** increase (°C) with respect to 1986-2005 (Caribbean) * shows the range of the projections (Taylor *et al.*, 2020)	**SSP1/RCP2.6**	**0.86°C** *0.39 - 1.57°C	**0.83°C** *-0.04 - 1.74°C	
		SSP3/RCP6.0	**1.00°C** *0.69 - 1.66°C	**1.85°C** *1.00 - 2.92°C	
		SSP5/RCP8.5	**1.50°C** *0.94 - 2.23	**3.05°C** *2.10 - 4.22°C	
		SSP1/RCP1.9	NA	NA	
	Projected mean **precipitation** change (%) with respect to 1986-2005 (Caribbean)	**SSP1/RCP2.6**	-0.09	-0.46	
		SSP3/RCP6.0	-2.42	-6.91	
		SSP5/RCP8.5	-6.27	-16.95	
		SSP1/RCP1.9	0.23	0.47	0.70
	Projected **sea level rise** (m) relative to 1995-2014 (Bonaire)	**SSP1/RCP2.6**	0.24	0.51	0.78
		SSP2/RCP4.5	0.25	0.64	1.05
		SSP5/RCP8.5	0.27	0.85	1.45

2.2.3 Precipitation and sea level rise

As shown in table 1, the Caribbean can expect an increase in temperature, in the frequency of heat waves and SLR, and a decrease in precipitation in all IPCC scenarios (Taylor *et al.*, 2020; NASA, 2022). Currently, there has already been a declining trend in rainfall during the summer months in the Caribbean (IPCC, 2021). However, this trend is not statistically significant at the five percent significance level (Taylor *et al.*, 2020; Jones *et al.*, 2015). In fact, for Bonaire no significant positive or negative trend in precipitation has been observed so far (KNMI, 2021).

The sea level in the Caribbean is rising at a similar rate (1.8mm/year) as the global rate (1.7mm/year) and has risen by 10.6 cm from 1950 to 2009 (Taylor *et al.*, 2020; Palanasamy *et al.*, 2015; Torres & Tsimplis, 2013). This means that the SLR around Bonaire and the Caribbean is expected to rise slightly faster than on average around the world (KNMI, 2021). According to the IPCC's scenario pathways, the projected range of SLR for 2081-2100 compared to 1986-2005 for the Caribbean region is between 0.47 (SSP1-1.9) and 0.85 (SSP5-8.5) metres rise in sea level (Akpinar-Elci & Sealy, 2014; Nurse

et al., 2014). Verweij *et al*. (2020) argue that one of the challenges for Bonaire is the adaptation to SLR.

2.2.4 Extreme weather events

Extreme weather events due to climate change are projected to increase in the Caribbean (Hersbach *et al.*, 2019; Debrot *et al.*, 2018; Verweij *et al.*, 2020). Bonaire is threatened by an increasing frequency, duration, and intensity of heat waves, and increased aridity resulting from a higher intensity and frequency of droughts (Hersbach *et al.*, 2019; Debrot *et al.*, 2018; IPCC, 2021). Tropical cyclones considerably damage Bonaire ca. every 100 years with flooding, and worse storms due to climate change also can also cause damage on Bonaire (Dutch Caribbean Nature Alliance, 2019; Meteorological Service Netherlands Antilles and Aruba, 2010).

2.3 The impacts of climate change on cultural heritage

The impact of climate change on culture is increasingly described in the literature. Adger *et al.* (2012) show that climate change threatens livelihoods, culture, and identity, for example as loss of fish stocks can impact the culturally valued fishing practices. In the UK, research concludes that underwater, coastal, and land heritage can be impacted by changes in ocean temperatures and acidity, SLR, and extreme weather events (Harkin *et al.*, 2020). A recent literature review on the climate change impacts on TCH finds that climate change can increase damage to cultural heritage through climatic stressors. However, the authors acknowledge that most revised studies only considered one climate change scenario, neglecting the uncertainties inherent in climate change (Sesana *et al.*, 2021). This project aims to consider this uncertainty by analysing the climate change impacts on TCH in three climate change scenarios.

In their desk study, Aubertin and colleagues (2012) have identified threats to cultural ES on Bonaire. However, the main threats identified are linked to tourism, fishing, and the lack of cultural transmission, and do not include specific climate change threats. Accordingly, there is a significant gap in literature on the climate change impacts on Bonairian cultural heritage.

3 Methodology

3.1 Desk research

The TCH and ICH on Bonaire were identified by reviewing (I) the beleidsnota Cultuur, (II) the *Intangible Cultural Heritage Bonaire*'s website, (III) various academic articles. The literature search was performed in Google and Google Scholar, by searching terms including "cultural heritage Bonaire", "cultural ecosystem services Bonaire", and "impacts of climate change on cultural heritage (on Bonaire)". The results of the desk research are presented on a map showing the cultural heritage of Bonaire.

3.2 Expert interviews

The desk research was complemented by expert interviews and a visit to Mangazina di Rei to validate the identified cultural heritage and to explore how climate change is expected to affect TCH on Bonaire. Five experts from culturally engaged non-governmental organisations (NGOs) and foundations on Bonaire, such as *Fundashon Históriko Kultural Boneriano* and *Hòfi Kultural Bonaire* were interviewed. The organisations were determined through desk research and suggestions from local experts. The snowballing technique was used to get in touch with additional experts.

To interview the experts, semi-structured, in-depth interview techniques were performed. The usage of an interview guide ensured that the most important topics were touched upon while allowing for flexibility through probing (Hesse-Biber & Leavy, 2011; Young *et al.*, 2018). The interviews lasting between 40 minutes to one hour were performed in April and May 2022. Furthermore, experts were asked to indicate where TCH was located on a map of Bonaire (see participatory mapping).

The interviews were transcribed using the software otter.ai in a verbatim format. After the transcription, the transcripts were thoroughly read multiple times to highlight the expert opinions and knowledge useful for the research.

3.3 Participatory mapping

Participatory mapping (PM) was used to further identify and validate Bonaire's cultural heritage. The mapping was not only performed with cultural experts, but also with Bonairian residents. Involving the residents was essential as they will be most affected by the climate change impacts on their cultural heritage. The residents were approached in front of *Bonaire Super Store*, taking part in sports classes, and interacting with tourist activity tour guides. Bonaire has a diverse population, which led to the choice to let everyone living on Bonaire participate. Resident participants had to have lived on Bonaire for more than two and a half years, to ensure that they had been able to experience the Bonairian culture and traditions before COVID-19.

The respondents were shown a map of Bonaire and asked to pinpoint the TCH and ICH they value and find important for the Bonairian culture. To make it simple and cost-efficient, the mapping used paper maps, coloured pens, and sticky notes (Hupmobile, n.d.). The respondents could also explain why they value things they indicated. The

respondents' sketches were then digitised into polygons on a map using QGIS to show locations respondents consider important for cultural heritage and the Bonairian identity (de Vreese & Fontaine, 2014). Two different maps were created: one map combining the results from the expert interviews and participatory mapping (PM), and one map comparing these results to those from the literature review and the social media analysis.

The cultural heritage maps from the literature review and Bonairian participants were combined into one map showing the TCH identified and valued, which was overlaid with the different inundation maps created by Dullaart & van Manen (2022). This showed which TCH is at risk in which scenarios. Using three different scenarios ensured that the analysis took into account the existing uncertainty around the possible climate change pathways. Qualitative interviews and the PM conversations were used to assess the climate change impacts on ICH that are being felt and that are expected.

3.4 Social media analysis

Finally, this project used the novel method of social media analysis to validate the literature review, PM, and expert interviews. Social media is valuable because it reveals spatial behaviour and helped to reveal the Bonairian cultural hotspots most visited by tourists and residents.

Raw data from an earlier social media analysis of Bonaire were used, including information on 1137 pictures posted by tourists and residents on the platform Flickr (Wolfs Company, *forthcoming*). The pictures included in the analysis were limited to one picture per person per km2 per day to reduce bias.

The following protocol was followed. First, the pictures were downloaded using the links from the raw data file. This process was facilitated using Amaury Tisseau's script, which downloaded the pictures with their geographical coordinates in the title of the downloaded pictures. Second, the pictures were manually screened for cultural heritage, such as the salt pans, Boka Slagbaai, or slave huts. Third, the coordinates of the pictures showing cultural heritage were entered into a point-layer in QGIS to show the cultural hotspots that were identified during the social media analysis.

4 Results: identified cultural heritage

This chapter first describes the results of the desk research to identify TCH and ICH. Additionally, it presents the results associated with the fieldwork by explaining which Bonairian cultural heritage is valued by local stakeholders and shows Bonairian cultural heritage's presence in a social media analysis.

4.1 Cultural heritage identified by literature

Bonaire's 2010 culture policy plan, 'Beleidsnota Cultuur Bonaire', aims to maintain the island's most important cultural activities, habits, and characteristics for future generations. The plan identified TCH and ICH of Bonaire through conversations with island stakeholders and with the local population. The report concludes that Bonairians value the market Marshe di Rincon, the kunuku's, nature conservation, and fishery culture (Beleidsnota cultuur, 2010; Schep *et al.*, 2012). The Bonairian coral reefs also provide cultural ES in terms of artistic inspiration and support of recreation and cultural identity (van Beek, 2011). Lacle and colleagues (2012) identified further cultural ES, such as the use of medicinal plants, and identified the traditional and historical locations most visited by Bonairians, which include the Indian scriptures, the Lourdes cave, Lac/Sorobon, Boca Slagbaai, Washington Slagbaai, Playas Frans, and Karpata (Lacle *et al.*, 2012). Lastly, *Intangible Cultural Heritage Bonaire* has identified ICH on Bonaire, as shown in table 2.

Table 2 Intangible cultural heritage on Bonaire (Intangible Cultural Heritage Bonaire, n.d.)

Social practices, rituals, & festivals	Artistic expressions	Oral tradition and expressions	Traditional crafts	Knowledge & practices related to nature & the universe
Día de Rincón	Playing the 'kachete di buriku' (donkey's jaw)	Papiamentu	Making of Kas di Bara	Kuranderia (herbal medicine & healers)
Simadan	Playing the bamba	Fisherman's songs	Making of boats	Natural disasters
San Juan & San Pedro	Playing the beku	Harvest songs	Harvest of aloe	Indian drawings
La Birgen del Valle	Playing the karkó (large shell)	Marónt (song & dance)	Kose trankera ku chi ku cha (Fence of cacti construction with chi ku cha)	Traditional cuisine
Maskarada	Playing the 'zag' (saw)	Oral history	Making of Barí (drum)	Topography of Bonaire
Barí	Playing the marimba	Customs, norms, & values	Pal'í lele i funchi (special twig used in preparing funchi)	
Marshe de Rincón	Dance & theatre		Tanning of leather	

Food production through agriculture and fishery, as well as goat keeping, are ICH that are especially important for the Bonairian culture. Bonairians have eaten sea fish, turtles, and shellfish for generations, as well as sorghum (maichi chikitu) and goats from

their kunuku's (Verweij *et al.*, 2021). Annex B contains a more detailed overview of all the cultural heritage identified.

4.2 Tangible cultural heritage identified by participatory mapping and social media analysis

Figure 4 shows the cultural heritage that has been identified by literature, cultural experts, Bonairian residents and the social media analysis.

To start, multiple participatory mapping candidates found that everything on the map is important for the Bonairian culture (PM1; PM2) and that all the components of culture are valuable to them (PM4). Others stated that they value the ocean and nature (PM1; PM7). Bonairians value Washington Slagbaai (2) because they see nature as their cultural heritage and support the fact that such a big area of their island has been protected (CE1).

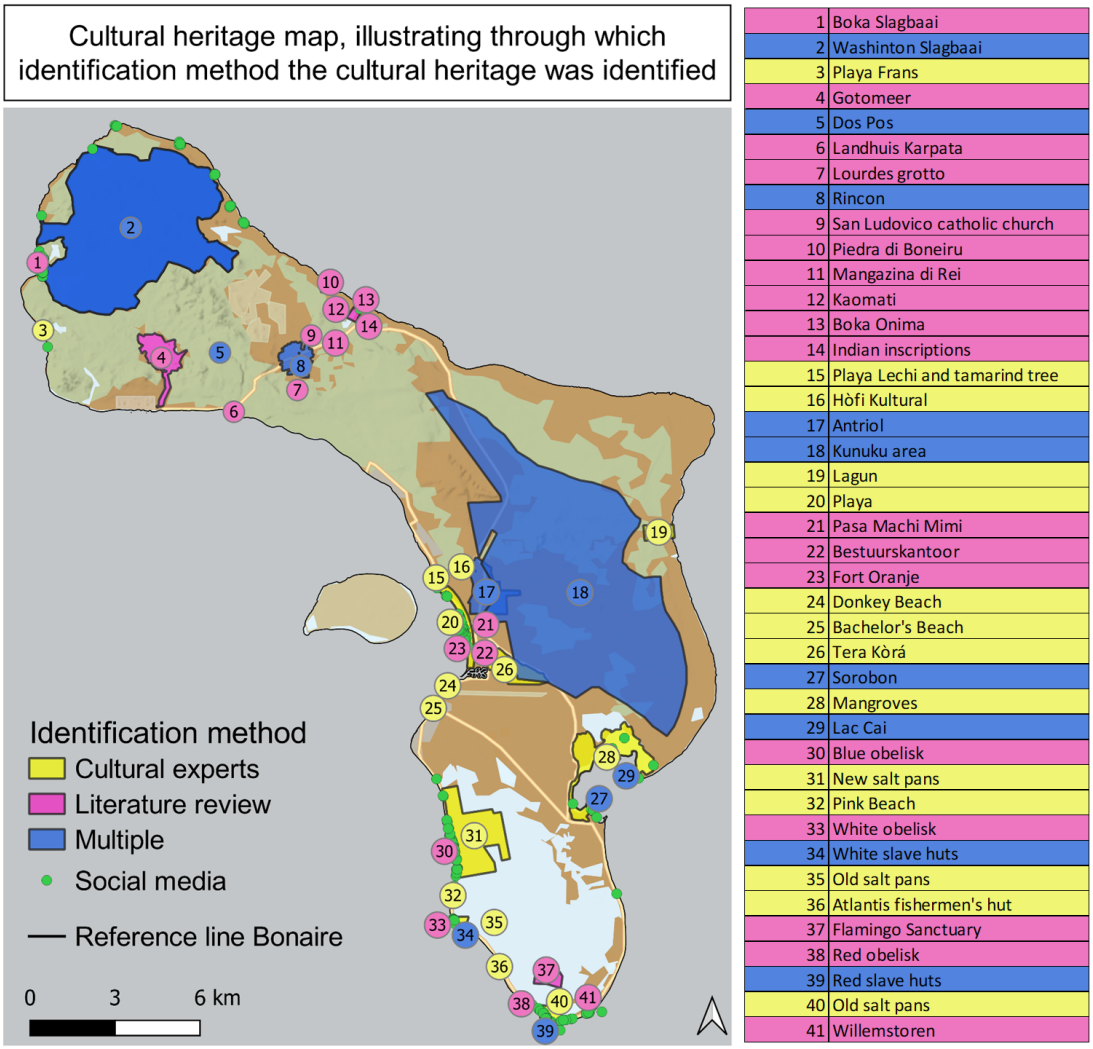


Figure 4 Map comparing the cultural heritage identified during the literature review, by the cultural experts and Bonairian residents, and social media analysis

Playa Frans (3) is a beach that is often visited by locals for fishing and recreational purposes (CE1; Lacle *et al.*, 2012). Dos Pos (5) and the other Bonairian water wells are historically significant to the Bonairians, as they have provided farmers and the inhabitants of Rincon with potable water for centuries (CE1).

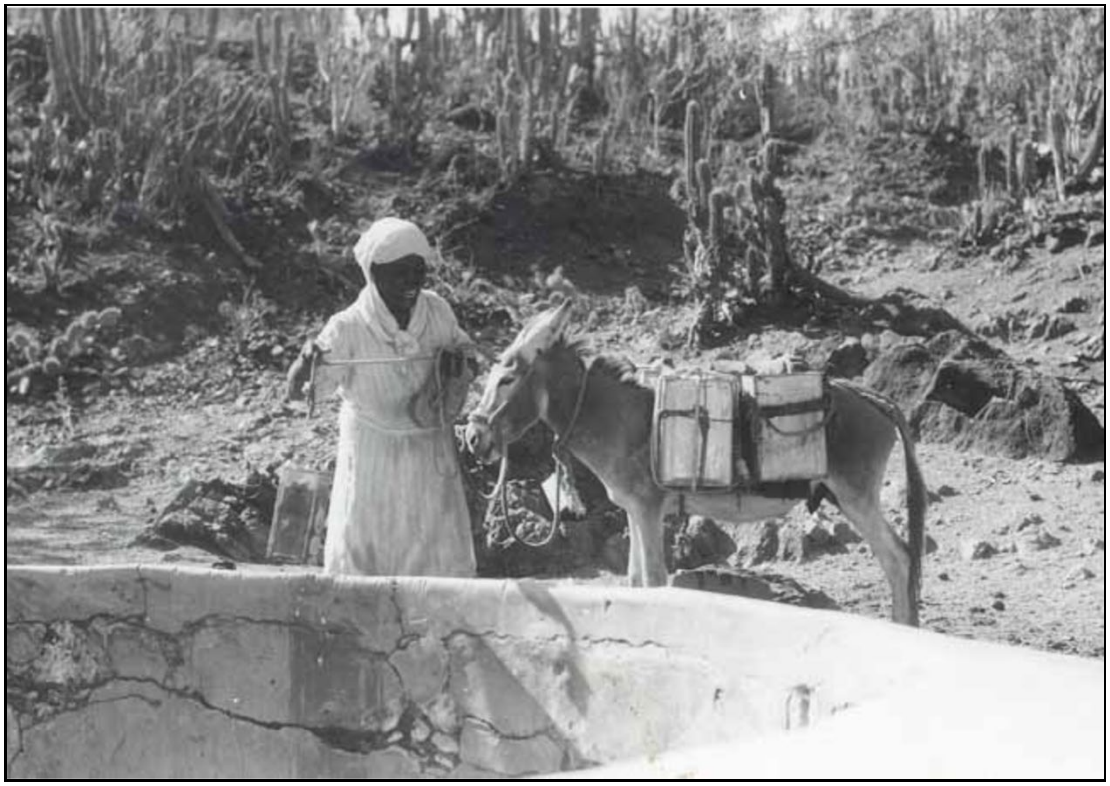


Figure 5 A woman with a donkey at the Dos Gurubu water well (Fundashon Históriko Kultural Boneriano, n.d.)

Rincon is important to many Bonairians and experts because it is the oldest village in the Dutch Caribbean and on Bonaire (CE1; PM2; PM3). Playa Lechi and its tamarind tree (15) are considered heritage because they are important for fishing, and the fishermen used to hide under the tree for shade (CE1). CE2 considers Hòfi Kultural (16) important for Bonairian culture, as it is a cultural center where people can create art and culture together. Playa (20), i.e. the coastline of Kralendijk, has historically also been important for fishing and is important to the locals (CE1; PM7). Two neighbourhoods that are important for Bonairian culture are Antriol (17) and Tera Kora (26). Antriol with the Kaya Korona hosts many businesses and accommodates a mix of farmers, fishermen, and businesspeople (CE3). Cultural expert 3 furthermore stated that "Tera Kora used to be the neighbourhood that 'badly behaving' enslaved people got sent to so they could go work in the salt pans from there". The Kunuku area (18) is valued on Bonaire because agriculture is embedded in the Bonairian culture (CE3; CE4). Lagun (19) is another important location for fishing, a practice which also represents an iconic and important part of Bonairian culture (CE1, PM3; PM6). Donkey (24) and Bachelor's beach (25) are the beaches most used by the Bonairians, and traditions include camping on Donkey Beach for the Easter weekend (CE1). The mangroves (28) are also culturally important for Bonaire because they allow for fishing and used to provide building materials (CE1; CE2; CE5). The Lac Cai area (29) is traditionally known for the fishing of

the Queen Conch, whereas Sorobon (27) is famous for the world-class windsurf champions it has produced (PM5). CE5 also mentioned that the salt pans (31, 35, & 40) are historically important for the Bonairian culture because the enslaved people used to work there to harvest the salt, with the salt being an important export product for Bonaire in the past.

Figure 6 Salt harvesting by a worker in the salt pans (xpbonaire, n.d.)

Other culturally important locations in the South of the island related to the island's slavery history are the white (34) and red slave huts (39), where the enslaved people used to sleep in between their work at the salt pans (CE1; PM2). Lastly, Pink Beach (32) and the fisherman's hut (36) at Atlantis beach, as seen in figure 7, are popular locations for fishing (CE1; CE5; PM3).

Figure 7 Atlantis Kite Beach and its fisherman's hut (Buijs, 2022)

As shown in figure 4, some locations have been identified in all three analyses, however, there are also differences in the outcomes of the three methods. Images of the identified TCH can be found in Annex C. The literature review identified multiple locations around Rincon (e.g. 10, 12, 13, & 14 on the map) and traditional buildings in Kralendijk (e.g. 21, 22, & 23) which were not mentioned during the fieldwork. The fieldwork revealed locations that are important for fishing (19 & 20) and for recreation (24 & 25). The social media analysis features cultural heritage around Washington Slagbaai and mostly Boka Slagbaai, Kralendijk, the salt pans, the slave huts, Willemstoren, and Lac Bay, thereby validating the literature review and fieldwork results.

4.3 Intangible cultural heritage

This section describes more about some of the identified ICH on Bonaire, namely fishery, agriculture, and goat keeping. Farmers and fishermen are often vividly aware of nature and have an intrinsic motivation in protecting it, also because they depend on nature so much.

Fisheries

Fishing is an iconic and important part of Bonairian culture and indigenous people (Caquetio, a strain of the Arawak people) relied on fisheries and contributed the first cultural elements. As such, fishing is one of the oldest economic activities that is still

performed in the Dutch Caribbean (CE5; Dutch Caribbean Nature Alliance, 2019; Mac Donald, 2018; PM6). This is demonstrated by the fact that the circle on the Bonairian flag represents a compass, alluding to the Bonairians' reputation as skilled sailors and fishermen (CE4). Until 50 years ago, most of the island's population relied mainly on fish for their protein intake (Dutch Caribbean Nature Alliance, 2019). An important part for the fishery practice are the fishermens' huts, such as those found in Sorobon and on Atlantis beach, where the fishermen can stay overnight before leaving for an early fishing trip (CE1). Another important location for the fishermen's practices is Lac Bay with its mangroves, which offer small islands that have been used by fishermen in the past to fish (CE1). Historian Arthur Sealy (CE3) points out that fishing is still important, but that the industry has shrunk mainly as a result of regulations aiming to preserve the coral reefs and species such as the Queen Conch and turtles.

Agriculture

Agriculture generally represents an economic sector (CE4). However, this study mainly interprets agriculture as food production, whether it is at an industrial or personal scale. Agriculture is embedded in Bonairian culture. In the past, everyone grew their own food, and most of the inhabitants were self-sufficient through growing crops and keeping goats (CE4; Verweij *et al*., 2020). Bonaire is currently 99% dependent on imported food (Verweij *et al*., 2020). In the past few years, the island governments and inhabitants have started initiatives to take up food growth practices again (CE4; Lotz *et al*., 2020). CE4 suggests two possible reasons for this result: (i) the government and NGOs are actively promoting agriculture, and (ii) the border closure with Venezuela in 2018 led to a decrease in availability of fresh fruits and vegetables. The reliance on imported food may influence the prices (Wageningen University & Research, 2021), although self-cultivated food is not necessarily less expensive than imported food. Despite the government's initiatives, food production on the islands of Bonaire remains limited, and the majority of food is imported from neighbouring nations (Lotz *et al*., 2020).

Goat keeping

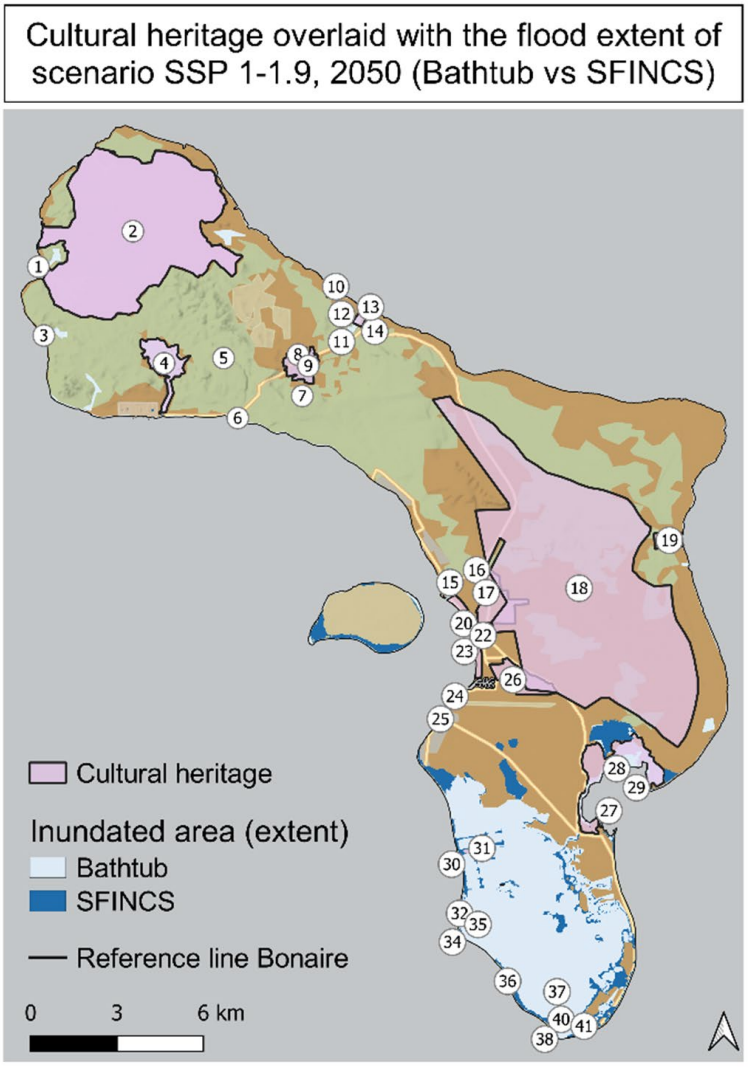
Even though they were initially not present on Bonaire, goats and goat keeping have become part of the Bonairian culture. Goats, sheep, donkeys and pigs were introduced by the Spaniards in order to found a colony (Hartog, 1978). Many Bonairians have lived off the goats in the past, as they were one of the only livestock that could withstand the harsh Bonairian conditions (*Fundashon Históriko Kultural Boneriano* representative). CE3 explains that in the 1950s and 60s the goats were also used for their milk, but that this milk has now been replaced by imported milk and that there is no market for it anymore. Today, Bonairians are still eating goat stoba (stew) and soup (CE3). Goats are today one of the only parts of what is left of Bonairian agriculture (CE4). However, CE4 emphasises that goats have been receiving more political attention due to increasing numbers. He puts forward that older Bonairian people would judge agriculture in a broader sense just as important for their culture as goat keeping. Additionally, goat keeping as a cultural practice involves kunukeros with big herds of goats roaming the island, but not ownerless goats roaming on Bonaire as they increasingly appear today as a result of industrialisation and people leaving the kunuku's (CE4).

5 Results: the impacts of climate change on culture

Climate change is changing life in the Caribbean and on Bonaire (Macpherson & Akpinar-Elci, 2013). However, there has been little academic research on the predicted climate change impacts on the Bonairian culture. On the one hand, CE2 said that "it is not apparent which changes have happened to [the Bonairian] culture with climate change". On the other hand, CE5 puts forward that most people on Bonaire have a narrative about the changes they have been seeing as a result of climate change. The results displayed in this section emerged from conversations with Bonairian residents and cultural experts. The results are based on the respondents' view of their culture and of how their culture has changed or is expected to change with climate change. This section is split into two parts investigating the climate change impacts on TCH and ICH, respectively.

5.1 Tangible cultural heritage

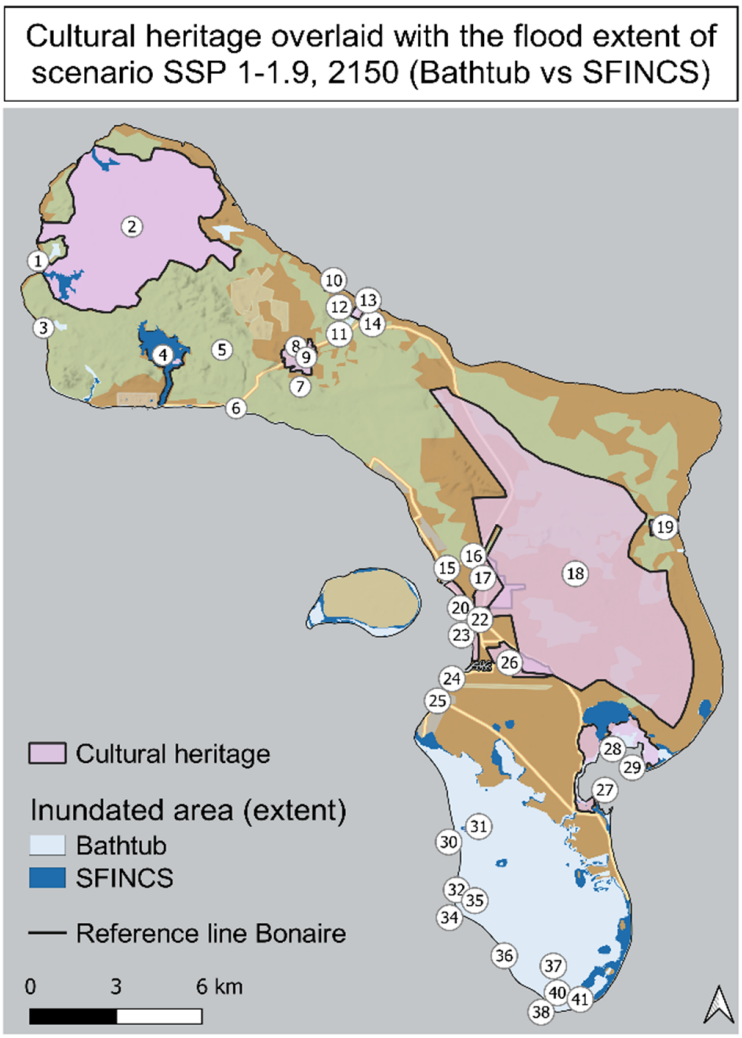
The majority of Bonaire's TCH is located in coastal, mostly low-lying areas, and is vulnerable to inundation from SLR and storm surges. The vulnerability of identified TCH to permanent and storm flooding was examined and visualised by maps, which present the identified TCH on Bonaire and indicate with colour coding whether the TCH is (I) not projected to be at risk (green), (II) at risk of storm inundation (orange), or (III) at risk of permanent inundation (red). Due to varying data accuracy, for instance in the coastal elevation model (DEM), and the uncertainties inherent in climate change, the inundation maps are an indication of what could happen in the different scenarios, but also come with a certain level of uncertainty. Please refer to the study by Dullaart & van Manen *et al.* (2022) for a more elaborate discussion on the implications of the selected DEM. As shown in Figure 8, in 2050 no identified TCH in the North will be vulnerable to permanent or storm flooding, but all TCH in the South is considered susceptible already under climate scenario SSP1-1.9.



1	Boka Slagbaai
2	Washinton Slagbaai
3	Playa Frans
4	Gotomeer
5	Dos Pos
6	Landhuis Karpata
7	Lourdes grotto
8	Rincon
9	San Ludovico catholic church
10	Piedra di Boneiru
11	Mangazina di Rei
12	Kaomati
13	Boka Onima
14	Indian inscriptions
15	Playa Lechi and tamarind tree
16	Hòfi Kultural
17	Antriol
18	Kunuku area
19	Lagun
20	Playa
21	Pasa Machi Mimi
22	Bestuurskantoor
23	Fort Oranje
24	Donkey Beach
25	Bachelor's Beach
26	Tera Kòrá
27	Sorobon
28	Mangroves
29	Lac Cai
30	Blue obelisk
31	New salt pans
32	Pink Beach
33	White obelisk
34	White slave huts
35	Old salt pans
36	Atlantis fishermen's hut
37	Flamingo Sanctuary
38	Red obelisk
39	Red slave huts
40	Old salt pans
41	Willemstoren

Figure 8 Cultural heritage identified on Bonaire overlaid with the inundation map for the SSP 1-1.9 scenario in 2050

Permanent and coastal storm inundation for climate scenarios SSP 1-1.9 and SSP5-8.5 LC in 2150 are analysed and visualised in Figure 9 and 12. Figure 9 shows that in 2150 under the SSP1-1.9 climate scenario, permanent inundation is predicted to impact Boka Slagbaai and Playa Frans in the Northern part of Bonaire. In Bonaire's most Southern part, everything besides the red obelisk is projected to be permanently inundated. The red obelisk is at risk from storm inundation. Hence, permanent inundation poses a significant threat to the TCH at Boka Slagbaai, presented in figure 10, and the TCH in the South, such as the salt pans, the slave huts seen in figure 11, fishermen's huts, obelisks, and Willemstoren, among others.



1	Boka Slagbaai
2	Washinton Slagbaai
3	Playa Frans
4	Gotomeer
5	Dos Pos
6	Landhuis Karpata
7	Lourdes grotto
8	Rincon
9	San Ludovico catholic church
10	Piedra di Boneiru
11	Mangazina di Rei
12	Kaomati
13	Boka Onima
14	Indian inscriptions
15	Playa Lechi and tamarind tree
16	Hòfi Kultural
17	Antriol
18	Kunuku area
19	Lagun
20	Playa
21	Pasa Machi Mimi
22	Bestuurskantoor
23	Fort Oranje
24	Donkey Beach
25	Bachelor's Beach
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27	Sorobon
28	Mangroves
29	Lac Cai
30	Blue obelisk
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35	Old salt pans
36	Atlantis fishermen's hut
37	Flamingo Sanctuary
38	Red obelisk
39	Red slave huts
40	Old salt pans
41	Willemstoren

Figure 9 Cultural heritage identified on Bonaire overlaid with the inundation map for the SSP 1-1.9 scenario in 2150

Figure 10 The house at Boca Slagbaai with a protective seawall (Buijs, 2022)

Figure 11 The white slave huts (Buijs, 2022)

Compared to SSP1-1.9, the SSP2-4.5 SSP5-8.5 scenarios for 2150 show similar patterns in terms of the TCH that is predicted to be inundated. The three scenarios in 2150 show minor inundation differences and do not suggest additional affected TCH. However, the SSP5-8.5 LC scenario for 2150 in figure 12 shows a more significant increase in inundation. The inundation in this scenario affects a larger part of Bonaire's Eastern coast and a major part of Klein Bonaire. Due to SLR under climate scenario SSP5-8.5 LC, relatively small parts of the Washington Slagbaai and Gotomeer in the Northern part are projected to be permanently inundated, as is the Red Obelisk in the South. Additionally, TCH at the eastern coast is at risk from coastal storm inundation, including Fort Oranje and Playa (the centre of Kralendijk), as well as a small part of the kunuku area. Thus, inundation due to SLR could trigger forced moving in the long run, which can negatively affect culture if people have to move away from their long-term homes or traditional neighbourhoods.

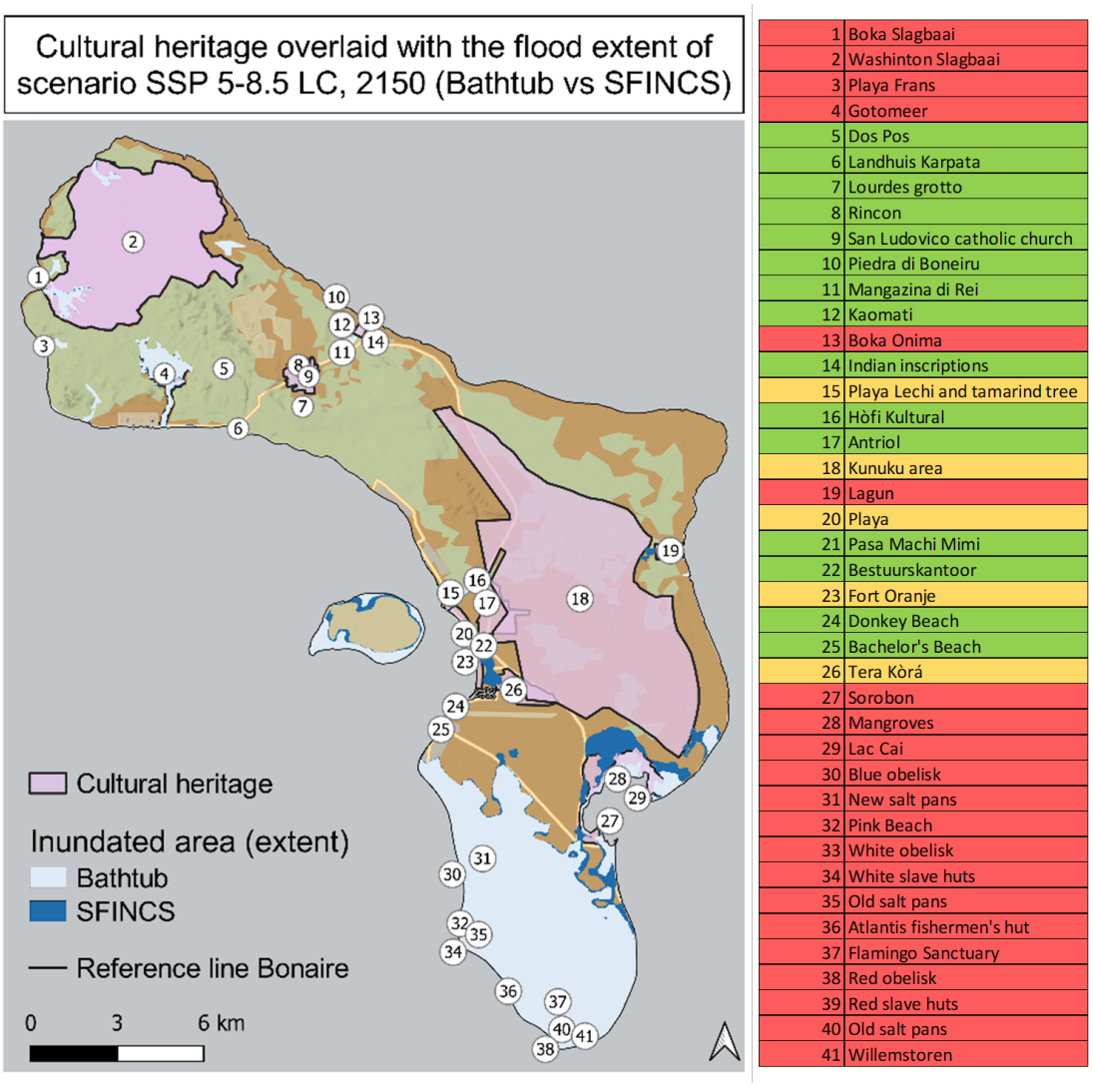

Figure 12 Cultural heritage identified on Bonaire overlaid with the inundation map for the SSP 5-8.5 Low Confidence scenario in 2150

In 2300, under the SSP1-2.6 LC climate scenario, Boka Slagbaai, Playa Frans, Washington Slagbaai Gotomeer in the north and everything south of the mangroves are projected to be permanently inundated. Under the climate scenario SSP5-8.5 LC, all identified TCH, with the exception of those in the North-Western region (5-12 & 14), are anticipated to be permanently flooded as a result of SLR (Annex D).

5.2 Intangible cultural heritage

ICH and traditional ways of life in the Caribbean SIDS can be threatened by climate change, due to extreme weather events and increasing temperatures (UNESCO, 2021). As the distinction in the effects of different levels of climate change in ICH is complex, the climate change impact on ICH in this section is considered in general regardless of the different climate scenarios.

Fisheries

Bonaire's traditional fishing culture is at risk of climate change impacts. Healthy reefs and mangroves are essential for the Bonairian fishing practices (CE1). However, climate change negatively affects both, as increasing ocean temperatures, ocean acidification, and stronger storms resulting from climate change seriously threaten coral reef health and weaken the reefs' resistance to diseases (Dutch Caribbean Nature Alliance, 2019; Hoey *et al*., 2016; Verweij *et al*., 2020). As a result, the reef fish habitat is destroyed, reducing Bonaire's fishing possibilities (CE5; Hoey *et al*., 2016). Since professional fishermen, as opposed to traditional fishermen, do not fish near coral reefs, but instead target pelagic fish species, coral reef degradation may not have a direct effect on the productivity of fisheries, but rather on recreational fishing (CE4).

Rainwater from heavier precipitation, and soil erosion from periods with decreased precipitation, carry sediment to the ocean and negatively affect the reefs and marine life (Goatley & Bellwood, 2013; HE5; Verweij *et al*., 2020). Accordingly, declining reef health due to climate change, along with marine pollution and human factors, are certain to have a negative impact on Bonairian fishing through their threat to important fish stocks (Dutch Caribbean Nature Alliance, 2019).

Mangroves are at risk from SLR, storms, and changing precipitation and temperatures due to climate change (Dutch Caribbean Nature Alliance, 2019; Verweij *et al.*, 2021). This presents a risk for fishermen, as mangroves provide and host fish and crustacean nursing and hiding, as seen in figure 13 (CE5; Gilman *et al.*, 2008).

Figure 13 The mangrove roots act as a nursery and hiding spot for juvenile fish (Mittiga, 2020)

Another phenomenon threatening the mangroves and Bonaire's culturally significant beaches are *Sargassum* blooms (CE5). *Sargassum* is a floating macroalgae whose blooms in the Caribbean sea appear to have become more frequent and intense (Wang & Hu, 2017). This increase in *Sargassum* blooms can be attributed to rising sea surface temperatures and nutrient enrichment in the sea (Wang *et al.*, 2019). Accordingly, a lot more *Sargassum* than usual has been washed onto Bonaire's coasts in the past years, as portrayed in figure 14 (CE1; PM2). The extreme *Sargassum* inflows negatively affect fishing practices, as the algae can block the fishing areas of Lac Bay, Lagun, and the mangroves (CE1). As the *Sargassum* accumulates in the mangroves, it decomposes, which can be toxic to the mangroves' roots and can lead to mangrove habitat destruction (Hernández *et al.*, 2021; van Tussenbroek *et al.* 2017).

Figure 14 Sargassum bloom on the Bonairian coast and efforts by the Mangrove Maniacs to protect the mangroves (Mangrove Maniacs Bonaire, 2022)

Agriculture

Climate-related impacts on the Bonairian agriculture due to hurricanes, storms, and droughts would damage the island's cultural identity (CE1). On the one hand, CE4 argues that climate change currently causes little concern for the Bonairian agriculture sector, as the sector is not properly established yet. On the other hand, changing weather, such as drier seasons or heavier rain (CE1; PM2; PM4), already directly affects the small number of current farmers and their practices (CE1).

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Many Bonairians have a piece of land (owned or rented) with a simple house (Public Body Bonaire 2010a). These small rural parcels are known as kunuku's, and while a portion of them are still used for agriculture and recreation, the majority have been abandoned. The kunuku's provide a variety of services and environmental, economic, and cultural values to the Bonairians (Lotz *et al*., 2020). PM6 specifies that the Bonairians have always been trying to plant most crops during the wet season when it rains the most. However, drought and a shift in the times of the wet season, i.e. strong rain timing has changed from October to November to December to January, can cause problems. The kunukeros will face uncertainties in terms of when to plant their crops and when to rent the tractors to do so. This is crucial, as if they rent the gear too early,

their crops will be damaged due to a lack of rain (PM7). CE4 sees the climate change impacts as reinforcing current challenges for Bonairian agriculture, such as water availability and a limited range of crops that can be grown. The climate change challenge is additionally surpassed by challenges concerning the economic struggles of starting agricultural practices and the limited expertise on how to start a business (CE4).

Water wells such as the Dos Pos (figure 15) are essential for the kunukeros (CE1), but these groundwater systems may also be impacted due to climate change induced salinization, which can disturb the freshwater supplies (PAHO, 2019). This may pose a problem for traditional Bonairian agriculture as it impacts agricultural yields (Verweij *et al*., 2020) and threatens the provision of ecosystem services associated with the kunuku's.

Figure 15 The Dos Pos water well in 2022 (Buijs, 2022)

However, there are also opportunities for the agricultural and fishery sectors on Bonaire. Bonaire still has the potential to reduce its dependence on imports by increasing its domestic agriculture and fishery domains (Wageningen University & Research, 2021). Additionally, a diversification of the economy would be beneficial (Wageningen University & Research, 2021), especially in the light of climate change threatening coral reefs and the diving industry (Schep *et al*., 2022).

Artistic inspiration

Climate change can also negatively affect the artistic inspiration offered by the Bonairian nature. In CE2's eyes, nature degradation through climate change has an indirect impact on the Bonairian culture. Because nature acts as an inspiration for artistic work, a degraded nature will likely offer less artistic inspiration, and in return, there will be less art inspired by nature that can be used to raise awareness about nature and the impacts. Accordingly, their degradation could have an impact on the cultural ES of artistic inspiration provided by nature. CE2 emphasises that the changes in nature due to climate change can change art as it is currently being performed on Bonaire, such as the one seen in figure 16.

Figure 16 Painting inspired by Bonaire's coral reefs (Underwater painting of Bonaire, n.d.)

Festivities

It is not exactly known how the many festivities on Bonaire might be affected by climate change. Respondents have put forward that they think nothing, except for a complete natural disaster such as an earthquake, can stop the Bonairians from celebrating Dia de Rincon and other festivities (CE2). Additionally, they could adapt to the heat by celebrating later during the day or in the evenings (CE3). Nevertheless, this would change a long existing cultural tradition. One festival that could be specifically impacted by climate change is Simadan, the harvest festival (CE1). Simadan is shown in figure 17. During this festival, which CE3 already sees happening less, the farming communities used to go to different farmers to help out with planting the crops, cutting the grains, and then dance, sing, and eat together (CE1). However, if getting a harvest

becomes more difficult, Simadan may not take place anymore (Beleidsnota cultuur, 2010; CE1).

Figure 17 Simadan celebrations in Rincon (Groenenboom, 2007)

6 Discussion

6.1 Main finding

The fieldwork results confirm the results from the literature review on Bonairian cultural heritage. The residents and experts did not mention the Marshe di Rincon referred to in the Beleidsnota cultuur (2010), nor the medicinal plants that Lacle *et al.* (2012) name. Moreover, not all of the locations most visited by Bonairians mentioned in Lacle *et al.* (2012) emerged from the fieldwork. Lastly, much of the ICH identified by *Intangible Cultural Heritage Bonaire* (n.d.) did not arise in the interviews, making the literature review a crucial component for identifying all relevant cultural heritage of Bonaire. However, the fieldwork confirmed that agriculture and fishery are important for the Bonairian culture (Verweij *et al.*, 2021) and a respondent confirmed van Beek's findings (2011) that Bonairian coral reefs provide artistic inspiration. Concerning the climate change impact on culture, the interviewees confirmed Adger *et al.*'s (2012) point that climate change threatens the fishing practices and the maps validated Harkin and colleagues' (2020) research that TCH can be impacted by SLR and extreme weather events.

6.2 Limitations

A serious limitation is that the impact of climate change on ICH is uncertain and difficult to predict, which is reflected in the fact that neither literature nor the Bonairian residents know what will happen to their culture with climate change. Therefore, the fieldwork's results on the possible climate change impacts on fishery, agriculture, Bonairian festivities, and other ICH remain difficult to measure. The results of this study should be considered as an exploration of potential impacts of climate change on ICH.

Regarding the TCH, climate change impact is highly dependent on the location, land elevation and SLR. However, the available DEMs appeared to be imprecise, which may result in significant underestimations on the damage caused by SLR.

During the social media analysis, it was not possible to filter out the pictures posted by residents. Accordingly, many of the pictures showed cultural heritage that is often visited by tourists, such as Boka Slagbaai and the slave huts. However, this does not necessarily mean that local residents specifically value these locations as Bonaire's cultural heritage. Thus, the social media analysis should be used only to complement the information from the fieldwork. However, the scope of this project did not allow for a more scientific approach to the social media analysis. Further research could engage in a more thorough social media analysis, using popular platforms such as Instagram and filtering out the Bonairian residents' pictures.

6.3 Policy recommendations

Even though the results are uncertain, policy recommendations are valuable to allow Bonaire to protect its inhabitants against the climate change impacts on culture. These recommendations stem mostly from the experts interviewed.

To maintain the Bonairian culture and protect its ICH from climate change, Bonairian schools should offer more cultural education, transmitting the connection to nature that the Bonairians have historically had to the next generation, in addition to making children more aware of climate change and involving them in nature preservation and in climate change adaptation projects (PM7). CE5 recommends making Bonairians aware of the climate change threats to their culture in a similar fashion, to foster the realisation that the threatened TCH and ICH make up their heritage and that they should mobilise to protect them. Ngo *et al.*'s framework (2019) confirms that community mobilisation to adapt to climate change would positively affect Bonaire's resilience to climate change impacts.

Because climate change also threatens Bonaire's agriculture and food security in the Caribbean (FAO *et al.*, 2020), Bonaire should expand its domestic agriculture production to mitigate this climate change impact on health and culture (CE4). A possible solution is a fruit forest (D. Christiaan, personal communication, April 19, 2022), an example of nature inclusive planning where "societal challenges are addressed while simultaneously providing benefits to nature." (Verweij *et al.*, 2021, p.19). Such a forest provides benefits to nature in the form of erosion reduction and social benefits in the form of food provision (CE4; D. Christiaan, personal communication, April 19, 2022). Additionally, Bonaire should improve its water collection during heavy rainfall, for instance through dams, and use the freshwater that is currently running off into the sea for agriculture (Natural disasters Bonaire, n.d.). Bonaire and the Ministry of Agriculture could also expand the Salt Farm Foundation's saline agriculture project on Bonaire and promote the use of drought-resistant crops (Macpherson & Akpinar-Elci, 2013).

7 Conclusion

With increasing awareness of climate change and its potentially disastrous consequences in the Caribbean, it is essential to analyse how climate change is predicted to impact the vulnerable Caribbean SIDS, such as Bonaire. This research focused on the predicted climate change impacts on Bonairian cultural heritage, a component of NELD that is often ignored in the research arena.

In the cultural domain, the research methods have revealed many similarities in the identification of Bonairian cultural heritage and confirmed that Bonairian TCH and ICH are threatened by climate change. Under all scenarios in 2150, there is a possibility that the TCH on the Southern tip of the island, such as the salt pans, slave huts, and lighthouse, will be inundated due to SLR, storm tide, and wave setup. In the SSP5-8.5 Low Confidence scenario, the capital Kralendijk and its TCH could additionally become inundated. Furthermore, climate change is predicted to impact ICH such as Bonaire's culturally relevant fishery, agricultural practices, nature-inspired art, and festivities.

However, Bonaire's small island character and strong community cohesion could strengthen its resilience to climate change impacts. These characteristics facilitate decision-making in critical instances and foster community support in times of disasters, which could reduce the non-economic loss and damage suffered from in terms of public health problems and damage to cultural heritage. Lastly, even though this research faces many uncertainties resulting from the uncertain nature of climate change and its impacts, there is no doubt that Bonaire will be disproportionately affected by climate change, including effects on culture, albeit in ways that are not fully known yet. This potential impact should be taken seriously, and the Netherlands should take their responsibility to support Bonaire's adaptation to the expected impacts accordingly.

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Annex A The impacts of climate change on Bonaire

Temperature

In the Caribbean, extreme temperatures are already occurring at an increased frequency (Taylor *et al.*, 2020; Stephenson *et al.*, 2014). However, no multi-year temperature time series is available for Bonaire (Dullaart & van Manen, 2022). On Curaçao, Bonaire's neighbouring island, mean temperature has increased by 0.6℃ since 1980 (KNMI, 2021). According to the IPCC's intermediate low pathway (RCP4.5), the projected change in temperature for 2081-2100 compared to 1986-2005 for the Caribbean region is a 1.4℃ increase in temperature (Akpinar-Elci & Sealy, 2014; Nurse *et al.*, 2014). More specifically, in all IPCC scenarios a temperature increase is expected (Taylor *et al.*, 2020).

Precipitation

Currently, there has already been a declining trend in rainfall during the summer months in the Caribbean (IPCC, 2021). However, this trend is not statistically significant at the five percent significance level (Taylor *et al.*, 2020; Jones *et al.*, 2015). On Bonaire specifically however, no positive or negative trend in precipitation has been seen so far (KNMI, 2021). Figure A1 shows annual anomalies in temperature and precipitation on Bonaire from 1979 to 2019.

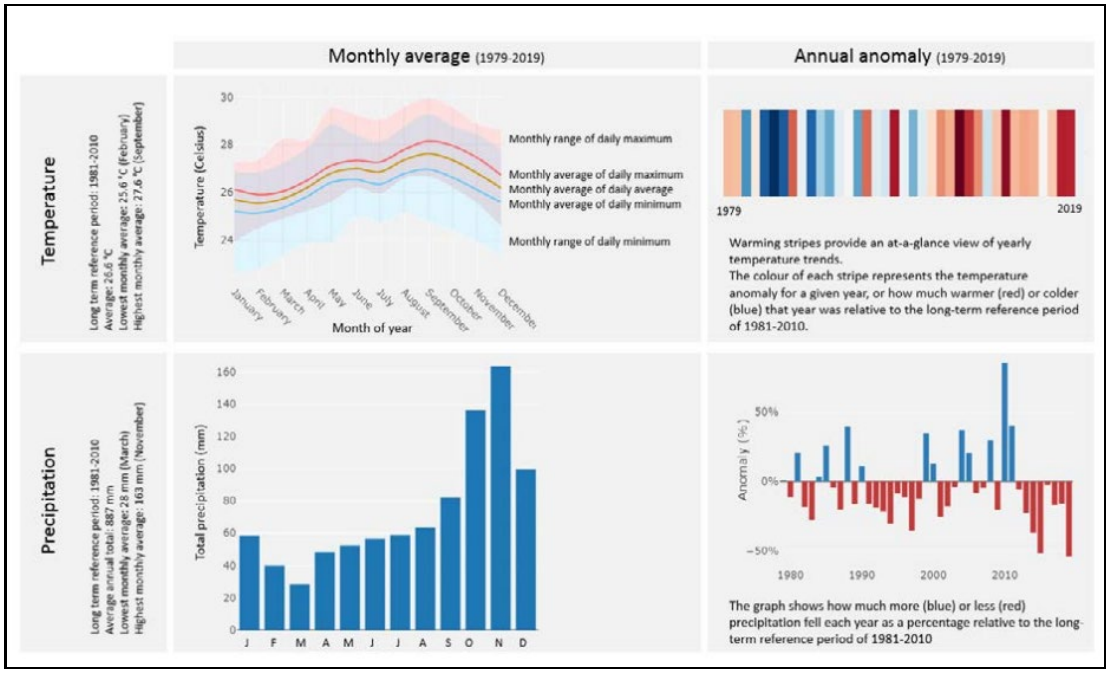


Figure A1 Bonairian average climate and annual anomalies from 1979 to 2019 (Hersbach et al., 2019)

According to the IPCC's intermediate low pathway (RCP4.5), the projected change in precipitation for 2081-2100 compared to 1986-2005 for the Caribbean region is a 5% decrease in precipitation (Akpinar-Elci & Sealy, 2014; Nurse *et al.*, 2014). More

specifically, in all IPCC scenarios a precipitation decrease is expected (Taylor *et al.*, 2020).

Sea level rise

The sea level in the Caribbean is rising at a similar rate (1.8mm/year) as the global rate (1.7mm/year) and has risen by 10.6 cm from 1950 to 2009 (Taylor *et al.*, 2020; Palanasamy *et al.*, 2015; Torres & Tsimplis, 2013). This means that the SLR around Bonaire and the Caribbean is expected to rise slightly faster than on average around the world (KNMI, 2021). According to the IPCC's intermediate low pathway (RCP4.5), the projected SLR for 2081-2100 compared to 1986-2005 for the Caribbean region is a 0.5 to 0.6 metres rise in sea level (Akpinar-Elci & Sealy, 2014; Nurse *et al.*, 2014). Verweij *et al.* (2020) argue that one of the challenges for Bonaire is the adaptation to SLR.

Extreme weather events

Heat waves and drought

Climate change has increased the frequency, duration, and intensity of "warm and hot days and nights" in the Caribbean between 1961 and 2010 (Taylor *et al.*, 2020, p.99). climate change predictions project increased aridity and a higher frequency and intensity of agricultural and ecological droughts across most of the Caribbean (Hersbach *et al.*, 2019; Debrot *et al.*, 2018; IPCC, 2021).

Tropical cyclones

The IPCC has expressed low confidence in a global increase in tropical cyclone frequency and intensity (Stephenson & Jones, 2017). Bonaire lies on the Atlantic hurricane belt's southern border and experiences tropical cyclones at a much lower frequency than the Dutch Windward Islands (Meteorological Department Curaçao, n.d.). Historically, the ABC-islands are considerably damaged by hurricanes about every 100 years, due to heavy rains and rough seas that can cause flooding for several days (Meteorological Service Netherlands Antilles and Aruba, 2010).

Storms

Storms are predicted to worsen with climate change. Stronger storms, in combination with Bonaire's coral reef degradation, can likely trigger an increase in storm-related damages on Bonaire (Dutch Caribbean Nature Alliance, 2019). Additionally, flooding is expected to increase in frequency and intensity in the Caribbean (CDC, n.d.). Inundation maps for Bonaire in 2150 in the scenarios SSP1-2.6, SSP2-4.5, SSP5-8.5, and SSP8.5 Low Confidence are found in Dullaart & van Manen (2022).

Annex B Lists of tangible and intangible cultural heritage

Table B.1 Tangible cultural heritage identified through literature review and a visit to Mangazina di Rei

Cultural heritage	Location	Description and importance	Source(s)
Antriol	Kralendijk	Neighbourhood	Beleidsnota cultuur (2010)
Bestuurskantoor (1837)	Kralendijk	Previously the staff residence for the governor of the island and now the government's main office building	Beleidsnota cultuur (2010); InfoBonaire (n.d.)
Boka Onima	Close to Rincon	One of the places most visited by locals; it used to be popular for fishing from Rincon when there was no wind or wind reversal	Lacle *et al.* (2012); Mangazina di Rei (n.d.)
Boka Slagbaai	Washington Slagbaai	Historically important for goat exports to Curaçao	Mangazina di Rei (n.d.)
Dos Pos	Rincon	A water well that has provided residents with water since 1898 and still provides farmers, livestock, and wildlife with water	Mangazina di Rei (n.d.); WEB Bonaire (n.d.)
Chogogo flamingoes (Southern Caribbean Flamingo)	Flamingo Sanctuary, Gotomeer, Salinas	An endangered species that is a cultural heritage icon of the island and is the most famous bird on Bonaire; Bonaire is the primary breeding site (sanctuary in the South)	Beleidsnota cultuur (2010); Verweij *et al.* (2020)
Donkeys	Donkey sanctuary and wild	They were laboured faithfully on Bonaire over hundreds of years until motorised vehicles replaced them; they are considered Bonaire's living cultural heritage	Mangazina di Rei (n.d.)
Fort Oranje (1639)	Kralendijk	The oldest building on Bonaire; a fort at the end of a dike of coral stone, which is now the island's courthouse	Beleidsnota cultuur (2010); InfoBonaire (n.d.)
Gotomeer	Washington Slagbaai	A shallow, saline, closed lagoon that is home to birds and flamingoes	Mangazina di Rei (n.d.)
Indian inscriptions	Close to Boka Onima	They were painted by the Caquetio-Arawak Indians at what was probably a sacred place where they held religious ceremonies	Antczak (2018); Beleidsnota cultuur (2010); Lacle *et al.* (2012); Mangazina di Rei (n.d.)
Kaomati	Rincon	A mystical limestone hill	Mangazina di Rei (n.d.)

Cultural heritage	Location	Description and importance	Source(s)
Kunuku's	Three areas: Rincón, Tra'i Montaña and east of Kralendijk	There are hundreds of Kunuku's on Bonaire; they were Initially small farms with extensive agriculture and animal breeding (sorghum, several types of fruits and vegetables, goats, sheeps, pigs, chickens, and turkeys) that allowed a life of freedom and independence; many families of Rincon have owned kunuku's for generations; today, it is more popular to spend time at the kunuku's in the weekend with family and friends	Aubertin *et al.* (2012); Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Lac Cai/Sorobon	Lac Bay	It is one of the places most visited by locals	Lacle *et al.* (2012)
Landhuis Karpata (ca. 1870)		Karpata used to be a plantation and a thriving economic centre in the 1900s; the landhuis served as inventory and storage for the products and is now an ecological centre	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Lourdes Grotto	Rincon	A cave that is part of one of the places most visited by locals	Lacle *et al.* (2012)
Mangazina di Rei (1816-1824)	Rincon	The former king's repository was a provision depot for enslaved people and is now a cultural center telling the history of Rincon	Beleidsnota cultuur (2010); Intangible Cultural Heritage (n.d.)
Obelisks	Southwest	They were used as navigational shore markers to guide ships coming in to load salt; they were painted red, white, blue, and orange (the colours of the Dutch flag) and can be found with each group of slave huts, the orange one is now gone	Beleidsnota cultuur (2010)
Passanggrahan (1890)	Kralendijk	The former residence of Cornelis Raven Debron, it is now the island's parliament house	Beleidsnota cultuur (2010); InfoBonaire (n.d.)
Piedra di Boneiru	Northeast Coast	A magical, massive free-standing rock where mythology says that the First Bonairian Boynay was born; one can find sacred soil; here the Bonaire Stone Ritual takes place which makes you a spiritual Bonairian	Booi (n.d.); Mangazina di Rei (n.d.)
Plasa Machi Mimi	Kralendijk	An open-air fruit and vegetable marketplace	InfoBonaire (n.d.)
Protestant church → San Ludovico Catholic Church	Rincon	Monument	Skyviews map Bonaire

Cultural heritage	Location	Description and importance	Source(s)
Rincon (1527)	Rincon	The oldest village on the island and the oldest village in continuous existence in the Dutch Caribbean; it is acknowledged as the cradle of Bonairian culture; it was located strategically safe from pirates and surrounded by arable land and water sources	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Slave huts	Southwest	They provided shelter and sleeping places for the enslaved people working in the salt pans	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.); Verweij *et al.* (2020)
Washington Slagbaai	North	The first nature sanctuary in the Dutch Caribbean; it takes up ca. 20% of the island; it initially encompassed two of the largest and most productive plantations in Bonaire's history	Mangazina di Rei (n.d.)
Water wells	Farming area	They supply farmers, livestock, and wildlife with water	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Willemstoren (1837)	Southern tip	The oldest lighthouse on the island; the southernmost point of the island	InfoBonaire (n.d.)

Table B.2 Intangible cultural heritage identified through literature review and a visit to Mangazina di Rei

Cultural heritage	Location	Description and importance	Source
Bari	Rincon	A festival that is celebrated near the end of the year; its name comes from the instrument that is also called bari (a drum with goat skin); a group of musicians go onto the streets and sing about the events of the past year; the event also serves an important social function as the musicians can sing about different people	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Culture in relation to the sea	/	The building of boats for shipping and fishing, fishermen's songs, etc.	Beleidsnota cultuur (2010)
Cultural and artistic expression			Beleidsnota cultuur (2010)
Dia di Rincon (April 30th)	Rincon	A day to celebrate Rincon; folkloric dance groups perform on multiple stages; there is a Simadan parade in the afternoon and a modern simadan later in the evening	InfoBonaire (n.d.)
Dia di Boneiru (September 6th)	/	This is Bonaire's flag day, it shows the island's national pride; the day is dedicated to all the things that make Bonaire unique; a different neighbourhood hosts the party each year	InfoBonaire (n.d.)

Cultural heritage	Location	Description and importance	Source
Fishery culture	Lac Bay, Lagun	Fishing using traditional techniques with three to seven handlines; fish is an important part of the Bonairian diet	Aubertin *et al.* (2012); Beleidsnota cultuur (2010)
Holding of goats	/	Goat holding has a social and economic function; the animals are the heritage from the past; goat meat is very popular on Bonaire	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Interaction between man and nature	/		Beleidsnota cultuur (2010)
Luna Yen	/	A cultural meeting at full moon that takes place in a pre-planned location; people are reciting poems and stories	Antczak (2018)
Marshe di Rincon	Rincon	A street market with folklore, values, and traditions from the past	Aubertin *et al.* (2012)
Maskarada (January 1st)	/	A festival, the performers wear costumes and masks and perform a theatrical piece accompanied by music; originally it was meant for people to visit their family to wish them a happy new year	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Medicinal plants (Aloe)	/	Aloe vera plants successfully grow in the arid Bonairian conditions	Intangible Cultural Heritage (n.d.); Lacle *et al.* (2012); Mangazina di Rei (n.d.)
Papiamentu	/	The official language on Bonaire; an important part of the cultural heritage	Mangazina di Rei (n.d.)
Recreational activities on the beach	/	E.g. eating stoba on the beach; camping on the beach for Easter	Aubertin *et al.* (2012)
San Juan (June 24th)	/	To honour the holy San Juan who asked God for rain in April, May, and June; anyone whose name derives from Juan is visited and receives a serenade	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
San Pedro celebration	/	Anyone whose name derives from Pedro is visited and receives a serenade	Antczak (2018)
Simadan (March or April)	Rincon	A harvest festival that comes from slavery times; family and friends come together to harvest sorghum and the kunukero cares for food and drinks for the dansfeest (pancakes from the fresh sorghum); people dance the wapa and sing the traditional harvest song “Remailo”	Beleidsnota cultuur (2010); Mangazina di Rei (n.d.)
Traditional agriculture at Kunuku’s			Beleidsnota cultuur (2010)

Annex C Images of TCH identified by literature, participatory mapping and social media

1. Boka Slagbaai

2. Washington Slagbaai

3. Playa Frans

4. Gotomeer

5. Dos Pos

6. Landhuis Karpata

7. Lourdes Grotto

8. Rincon

9. San Ludovico catholic church

10. Piedra di Boneiru

11. Mangazina di Rei

12. Kaomati

13. Boka Onima

14. Indian inscriptions

15. Playa Lechi

16. Hofi Kultural

17. Antriol

18. Kunuku area

19. Lagun

20. Playa

21. Plasa Machi Mimi

22. Bestuurskantoor

23. Fort Oranje

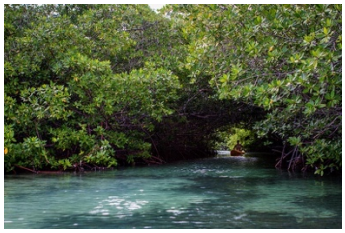
24. Donkey Beach

25. Bachelor's Beach

26. Tera Kora

27. Sorobon

28. Mangroves



29. Lac Cai

30. Blue obelisk

31. New salt pans

32. Pink Beach

33. White obelisk

34. White slave huts

35. Old salt pans

36. Atlantis fishermen's hut

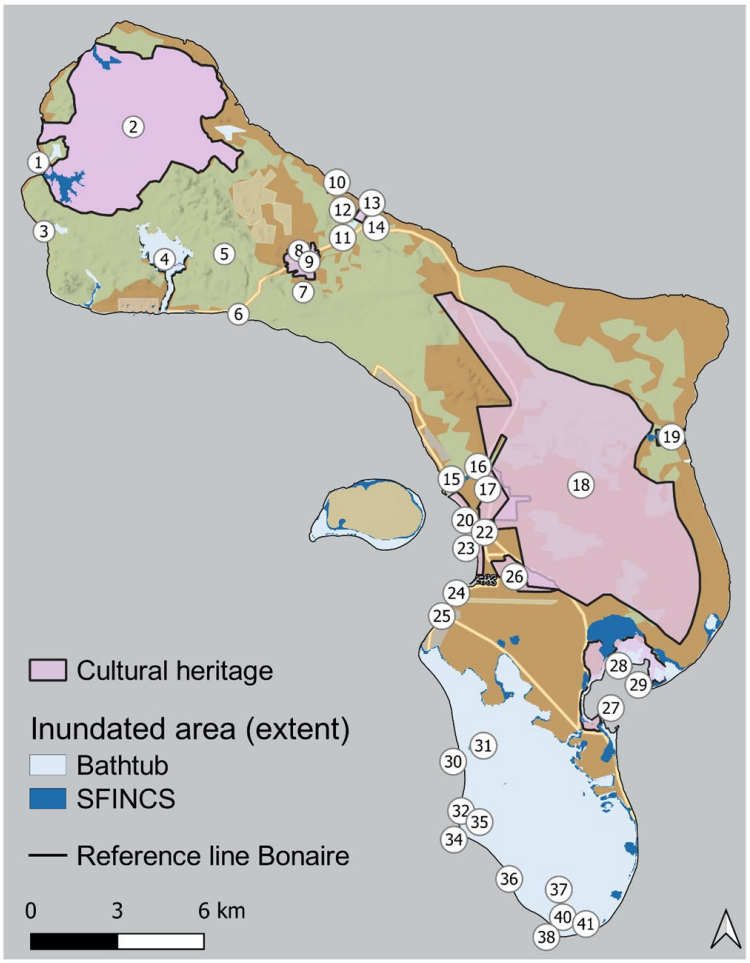
37. Flamingo Sanctuary

38. Red obelisk

39. Red slave huts

40. Willemstoren

Annex D Cultural heritage overlaid with the flood extent of SSP1-2.6 LC and SSP5-8.5 LC in 2300



1	Boka Slagbaai
2	Washinton Slagbaai
3	Playa Frans
4	Gotomeer
5	Dos Pos
6	Landhuis Karpata
7	Lourdes grotto
8	Rincon
9	San Ludovico catholic church
10	Piedra di Boneiru
11	Mangazina di Rei
12	Kaomati
13	Boka Onima
14	Indian inscriptions
15	Playa Lechi and tamarind tree
16	Hòfi Kultural
17	Antriol
18	Kunuku area
19	Lagun
20	Playa
21	Pasa Machi Mimi
22	Bestuurskantoor
23	Fort Oranje
24	Donkey Beach
25	Bachelor's Beach
26	Tera Kòrá
27	Sorobon
28	Mangroves
29	Lac Cai
30	Blue obelisk
31	New salt pans
32	Pink Beach
33	White obelisk
34	White slave huts
35	Old salt pans
36	Atlantis fishermen's hut
37	Flamingo Sanctuary
38	Red obelisk
39	Red slave huts
40	Old salt pans
41	Willemstoren