Cultural pathways to climate action in the Anglophone Caribbean

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CHAPTER FOUR

CARIBBEAN COASTAL ARCHAEOLOGICAL VULNERABILITY ASSESSMENTS

This chapter presents data from vulnerability assessments and observations of the coastal archaeological record on the islands of Antigua, Barbados, Jamaica, and Saint Lucia in the Anglophone Caribbean. The data is presented as a guide for applied archaeology and the utilisation of contemporary archaeological research, through vulnerability assessments of this record. The aim being to contribute to a framework that utilises varied data sources, with cultural heritage being one, for studying current climate impacts, examining and determining coastal health, facilitating planning, and developing relevant climate action for future impacts, as well as building coastal resilience in the region.

It also serves as an opportunity for the wider public to become involved in heritage programming that monitors coastlines and can be applied throughout the Caribbean at the local and national levels. The premise of this chapter, as such, is anchored in the applicability of using cultural data from archaeological sites for integration into broader strategies, plans, programmes, policies, or forming a part of data for decision-making. Documenting the present effects of climate-induced hazards and related disasters being experienced by coastal sites also supports the importance of climate action in coastal areas (Miller et al., 2024).

Studies focusing on coastal areas at risk have highlighted the strong correlation between environmental degradation and coastal vulnerability to hazards (Beck, 2014). Small islands are exposed to varying climate-induced hazards due to myriad factors, and in the Caribbean's specific context, its physical vulnerability often stems from its geophysical characteristics (Strauss & Kulp, 2018). The socio-ecological relationships in the region are also heavily rooted in and influenced by their historical context (Baptiste & Devonish, 2019; Douglass & Cooper, 2020; Stancioff, 2018; von Meding, 2019), which has further implications for vulnerability, specifically as it relates to landscape relationships, and these processes of environmental degradation.

Although the region does not present as a monolith in terms of its experiences with vulnerability, there are nevertheless similarities in its historical and environmental background and context, how it pursues coastal planning, and how it approaches this human-environment dynamic in the present day and within the existing legislative, policy, planning, and programming framework considered for this research. Specific similarities exist in the significant development of the region's coastal spaces, particularly tourism infrastructure, and a high level of coastal ecosystem degradation, and encroachments into hazard-prone and environmentally sensitive areas, resulting in susceptibility to the damaging effects of climate-induced and other natural hazards (Cashman & Nagdee, 2017; Lewsey et al., 2004; UNISDR, 2009).

In the 2014 Coasts at Risk report (Beck, 2014), it was highlighted that the Caribbean had risen in its risk and vulnerability ranking, with Haiti being the most vulnerable nation in the region, St. Kitts and Nevis the island state most exposed to coastal hazards, and Antigua and Barbuda at the greatest overall risk when exposure and vulnerability were combined. Subsequent reports on coastal cities at risk have suggested that Caribbean cities might lose up to *five percent* of these coastal spaces by the end of the century.

Concerning the management and protection of archaeological and built heritage, the existing legislative context in the Anglophone Caribbean contributes to the vulnerability of heritage, as legislation is often not robust or being implemented in ways that do not address or support protecting heritage from risks (Byer, 2022; Scobie, 2019; Siegel et al., 2013; Siegel & Righter, 2011). Legal frameworks for heritage in the region often focus on defining categories of cultural heritage (objects or structures), listing heritage resources, and mandating who should do what, but in reality offer very little protection to heritage, are static, and do not sufficiently evolve to address contemporary challenges with protecting heritage in the region such as from the impact of natural hazards or specifically climate-induced hazards. This challenge is perhaps also linked to the limitations of heritage policy and legislation in the region, which can be perceived as siloed and not in line with a landscape management approach in relation to heritage.

Existing legislation has not been made relevant or current to present and constantly evolving natural hazards. However, for sites that are listed as world heritage properties, site managers are required to consider climate-related risks and issues as part of their programming. There is some hope that this approach would eventually trickle down to wider national heritage sites from a programming perspective. Chapter Two provided a more comprehensive discussion of heritage legislation issues in the Caribbean.

Archaeological research in the region in the most recent decades has produced a more comprehensive awareness of large numbers of sites that have been and are being lost due to sea-level fluctuations and tropical cyclones contributing to exacerbated coastal inundation and erosion and dangerous storm surges along the region's coastline (Fitzpatrick, 2012; Hofman & Hoogland, 2016; Peterson et al., 2004; Richards, 2022). Although a fuller discussion on the significance of the loss of our heritage as a region is not the research focus of this dissertation, the destruction of this heritage will nevertheless serve as the platform to discuss approaches to addressing this loss and the general health of our coastline, which has undergone significant land-use transformations from the earliest occupation of the region (Castilla-Beltrán et al., 2018, 2020; Stancioff, 2018; Siegel et al., 2018) to its current residential, commercial, and tourism-oriented and focused context (Cashman & Nagdee, 2017).

Coastal areas provide the opportunity for exploring transformational resilience when management approaches utilise multidisciplinary data. Mycoo et al. (2021, p. 1), in discussing human adaptation to coastal hazards in Bridgetown, Barbados, highlight that "as risks associated with the changing climate increase and evolve, it is important to broaden our understanding of climate vulnerabilities in coastal cities or areas." One way of broadening this understanding is through the elaboration of an integrated coastal zone management framework that integrates considerations of the archaeological record, its data, and its vulnerability as vital components.

This integrated approach to tackling the challenges presented by climate change is necessary due to the large numbers of people and infrastructure living and working in the region's coastal areas. When undertaken, vulnerability assessments or risk analyses can serve as a useful tool in developing climate action, and individuals and communities can participate in them as localised actions and also at the national level.

When applied to heritage, they can guide the development of a sector-wide strategy in relation to natural hazards and risk, as well as assist practitioners, communities, civil society organizations, and government actors involved with cultural heritage in developing targeted and appropriate data-driven actions, to support community-based monitoring and the management and protection of sites. This will also allow prioritisation of sites at the highest risk as suggested by Daly (2014). These assessments also support the development of climate change narratives, where sites are used as the foci for exploring climate change, and laboratories for climate action, such as through the monitoring of coastlines, and as spaces for the identification of past human climate change adaptation solutions as well as the reintroduction of same. This research posits that an approach that integrates the coastal archaeological record will, by extension, protect coastal areas generally.

Vulnerability Context of the Caribbean's Archaeological Record

The Caribbean's archaeological record is exposed to a variety of risks, including ongoing infrastructural development generally and specifically in coastal areas, natural and other anthropogenic hazards such as sand mining and other extractive industries, and the emerging threat of sites impacted by conflict. These threats are often exacerbated within the context of a broader framework of poor maintenance, limited safeguarding of heritage, non-existent site inventories, which in most cases cannot provide basic information on threatened sites, varied capacities and resources available to government agencies and non-governmental or civil society organizations responsible for heritage, and finally, a limited legislative and policy framework as mentioned previously (Byer, 2022; Hofman & Hoogland, 2016; Siegel & Righter, 2011). Heritage management in the Caribbean has also not extensively or sustainably benefited from the use of innovative tools and solutions in the sector, except in circumstances where an externally funded project is being implemented.

Although other climate-induced hazards are discussed throughout this research, the vulnerability assessment approach and data presented in this chapter are based on a qualitative survey and focus on an exploration of the climate phenomenon of sea level rise and the related impacts of coastal erosion and coastal flooding, and stronger storm surges due to SLR on the Caribbean's archaeological record. It is then discussed within the context of existing threats to this record as highlighted in the vulnerability schema presented in Table 10, which also serves as a wider context in examining threats in general to coastal settlements and coastal resilience.

In relation to coastal settlements, research in these areas suggests that SLR should be considered as a key factor when pursuing vulnerability assessments, as its impacts of storm surges and coastal inundation affect lives, critical infrastructure and economic activities (Alleyne, 2019; Cashman & Nagdee, 2017; Hay et al., 2013; Hay, 2013; Mycoo et al., 2021; Mycoo & Donavon, 2017), in addition to the previously mentioned impacts to the coastal archaeological record of the islands of the region (Fitzpatrick, 2012; Hofman & Hoogland, 2016; Siegel et al., 2013).

Table 10. Vulnerability Schema for the Caribbean's Coastal Archaeological Record

Climate Change Phenomena	Accelerated by	Impacts
Rising sea level	Coastal mining (i.e., sand); storm surges from storm activity	Erosion of coastal sites (visible and buried); inundation of coastal heritage sites
Increasing temperatures	Coastal development	Inundation of sites; storm surges; conservation issues; thermal stress to historic building materials
Wet and dry weather extremes	Loss of coastal ecosystem and natural barriers	Biodiversity loss at natural sites; damage to water systems; physical damage to historic built environment and building materials and structures due to damp and mold, damage to stone structures; loss of unsupported walls of historic structures
Intense tropical cyclone activity	Poor maintenance of sites; no protective	Structural damage to historic structures and towns; inundation and erosion of coastal sites from storm surges

	framework; human-induced hazards	

Source: Author compiled

Coastal erosion and inundation can be exacerbated by numerous activities, such as the extent to which coastlines have been transformed by development, coastal geomorphology, the state of reef ecosystems, and whether mangroves, coastal dunes, or other natural ecosystem barriers have been destroyed, among others that can provide natural mitigation solutions to climate-related disasters (Cashman & Nagdee, 2017). As we have seen in the case of the archaeological record, sand mining in coastal areas has been detrimental to accelerating coastal erosion (Fitzpatrick, 2012; Hofman & Hoogland, 2016). The disappearance of these sites contributes to the loss of physical evidence of Indigenous knowledge, adaptation strategies, artefacts, landscape modifications, and markers, in addition to social memories and lost stories.

The extent of coastal archaeological site loss provides a valuable indicator of coastal retreat, erosion, and loss. Archaeologists have mapped these impacts on sites and responded accordingly through rescue archaeology or, in some cases, through the utilisation of sandbags as one example of temporary mitigation actions, such as was used at the Seaview pre-Columbian site in Barbuda (A. Murphy, personal communication, June 17, 2022).

While it may be possible to relocate some historical structures, this is an expensive process and not seen as a worthwhile one, and a solution which impacts the archaeological context of the site. This action has, however, been most suggested in relation to development works, such as the removal of aqueducts or parts of historic walls. Other actions, such as the elevation of historic structures, are attempted in some islands, however, there is no specific evidence that suggests this is being done at an extensive scale or as a targeted strategy.

The impacts from rising sea levels have already presented themselves as critical issues for the region, with projected continued loss, as highlighted by this sample in Table 11, which provides compiled information on some studies that have detailed projected land loss due to rising sea levels and its attendant effects. The studies indicated are however not exhaustive and are based on a desk survey of various regional projects, undertaken as part of this research.

Table 11. SLR Studies and Estimated and Projected Land Loss throughout the Caribbean

Country	Projected Loss	Study/Author (s)
Antigua and Barbuda	40 – 49% (Barbuda 90% less than 10ft ASL); coastal erosion of 0.9m per year	IADB 2018
Saint Kitts and Nevis	25 – 54% beach loss	IADB 2018
Barbados	73% loss of beach resources in Holetown	IADB 2018
The Bahamas	69% loss of beach resources	IADB 2018
Jamaica	Severe coastal erosion	IADB 2018
Antigua, Nevis	1m SLR = 940 and 340 hectares of land respectively	Project: Undertaking Synthesis and Up-scaling of Sea Level Rise Vulnerability Assessment Studies (SURVAS), Davis et al. 2010
Jamaica	1m SLR = 400km sq.	Richards 2008
Cuba	1m SLR = Submersion of 98 coastal communities; lives of 50,000 persons threatened	Davis *et al.* 2010
Barbados	1m SLR = Beach width losses between 5 and 30m	Caribbean Planning for Adaptation to Climate Change (CPACC) 1997 – 2001 Project (CCCCC 2005)

Source: Compiled from various sources by Author

Table 11 (continued). SLR Studies and Estimated and Projected Land Loss throughout the Caribbean

Country	Projected Loss	Study/Author (s)
Grenada	0.5m SLR = Disappearance of 60% of beaches	Modelling Application of Bruun rule in Haites *et al.* 2002
Guyana	Shoreline retreat of approximately 10m for every 0.1 m of SLR	Modelling Application of Bruun rule in Haites *et al.* 2002
CARICOM countries	Shoreline retreat of 1 m per 0.1 m of sea level rise in the low scenario and 1.5 m per 0.1 m of sea level rise in the high scenario. By 2080, that represents about 3% and 21% of the total land area of most CARICOM countries in the low scenario and high scenario, respectively.	Assessment of the impact of climate change on CARICOM Haites *et al.* 2002
Carriacou (Grenada)	Beach recession estimated at 1m year	Fitzpatrick, Kappers, and Kaye 2006
	Generally, Caribbean SIDS beaches are estimated as eroding at rates of 0.25 – 9m per year.	Agard *et al.* 2007
Eastern Caribbean	For each cm of sea level rise, a shoreline retreat of up to several meters horizontally could occur.	Udika 2009
Suriname, Guyana, French Guiana, and the Bahamas	With a projected 1 m sea level rise scenario (within the 21st century), 7.0%, 6.3%, 5.4% and 4.5% of the populations respectively 30% in Suriname and 25% in Guyana for a projected 3 m sea level rise scenario for the 21st century	Dasgupta *et al.* 2009
Suriname and Guyana	50% of the population of Suriname and Guyana would be under threat with a projected 5 m sea level rise scenario (21st century)	Dasgupta *et al.* 2009

Table 11 (continued). SLR Studies and Estimated and Projected Land Loss throughout the Caribbean

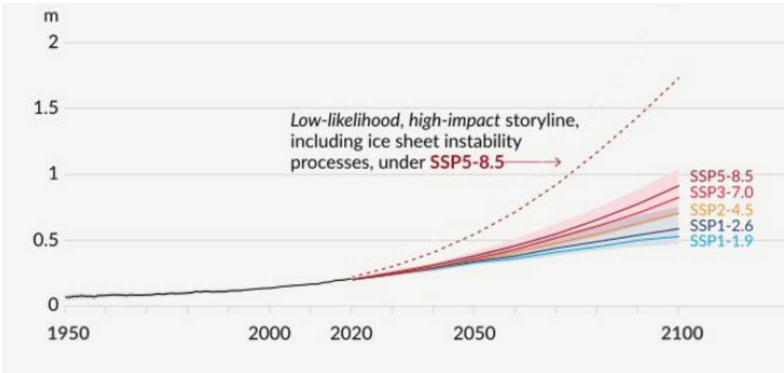
Country	Projected Loss	Study/Author(s)
Jamaica and Belize	1m SLR scenario: approximately 30% of wetlands	Dasgupta *et al.* 2009
Bahamas and Cuba	Projected 5m SLR scenario: most of the wetlands affected + more than half of Cuba's wetlands	Dasgupta *et al.* 2009
Anguilla, Antigua and Barbuda, Dominica, Grenada, Montserrat, Nevis, and Saint Kitts	0.5m years with elevated rates in countries that experience hurricanes	Coast and Beach Stability in the Caribbean (COSALC) Eastern Caribbean Beach Monitoring Programme: 1985 – 2000 Cambers (2009)
Saint Kitts	Net Shoreline Movement (2006–2015) of coastal villages in Saint Kitts up to 89.55m	Stancioff (2018)

Although not presenting as a uniformity throughout the region, sea levels have been rising and amounted to 1.8mm per year from 1950 to 2009. Palanisamy et al. (2012, p. 130) indicate that "interannual sea level variability was higher in the northern Caribbean than the southern, while the eastern shows greater interannual variability." Since SLR is layered on top of storm-driven sea surges and tidal ranges, the intensification of hurricanes resulted in more significant destruction to coastal communities (Cashman & Nagdee, 2017; see also Cazenave & Llovel, 2010; Church & White, 2011).

Based on the IADB's 2018 study on sea-level rise in the region (Strauss & Kulp, 2018), most islands were projected to have between 0.13 to 0.6m of sea-level rise by the year 2100, based on unabated climate pollution. The most recent IPCC Assessment Report, AR6, highlighted that "inland flooding and flood and storm damages in coastal areas" were likely to be the most common impacts on small islands cities and settlements (Pörtner et al., 2022, p. 47).

This research acknowledges that relative SLR is not uniformed across the region but assumes a 1m rise in sea levels by 2100 (IADB, 2018) in line with global projections for SLR by the IPCC (2022) of up to 0.74m by 2100. Church et al. (2013) previously noted that estimations could be ten to twenty percent higher in equatorial regions, due to a warming of the oceans, resulting in the melting of glacial ice and the rushing of water away from some polar regions and toward the Equator. Figure 7 highlights the extent to which the global sea level has changed significantly relative to the 1900s.

Figure 7. Global Mean Sea Level Change Relative to 1900[84]



Source: Figure SPM.8 in IPCC, 2021 (Summary for Policymakers)

Summary of Vulnerability Assessment Approach

Chapter Three detailed the vulnerability assessment approach utilised for this research. However, for illustrative purposes, the key elements of that section will be included here in a summary of the vulnerability assessment approach utilised in case study islands as an introduction to the concepts and methodology used.

Vulnerability assessments are a critical component of any activity seeking to have a comprehensive understanding of threats. These are also required for climate action involving cultural heritage. Specifically, as it relates to cultural heritage, a key consideration for this process includes knowing the type of cultural heritage that will be assessed. In this case, it is important to include as much information about the archaeological site as possible, including its size and function. Other important information include threats being experienced, information on the rate of loss, and value to local communities. Knowing whether the site has a priority ranking in terms of importance at the island's national level is also useful.

[84] The historical changes are observed (from tide gauges before 1992 and altimeters afterwards), and the future changes are assessed consistently with observational constraints

Although vulnerability assessments have become commonplace in many sectors throughout the region, this is hardly the case in the cultural heritage sector. Numerous factors contribute to this, as discussed in earlier chapters. Cultural resources are also often overlooked in coastal studies or assessments by other sectors, even when the intersections are clear.

The vulnerability assessment, therefore, provides the opportunity to create a broad overall understanding among varied actors such as for example, local communities, heritage, and disaster management and coastal zone management agencies. Regarding localised climate action strategies, vulnerability assessments also provide unique opportunities for local communities to become involved, as well as the creation of spin-off monitoring activities, which increase the voice and actions of these communities in safeguarding their heritage (Miller et al., 2024). On a broader national scale, vulnerability assessments allow the evidenced-based prioritisation of heritage at risk and the development of targeted actions. The application of heritage or even coastal heritage vulnerability assessments is virtually unheard of or practiced in many of the islands of the Caribbean and specifically the Anglophone Caribbean, largely due to limitations on the resources available to undertake these as well as to develop and implement follow-up actions.

The assessment approach utilized in this research integrated the vulnerability framework adapted for cultural heritage by Daly (2014), which utilises the IPCC-elaborated approach in relation to exposure, sensitivity, and adaptive capacity in articulating the measure of vulnerability and incorporates elements of the IPCC inspired UNESCO climate vulnerability index (CVI) framework which serves as a rapid assessment tool applied at world heritage properties (Daly et al*.,* 2019).

As mentioned in Chapter Three, slight amendments were made in relation to defining the adaptive capacity of sites to better capture what this research perceives to be the reality for the Anglophone Caribbean. This includes historical processes, economic drivers, policy and institutional framework and sustainable development as being critical to adaptive capacity. As such, the adaptive capacity component is further expanded to consider the existence of supportive frameworks to adapt or reduce vulnerability contributions to the level of coastal development and ecosystem degradation. In reality, the factors impacting the adaptive capacity of a site are numerous, and so this research prioritises specific components considered to be the most relevant within the Caribbean context.

The Vulnerability Assessment Framework approach, therefore, considers exposure (E), sensitivity (S), and the defined adaptive capacity (AC) as central to measuring the vulnerability of a specific archaeological or built heritage site. Each criterion is ranked from low (1) to very high (4).

For each island case study, portions of the coastline were mapped and assessed, and an estimation of the measure of vulnerability was provided for the portion of the mapped coastline and one to three individual sites on each island. The data available for each island and site vary significantly. So, in most cases, this disparity is evident, such as an abundance of information available for Antigua, limited for Saint Lucia, and a point in between for Jamaica and Barbados. This is largely due to disparities in inventories and archaeological survey work undertaken in each country in relation to sites impacted by climate-induced hazards.

Data from Case Studies

Antigua

Introduction

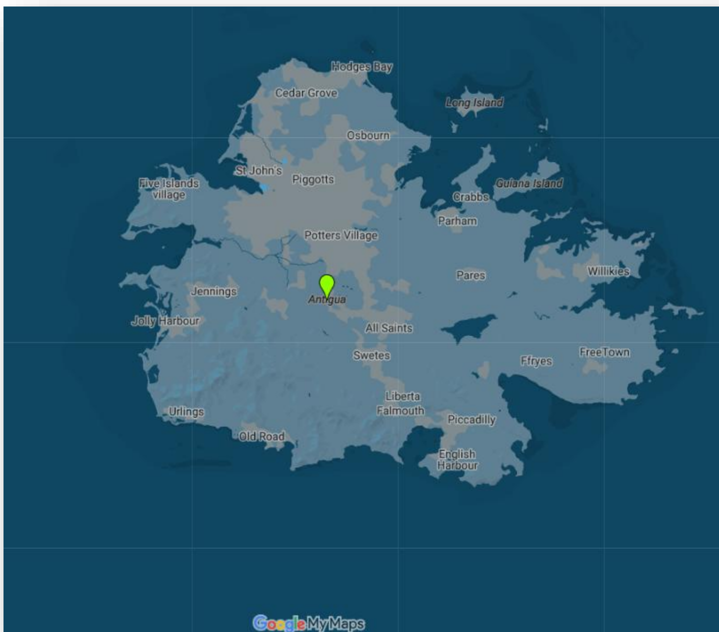
Antigua is a dry tropical island of 281 square kilometres, rising to a height of 402 m. It has a mixed geological formation of ancient rocks, comprising both volcanic and limestone, with a flat central plain of clay and sedimentary rocks, coralline and volcanic in origin. Antigua is one-half of the twin-island state of Antigua and Barbuda.

The island has long been recognised as one of the drier islands in the region and among the most water-scarce islands globally (Food and Agriculture Organization and Caribbean Institute for Meteorology and Hydrology, 2016; Trotman et al., 2017; WHO, 2020[85]). The island has experienced severe and frequent droughts and has in the past experienced loss of life as a result. It has also had

[85] WHO Country Health and Climate Change Profile 2020: Antigua and Barbuda. Accessed at: https://iris.who.int/bitstream/handle/10665/336273/WHO-HEP-ECH-CCH-20.01.06-eng.pdf

to purchase water from neighbouring islands. As a small island, Antigua has a high vulnerability to climate change, with high temperatures in relation to the sea surface. The island continues to experience risks associated with sea-level rise, flooding, droughts, and increased tropical cyclone activity (Antigua and Barbuda National Communication NC3, 2017).

Figure 8. Map of the Island of Antigua in the Lesser Antilles of the Caribbean



Source: Author generated from Googlemaps.com

Climate Trends and Modelling Projections

Antigua and Barbuda's National Communications highlight that due to the island's small size and limitations in the downscaling of climate models it is not easy to make projections with a high level of certainty for the island. There, however, is concurrence that the coastal zone of Antigua, like many islands of the Caribbean, is susceptible to SLR, coastal erosion, storm surges, and flooding. Antigua is particularly exposed to rising sea levels and storm surges, given the low-lying and flat terrain (USAID, 2021, p. 2).[86] The island also lies in the Atlantic tropical cyclone belt, and the mean annual temperature in Antigua has increased by around 0.6 ˚C since 1960 (Caribbean Community Climate Change Centre, 2012; Government of Antigua and Barbuda National Communication NC3, 2015; UNDRR, 2022).

Studies conducted by Simpson et al., 2012 suggest that with 1m of sea-level rise, ten percent of major tourism will be impacted, twelve percent of sea turtle nesting sites, two percent of major road networks, and one hundred percent of seaport lands. With a 2m sea-level rise, the percentages for major tourism, sea turtle nesting sites, and major road networks increase by eight percent, and one hundred percent of airport lands are also included. Areas identified as being at greatest risk include Dickenson Bay, Fort Bay, and Runaway Bay (Government of Antigua and Barbuda NC3 2015).

Similar to other islands of the region, strong winds, storm events, and other climate-induced hazards pose significant risks to the archaeological and historic built and natural environment. Climate modelling projections for Antigua[87] (CARIBSAVE 2012) indicate that the mean annual temperature is projected to increase by 0.4 - 2.1˚C by the 2060s and 0.9 – 3.5˚C by the 2090s, and the range of projections by the 2090s under any one emission scenario is around 1 to 2˚C. Projections of mean annual rainfall from different models are consistent in indicating decreases in rainfall by 45.7 mm (-277.2 mm to 101.2 mm) by 2040 - 2059 or thirty to fifty percent by 2090 (see also Antigua and Barbuda NC3, 2015; O'Marde, 2017).

In relation to Sea Surface Temperatures (SST), projections indicate increases throughout the year, with projected increases ranging from +0.8˚C and +3.0˚C by the 2080s across all three emissions scenarios. For tropical cyclones, North Atlantic hurricanes and tropical storms appear to have increased in intensity over the last thirty years. Observed and projected increases in SST indicate the potential for continuing increases in hurricane activity, and model projections indicate that this may occur through increases in the intensity of events but not necessarily through increases in the frequency of storms. The mean annual temperature will also rise by 1.3°C (range of 0.9°C to 1.9°C),

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[86] Antigua and Barbuda Resilience Profile. USAID 2021. Accessed at https://www.readkong.com/page/antigua-and-barbuda-resilience-profile-may-2021-3634928

[87] CARIBSAVE 2012 Climate Change Risk Atlas (CCCRA) - Antigua and Barbuda.

and annual precipitation will also increase (CARIBSAVE, 2012). Figure 9 identifies likely areas along Antigua's coastline that are projected to be submerged under one meter in sea level rise by the year 2100.

Figure 9. Antigua Coastal Areas to be Submerged under 1m Sea Level Rise

Source: Climate Central's Surging Seas Global Risk Zone Map http://sealevel.climatecentral.org/)

Overview of the impact of climate-induced hazards on select Antiguan sites

Archaeological research and observations[88] over the years in Antigua (and Barbuda) noted an abrupt acceleration of detrimental effects to its archaeological heritage that go well beyond normal impacts (see Murphy, 2011). When studies at coastal sites over the past fifty years are reviewed, they allow a comparative analysis of how climate-induced change is advancing, pointing to the need for immediate response strategies. This comparative analysis of change over fifty years is unique to Antigua and is not widely practiced across the Caribbean due to the varying factors

[88] A. Murphy, personal communication, June 17, 2022

elucidated throughout this research. These observations highlighted the catastrophic impacts of cyclone activity, with the Shirley Heights extant historical structures being highlighted as destroyed by hurricanes between 1989 and 1999. More recently, there has been significant erosion that has caused Black Point Fort and Fort William to collapse into the sea. There has also been a significant recording of the loss of pre-Columbian sites, which are noted as having lost meters.[89]

Data Collection and Vulnerability Assessment of Archaeological sites in Antigua

Winthorpe's Bay Sites

Winthorpe's Bay has experienced significant coastal development over the decades to the present day. The Bay is also home to a series of archaeological sites. Sites mapped and surveyed archaeologically include one small colonial cemetery, one coastal battery known as Fort Byam, two archaic age sites (see Figure 12 for a map of archaic sites located on Antigua), one multi-component site known as GE-01, one Ceramic Age site known as GE-06 or Winthorpe's West (Murphy, 2023). One of these archaic sites known as GE-10, was located on the eastern end of the runway at the international airport. This once substantial site was lost to repeated episodes of land clearing, and during archaeological surveys of 1997 to 2003, the waterfront archaic age midden was exposed and subsequently eroded into the sea. Since that time, the exposed waterfront has been covered with large boulders as a strategy to halt the coastal erosion of the site, and this has greatly assisted in mitigating erosion but undoubtedly contributes to coastal erosion in other areas.

Murphy (2023) suggests that the site of GE-01 was initially occupied during the archaic age, subsequently abandoned for several hundred years, and reoccupied in the Late Ceramic Age between AD 1000 and 1400. The site sits on an elevated point west over the marina, in an area that is slowly eroding, and cultural materials can be observed on the eroded waterfront, as well as postholes and evidence for the settlement being larger. This information also suggests the necessity of further studies to identify climate change adaptation strategies, which may be evident

[89] Antigua and Barbuda Sectoral Adaptation Plan: Culture, Arthur Reginald Murphy (2023)

in the archaeological record. The presence of adaptation strategies are discussed further in Chapter Five.

Site GE-06 is of a lower elevation and is a large site that radiocarbon dates suggest had an occupation period beginning around AD 555 to 1390. It begins on the waterfront and extends beneath the coastal road. This site has benefited from ongoing monitoring over the past twenty-five years and has provided the opportunity to observe coastal erosion and changes to the coastline. It was also selected as one of the sample sites for the vulnerability assessment, being located on a low-energy beach and due to its long period of monitoring. Murphy (2023) notes that cultural materials can be clearly observed eroding into the sea along a one-hundred-meter strip of coastline. The site was last excavated in 2004, and today, those excavation areas are now submerged. Some areas along the waterfront were filled with concrete slabs to halt erosion and protect the nearby main road, and comparisons now show that the protected areas remain stable. In contrast, the unprotected areas have continued to erode inland.

A case study of this site could provide interesting data on monitoring and adaptation practices for the wider region over a specific timeframe, not just for those working in the cultural heritage field but also for non-culture actors working to manage coastal retreat.

Nelson's Dockyard National Park (NDNP) World Heritage Property

Around fifty forts and defence platforms, as well as arsenals, barracks, and hospitals were constructed on Antigua. A fort was placed every two miles along the coast in an attempt to safeguard the island's profitable sugar business. By 1795, the island was being used as a navy dockyard and military staging area with support structures built in English Harbour (Murphy, 2011).

Nelson's Dockyard was established as a British Naval Dockyard, and today, it is the primary and largest heritage site in Antigua, and currently its only world heritage property inscribed to the World Heritage List in 2016. The Dockyard is, however, presently experiencing major challenges due to climate-induced hazards, with projections for future impacts. This is due primarily to the site being coastal and partially built on reclaimed land, and it is less than one meter in elevation above sea level at its highest point. The site has benefited from studies that have mapped the site and established elevations and other critical information, such as mapping the property's most flood-prone areas in relation to planned sea-level rise (see Figure 10; and Friedman, 2013).

These results are said to be contributing to the development of climate action to manage the threat. Drains have had to be placed beneath the road, and sump pumps have been installed. However, while roads, lawns, and parking areas can be raised, the original floors in the buildings cannot be raised, and today, the ground floor levels of some structures are now below sea-level. The vulnerability assessment observations for Nelson's Dockyard were considered for the entire site while specifically being applied to its coastal components.

Figure 10. Flood Hazard Likelihood in Nelson's Dockyard

Note: Adapted from *Sustainability Challenged: Assessing the impact of sea-level rise on Antigua's coastal economy and infrastructure* by E. Friedman, 2013 [Unpublished master's thesis] Hunter College, CUNY Department of Geography and Environmental Science).

Fort Berkeley

Fort Berkeley is located at the entrance to English Harbour and is the oldest fortification in the Harbour, dating back to 1704. Increasing storm surges and hurricanes have eroded the walls of the fort, and major undercuts have been filled over the past ten years. Despite this limited and costly activity, the erosion continues to accelerate, and a section of the wall and cut-stone floor have now fallen into the sea (see Figure 11). Underpinning the stone walls, repairs to the fort's drainage system, and the placement of boulders to create a breakwater to reduce wave energy will be essential as erosion increases.

Figure 11. Missing Wall and Eroding Components at Fort Berkeley

Source: Author.

Other Sites Not Included in Vulnerability Assessment[90]

Across the bay on the eastern side, the lower section of **Fort Charlotte** no longer exists. Only a small section of the gun-platform wall that guarded the harbour entry opposite Fort Berkeley remains to mark the position of the lower defence platform. At Pigeon Point Beach's southernmost point, **Black Point Fort** is situated near the eastern entrance to Falmouth Harbour. Constructed on a raised stretch of land along the coastline, the fort served as defence for the ships anchored in the harbour and the commercial town of Falmouth. Landowners have reported that the sea has started to erode the land and encroach on its boundary lines within the last ten years. When the historic site was examined in 2005 as part of a regular inspection of National Park sites, the western wall of the waterfront along the low-energy shallow sea was still intact. Since then, further surveys have shown that the sea has weakened the fort, and the fence is now in the sea.

Within English Harbour, at Freeman's Bay, is **Galleon Beach**. Major flooding episodes have occurred at the location due to tropical cyclones that have worn away and uncovered unmarked and previously hidden graves on the beach. The water at the waterfront resort has in the past reached four feet deep, flooding automobiles and structures. A portion of the dune was also devastated by floodwater, revealing human bones from an unidentified cemetery. Severe landslides have also damaged other structures.

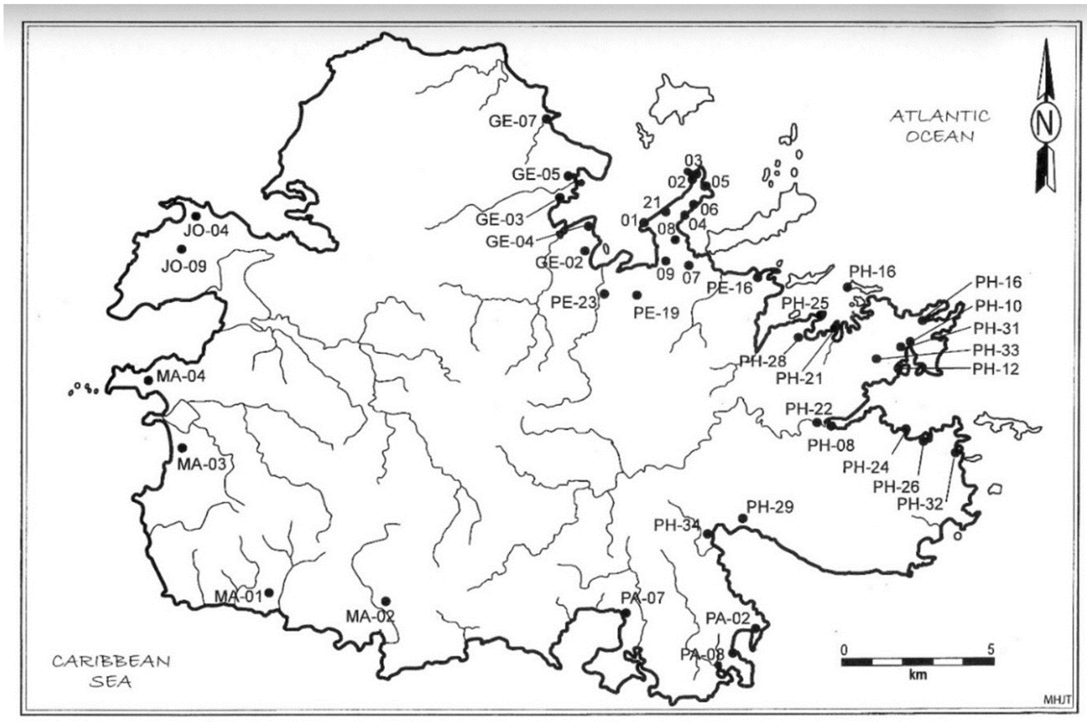
Mostly shielded by a barrier reef system that stretches from Mamora Bay in the south to the northern highland at the bay's entrance (St. Phillip's), **Willoughby Bay** is an open and vast bay on Antigua's east coast. During the colonial era, the region did not receive enough rainfall to generate significant amounts of sugar. In the middle of the seventeenth century, poor white Barbados residents founded a small village known as Bridgetown on a sheltered stretch of the bay's northeastern waterfront. The settlers eventually moved uphill to higher land to the village of St. Phillips, and by 1855 the town lay in ruins. Locals ascribe this relocation to a nineteenth-century tsunami that devastated the region and resulted in significant erosion.

[90] Based on the Sectoral Adaptation Plan: Culture (Murphy 2023) and Field assessment (Richards and Murphy 2022)

Midway through the seventeenth century, **Fort James** was constructed to guard St. John's, a recently founded settlement. The location experienced damage from fire, hurricanes, droughts, unauthorised brick removal, and erosion of the coastline. On the eastern-facing slope where a wooden pier once stood, there has been major erosion that has washed out the roots of the trees that stabilised the waterfront and under the corner of the stone wall of the fort. This corner section is now collapsing into the sea, and major structural cracks have developed. The erosion has also undermined the old concrete stairs down to the waterfront. Undercutting and erosion of the seawall face on the west side of the fort has become a major issue that threatens the gun platform above. All the buildings within the fort are in an extremely fragile condition.

Multiple sources were used to compile an inventory of coastal sites. These include the report *Sectoral Adaptation Plan: Culture* (Murphy, 2023), a desk review of smaller studies on archaeological sites in Antigua and Barbuda, and a pre-existing map of archaic sites in Antigua (see Figure 12). This was followed by site visits to randomly selected coastal sites to facilitate obtaining GPS coordinates and making site and coastal observations as part of the vulnerability assessment. Murphy (2023) records 180 pre-Columbian sites, over 170 sugar estates, 54 fortifications, and an estimated 300 shipwrecks split between the islands of Antigua and Barbuda.

Figure 12. Archaic Archaeological Sites on Antigua



Source: A.R Murphy. Used with permission.

Table 12. Vulnerability Assessment of Selected Sites in Antigua

Climate Hazard Phenomena	Heritage Value	Impact	Sensitivity	Exposure	Adaptive Capacity				Measure of Vulnerability
					LCD	LCED	CA	MR	MV = (E + S) - AC
			1 - 4	1 - 4	1-4	1-4	1 - 4	1 - 4	
SEA LEVEL RISE	Withrope Bay G-06 Pre-Columbian site cultural materials	Coastal erosion; Storm surge	3	4	2	1	3	1	4 *(5.25)*
	Fort Berkeley	Coastal erosion; Wave action	4	3	1	1	3	3	4 *(5)*
	Nelson's Dockyard built heritage	Coastal Erosion, Coastal Inundation	2	3	2	2	3	3	3 *(2.50)*

Key: 1 – Low; 2 – Moderate; 3 – High; 4+ – Extremely High. LCD – Level of Coastal Development; LCED – Level of Coastal Ecosystem Degradation; CA – Climate Action; MR – Management Response. Note: Adaptive Capacity = Average of LCD, LCED, CA, and MR

Summary of Assessment and Results

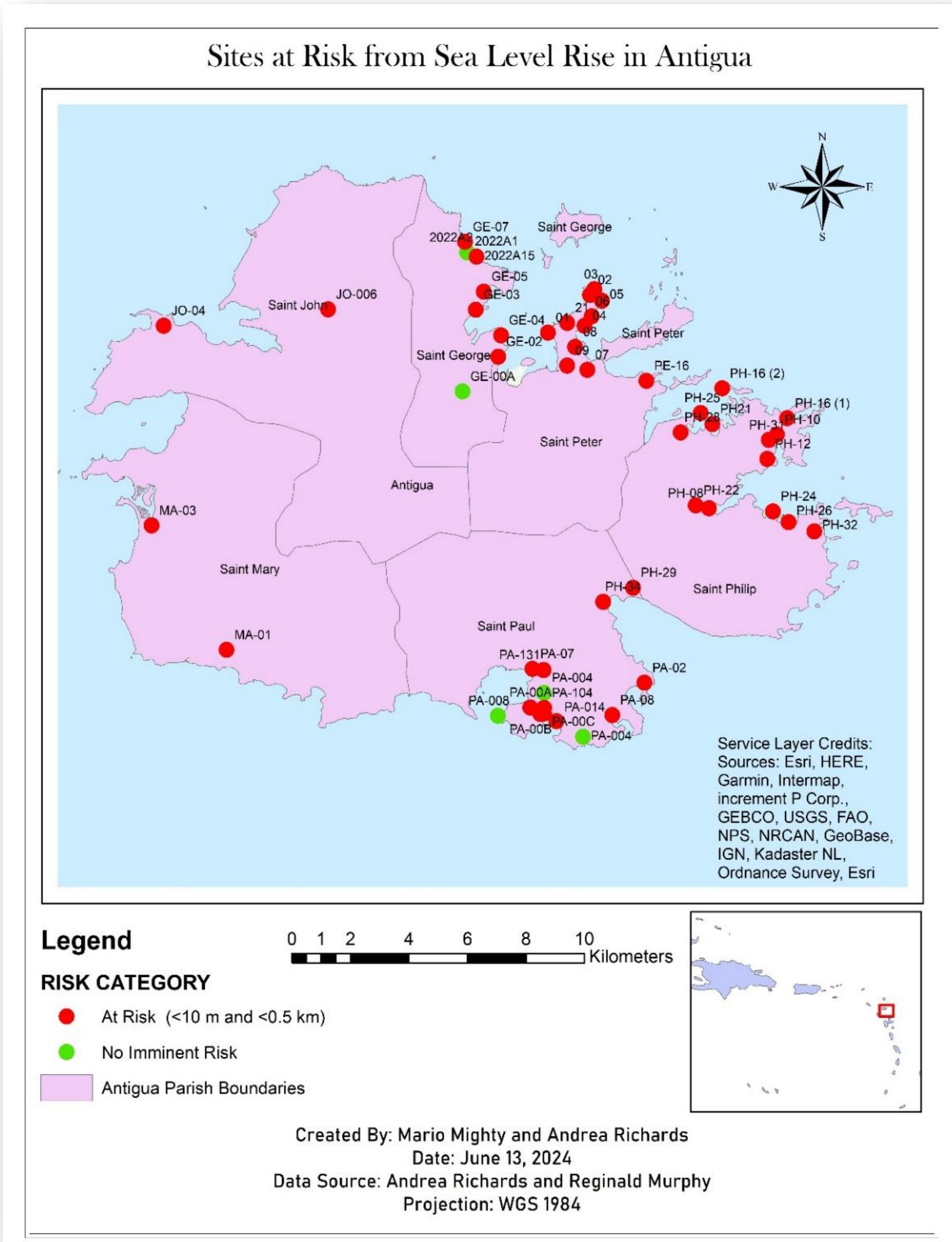
The documentation reviewed and field survey, suggests that archaeological sites in Antigua have experienced significant impacts from climate-induced hazards in the past and continue to do so in the present time with extremely detrimental effects. For the sites identified in Table 13, site GPS locations have been excluded. Figure 13 highlights all sites observed during the field assessment, identifying those at particular risk from climate-induced hazards.

Table 13. Sites Visited as part of Field Vulnerability Assessment

Site Code	Name of Site	Distance from Water	Elevation M.A.S.L or M.B.S. L
GE-0B	Winthrope Bay Historic Bunkers	< 0.5 km	+8
PA-004	Shirley Heights Officers Complex Lookout Cistern	< 0.5 km	+138
PA-131	Shirley Heights Water Catchment System and Lookout	< 0.5 km	+5
PA-00B	Mast Shed/Joiners Lodge (Nelsons Dockyard)	< 0.5 km	+4
PA-00C	Pay Office Nelsons Dockyard	< 0.5 km	+4
PA-004	Indian Creek	< 0.5 km	+23
PA-014	Fort Charlotte	< 0.5 km	+8
JO-006	Fort James	< 0.5 km	+8
PA-008	Black Point Fort	< 0.5 km	+13
PA-00A	Saint Paul 1700s Water Catchment	< 0.5 km	+2
PA-104	Fort Berkley	< 0.5 km	0
GE-00A	Saint George Water Well	< 0.5 km	+14

Note: In relation to the site codes provided, letters indicate established parish codes used as part of the national inventory, with the number identifying the number the site was allocated in that parish. Codes with a ‘0’ following parish letters are sites that were mapped during the 2022 field exercise and did not have pre-existing codes or might be a sub-component of a wider site that was specifically observed.

Figure 13. Some sites at risk due to climate-induced hazards in Antigua



Source: Author compiled from various sources highlighted throughout research

The seawall in the Dockyard illustrates an example of critical actions that will be needed to protect archaeological sites in Antigua. In 2003, the eastern wharf or seawall in the dockyard began to sag, and a section eventually slumped into the sea. The wall had taken a pounding from the active decade of hurricanes in the 1990s, so a major restoration programme was planned and implemented by the National Parks Authority, with partial assistance from external sources. Under the supervision of the Park's archaeological team, which was responsible for documenting the construction methods of the ancient wall, the original wall was removed, and the upper layers of stones were marked and kept for reuse in their original positions. These actions aimed to build resilience at the site.

At high tide, the seawall is only 20 to 40 cm above the water, which is its original height. In certain places, the sea rises above the top of the wall during exceptionally high tides. Although the wall was built to modern specifications, many questions arise regarding its future and what actions will be required to protect the property, when due to rising sea-levels, high tides become normal height. Inspired by the results of the Friedman initial study (2013), a new project with computer simulations was proposed to better understand the threats to the World Heritage property and the nearby communities. In addition, discussions to establish methods for systematic monitoring were planned, as well as meetings with experts to develop and explore options and develop a long-term plan for the site and its community are on the agenda.

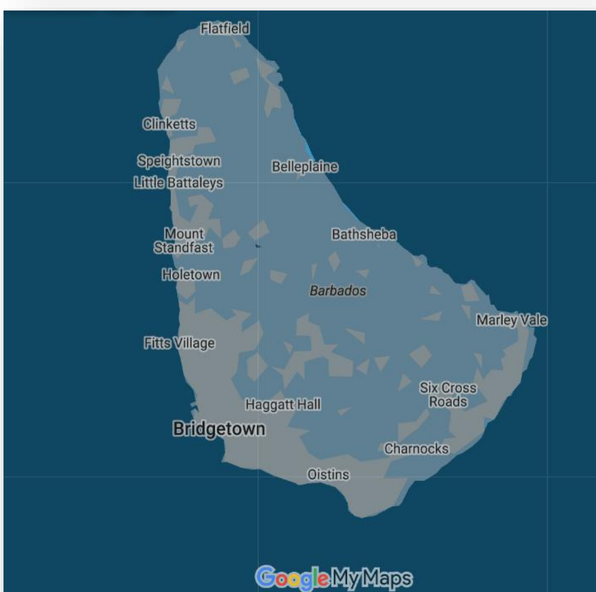
In summary, a comprehensive approach is essential for planning, mitigation, and adaptation in relation to the new exigencies of climate change. The development of Antigua's cultural heritage sectoral climate change adaptation plan is a good, evidence-based platform from which initiatives can be built and has already commenced with comprehensive documentation of the status of archaeological and built heritage in relation to climate-induced hazards.

Barbados

Introduction

Barbados[91] is the easternmost island in the geographic sub-region known as the Lesser Antilles. Although other islands in this chain are volcanic and mountainous, Barbados is relatively flat, with the highest point at 334m, and a total land area of approximately 432 km^2 and 92 km of coastline (Alleyne, 2019; Mycoo et al., 2021). The local geology is largely comprised of non-volcanic sedimentary rocks such as limestone coral (Mycoo et al., 2021; UNDRR, 2023[92]). These geophysical characteristics contribute to varying levels of coastal susceptibility (Fitzpatrick, 2011) with, for example, the east coast's Scotland District displaying high levels of coastal erosion (Evanson and Department of Emergency Management, 2014).[93] Various studies estimate that the island has been rising about a foot every one-thousand year but sinking in some areas (Krajick, 2018).

Figure 14. Map of Barbados



Source: Author generated from Googlemaps.com

[91] Components of the Barbados case study were presented at the 2022 Session of the International Association of Caribbean Archaeology by Andrea Richards
[92] Disaster Risk Reduction, United Nations Office for Disaster Risk Reduction (UNDRR) 2023
[93] Country Document for Disaster Risk Reduction: Barbados 2014. Accessed at https://dipecholac.net/docs/files/784-documento-pais-barbados-web.pdf

Climate Trends and Modelling Projections

Barbados exhibits specific "geographic, topographic, historical, economic, and political characteristics that make it vulnerable to the effects of severe climate change" (Alleyne, 2019, p. 1) and other extreme hydro-meteorological events (UNDRR, 2023). Its coastal zone is particularly vulnerable to SLR, flooding, and storm surges have been estimated to extend over 150 to 300m inland (Nurse, 2011; Mycoo et al., 2021).

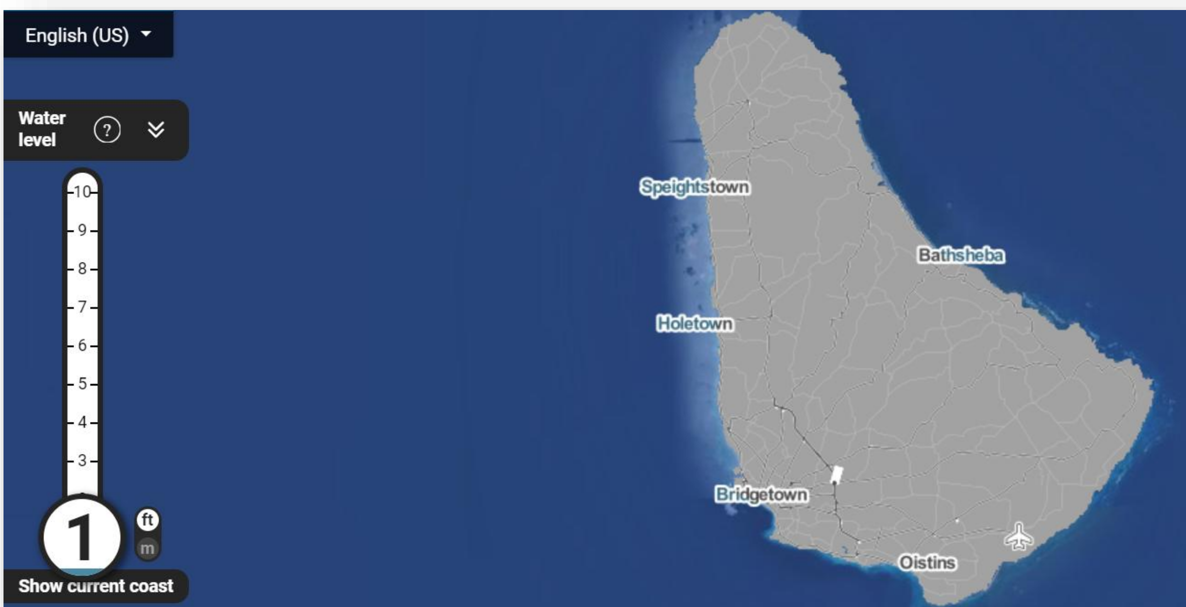
Through damages from catastrophic weather systems and other occurrences, as well as more subtle changes in rainfall patterns and temperatures, the island is already feeling some of the effects of climate variability and change. Climate modelling projections for Barbados (CARIBSAVE, 2012) predicted an increase in mean annual temperatures between 2.4˚ to 3.2˚C by 2080s in higher emissions scenarios. The General Circulation Model (GCM) projections for precipitation span both overall increases and decreases, ranging from -36 to +12 mm per month by 2080 under the high emissions scenario. Most projections however, trend toward decreases. SSTs are projected to increase throughout the year ranging from +0.8˚C and +3.0˚C by the 2080s across all three emissions scenarios.

In relation to tropical cyclone activity, these have increased in intensity in recent decades. Observed and projected increases in SST indicate the potential for continuing increases in hurricane activity, and model projections indicate that this may occur through increases in the intensity of events but not necessarily through increases in the frequency of storms.

According to Barbados' Second National Communications (2018), extrapolation of historical data projected SLR of 0.28m by 2100, however this was later adjusted to 0.5m to 1.4m by 2100 (Barbados Second NC, 2018, p. 40). In some studies, such as in the Holetown historic town and urban corridor, relative SLR has been projected at 1.6m to 2100 (Alleyne, 2019).

Mycoo et al. (2021, p. 2) suggest that whatever projections have been made in relation to higher sea levels and increased tropical storm activity are likely to increase storm surge frequency and intensity. The main impact of storm surge is flooding because of Barbados' generally low-lying topography. This situation was evidenced in June 2024 when Hurricane Beryl resulted in significant impacts on the island's port and coastal roads during its passage with twenty-foot storm surges in some areas. According to Mycoo et al. (2021, p.3), and aligned to data presented earlier, a significant portion of Barbados' population, coastal infrastructure, and human settlements are in the area defined as the Low Elevation Coastal Zone (LECZ), "which is the land area that is contiguous to the coastline up to a 10m rise elevation" (also see Udika, 2009). Highlights of coastal areas projected to be submerged under 1m sea-level rise by the year 2100 based on Climate Central's Surging Seas Risk Map are shown in Figure 15.

Figure 15. Barbados Coastal areas projected to be submerged under 1m Sea-Level Rise



Source: Climate Central's Surging Seas Global Risk Zone Map http://sealevel.climatecentral.org/)

Overview of the impact of climate-induced hazards on select Barbadian sites

The impact of climate-induced hazards on archaeological and built heritage has received small mentions in studies undertaken in historic towns such as Holetown and Speightstown on Barbados' west coast (see Alleyne, 2019). Climate warming was also highlighted as a threat in the world heritage nomination dossier for Historic Bridgetown and its Garrison.[94] Research by Drewett (2007) also suggests erosion impacting the site at Heywoods.

Records of flooding events in Barbados suggest that while impacts on different types of infrastructure, such as schools and churches, are noted (Alleyne, 2019), there is very little reference made regarding the heritage values of those spaces that are recorded. Neither is cultural heritage mentioned in these assessments, except in the cases mentioned above where these structures also have some historic value. Notwithstanding the very limited documentation in relation to how climate-induced hazards impact sites, many archaeological sites are to be found in this coastal strip, including portions of the World Heritage Property of Historic Bridgetown and its Garrison. Barring these extremely limited references, no comprehensive study of the impact of climate-induced hazards on Barbados' built and archaeological heritage has been undertaken. The available information on various sites is, therefore, extremely limited. In 2024, the island initiated an assessment to understand how climate-induced hazards were impacting tangible and intangible heritage. This activity is ongoing and is aligned to requirements of the Physical Development Plan of Barbados.

Data Collection and Vulnerability Assessment of Select Archaeological Sites in Barbados

To undertake this study, the methodology for Barbados focused on desk-based review studies on (a) prior research on Barbados' archaeological heritage, with references to the natural environment and environmental impacts at sites, (b) climate change research specific to Barbados and (c) various archaeological site surveys and inventories of Barbados' archaeological record. These surveys and inventories include those undertaken for Barbados' Physical Development Plan (2017,

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[94] Historic Bridgetown and its Garrison World Heritage Nomination document. Accessed at: https://whc.unesco.org/en/list/1376/documents/

updated 2023), Bright (2011), and Drewett (2000) of University College London in partnership with the Barbados Museum and Historical Society's baseline study of coastal sites conducted in the early 1990s. This review was then anchored within a field and vulnerability assessment of randomly selected coastal sites along the north, south, east, and west coasts of Barbados.[95] These assessments were undertaken throughout 2022 and made observations in relation to climate stressors and human-induced contributions to these stressors. The sites selected highlighted in Table 14 also represented both pre-Colombian and colonial-era sites. They were primarily extracted from Peter Drewett's survey of pre-Colombian sites in collaboration with the Barbados Museum and Historical Society (BMHS) as the first inventory of such sites, along with other site research reports and publications where available.

In keeping with the climate challenges identified in this research, sites were also selected due to their proximity to the coastline and representing the variety in Barbados' geophysical characteristics. The compilation of coastal sites was followed by field visits to obtain GPS coordinates and site observations to facilitate the vulnerability assessment (Table 14). GPS coordinates have not been presented in this research. This information was then input into Table 15 to support calculations of the measure of vulnerability of each site. Figure 16 highlights all sites observed during the field assessment.

Table 14. Barbados Field and Vulnerability Assessment Sites

Parish	Name of Site	Distance from Visible Coast	Elevation M.A.S.L or M.B.S. L
St. Michael	Bethel Methodist	< 0.5 km	11
	Bay Street	< 0.5 km	4
	Bridgetown Car Park Bond	< 0.5 km	0
	Pierhead/Cavans Lane Warehouses	< 0.5 km	0
	Cavans Lane Bonds	< 0.5 km	0

[95] Field and Vulnerability Assessment by Richards and Farmer 2022. Selected sites: West coast - Holetown and Speightstown, Folkstone; South coast - Silver Sands, Oistins, Chancery Lane Swamp, Historic Bridgetown, Carlisle Bay; East coast – along former trailway; North – Maycocks Fort

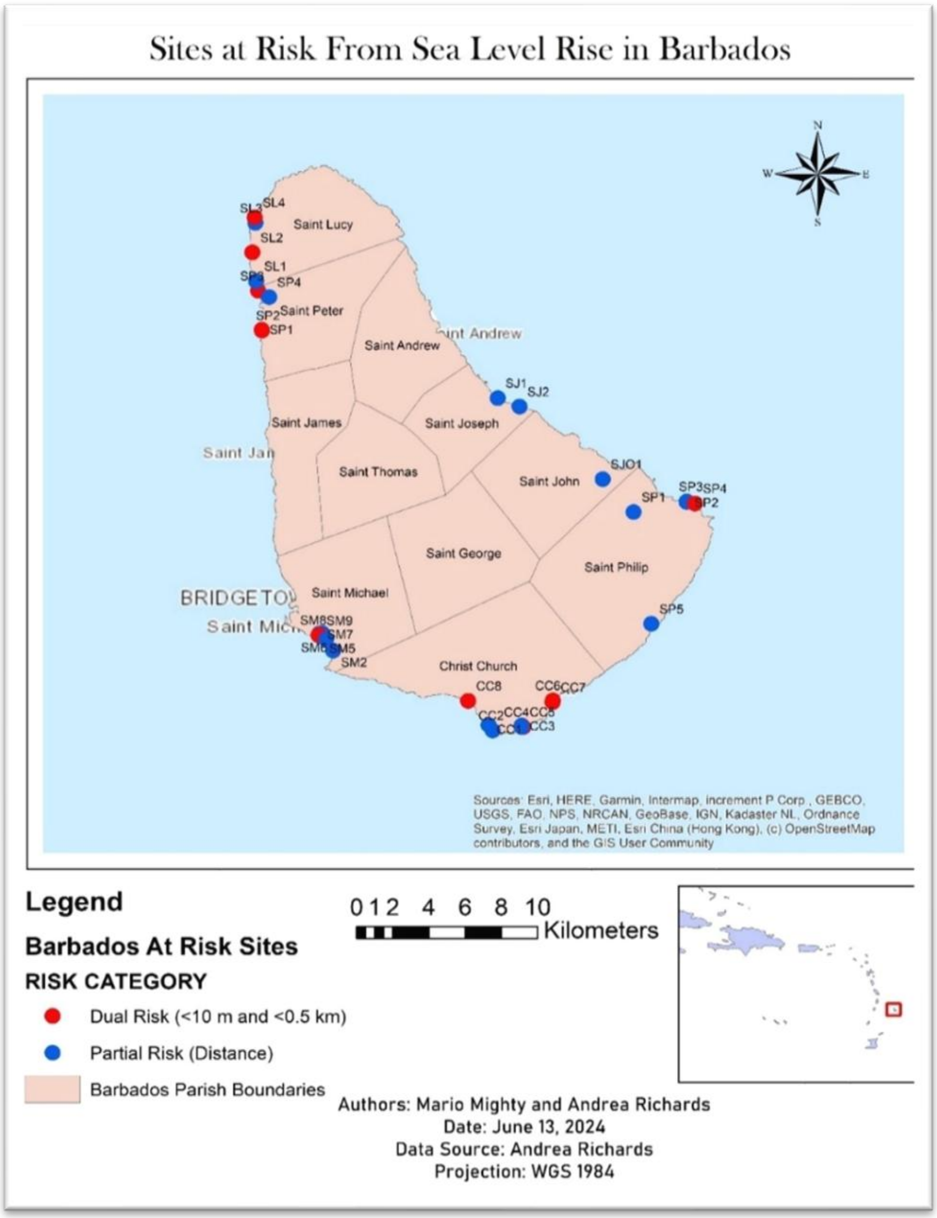
	Barbados Parliament	< 0.5 km	12
	Spirit Bond	< 0.5 km	10
	Dry Dock (Cavans Lane)	< 0.5 km	0
	Blackwood's Screw Dock (Pier Head Lane)	< 0.5 km	0
	Possible Royal Barracoon Burial Ground	< 0.5 km	0
	Former Harbour Police Station Arch (Hyatt Hotel)	< 0.5 km	11
St. Joseph	Joe's River (Ermy Bourne Highway/Trail Way))	< 0.5 km	20
	Hillcrest Pre-Columbian Site (Tent Bay)	< 0.5 km	23
St. John	Codrington Amerindian site and 17th-century factory yard	< 0.5 km	91
St. Phillip	Three Houses Pre-Columbian site (Highway 7)	< 0.5 km	53
	East Point Lighthouse Old Privy	< 0.5 km	30
	East Point Lighthouse	< 0.5 km	30
	Cloud Station	< 0.5 km	0
St. Phillip	Foul Bay Shell Midden (Foul Bay Road)	< 0.5 km	18
Christ Church	Spring Road Mill Tower (Pearl Avenue)	< 0.5 km	16
	South Point Lighthouse	< 0.5 km	17
	Silver Sands Amerindian Site[96]	< 0.5 km	11
	Chancery Lane Amerindian Site	< 0.5 km	6
	Remnants of Oistins Fort	< 0.5 km	9
St. Peter	Old Two Storey Historic Structure Next to Bakery (Queen's Street)	< 0.5 km	0
	Formerly Fort Denmark (Queen's Street)	< 0.5 km	0
	Fort Rupert	< 0.5 km	0

[96] Site is protected by a sand dune and is likely at risk although recorded as 11m ASL

	Six Men's Fort	< 0.5 km	29
St. Lucy	Old Fort Cannons (Sherman Hall Moon Fort)	< 0.5 km	11
	Maycock's Fort	< 0.5 km	0
	Mill (near Harrison's Point)	< 0.5 km	39
	Harrison's Point/North Point Lighthouse	< 0.5 km	0

Source: Author compiled. Based on Field and Vulnerability Assessment by Richards and Farmer 2022.

Figure 16. Mapped sites at risk due to climate-induced hazards



Source: Based on Field and Vulnerability Assessment by Richards and Farmer 2022.

Table 15. Field and Vulnerability Assessment of select Barbadian Sites

Climate Hazard Phenomena	Heritage Value	Impact	Sensitivity	Exposure	Adaptive Capacity				Measure of Vulnerability
					LCD	LCED	CA	MR	MV = (E + S) - AC
			1 - 4	1 - 4	1-4	1-4	1 - 4	1 - 4	
SEA LEVEL RISE	Maycock's Fort (St. Lucy): exposed remains of Fort	Coastal erosion, Storm surge, Coastal Inundation	3	3	1	2	1	1	4 *(4.75)*
	Warehouse District – Historic Bridgetown: extant structures[97]	Storm surges; Coastal inundation	2	3	4	1	2	1	3

[97] In 2024, a portion of the Warehouse District was demolished to make way for commercial development

Table 15 (continued). Field and Vulnerability Assessment of select Barbadian Sites

SEA LEVEL RISE	Chancery Lane Pre-Columbian site	Storm surges; Coastal inundation	3	3	2	2	3	1	4
	Speightstown, St. Peter historical town and urban centre	Coastal erosion, Storm surge, Coastal Inundation	2	3	3	2	2	2	3 *(2.75)*

Note: Adaptive Capacity = average of LCD, LCED, CA, and MR. *Key*: 1 – Low; 2 – Moderate; 3 – High; 4+ – Extremely high

Summary of Assessment and Results

The assessment reveals a high level of vulnerability in Barbados' coastal archaeological record, requiring urgent action. Sea-level rise over thousands of years may have also resulted in the submersion or erosion of archaic coastal sites in Barbados. In addition to archaeological sites at risk along the coast of Barbados, historic towns such as Bridgetown, Speightstown, and Holetown are prone to impacts from storm surges and coastal inundation, with added risk due to their low elevations or being at sea level.

Concerning Barbados' coastal ecosystem, high levels of tourism and other development, low-lying areas, and proximity to the coast, have severely compromised the adaptive capacity of coastal heritage. Over sixty percent of the island's population lives in the coastal zone (Alleyne, 2019), and according to Udika (2009), a history of land use policy provided the momentum for development along coastal areas. This resulted in the clearance of the coastal ecosystem such as mangroves, and specifically wetlands along the west and south coasts notably in Heywoods, Holetown, Bridgetown, Accra, Oistins, and Silver Sands, to make way for tourism and residential development. Today, the Graeme Hall Swamp is the only remaining significant mangrove, which is about 20 hectares (Schueler, 2016). This destruction of the coastal ecosystem now contributes to increasing vulnerability in these areas, with coastal inundation occurring at the smallest rainfall levels.

Protecting Barbados' coastal archaeological record within the context of a changing climate requires a multi-pronged approach. As indicated, the coastal assessment undertaken revealed a high level of vulnerability of coastal archaeological sites with low adaptive capacity. This is within the context of significant infrastructural development, particularly linked to tourism in coastal areas, and other human-induced actions, and loss of or severely degraded coastal ecosystems. The issue of sand mining is however not as pervasive as on other islands of the eastern Caribbean.

The legislative and policy landscape for heritage in Barbados has remained unchanged since Farmer's (2011) research. Threats to heritage are constantly evolving, calling for the revision and strengthened implementation of legislation, ongoing reflection, and the utilisation of tools, methodologies, and other actions to address an impact that has already been realised. Complete inventories are non-existent, and where they do exist, detailed locations are unknown. Neither has there been a mapping of risks to cultural heritage generally. The Planning Office maintains a list of sites throughout Barbados for its Physical Development Plan. However, this list is by no means complete and tends to be skewed towards the built heritage environment, and many previously documented sites are also unknown to this record.

The actions and steps taken can mitigate ongoing loss as well as determine how well archaeological sites can adapt in the future while responding to climate-hazards. Limited or no monitoring results in many impacts going unchecked, unreported, and unaddressed, resulting in the continued loss of sites, both documented and undocumented. As a result of this, no significant actions have been developed that focus on monitoring, and although climate change is something the heritage community in Barbados has been discussing for a while, assessments, and monitoring programmes for these sites remain non-existent. Neither is there good and available baseline data to develop robust monitoring programmes for these sites. Vulnerability assessments can provide this baseline data to support the development of relevant programmes.

To support the need for critical baseline data and as a useful planning tool for the heritage community, tools such as risk maps are needed to assess levels of risk and projected over specific timelines. As indicated previously, there is no systematic mapping exercise, nor is monitoring being undertaken. The lack of resources, both human and financial, is also critical. The state and vulnerability of the vast majority of Barbados' coastal archaeological record are unknown. To develop appropriate strategies and actions to safeguard this archaeological record, actions must be developed around the site's identification, threats, and vulnerability. These actions can be developed through various steps.

In terms of data collection, the work done by Drewett (2000) and Bright (2011) remain the most comprehensive documentation and mapping of sites, with a heavy focus on the pre-Columbian, providing some data on their location. In some instances, a description of the site's environment, data on elevation, and distance from the sea were also included. This data can be used as a basis to expand survey data and, through modelling, undertake a programme to identify previously unknown sites. This action can then serve as the basis for an expanded coastal heritage survey, joint collaborative projects involving the BMHS, and other partners such as Coastal Zone Management Agency, the Barbados National Trust and the University of the West Indies (UWI). Barbados' Physical Development Plan also provides an avenue for this to be undertaken, in mentioning that risk studies should be undertaken in relation to climate change and cultural heritage.

Jamaica

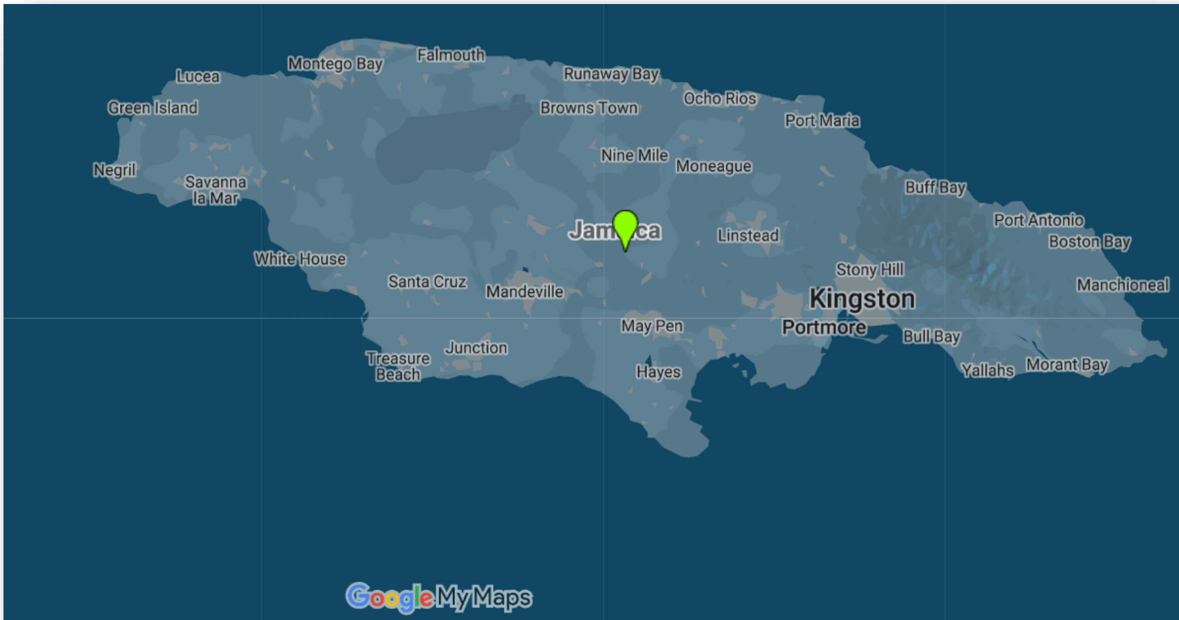
Introduction

Jamaica[98] is an island of 11,264 square km in addition to 9,600 square km of offshore banks and shoals in the Greater Antilles sub-region of the Caribbean (see Figure 17), with geophysical characteristics highlighted by a limestone plateau for its greater part, a mountainous interior and coastal plains that are largely alluvial with interior valleys and rivers (Robinson, 1994). Jamaica's coastline is characterized by variations, such as volcanic on the south and limestone on the north, with attending erosion susceptibility (IADB, 2018).

As is the case for most of the Caribbean, Jamaica's population resides within 1.5 kilometres of the coast, and the island's coastal zone generates about ninety percent of its Gross Domestic Product (CARIBSAVE Jamaica Profile, 2012). This environment, together with the ensuing destruction of coastal ecosystems that provide protection and stressors from tourism and other forms of coastal development, has guaranteed a limited ability to adapt to climate change in the coastal zone.

[98] Components of this case study were included in the article 'Richards, A., (2022). The Potential Effects of Climate Change on Jamaica's Pre-Columbian Archaeological Record: Monitor, Assess, Mitigate and Adapt' in the Journal of Caribbean Archaeology.

Figure 17. The Island of Jamaica in the Greater Antilles



Source: Author generated from Googlemaps.com

Climate Trends and Modelling Projections

The State of the Jamaican Climate Report (2015) projects increased heat and drying in the future and larger and more frequent tropical storms. A 0.5 mean SLR could lead to an increase in the frequency of sea level extremes. With projections of a conservative mean SLR of 0.87 to 0.9 meters throughout its coastal areas by the end of the century, SLR will be a climate phenomenon of concern for Jamaica. Jamaica's Vision 2030 National Development Plan (Government of Jamaica, 2009) anticipates that SLR will exacerbate beach erosion and result in permanent flooding in some locations. This eventuality will have significant implications for cultural life and livelihoods in these coastal areas.

The projected rise in temperature indicates values ranging from 1.18 to 1.31 in the 2020s to 2.76 to 3.62 in 2100. The intensity of tropical cyclones in the North Atlantic has increased in recent decades, and SST rises, both observed and predicted, suggest the possibility of further increases in tropical cyclone activity.

The tourism sector will experience severe erosion and inundation in many areas, and these impacts will also extend to cultural traditions associated with the sea and beach areas, as well as amenity value and infrastructural damage. The very graphic and visual loss of the popular Hellshire Beach served to drive the climate crisis home for Jamaicans.[99] [100] The impacts experienced by these spaces linked to the national cultural identity of Jamaicans highlight the social value in using such places as part of climate heritage social action discussed throughout this research.

Climate warming has also been identified as a threat to Jamaica's reefs due to an increase in the temperature of coastal waters, resulting in the death of a significant number of corals. Along the Jamaican coast, climate change and non-climate stressors combine to contribute to the island's beach erosion. The rate of erosion is said to be very site-specific, with some beaches "experiencing significant erosion over the past sixty years while others have not experienced significant erosion" (Simpson et al., 2012, p. 79; also see CCCRA, 2012: Climate Risk Profile for Jamaica; Marine Geology Unit, n.d.). Regular monitoring of coastal erosion has only been conducted in Jamaica for the last fifty years (CARIBSAVE, 2012; Marine Geology Unit, n.d.). SLR scenarios of one and two meters, beach erosion, and SLR forecasts for the Caribbean are in line with prior evaluations of the possible effects of sea level rise (Dasgupta et al., 2007), and Figure 18 highlights coastal areas projected to be submerged under 1m sea-level rise by the year 2100.

[99] A beloved Jamaican beach is succumbing to climate. It won't be the last. Accessed at https://www.theguardian.com/us-news/2020/oct/27/jamaica-hellshire-beach-climate-change

[100] What happened to Hellshire Beach Accessed at https://www.jamaicaobserver.com/columns/what-happened-to-hellshire-beach/

Figure 18. Coastal Areas to be Submerged under 1m Sea-level Rise

Source: Climate Central's Surging Seas Global Risk Zone Map http://sealevel.climatecentral.org/)

Overview of the Impact of Climate-hazards on Jamaica's Archaeological Record

The Jamaica National Trust (JNHT) maintains a national inventory to include designated national heritage of archaeological and built heritage sites across Jamaica. There has been no systematic assessment of risks faced by Jamaica's archaeological record and specifically those that are coastal. Simple observations will however provide evidence of a coastal archaeological record that is threatened by climate-induced hazards through continued erosion, inundation, and submersion of sites or threats to the structural integrity of built heritage.

Jamaica's pre-Columbian heritage is particularly vulnerable. This record underwent a period of rapid documentation by James Lee starting in 1959 (Allsworth-Jones, 2008). Allsworth-Jones also outlines an extensive history of pre-Columbian investigations in Jamaica in his book *Pre-Columbian Jamaica* (2008). Researchers of Jamaican archaeology have generally agreed that while much research has been completed, limited publication has ensued, resulting in the view that very little archaeological research has taken place on the island (Keegan & Atkinson, 2006; Wesler, 2013). Few pre-Columbian sites have benefited from extensive research by international and national researchers alike. As such, many remain unresearched, others undocumented, and many their status unknown since initial mapping by Lee in the 1960s to 1970s.

Research to date indicates that the network of pre-Columbian sites in Jamaica is quite extensive, with many focusing on the coastal area or elevations with a good view and path to coastal areas. In his extensive mapping exercise, Lee (1976) concluded that the Redware[101] culture preferred coastal settlements and was located predominantly on the seashore or near rivers at elevations of 0-15m above sea level (Allsworth-Jones, 2008). This fact means that many of these sites are vulnerable to climate-induced hazards, as approximately thirty-five percent of these known sites are located within 1.5 km of the coast, echoing true that coastal sites are caught between the dynamic of land, sea, and human-induced development, rendering them extremely vulnerable (Crock, 2019).

The research of James Lee, credited with mapping 265 of these sites, and the Archaeological Society of Jamaica (formerly Archaeological Club of Jamaica) have been critical to the documentation of Jamaica's pre-Columbian archaeological resources (Atkinson & Keegan, 2006; Allsworth-Jones, 2008). While sites such as White Marl, Paradise Park, Green Park, Newry, and Coleraine—among few others—have benefited from extensive research and have been the most published in the last decades, there has generally been limited references to environmental changes at sites that could be characterized as related to climate change. The Little River site in St. Ann is one of the earliest references to these impacts, with reports detailing the challenges of coastal erosion (DeWolf, 1953).

As highlighted, James Lee, in his various mapping exercises detailed in the *Archaeology Jamaica* newsletter and Allsworth-Jones (2008), indicated that Jamaica's pre-Columbian population demonstrated a preference for coastal occupation, often at high-tide coastline, making these sites susceptible to coastal erosion, ongoing wave action and rising sea levels (Wesler, 2013). Ongoing coastal changes and rising sea levels will only continue the trend of erasing this record.

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[101] Around 650 A.D, Jamaica was settled by the people of the *Ostionoid* culture (ancestors of the Taíno), also known as the Redware culture (see Atkinson, 2008; Keegan, 2019; P. Allsworth-Jones, 2008). Ostionan pottery is characterized by simple black smudging, very basic modelling, and an orange-red slip applied to the whole of the typically thin and hard ceramic vessel. It is widely referred to as redware.

Climate change through SLR is also sometimes mentioned as a possible reason for the lack of identification of archaic sites in Jamaica. Callaghan (2008) examined the place for environmental factors such as tropical cyclone activity and sea-level changes for the dearth of archaic sites while highlighting that other countries in the Greater and Lesser Antilles were home to these sites. He noted that Jamaican data on Holocene SLR does not suggest a mid-Holocene high stand above present in the region, which would have caused the erosion or inundation of coastal archaic sites, nor do sea-level curves for Jamaica indicate a significant difference between the archaic period and present sea levels. He concludes that if archaic inhabitants were coastally oriented, and the sea level is 2 to 4 m higher today than four to five thousand years ago, it is likely that many of those early sites are now inundated and submerged (also see Keegan, 2019).

Data Collection and Vulnerability Assessment of Select Archaeological Sites in Jamaica

To frame this vulnerability assessment of Jamaican sites, a review of the existing literature was undertaken to identify references to sites being impacted by sea level rise, wave action, flooding, and erosion by the sea, among other key terms. The back issues of *Archaeology Jamaica* served as the primary source for the largest number of sites, followed by the Jamaica National Heritage Trust (JNHT) site inventory, files, research reports, and publications where they were available. This review indicated a few specific site references in relation to ongoing environmental and climate change. From this desk review, the following environmental or climate change or stressors-related references to sites were noted and highlighted below.

The **Little River** site is one of the earliest dated redware sites on the island. It has one of the earliest recorded references to climate change or environmental impacts on a pre-Columbian site. The site is noted as having been fully eroded by the sea, with none of the site remaining. Researcher de Wolf (1953) indicated that “the largest midden, about 2 meters high, was half washed away by the sea at that time and may well be completely washed away by now.” The precarious position of the site was confirmed by Lee (1976), who stated that when he last inspected it, it contained barely half of a single small midden held together by the roots of a coconut tree.

Nonetheless, the location retains its importance as the type of site that Lee referred to as the Jamaican Redware culture. Vanderwal (1968) estimated that “before its destruction, the site may have covered an area of about three-quarters of an acre" (Allsworth-Jones, 2008, p. 140). In 2004, while undertaking a site visit for the Mammee Bay Archaeological Impact Assessment, the archaeology team from the JNHT found that only a part of the site on the eastern quarter strip of the beach appeared to be intact and undisturbed. Still, there was an area where waves had undercut a small bank, and numerous pieces of Amerindian pottery sherds, conch shells, and debitage protruded at the surface.

The **Ross Craig # 2** site in Portland is categorized as a submerged site and below present sea level. It was discovered in the late 1990s, and surveying was completed by archaeologist Ivor Conolley and the Archaeological Society of Jamaica to identify it positively as a pre-ceramic age site (Conolley, personal communication October 11, 2021; Keegan, 2019). Conolley suggests that while it is apparent from investigations that artefacts were washed in from offshore to the beach, there is some indication that these artefacts may have been deposited in the sea by an earthquake.

Sites in the parish of Westmoreland include **Auchendown,** which was reported as being at sea level and impacted by flooding, erosion, and wave action. At **Long Acre Point,** it was noted that storm waves were impacting the site and its artefacts. At **Fort Charles A**, a portion of a burial was reportedly revealed by wave erosion, and **Fort Charles B** was noted as being in proximity to the sea. The same is true for the **Billy Bay** site which is described as near the sea with artefacts being scattered by storm waves. The **Alligator Pond River** was highlighted as being near the sea and was being exploited for construction sand. The **Paradise Park and Sweetwater** sites were "located on a coastal dune between the Deans Valley River and Bluefields Bay" (Paradise Park 2000, n.d., p. 2). These sites were recorded as being strategically located on the only high ground, about one and two meters above sea level in the area. It was noted that changes "in exploitation patterns between the two sites suggested that these may reflect in part a change in environmental conditions, such as a rise in sea level of up to one meter between the two sites" (Allsworth-Jones, 2008, p. 54). Keegan et al. (2003) note that this may be the reason why a part of the deposit is below the water table and suggest that when the site was occupied, the sea was perhaps a meter lower than at present. If this is the case, then "all the other sites mentioned would also have been farther from the high-water mark than they are now"' (Allsworth-Jones, 2008, p. 54).

The **Prospect Point** site in St. Thomas was mapped in 1984 and noted as being in a beach area where severe corrosion by the sea had altered the surface of most exposed sherds. The **Holmes Bay** site in Clarendon was recorded as being a village site right at the sea's edge, with evidence that storm waves had disarranged practically all the material. In Clarendon at **Round Hill**, wave erosion was noted over a few years and contributed to a collapsed strip of between five and ten feet, more than half of the site, with more collapses imminent. It was felt that the terrace on which the site sat would be completely eroded in about one hundred years.

The **Mammee Bay** site in St. Ann was discovered in 1984 and subsequently mapped that year by James Lee. Objects were collected from an area exposed to rough seas. Evidence at the site suggested that storm waves had demolished the village. Also, in St. Ann, the **Fortlands** site was discovered in 1954 and described as near sea level and not more than 100 yards from the sea.

In 2022, as part of this research, the coastline between Annotto Bay in St. Mary and Falmouth in Trelawny was surveyed with a team from the JNHT, and its coastal heritage subjected to a vulnerability assessment. This survey exercise revealed that the **Annotto Bay Baptist Church** was vulnerable as it was near the sea and being impacted by coastal inundation and storm surges. The **St. Ann's Bay Fort**[102] was built in the mid-1700s using stone blocks taken from the nearby Sevilla la Nueva (New Seville) site. The sea was already encroaching on the fort in 1795, so it could no longer be used, and a new fort was constructed at a different location. During the assessment in 2022, the site was noted as being below sea level, and the site will continue to erode and be fully submerged in the years to come. The **Old Naval Hospital** and its extant structures and historic seawall in Port Royal were built around 1818. The site is presently at sea level and is often impacted by coastal inundation, erosion, and storm surges.

Table 16 identifies sites that were considered in this desk-based vulnerability assessment. Based on what is known of current and projected future impacts on coastal areas, it is evident from the selected sites that they could have already been lost or are being destroyed, and urgent actions are needed to mitigate loss, guided by appropriate data collection, surveys, and analysis.

[102] St. Ann's Bay Fort on the Jamaica National Heritage Trust Website. Accessed at http://www.jnht.com/site_st_anns_bay_fort.php

Assessments undertaken for sites at Mammee Bay and Ross Craig revealed very little remaining. It should be noted that the extent of the Mammee Bay site is unknown, which is very much the case with other sites as they have not been surveyed or monitored since their initial mapping in the 1960s to 1970s.

As mentioned, in reviewing documentation concerning these sites, references to sites *washing away, eroding due to coastal erosion, being subjected to environmental changes* are used as the primary determinant keywords in identifying early impacts from climate-induced hazards. Table 17 highlights the field component of the vulnerability assessment applied to select sites, and Figure 19 provides a visual of Jamaican sites at risk due to climate-induced hazards, such as by being too close to the coastline or having an elevation below 10m.

Table 16. Sites in Jamaica considered in Desk-based Vulnerability Assessment

Parish	Name of Site	Distance from Visible Coast	Elevation M.A.S.L or M.B.S. L
St. Ann	Little River	< 0 km	0
Portland	Ross Craig	< 0 km	0
Westmoreland	Auchendown (Westmoreland)	< 0.03 km	3
St. Elizabeth	Long Acre Point (St. Elizabeth)	< 0 km	2
	Fort Charles A (St. Elizabeth)	< 0 km	8
	Billy Bay (St. Elizabeth)	< 0.03 km	8
	Alligator Pond River (St. Elizabeth)	< 0.06 km	3
St. Ann	Fortlands (St. Ann)	< 0.01 km	3
St. Thomas	Prospect Point (St. Thomas)	< 0 km	2

Parish	Name of Site	Distance from Visible Coast	Elevation M.A.S.L or M.B.S. L
Clarendon	Holmes Bay site (Clarendon)	< 0.03 km	2
	Round Hill (Clarendon)	< 0 km	15
Westmoreland	Paradise Park and Sweetwater sites (Westmoreland)	< 0.25 km	2
St. Ann	Mammee Bay (St. Ann)	< 0 km	1
Kingston	Old Naval Hospital	< 0.1 km	0
St. Mary	Historic St. Mary's Parish Church	< 0.5 km	5
	Historic 1824 Annotto Bay Baptist Church	< 0.5 km	2
St. Ann	1750 St. Anns Bay Fort	< 0.5 km	5 (BSL)
	Victoria and Albert Battery, Port Royal	< 0.2 km	0
Kingston	Old Naval Dockyard	< 0.5 km	0
	Fort Rocky	< 0.5 km	0
St. Mary	Old Court House (Port Maria Civic Centre)	< 0.5 km	-

Source: Research data compiled by Author

Table 17. Field Vulnerability Assessment of Select Sites in Jamaica

Climate Hazard Phenomena	Heritage Value	Impact	Sensitivity	Exposure	Adaptive Capacity				Measure of Vulnerability
					LCD	LCED	CA	MR	MV = (E + S) - AC
					1 - 4				
SEA LEVEL RISE	Old Naval Hospital (Port Royal): extant structures, historic seawall, and cultural materials	Storm surge; Coastal inundation	2	3	1	1	2	2	4 *(3.5)*
	Coastal road from Annotto Bay to Falmouth: several extant smaller historic structures; archaeological sites	Storm surges; Coastal inundation	3	4	3	3	1	1	4 *(5)*

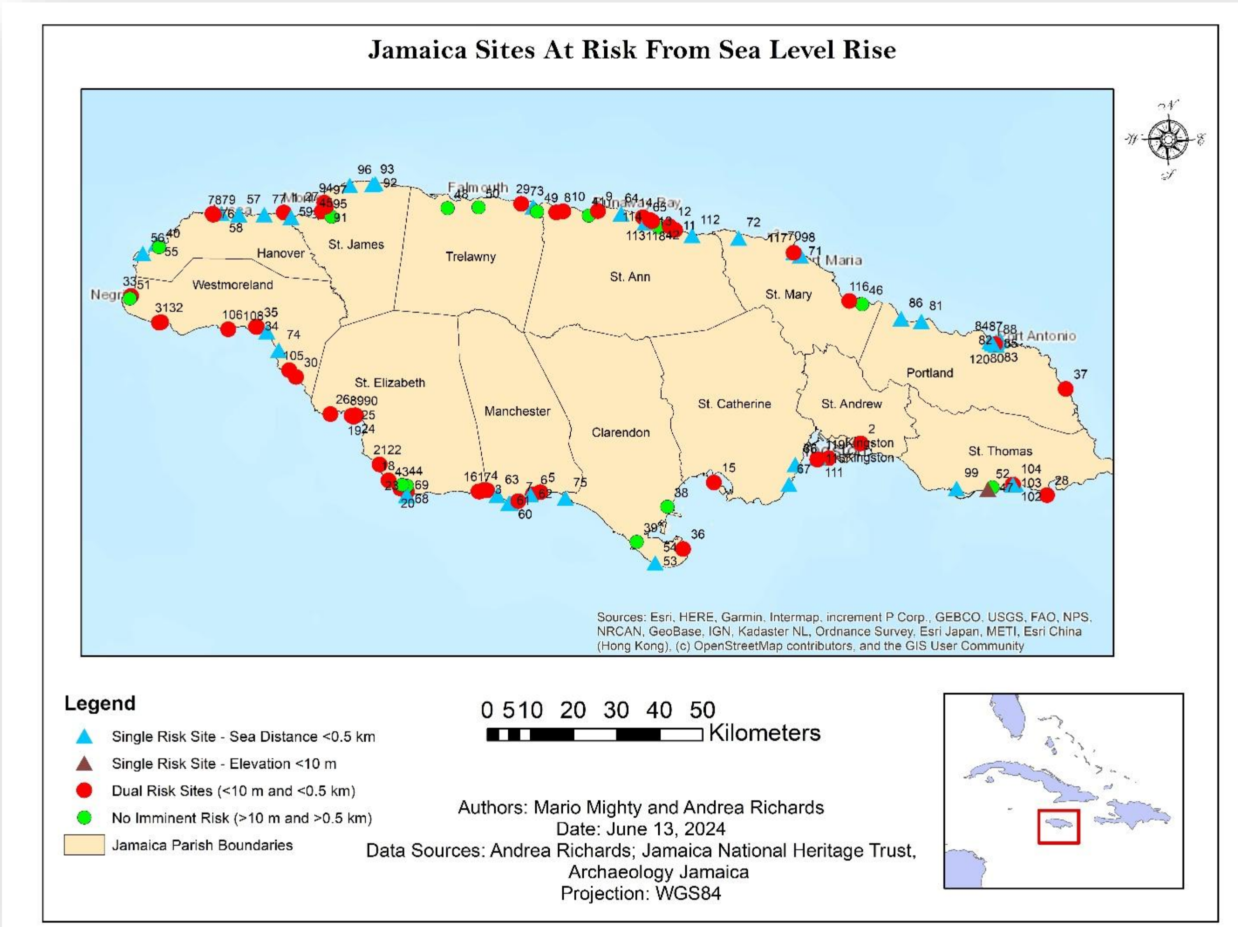
Source: Research data compiled by Author from Field Vulnerability Assessments undertaken with the Jamaica National Heritage Trust Archaeology Division, Summer 2022. Key: 1 – Low; 2 – Moderate; 3 – High; 4+ – Extremely high.
Note: Adaptive Capacity = Average of LCD, LCED, CA, and MR. LCD – Level of Coastal Development, LCED – Level of Coastal Ecosystem Degradation, CA – Climate Action, MR – Management Response.

Table 17 (continued). Field Vulnerability Assessment of Select Sites in Jamaica

Climate Hazard Phenomena	Heritage Value	Impact	Sensitivity	Exposure	Adaptive Capacity				Measure of Vulnerability
					LCD	LCED	CA	MR	
			1 - 4						
SEA LEVEL RISE	Ross Craig	Coastal Erosion	3	3	1	1	1	1	4 *(5)*
	1750 St. Ann's Bay Fort	Coastal erosion, Storm surge, Coastal Inundation	3	3	1	1	1	1	4 *(5)*

Key: 1 – Low; 2 – Moderate; 3 – High; 4+ – Extremely high.
Note: Adaptive Capacity = Average of LCD, LCED, CA, and MR. LCD – Level of Coastal Development, LCED – Level of Coastal Ecosystem Degradation, CA – Climate Action, MR – Management Response.

Figure 19. Select Sites at Risk due to Climate-induced Hazards



Source: Author compiled from various sources highlighted throughout research

Summary of Assessment and Results

Field observations in 2022 revealed that the part of the coastline (eastern to northern) assessed was extremely vulnerable to sea-level rise and associated coastal erosion, inundation, and storm surges. The **Annotto Bay Baptist Church** was located in proximity to the sea and was previously impacted by coastal inundation and storm surges. For the **St. Ann's Bay Fort** portions of the site are now below sea level, and the site will continue to erode and be completely submerged in the years to come.

This research acknowledges that although assessments are key for developing appropriate responses, there are difficulties in determining the extent of damage and loss that could occur due partly to uncertainty about future severe weather events. As such, assessing the vulnerability of sites is key to developing appropriate climate action to begin to address the impacts of future impacts.

The legislative and policy landscape for the protection of heritage in Jamaica, like much of the study area, has also remained largely unchanged and primarily centres on the JNHT Act (1985, and currently slated for an update) However threats to heritage are constantly evolving. Since the significant mapping of pre-Columbian sites by James Lee and the Archaeological Society of Jamaica in the 1960s to 1980s, there has been very limited to no extensive surveying and mapping of sites, except in instances related to large-scale infrastructural projects such as for highway development. Few sites have been fully researched, and there has been no systemic or periodic monitoring programme targeting these sites by the JNHT or any other partner, such as the Archaeological Society of Jamaica (ASJ). Limited or no monitoring results in many impacts going unchecked, unreported, and unaddressed, resulting in the continued loss of sites, both documented and undocumented. As a result, no actions are developed that focus on evidence-based monitoring, nor have baselines for sites been established.

The research does not provide evidence of archaic peoples in Jamaica, and it is largely felt that if an archaic culture inhabiting Jamaica at some point existed, its sites would be located on the coasts but would likely have been submerged due to past sea level fluctuations. Redware sites were also primarily located along the coast. By working to identify and map these sites, we are providing the space and opportunity to learn more about these earlier cultures.

Safeguarding Jamaican coastal heritage requires a multidisciplinary and collaborative approach and cannot solely focus on the work being done by heritage institutions. In order to prioritise actions, Jamaica's first step should be to undertake a comprehensive climate change vulnerability assessment or a multi-hazard assessment and (re) mapping of pre-Columbian, colonial, and postcolonial sites within or without a wider strategy for addressing impacts on heritage. For threatened coastal heritage, it means awareness, observation and monitoring, data collection, studies, prioritisation, and the development of key actions.

In terms of data collection, the work done by James Lee and the Archaeological Society of Jamaica remains the most comprehensive documentation and mapping of sites, providing data on their location, elevation, distance from the sea, and a basic description of the site's environment. This data can be used as a basis to expand survey data to include mapping undertaken by the JNHT and, through predictive modelling, undertake a programme to identify previously unknown sites. This action can then serve as the basis for an expanded coastal heritage survey undertaken by the JNHT in collaboration with other partners such as the Universities of the West Indies and Technology and the Archaeological Society of Jamaica. This data can also guide persons doing future work at sites as they would have been exposed to the site's vulnerabilities, as well as establishing monitoring schedules for responses by communities and other heritage actors. This context is also an opportunity for the ASJ to scale up an activity it was once heavily invested in.

Following this survey exercise and with inventories in place, heritage managers in Jamaica can utilise various tools to undertake simulation exercises in relation to current and future risks. The use of satellite imagery is useful for highlighting coastal changes. Geographic information systems (GIS) can also be used to undertake predictive modelling exercises that can expose future risks and vulnerabilities and develop interactive tools such as Heritage at Risk Maps for use not just by the heritage community but also by those involved in coastal and or urban planning and or management. For example, the maps developed can be combined with the beach monitoring work being undertaken by the National Environment and Planning Agency (NEPA) or other monitoring work by, for example, the University of the West Indies. The improved organization and use of data will also create good entry points for the involvement of other actors, such as local communities, and in developing climate change narratives to build awareness and support engagement.

In Jamaica, the Department of Geology of the University of the West Indies, Mona Campus, and societies such as the Geological Society of Jamaica have already generated valuable coastal studies and SLR data, which can be of use in examining the risk to the coastal archaeological record and could be pursued through collaborative work. This process actualises a truly multidisciplinary approach to examining the vulnerability of this coastal archaeological record. Already, the ASJ is comprised of individuals representing many scientific disciplines, not just archaeology, and so this platform presents an excellent gateway for pursuing this. These suggestions also apply across all islands in the study area.

Saint Lucia

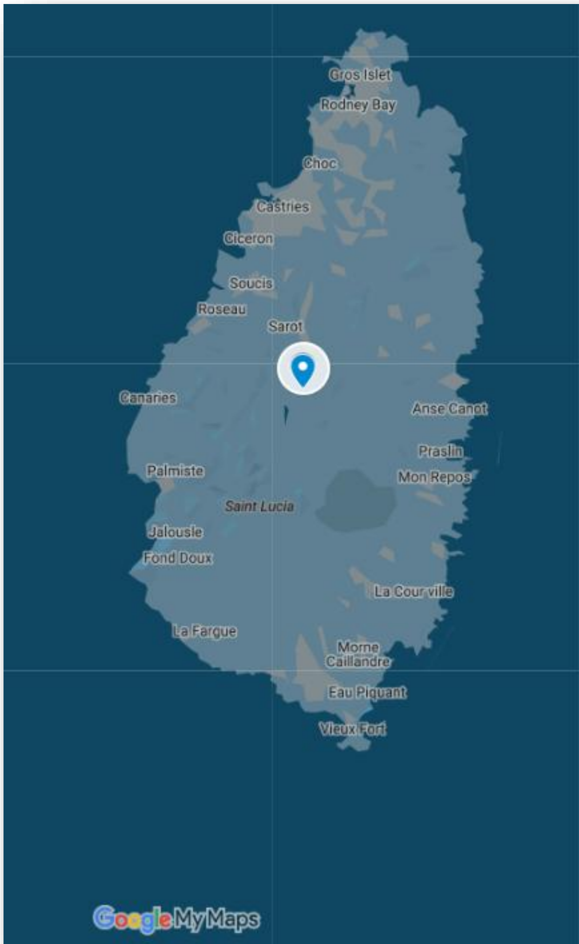
Introduction

The island of Saint Lucia is approximately 616 km^2 and is located within the eastern Caribbean, specifically the Lesser Antillean archipelago (Figure 20). It sits on top of an old volcanic ridge that links Saint Vincent and the Grenadines to the south, with Martinique in the north. The island has a relatively narrow coastal shelf area of 522 km^2 and a steep drop-off along the west coast. The long and sweeping coastline spans around 158 km (Saint Lucia Third National Communication, 2017[103]). The terrain of Saint Lucia is made up of deep valleys, rivers, and mountains along a centrally situated north-south mountain line (Branford, 2011; Government of Saint Lucia, 2018; UNDRR, 2022).

The island's geographic location in the tropical cyclone belt means that the annual passage of these storms impacts it, resulting in an environment where heritage, both tangible and intangible, cultural landscapes and natural heritage are vulnerable. The natural hazards are many, ranging from volcanic activity, hurricanes, floods, drought, tsunami, and seismic activity to anthropogenic hazards such as fires.

[103] Saint Lucia's Third National Communication (NC 3) to the UNFCCC (2017). Accessed at: https://unfccc.int/documents/81558

Figure 20. Map of the Island of Saint Lucia in the Eastern Caribbean



Source: Author generated from Googlemaps.com

Climate Trends and Modelling Projections

According to the CARIBSAVE Climate Change Risk Atlas (CCCRA) for Saint Lucia, the island is "already experiencing some of the effects of climate variability and change through damages from severe weather systems and other extreme events, as well as more subtle changes in temperatures and rainfall patterns" (CCCCC, 2012). Projections for Saint Lucia suggest increases in atmospheric and sea surface temperatures and a reduction in annual rainfall. Similar to other islands in the study area, an increase in tropical cyclone intensity is also foreseen (CCCCC, 2012; see also UNDRR, 2022). Projections based on Regional Climate Models (RCMs) suggest that temperatures will increase with a range of 2.4˚C to 3.3˚C by the 2080s in higher emissions scenarios. General Circulation Models (GCMs) project an overall decrease in annual rainfall of -37 mm to +7 mm by 2080, with RCMs indicating decreases between -11% and 32%. Annual SST will see increases of +0.8 to 3˚C by 2080s.[104]

According to data in its National Communications 3 (NC3, 2017), SLR projections include up to 0.38m and kilometre squared land inundation up to 0.065 (2040 – 2069), and SLR up to 0.82m and inundation up to 0.313 (2081 – 2100). Simulations based on this rate of SLR with storm surges related to tropical cyclones suggest a storm surge of 2m and inundation of 2.2km sq. of land related to a Category 2 hurricane and a storm surge of 5.4m and inundation of 17.2km sq. of land related to a Category 5 hurricane up to the year 2100 (NC 3, 2017).

NC 3 (2017) goes on to identify the areas of Micoud and Dennery on the east coast and Gros Islet, Castries and Anse de la Raye on the west coast as being particularly susceptible to SLR. Saint Lucia's CCCRA (2012) identifies Pigeon Island and its causeway, Rodney Bay and Soufrière as areas also vulnerable to SLR. These areas contain infrastructure related to tourism and international transport. All lie within less than six metres above sea level. One metre of sea-level rise will place seven percent of tourism infrastructure, fifty percent of airports, and one hundred percent of ports at risk.[105] Figure 21 illustrates coastal areas projected to be submerged under one meter in sea-level rise by the year 2100.

Also similar to many of the islands of the Caribbean, a significant portion of the coastal zone is used for tourism, and "these areas already face pressure from strong natural forces such as wind, waves, tides, currents, and human activities through beach sand removal and inappropriate construction of shoreline structures" (CCCCC, 2012).

[104] Government of St Lucia. 2018. St. Lucia's National Adaptation Plan 2018-2028.
[105] Caribbean Climate Change Risk Atlas (CCCRA) CARIBSAVE St. Lucia Country Profile (2012)

Figure 21. Coastal areas in Saint Lucia Projected to be Submerged under 1m Sea-level Rise

Source: Climate Central's Surging Seas Global Risk Zone Map http://sealevel.climatecentral.org/)

Overview of Impacts of Climate-Induced Hazards on Saint Lucia's Archaeological Heritage

Saint Lucia has benefited from a significant amount of work in the documentation of its archaeological heritage through the organisational efforts of the Saint Lucia Historical and Archaeological Society (SLAHS) and the Saint Lucia National Trust (SLNT). Efforts by individuals such as Roger Stanley (petroglyphs) and Robert Devaux's extensive survey (1975) of historic sites on behalf of the SLNT have also extended the documentation of sites, in addition to investigations by Ripley and Adelaide Bullen, and the Florida Museum of Natural History, the University of Florida, Leiden University, Yale University, and Harvard University. Cultural resource management work in response to tourism development by non-Saint Lucian archaeologists and researchers have also been conducted (Branford, 2011).

Branford (2011) writes that the SLAHS located over 250 sites in coastal areas. Despite the threat posed by climatic challenges, few efforts have been implemented to address this threat, and there is no widespread monitoring of sites. In fact, although investigations by Leiden University produced extensive coastal surveys, these were not used to develop meaningful actions geared towards safeguarding Saint Lucian archaeological heritage, particularly within the context of ongoing and accelerated climate change.

Bright's inventory (2011) mentions the proximity of some sites to the coast and coastal erosion events. These sites include **Anse Capitaine, the Balembouche Petroglyphs, Banana Field, Black Bay, Lavoutte, Micoud Beach**, and **Sorciere Beach**. This inventory can be useful in identifying sites to monitor in the present and the future.

In the case of the **Pigeon Island National Park** this is an inland reserve situated on the northwest coast of Saint Lucia that was joined to the mainland by a human-made causeway in the 1970s. Since the construction of the causeway, the shore along Pigeon Island has experienced high erosion rates along the southern coast. Investments in coastal stabilisation, beach nourishment, restoration of structures, infrastructural development and upgrade, and general maintenance of the buildings and landscape have been made over the years to prevent and reduce erosion taking place. The island has been noted as having a high rate of erosion since the 1970s, having suffered from hurricane damage, with the shoreline retreating around the historic cemetery and the **Carib**

Caves. Other infrastructure, such as the groynes and jetty, were also damaged. These actions called into focus the urgent need for shoreline stabilisation and protection.

Data Collection and Vulnerability Assessment of Saint Lucian Archaeological Sites

A desk-based review of existing site inventories was undertaken, to include inventories detailed in Bright (2011), Field Reports of Leiden University (2002 – 2004), Deveaux's (1975), and Stanley's (2014) survey of historic sites and petroglyphs. These documents were augmented by a review of other archaeological reports and a brief field assessment to identify sites, undertake observations for the vulnerability assessment (see Table 18) and obtain GPS readings for sites which were not included in this document.

Table 18. Saint Lucia Field Vulnerability Assessment Sites

Parish	Name of Site	Distance from Visible Coastline	Elevation (M.A.S.L or M.B.S. L
Gros Islet	Comerette Point (SLU-42)	< 0.5 km	6
	Anse Lavoutte (SLU-91)	< 0.5 km	0
	The Ramp/Old Airstrip	< 0.5 km	2
	Pigeon Island National Park Burial Ground	< 0.5 km	4.8
Soufriere	Jalouise Petroglyphs (SLU-75)	< 0.5 km	0
	Hess	< 0.5 km	-
Castries	Fort Charlotte	< 0.5 km	251
Dauphin	Mill Dauphin Beach	< 0.5 km	17
	Dauphin Petroglyph (SLU-45)	< 0.5 km	4

Table 18 (continued). Saint Lucia Field Vulnerability Assessment Sites

Parish	Name of Site	Distance from Visible Coast	Elevation (M.A.S.L or M.B.S. L
Grand Anse	Grand Anse (SLU-70)	< 0.5 km	0
	Grand Anse Historical Structure	< 0.5 km	-
Dauphin	Sugar Mill at Dauphin	< 0.5 km	25
Micoud Highway, Vieux Fort	Vieux Fort Mill Tower	< 0.5 km	10
Laborie	Laborie Mill Remnants	< 0.5 km	21
Choiseul	River Doree Enslaved Burial Ground	< 0.5 km	1
	Copper Boiler at River Doree	< 0.5 km	24
	River Doree Aqueduct	< 0.5 km	25
	Anse Capitaine (SLU-04)	< 0.5 km	0
	Vierge Point # 1, 2, 3 (SLU-145, 146, 147)	< 0.5 km	0
Micoud	St Lucy's National Shrine	< 0.5 km	7
	Micoud Beach (SLU-97)	< 0.5 km	0
	Troumassie Estate House # 1	< 0.5 km	17
	Troumassie Estate House # 2	< 0.5 km	17
Micoud Highway	Troumassie Mill	< 0.5 km	13
Dennery	Dennery Bay Site (SLU-47)	< 0.5 km	6
Castries	Married Women's Quarters	< 0.5 km	25
	World War II Gun Mount	< 0.5 km	0

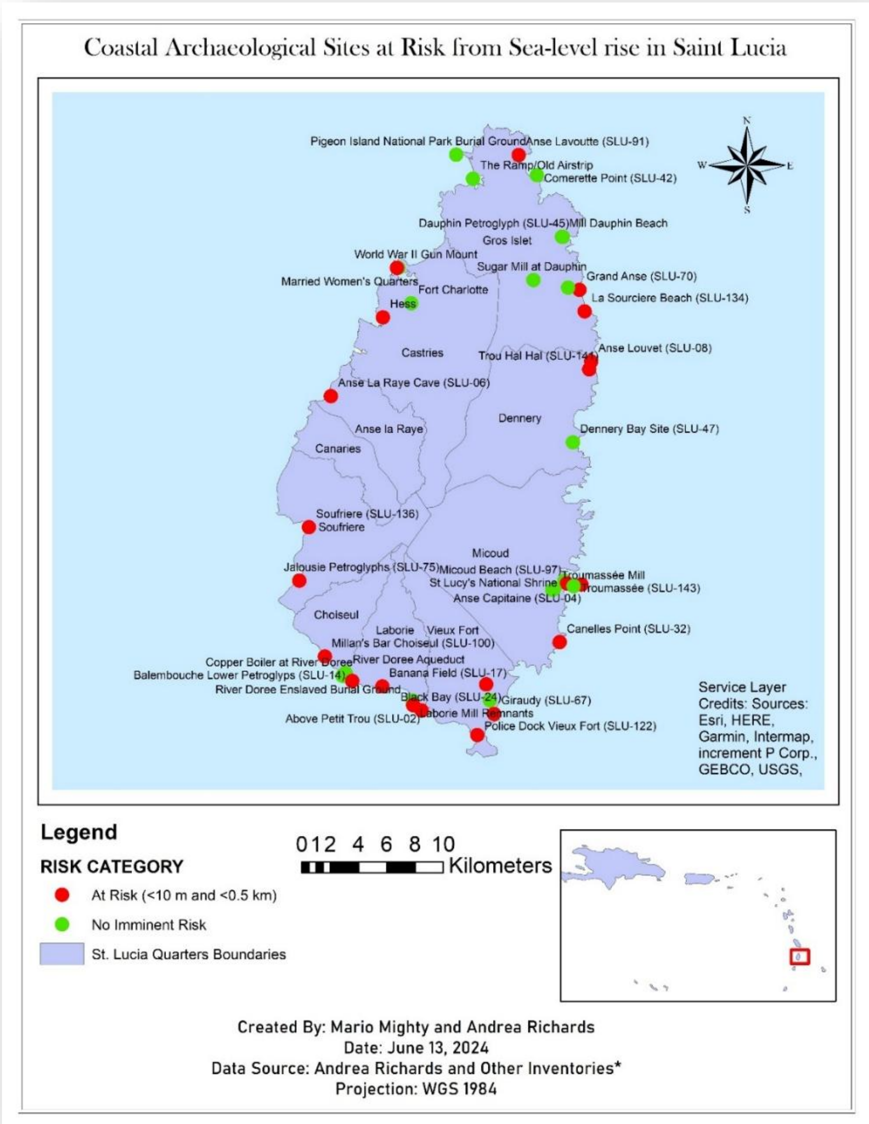
The sites of **Pigeon Island National Landmark**, **Dauphin Petroglyphs**, and **Sugar Beach Petroglyphs** were selected for the specific vulnerability assessment in consultation with national partners. The vulnerability assessment of select sites is presented in Table 19, and mapped sites at risk from climate-induced hazards due to being in close proximity (less than 0.5 km) to the coastline or having elevation below 10m are presented in Figure 22.

Table 19. Vulnerability Assessment of Selected Sites in Saint Lucia

Climate Hazard Phenomena	Heritage Value	Impact	Sensitivity	Exposure	Adaptive Capacity				Measure of Vulnerability
					LCD	LCED	CA	MR	MV = (E + S) - AC
					1 - 4				
SEA LEVEL RISE	Dauphin Petroglyphs	Storm surge; Coastal inundation	2	4	2	1	1	1	4 *(4.75)*
	Pigeon Island National Park	Storm surge; Coastal inundation; Coastal Erosion	3	3	1	2	2	2	4 *(4.25)*
	Sugar Beach Petroglyphs	Coastal Erosion	3	3	1	2	1	1	4 *(4.75)*

Note: Adaptive Capacity = Average of LCD, LCED, CA, and MR where LCD – Level of Coastal Development, LCED – Level of Coastal Ecosystem Degradation, CA – Climate Action and MR – Management Response. Key: 1 – Low; 2 – Moderate; 3 – High; 4+ – Extremely high

Figure 22. Saint Lucia Archaeological Sites at Risk Due to Climate-Induced Hazards



Source: Author compiled from various sources highlighted throughout research

Saint Lucia Vulnerability Assessment and Results

Saint Lucia's latest National Communication (NC 3, 2017) outlines an extensive programme of data gathering and simulating hazard scenarios in its coastal zone. It has also implemented more than twenty projects and programmes that target adaptation to the changing climate (2017, p. iii), particularly in relation to SLR and storm surges based on various tropical cyclone strengths. Through its Fisheries Department, a beach monitoring programme that includes beach changes and coastal erosion has been implemented since 1995.

However, specific observations of the coastal archaeological record revealed that sites remain extremely vulnerable, and limited actions have been taken to safeguard them. Some sites have already experienced erosion into the sea.

As presented for Antigua, Barbados and Jamaica, many of the recommendations made also apply to Saint Lucia. Safeguarding Saint Lucia's coastal heritage requires a multidisciplinary and collaborate approach which does not only focus on the work of heritage institutions but also incorporates work by non-heritage partners and research institutions – *such as the beach monitoring programme by the Fisheries Department* - and assessing the vulnerability of sites is key to developing appropriate actions. Critical actions are also needed concerning surveying and mapping of sites, ongoing monitoring and data collection, development of inventories and interactive tools such as Heritage at Risk Maps.

Summary

Data provided by assessments of archaeological sites can greatly assist in the development of valuable climate action that involves the mitigation of climate-induced hazards and disaster impacts. This data can also support and guide the development of adaptation strategies for the future, such as those related to constructing in coastal areas, protecting retreating coastlines, relocation of communities, protection of critical infrastructure, or the elevation of structures as needed, as well as the application of other innovative solutions coming from the past, as these actions continue to influence adaptation strategies today.

Vulnerability assessments utilize varying data sources and paint a picture of the extent of risks facing the coastal archaeological record. They, therefore, can support the culture sector in developing needed strategies to address threats presented by climate-induced hazards. Daly

(2014, p. 110) points out that “vulnerability assessments are vital, as in the absence of the voice of cultural heritage, coastal defences and other hard engineering solutions have the potential to harm the archaeological record” (also see Edwards & O’Sullivan, 2007), and it is important to have sufficient dialogue and inter-disciplinary actions to ensure that human interference in the coastline is not catastrophic.

Archaeological site monitoring based on vulnerability assessments is, therefore, a critical tool for engaging the public and stimulating important climate action (Cochran et al., 2023; Miller et al., 2024). Monitoring data informs policy, such as coastal resilience plans, and monitoring also becomes the method of data collection once policy is enacted.