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The Potential Effects of Climate Change on Jamaica's Pre-Columbian Archaeological Record: Monitor, Assess, Mitigate and Adapt

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The Caribbean region as a whole is impacted by numerous natural phenomena, some of which are exacerbated by climate change and varying anthropogenic causes. These anthropogenic causes in turn exacerbate the effects of climate change. Coastal areas in particular, have been referenced as being at the forefront of these effects, resulting in increased threats to these areas and the archaeological record located there, calling on us to broaden our understanding of these new vulnerabilities. Throughout the region, there are documented cases of the effects of climate change on coastal archaeological sites, evidenced by destruction from continued sea level rise (SLR), wave action, coastal erosion, storm surges and increased incidences of coastal inundation. Jamaica's varied geo-physical characteristics have contributed to varying levels of coastal susceptibility, evidenced through localized erosion, coastal inundation and flooding from storms (IADB 2018). This paper explores the challenges associated with safeguarding Jamaica's coastal pre-Columbian heritage amidst the changing climate, and within the context of this heritage already being severely affected by other well documented impacts such as infrastructural development and mining. In assessing these challenges, this research focuses on addressing the following questions: 1) How vulnerable is Jamaica's pre-Columbian archaeological record, 2) What actions can be taken to mitigate these impacts, and 3) What are the strategies which need to be considered and implemented to address the protection of these sites amidst the changing climate. I will undertake an analysis through the utilization and review of documented site inventories and historical and contemporary observations of environmental changes and impacts at these sites, where they exist. In addition, it utilizes some field assessments of selected pre-Columbian sites exposed to these impacts – where possible, supported by the use of various tools to arrive at data driven conclusions regarding impacts, and the potential effects of future climate change at these sites. The research concludes with specific recommendations for mitigation, adaptation planning and management responses in relation to assuring the safeguarding and resilience of these sites where possible.

La région des Caraïbes dans son ensemble est impactée par de nombreux phénomènes naturels, dont certains sont exacerbés par le changement climatique et diverses causes anthropiques. Ces causes anthropiques exacerbent à leur tour les effets du changement climatique. Les zones côtières en particulier ont été référencées comme étant à l'avant-garde de ces effets, ce qui entraîne une augmentation des menaces pour ces zones et les archives archéologiques qui s'y trouvent, nous invitant à élargir notre compréhension de ces nouvelles vulnérabilités. Dans toute la région, il existe des cas documentés d'effets du changement climatique sur les sites archéologiques côtiers, mis en évidence par la destruction due à l'élévation continue du niveau de la mer (SLR), l'action des vagues, l'érosion côtière, les ondes de tempête et l'incidence accrue des inondations côtières. Les caractéristiques géophysiques variées de la Jamaïque ont contribué à divers niveaux de sensibilité côtière, mis en évidence par l'érosion localisée, les inondations côtières et les inondations causées par les tempêtes (IADB 2018). Cet article explore les défis associés à la sauvegarde du patrimoine précolombien côtier de la Jamaïque au milieu du changement climatique, et dans le contexte de ce patrimoine déjà gravement affecté par d'autres impacts bien documentés tels que le développement des infrastructures et l'exploitation minière. En évaluant ces défis, cette recherche se concentre sur les questions suivantes : 1) Quelle est la vulnérabilité des archives archéologiques précolombiennes de la Jamaïque, 2) Quelles mesures peuvent être prises pour atténuer ces impacts, et 3) Quelles sont les stratégies qui doivent être envisagées et mis en œuvre pour assurer la protection de ces sites face au changement climatique. J'entreprendrai une analyse à travers l'utilisation et l'examen des inventaires de sites documentés et des observations historiques et contemporaines des changements environnementaux et des impacts sur ces sites, là où ils existent. En outre, il utilise certaines évaluations sur le terrain de sites précolombiens sélectionnés exposés à ces impacts - lorsque cela est possible, soutenus par l'utilisation de divers outils pour arriver à des conclusions fondées sur des données concernant les impacts et les effets potentiels du futur changement climatique sur ces sites. La recherche se termine par des recommandations spécifiques pour l'atténuation, la planification de l'adaptation et les réponses de gestion en vue d'assurer la sauvegarde et la résilience de ces sites lorsque cela est possible.

La región del Caribe en su conjunto se ve afectada por numerosos fenómenos naturales, algunos de los cuales se ven exacerbados por el cambio climático y diversas causas antropogénicas. Estas causas antropogénicas, a su vez, exacerban los efectos del cambio climático. Se ha mencionado que las áreas costeras en particular están a la vanguardia de estos efectos, lo que resulta en mayores amenazas para estas áreas y el registro arqueológico ubicado allí, lo que nos pide que amplíemos nuestra comprensión de estas nuevas vulnerabilidades. En toda la región, hay casos documentados de los efectos del cambio climático en los sitios arqueológicos costeros, evidenciados por la destrucción por el aumento continuo del nivel del mar (SLR), la acción de las olas, la erosión costera, las marejadas ciclónicas y el aumento de la incidencia de inundaciones costeras. Las variadas características geofísicas de Jamaica han contribuido a diversos niveles de susceptibilidad costera, evidenciados a través de la erosión localizada, inundaciones costeras e inundaciones por tormentas (IADB 2018). Este documento explora los desafíos asociados con la salvaguardia del patrimonio precolombino costero de Jamaica en medio del clima cambiante, y dentro del contexto de este patrimonio que ya se ve gravemente afectado por otros impactos bien documentados, como el desarrollo de infraestructura y la minería. Al evaluar estos desafíos, esta investigación se enfoca en abordar las siguientes preguntas: 1) ¿Qué tan vulnerable es el registro arqueológico precolombino de Jamaica? 2) ¿Qué acciones se pueden tomar para mitigar estos impactos? y 3) ¿Cuáles son las estrategias que se deben considerar y implementadas para abordar la protección de estos sitios en medio del clima cambiante? Emprenderé un análisis a través de la utilización y revisión de inventarios de sitios documentados y observaciones históricas y contemporáneas de cambios e impactos ambientales en estos sitios, donde existan. Además, utiliza algunas evaluaciones de campo de sitios precolombinos seleccionados expuestos a estos impactos, cuando es posible, con el apoyo del uso de varias herramientas para llegar a conclusiones basadas en datos sobre los impactos y los efectos potenciales del cambio climático futuro en estos sitios. La investigación concluye con recomendaciones específicas para la mitigación, la planificación de la adaptación y las respuestas de gestión en relación con garantizar la protección y la resiliencia de estos sitios cuando sea posible.

Introduction

The Caribbean's changing climate has varying implications for heritage in the region. Rising temperatures have contributed to an increase in sea level, coupled with an increase in tropical cyclone intensity and frequency and other erratic or severe weather changes, an increase in storm surges and increasing coastal erosion. This has resulted in a perilous context for our archaeological heritage, and specifically those in our coastal areas (Fitzpatrick 2012). The Caribbean's coastal zones are not only home to a significant number of persons and infrastructure, but also large numbers of archaeological sites. Islands – particularly low-lying limestone ones - have already experienced significant coastal erosion in recent decades (Crock 2019), and this is noted as probably the most salient threat to the many Indigenous archaeological sites located on or near the coastline, where many have already disappeared, are damaged or undocumented (Hofman and Hoogland 2016). A study of coastal change in the Lesser Antilles from 1985 to 1995 revealed that active erosion of coastal sites was taking place, in some places at a rate of 0.3 meters (m) per year (Cambers 2009), which clearly presents a significant issue for the safeguarding of coastal archaeological sites.

In past decades, Caribbean archaeologists – similar to archaeologists in the global community - contended with threats to heritage resources from development and looting of sites as two of the most pressing concerns (Siegel et al. 2013). The twenty-first century has however witnessed the strong emergence and greater awareness of a not so new phenomenon known as climate change, which has contributed to an increase in sea levels, receding coastlines and the loss of the archaeological record.

This increased awareness is debated within the context of and linked to a period referred to as the Anthropocene, where the influence of humans is seen as a significant cause for the rapidly changing climate. In many instances, sites have been destroyed as a result of coastal erosion and inundation or wave action but would have previously been placed in that perilous situation as a result of human related actions such as coastal development, sand mining or the destruction of natural coastal ecosystems, which only served to exacerbate impacts (Fitzpatrick 2012). In recent decades however, climate change has been documented extensively in the field of cultural heritage (ICOMOS 2019), both for how it stands to be impacted, as well as how it contributes to mitigation and adaptation and as a pathway to engendering social change.

An increased awareness of the extent of this loss due to climate change influences has not gone unnoticed in the Caribbean and has become more evident with each passing field research season. Significant documentation of these effects has been undertaken at sites throughout the region such as Anse Trabaud, Morel and Anse à la Gourde (Guadeloupe), Sauteurs (Grenada), Grand Bay (Carriacou), Lavoutte (Saint Lucia), Winthrope (Antigua) etc., with some mitigation measures put in place in some instances and where possible (Fitzpatrick et al. 2006; Fitzpatrick 2012; A. Reginald Murphy, personal communication 2021; Hofman et al. 2021). This research has provided valuable data on coastal erosion and the extent of impacts to sites. Mapping exercises undertaken by Fitzpatrick et al. (2006) at the Grand Bay site in Carriacou (Grenada) revealed that archaeological sites on the island were eroding at an average rate of around 1 m per year. Similar mapping exercises highlighted that this phenomenon was common throughout the region (Hofman and Hoogland 2015; Rivera-Collazo 2020; Hofman et al. 2021).

What is needed now is the investment of significant efforts in larger mitigation and adaptation efforts beyond the documentation of these impacts. Exercises such as these are also useful in making projections regarding when these sites are likely to be lost, critical for developing adequate responses and actions (Stancioff et al. 2018). Crock (2019) noted that marine transgression and coastal erosion were among the greatest threats to low-lying limestone islands and that the slightest increase in sea level could erode or drown low-elevation coastal sites, and so the continued impact of storm surges and sea level rise, makes the topic of climate change a very intimate one for Caribbean small islanders. This is also within the context of the region having a significant number of historic coastal towns.

Methodology

This research comprises a significant component of my doctoral research which examines climate change impacts on the archaeological heritage of the Anglophone Caribbean, through select country case studies. This paper however focuses solely on Jamaica's pre-Columbian archaeological record. This focus is not due to a specific fascination with Jamaica's prehistory, but because there is so much more to be researched and understood from the cultures that inhabited Jamaica prior to the arrival of European colonizers. Their record - more than others – is highly vulnerable and in danger of being erased, while so much remains unknown and undocumented, with very few actions being taken to address this. Throughout this paper, archaeological, historical, heritage data, and climate change and paleo-environmental studies are combined to achieve a holistic understanding of the impact of climate stressors on Jamaica's pre-Columbian record. This is then utilized as the primary source of data for the development of recommendations and strategies for addressing the impact of climatic hazards on coastal pre-Columbian archaeological sites in Jamaica.

A supplemental desk review of past documented climatic and environmental impacts on pre-Columbian sites will provide a broader picture of environmental change through time and will serve to identify further and future risk. This review will utilize information from the Archaeology Jamaica publications (1965 onwards), the Jamaica National Heritage Trust (JNHT) files, and various research site reports and publications where available. The desk review will be supported by a limited field assessment of specific sites which have been selected due to their proximity to the coastline and representing the variety in Jamaica's geo-physical characteristics. This assessment is limited due to many of these sites being destroyed already, inaccessible or simply because it was not possible to locate previously mapped sites. Where simulations are done or maps generated, these are linked to previously undertaken mapping exercises, which are in most cases almost 50 years old.

This data will be augmented by the use of available satellite imagery or maps looking at coastal changes in these selected locations and the use of geographic information system (GIS) tools to further assess risk and vulnerability. All data will be considered within the context of future climate predictions. Sites were selected based on availability of research data, their coastal location and providing a good selection of the north, south, east and west of the island of Jamaica. Where graphics are presented, they are not meant to represent the sum total of all sites that might be at risk, but more as a visual for reflection on the need for appropriate management responses. A simple

vulnerability methodology was applied to sites examined, focusing on exposure, proximity to the coastline, elevation and observations based on the level of deterioration of the natural landscape or environment. This assessment leads to recommendations for strategies which could be put in place to address present and future climate impacts through mitigation, response, adaptation and management. It is also hoped that these actions will guide the development of citizen science initiatives (CSI) – such as being implemented in Barbuda, Guadeloupe and Puerto Rico (See Boger et al. 2016, ALOA and DUNAS Projects) which benefit from the multi- and interdisciplinary involvement and intervention of varying stakeholders.

The Caribbean and Climate Change

Although recent climatic changes may seem to be newly unfolding or unprecedented phenomena; archaeology and paleo-ecological studies have directed us to a past of similar incidents of climate change, and the region is noted as being exposed to challenges with water and climatic fluctuations since its earliest known occupation 7500 years ago (Hofman and Antczak 2019). Cooper and Peros (2010) also highlighted that pre-Columbian populations in the Caribbean lived through a 6 m rise in relative sea levels, marked variation in annual rainfall and periodic intensification of hurricane activity.

The end of the Pleistocene geological epoch, beginning of the Holocene is recorded as a period of significant climatic instability marked by global warming, melting of ice sheets, and a rise in sea-level due to meltwater return to oceans (Rivera-Collazo 2019). Prior to this, during the glaciation period, sea levels decreased by ca. 120 m. The Holocene was noted for its hot and wet climate extremes, significant sea level fluctuations and coastal geomorphological changes. In their Caribbean research in 2011, Malaizé et al. noted important climatic changes such as a period of drought with hurricanes characterizing the entire Archaic Age (8000 – 500 BC) from 4300 BC on, followed by a dry spell and a decrease in the number of hurricanes during the Ceramic Age (800 – 200 BC). They also identified two dry periods 3700-2500 BP and 1150- 400 BP, and a major drought – known as the Maya drought – was identified as the most severe drought of the past 7000 years in the Yucatan Peninsula and was recorded between AD 700 and 900 (Gill et al. 2007). This provides evidence of a region that is in no way unfamiliar with severe climate fluctuations and extremes (Cooper and Peros 2010). The Holocene is however noted in the research community as a period of notable climatic fluctuations and is often used as a reference point in discussions and research on climate change.

To highlight the vulnerability of the region's coastal areas, an analysis of the vulnerability of CARICOM nations to sea level rise (SLR) and associated storm surge by the CARIBSAVE Partnership (2010) found that large areas of the Caribbean coast are highly susceptible to erosion, and beaches have experienced accelerated erosion in recent decades. It is estimated that with a 1 m SLR and a conservative estimate of associated erosion, 49% of the major tourism resorts in CARICOM countries would be damaged or destroyed. Erosion associated with a 2 m SLR (or a high estimate for a 1 m SLR), would result in 60% of the region's coastal resorts being at risk.

In the Caribbean basin, increased sea surface temperatures, SLR and extreme events are projected to accelerate in the coming decades and compound the existing threats to natural systems and society. The Caribbean is projected to experience greater SLR than most areas of the world due to its location closer to the equator and related gravitational and geophysical factors (Simpson et al. 2010, State of the Caribbean Climate 2020). Climate change models suggest that typically, beaches will retreat landwards by approximately 100 times the rate of SLR. If beaches are unable to retreat inland, either because of the natural geology or because of man-made structures (seawalls, buildings, roads) then they will gradually disappear in a phenomenon known as "coastal squeeze."

Severe storms such as hurricanes can do much damage to coastal areas changing the entire shape and area of the beach. Erosion of over 50% of beaches in Jamaica occurred during Hurricane Gilbert (UNEP/CEP 1989). Climate change projections suggest that hurricanes will likely increase in intensity, which may mean more severe damage to beaches and coastal areas with each extreme event and likely a longer recovery period. Without the presence of features such as dunes, storm surges can cause extensive damage to

infrastructure, which means that archaeological sites will not escape this destruction.

Jamaica and the changing climate

Jamaica is an island of 11,264 sq. km in addition to 9,600 sq. km of offshore banks and shoals, in the Greater Antilles of the Caribbean (Figure 1), 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 – volcanic on the south and limestone on the north, with attending erosion susceptibility (IADB 2018).

Figure 1. Map of the Caribbean situating Jamaica.

Similar to the rest of the Caribbean, more than half of the population of Jamaica lives within 1.5 km of the shoreline and approximately 90% of the island's GDP is produced within its coastal zone (Caribsave Jamaica Profile 2012). This context and the resulting destruction of protective coastal ecosystems have assured limited resilience to deal with a changing climate.

As highlighted previously, projections for the Caribbean's changing climate are characterized by rising sea levels, hotter temperatures, more variable rainfall with increased drying, increased sea surface temperatures, and frequent and more intense storms and weather events (State of the Caribbean Climate 2020). For Jamaica, the data indicates a continued warming and drying trend into the future, an increase in tropical cyclone strength and frequency, and a conservative projected mean SLR of 0.87 – 0.9 m across coastal areas by the end of the century (State of the Jamaican Climate 2015). A mean sea level rise of 0.5 could translate into an increased frequency of sea level extremes. The State of the Jamaican Climate report (2015) highlights projected future temperature, which indicates a change from a range of 1.18 – 1.31 in the 2020s to a range of 2.76 – 3.62 by the year 2100. Using the same report, Figure 2 highlights projected SLR for Jamaica's coastal areas and Figure 3 highlights Jamaica's coastal flood zone exposure and vulnerability, where the coastal flood zone includes coastal areas with elevations less than or equal to 10 m. It identifies maximum inundation areas at Annotto Bay, Farquhar's Beach, Homer's Cove, Margaret's Bay, and 100-year storm surge inundation for Montego Bay. Exposed population is also presented.

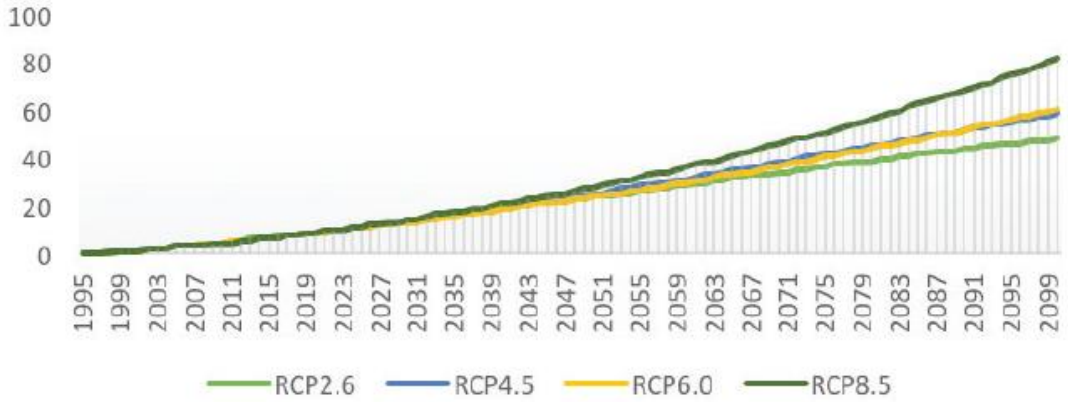

Figure 2. SLR projections under conservative (RCP 2.6), moderate (RCP 4.5) and high estimations (RCP 6,8.5) of the northern coast of Jamaica (Source: State of the Jamaican Climate Report 2015).

Figure 3. Jamaica's Coastal Flood Zone Vulnerability (Source: Pacific Disaster Centre 2016).

The combination of non-climate stressors and climate change impacts has a major effect on the rate of beach erosion along the Jamaican coast, and the rate of erosion is reported as being very site specific, with some beaches having retreated by 100 m or more over the past 60 years, while others have had no significant erosion (Robinson, Rowe, and Khan 2006). While routine monitoring has only been carried out in Jamaica over the past 30 years, concerns about beach erosion are increasing rapidly (Robinson, Rowe, and Khan 2006; CARIBSAVE 2010). Based on the SLR projections for the Caribbean, and consistent with other assessments of the potential impacts of SLR (Dasgupta et al. 2007), SLR scenarios of 1 m and 2 m and beach erosion scenarios of 50 m and 100 m were calculated to assess the potential vulnerability of major tourism resources across Jamaica.

Palaeoecological studies in Jamaica have shed light on the relationship between humans and their environment and climate change. Robinson et al. (2006) through Figure 4 have indicated what Jamaica would have looked like 18,000 years ago, when present coastlines extended much further. It identifies the area in light green as a flat shelf covered by a shallow sea today. During that period, the vast ice sheets which covered much of the world (Pleistocene) would have contracted so much water that the ocean levels would have lowered by approximately 120 m what it is today. From that period, to the present and into the future, the story will be one of rising sea levels as ice sheets continue to melt and release water.

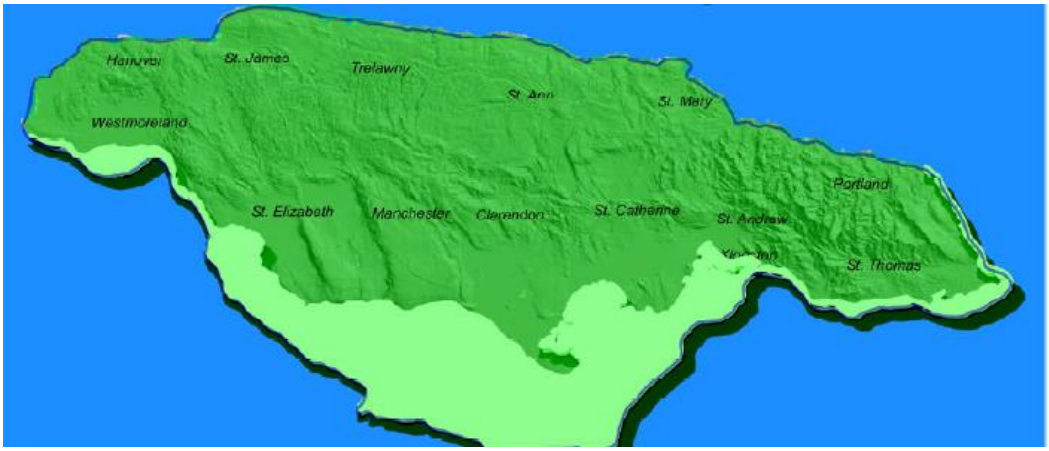

Figure 4. Map of Jamaica 18,000 years ago (Source: Marine Geology Unit, UWI, 2005).

Research undertaken by Hendry and Digerfeldt (1989) revealed that mean sea level at the start of the Holocene was at least 12 m below current levels. It rose rapidly in the early Holocene but slowed down considerably after about 5,000 years ago. A dry episode was noted 2400 to 1500 BP, followed by a "brief period of wetter conditions" between about 1500 and 900 BP.

Robinson et al. (2006) also wrote that if all the ice caps continue to melt, the sea would rise to about 70 – 80 m above its present levels and that a rise of 7 m would flood most of Jamaica's coastal communities and a rise of 70 would make Jamaica look like the map in Figure 5 with extensive loss of shoreline. If sea levels were to rise at the same rate as it did 14000 years ago, it would reach 7 m above today's level in 150 years, and that there is likely to be a 30 m erosion rate (retreat) in some of the flatter lying coastal areas by the end of the century due to SLR alone. In some areas, erosion rates are 100 m over the past 60 years as well as no significant erosion.

Figure 5. Projected Map of Jamaica if the Ice Caps continue to Melt (Source: Marine Geology Unit, UWI, 2005).

Jamaica's pre-Columbian environment

Having established the significant threats that our coastal areas face, this paper seeks to bring deeper awareness of the risks faced by our dwindling pre-Columbian heritage, already severely impacted by other threats, and so it seeks to analyze present threats faced by climate change, in order to make determinations as to the management responses that will be needed to protect this heritage moving forward and in the present and future context.

Current research suggests that Jamaica was inhabited after AD 600 by the ancestors of the Taíno (Rouse 1992; Keegan and Atkinson 2006) with the earliest known sites (AD 650) being archaeologically referred to as part of the Ostionan Ostionoid subseries, known locally as Redware (Rouse 1992; Keegan and Atkinson 2006). Jamaica's pre-Columbian archaeological record underwent a period of rapid documentation by James Lee starting in 1959 (Allsworth-Jones 2008). An extensive history of pre-Columbian investigation in Jamaica is also outlined by Allsworth-Jones (2008) in Pre-Columbian Jamaica. Researchers have generally agreed that while much research has been completed, limited publication has ensued, resulting in the view that very little investigation has taken place on the island (Keegan and Atkinson 2006; Wesler 2013). Few pre-Columbian sites have benefited from extensive research by international and national researchers a like, and so many remain unresearched and others still undocumented.

Research 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. Lee in his extensive mapping exercise concluded that the Redware culture preferred coastal settlements and were located predominantly on the seashore or near rivers at elevations of 0-15m above sea level (Keegan and Atkinson 2006, Allsworth-Jones 2008, Wesler 2013, Atkinson 2019). The later Meillacan culture (ca. AD 877) would also settle in coastal areas but also utilized the interior for their settlements (Keegan and Atkinson 2006).

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 (Allsworth-Jones 2008, Atkinson and Keegan 2006). Figure 6 highlights the extent of pre-Columbian sites mapped in Jamaica by James Lee, the Archaeological Club (later Society) of Jamaica), and other sources, and was developed by archaeologist Lesley-Gail Atkinson as part of her research.

Figure 6. Distribution of Jamaican prehistoric sites (© Mario Mighty and Lesley-Gail Atkinson 2018).

Assessing Jamaican Pre-Columbian sites for climate change impacts

As previously highlighted, pre-Columbian sites in Jamaica are threatened by many factors - land-based development and agricultural activities being among the most prominent (Richards 2006). Jamaica's prehistoric sites are also located at varying distances from the sea or coast, and as highlighted in Figure 7, approximately 35% of these known sites are located within 1.5 km of the coast (Atkinson 2019), echoing true that coastal sites are caught between the dynamic of land, sea, and human induced development, rendering them extremely vulnerable (Crock 2019).

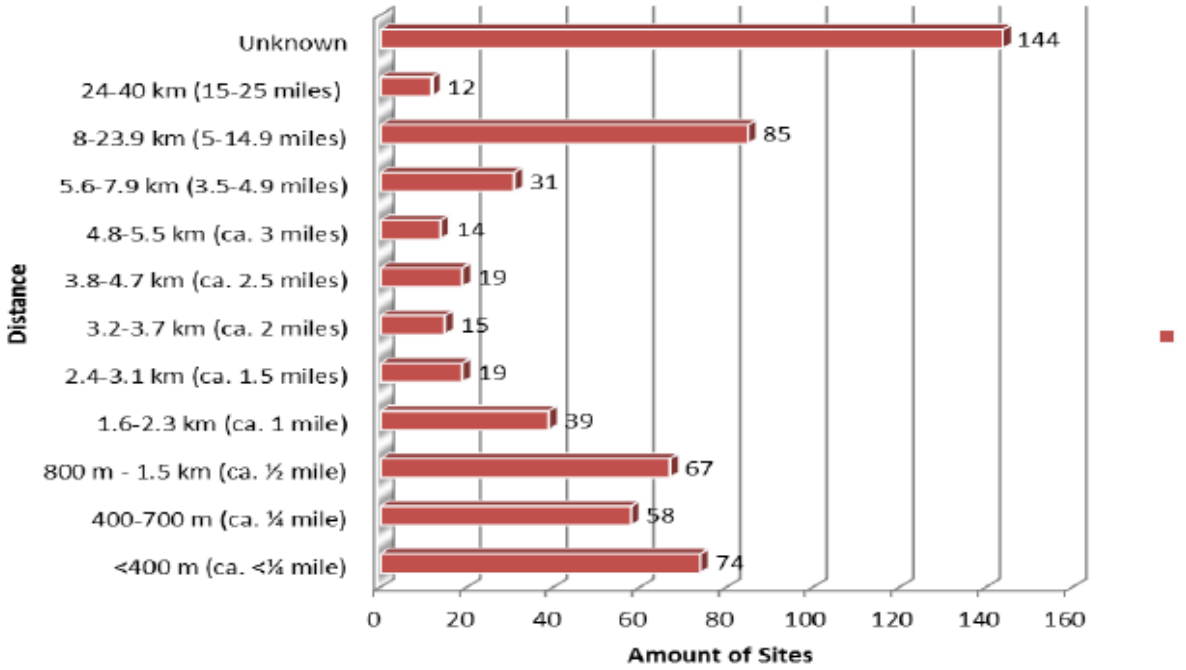

Figure 7. Distance of pre-Columbian sites from coast (Source: Atkinson 2019: Figure 4-19).

While Jamaican sites such as White Marl, Paradise Park, Green Park, Newry and Coleraine - among few others - have benefited from extensive research and are the most published in the last decades, there have generally been limited references to environmental changes at sites which 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 with coastal erosion (DeWolf 1953).

As highlighted earlier, James Lee in his various mapping exercises detailed in Archaeology Jamaica 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 sea level rise will only continue the trend of erasing this record.

Climate change through sea-level rise 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 hurricane activity and sea-level changes for the dearth of archaic sites, while highlighting those 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 (ibid). He concluded that if archaic inhabitants were coastally oriented and sea level is 2 - 4 m higher today than 4000 to 5000 years ago, it is likely

that many of those early sites are now inundated (ibid).

To frame this paper's discussion, 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 terms. The back issues of Archaeology Jamaica served as the primary source for the largest number of sites, followed by JNHT files and research reports and publications where they are available. This review indicated few specific site references in relation to ongoing environmental and climate change and is identified in Table 1 below.

Table 1. Some references to climatic stressors at pre-Columbian archaeological sites in the record (Source: *Archaeology Jamaica* and personal communications).

Archaeological Site	Reference to Environmental, Climate Change, Sea Impacts in the Record
Little River (St. Ann)	Distance from sea: 0 km Elevation: 2 m The Little River is 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. It is dated as one of the earliest sites redware sites on the island. Researcher M. de Wolf (1953) indicated that the largest midden, about 2 m 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 site of what 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. In 2004, while undertaking a site visit for the Mammee Bay Archaeological Impact Assessment, the Jamaica National Heritage Trust found that only a part of the Taíno site on the eastern quarter strip of the beach appeared to be intact and undisturbed, but there was an area where waves had undercut a small bank and numerous pieces of Taíno pottery sherds, conch shells and debitage protruded at the surface (JNHT 2004).
Ross Craig (Portland)	Distance from sea: 0 km Elevation: 0 m Categorized as a now submerged site and below present sea level. Discovered in the late 1990s, research on this site is on-going by archaeologist Ivor Conolley and the Archaeological Society of Jamaica, to identify it positively as pre-ceramic age site. While it is apparent from investigations that artifacts were washed in from offshore to the beach, there is some indication that these artifacts may have been deposited in the sea by an earthquake (Ivor Conolley, personal communication 2021).

Mammee Bay (St. Ann)	Distance from sea: 0 km Elevation: 1 m Site discovered in 1984 and subsequently mapped that year by James Lee. Objects were collected from an area exposed by rough seas. Evidence at the site suggested that the village had been demolished by storm waves. Mr. Basil Reid of the Archaeology Division JNHT conducted an archaeological excavation on a large Taíno site on the Mammee Bay Estate in 1986. He identified the site as a Redware type and described it as extending into the sea (JNHT 2004)
Paradise and Sweetwater sites (Westmoreland)	Distance from sea: 0.25 km Elevation: 2 m The sites are located on a coastal dune between the Deans Valley River and Bluefields Bay. The sites were strategically located on the only "high" ground (about 1 to 2 m above sea level) in the area (Keegan 2002). It was noted that changes in exploitation patterns between the two-site 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 occupations (sites) which may explain why part of the Ostionan deposit is today below the water table. William Keegan noted that part of the deposit is below the water table and suggests that when the site was occupied the sea was perhaps a meter lower than at present, and if so, all the other sites mentioned would also have been farther from the high-water mark than they are now (Keegan 2022).
Round Hill (Clarendon)	Distance from sea: 0 km Elevation: 15 m Wave erosion over a period of a few years at this site was noted as contributing to a collapsed strip of between 1.5 and 3 m (5 and 10 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 100 years (Allsworth-Jones 2008, Archaeology Jamaica 1970, 1984a, Lee 1977)
Holmes Bay (Clarendon)	Distance from sea: 0.03 km Elevation: 2 m Noted as being a village right at the sea's edge, with evidence that storm waves having disarranged practically all of the material (Archaeology Jamaica 1971, Allsworth-Jones 2008)
Prospect Point (St. Thomas)	Distance from sea: 0 km Elevation: 2 m Site mapped in 1984 located in a beach area where 'severe corrosion by the sea had altered the surface of most exposed sherds (Archaeology Jamaica 1984b, Allsworth-Jones 2008)
Fortlands (St. Ann)	Distance from sea: 0.01 km Elevation: 3 m Discovered in 1954 and described as near sea level and not more than 0.09 km (100 yards) from the sea (Allsworth-Jones 2008)
Alligator Pond River (St. Elizabeth)	Distance from sea: 0.06 km Elevation: 3 m

	Close proximity to the sea and being exploited for construction sand (Lee 1976, Allsworth-Jones 2008)
Billy Bay (St. Elizabeth)	Distance from sea: 0.03 km Elevation: 8 m Close proximity to the sea with artifacts reported as being scattered by storm waves (Lee 1976, Allsworth-Jones 2008)
Fort Charles A (St. Elizabeth)	Distance from sea: 0 km Elevation: 8 m Portion of a burial reportedly revealed by wave erosion. (Archaeology Jamaica 1967, Allsworth-Jones 2008)
Long Acre Point (St. Elizabeth)	Distance from sea: 0 km Elevation: 2 m Storm waves noted as impacting site and artifacts (Lee 1976, Allsworth-Jones 2008)
Auchendown (Westmoreland)	Distance from sea: 0.03 km Elevation: 3 m Site reported at sea level and impacted by flooding, erosion, and wave action (Archaeology Jamaica 1979, Allsworth-Jones 2008)

Based on what we know of current and future impacts to coastal areas, it is evident from the selected sites that they could have already been lost, or are being destroyed, and actions need to be put in place urgently to manage these losses, guided by appropriate data collection and surveys and analysis. Assessments were undertaken for sites at Mammee Bay and Ross Craig (**Figure 8A**), which 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 re-mapped or monitored since their initial mapping 1960s – 1970s.

This paper examined the impact of climate change within the context of environmental change experienced from the pre-ceramic archaeological period onwards and acknowledges that archaic sites may have been present but submerged as a result of sea level changes in previous eras, as well as sites still undiscovered, and that the majority of sites represent the Ostionan and Meillacan cultures. As mentioned, in reviewing documentation of these sites, references to sites washing away, or eroding due to coastal erosion, being subjected to environmental changes etc. are used as the primary determinant in identifying early climate change impacts.

Planning for the Future

This research recognizes that although assessments are key for developing appropriate responses, there are acknowledged difficulties in trying to determine the extent of damage and loss that could occur, due partly to uncertainty about future severe weather events. This paper instead proposes that assessing the vulnerability of sites is key to developing appropriate monitoring and other responses to attempt to address the impacts of future impacts.

The legislative and policy landscape for heritage in Jamaica has remained virtually unchanged since the JNHT Act (1985), although threats to heritage are constantly evolving. This calls for the revision and strengthened implementation of legislation, ongoing reflection and the utilization of tools, methodologies and other "out the box thinking and actions" to address an impact we know will surely come. Since the significant mapping of pre-Columbian sites by James Lee and the Archaeological Society of Jamaica 1960s – 1980s, very few sites have been fully researched, nor has there been a systemic or periodic monitoring program targeting these sites by the JNHT or any other partner. According to Selvenious Walters, JNHT Technical Director, the JNHT has however indicated that it is preparing to commence a parish-by-parish re-mapping exercise of these

sites (Personal communication 2021). With the exception of those few sites considered important enough for research, what can be said about the state of all the others? The actions and steps taken today determine how well prehistoric sites are able to adapt in the future while responding to the changing climate and its attending effects.

Limited or no monitoring, results in many impacts going unchecked, unreported and unaddressed, leading to the continued loss of sites both documented and undocumented. As a result of this, no actions have been developed which focus on monitoring, and although climate change is something the heritage community in Jamaica has been aware of for a while, assessments and a monitoring program for these sites remain non-existent, neither is there good and available baseline data to develop a robust monitoring program. However, regardless of where we are, an initial step can be made.

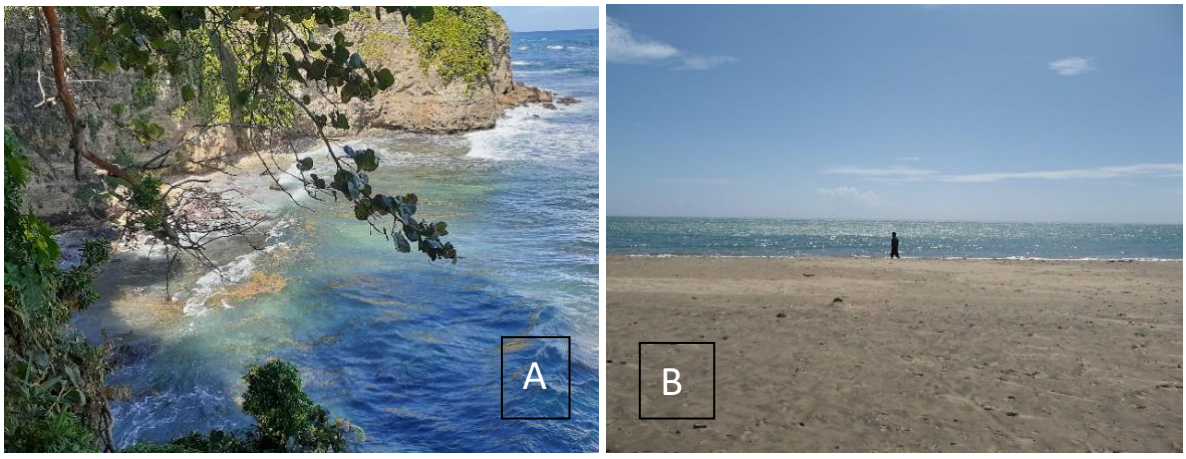

Figure 8A. Ross Craig (believed to now be submerged) (© Andrea Richards).
Figure 8B. View of the Sea from the Fort Charles Site (© Ivor Conolley).

The two main responses to climate change are mitigation and adaptation actions. In preparing for this change, it is acknowledged that some sites will be lost, but with no actions being taken, are we to just accept the loss of all our coastal sites?

As stated earlier, some pre-Columbian sites in Jamaica have been widely researched. There is however still a large number of sites that remain unresearched and yet still those that are undocumented due to the limited mapping taking place presently. Research speaks to there being no evidence of archaic peoples in Jamaica, and it is largely felt that if there was an archaic culture inhabiting Jamaica at some point, their 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, and so it is evident that by working to preserve these sites, we are providing the space to learn more about these cultures. The very next prehistoric site lost to the changing climate could be the one that provides us with important data and linkages to what remains unknown.

Safeguarding this heritage requires a multi-disciplinary and collaborative approach and cannot solely focus on the work being done by heritage institutions. Before a determination is made of what cannot be saved, needs rescue archaeology, or can be protected, our first action must be to undertake a comprehensive climate change vulnerability assessment and (re) mapping of our pre-Columbian sites, within or without a wider strategy for addressing impacts to heritage. For threatened coastal heritage, it means awareness, observation and monitoring, data collection, studies, prioritization and key actions.

Prioritizing Vulnerable Sites: Some we Save, Others We Cannot

Some countries have put in place a system of prioritizing vulnerable sites and taking actions based on this priority. Value may be inscribed due to national importance or uniqueness among other criteria (Dawson et al. 2017). When one considers just how much remains to be researched regarding Jamaica's pre-Columbian population and record, how will

value be accorded to each site, particularly those not previously documented or researched?

There are of course those sites which do not give us much of a choice or time to think about our actions due to their precarious state or imminent danger. Undoubtedly and even with our best efforts, we cannot stop the loss of some coastal sites. In these instances where loss cannot be mitigated, a rescue archaeology program should be implemented as matter of urgency, to capture all data that can be gathered from the site. Unfortunately, examples of rescue archaeology have become quite common in the Caribbean due to the many threats and little room for compromise in relation to prioritizing heritage.

To support the need for critical base-line data and as a useful planning tool for the heritage community, maps and other tools should be developed which provide a visualization of threats and which can guide any prioritization which needs to take place. Figure 9 identifies known sites at risk as a result of being too close to the coastline or of elevation below 10 m.

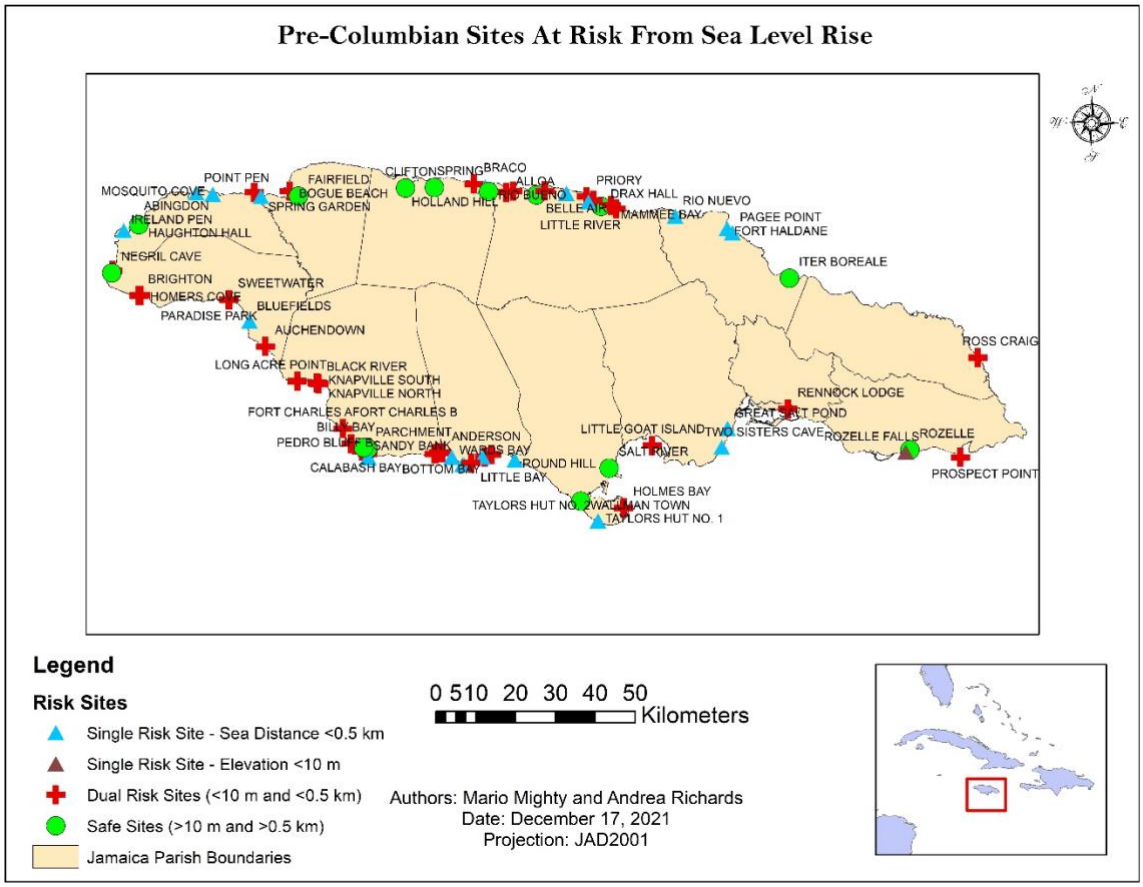

Figure 9. Projected impacts of sea level rise on coastal pre-Columbian sites.

Mitigation

Archaeologists will say that preserving an archaeological site in situ is the best action to take to protect it. This option, however, cannot be considered for sites in danger of being washed away or submerged. For these sites, mitigation actions will need to be developed.

Mitigation actions are unique to each site and will largely focus on defending the coastline while managing retreat. One such action is increasing vegetation cover, restoring coastal ecosystems or regeneration of coastal dunes to stabilize sites or act as a buffer where they can or act to slow down erosion, are sustainable and affordable measures to be considered. A reduction in human actions or use of the area can also have positive effects. In some instances, fortifying with sandbags or tires have been used to slow impacts as a temporary measure. More expensive mitigation measures involve breakwaters, revetments,

groins and seawalls. These are however not solutions to be considered for the protection of individual sites.

Actions we can take to save some

In order to develop solutions to manage the risks faced by coastal sites or adapt to future change, we must first identify the location of sites through a comprehensive survey program. This is added to a complete understanding of the risks being faced, the nature of sites and their vulnerability, only then can solutions and strategies be proposed or developed to respond to this threat.

As highlighted previously, Jamaica has not undertaken a significant mapping exercise since the work by James Lee and the Archaeological Society, nor is monitoring currently being undertaken, and the state and vulnerability of the vast majority of Jamaica's pre-Columbian record is unknown. In order to develop appropriate strategies and actions to safeguard this archaeological record, actions must be developed around the site's identification, threats and its vulnerability. This can be developed through various steps:

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 and through predictive modeling, undertake a program 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 survey exercise will also utilize other data sources such as maps, photographs, remote sensing research reports, publications and archival data. This coastal survey could also be undertaken on a parish-by-parish basis. From this activity, a comprehensive inventory can be developed with site descriptions, exposure to risks and sensitivity to this risk and other geographic information to establish vulnerability of documented sites, which can then guide further actions in relation to prioritizing vulnerable and other sites for present or future actions. 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 or heritage stakeholders. This is also an opportunity for the ASJ to scale up an activity it was once heavily invested in from the days of James Lee.

Following this survey exercise and with inventories in place, heritage managers in Jamaica can utilize various tools to undertake simulation exercises in relation to current and future risks. The use of satellite imagery can be useful for highlighting coastal changes, and the use of GIS can be used to undertake various predictive modeling exercises which can expose future risks and vulnerabilities and develop Heritage at Risk Maps for use not just by the heritage community, but also those involved in coastal planning and or management (See James-Williamson, Dolphy and Atkinson Swaby in this volume). For example the maps developed can be combined with the beach monitoring work being done 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 stakeholders such as local communities and in developing climate change stories to build awareness.

From this position of improved surveying and inventorying and the utilization of various tools and methodologies, heritage managers will be in a better position to utilize data from other fields such as paleo-environmental and other scientific studies (such as coastal zone studies), which can add to analysis of site vulnerabilities. In Jamaica, the Department of Geography and Geology of the University and societies such as the Geological Society of Jamaica have already generated valuable coastal studies and sea level rise data which can be of value to examining the risk to our pre-Columbian archaeological record and could be pursued through collaborative work. This process actualizes a truly multidisciplinary approach in examining the vulnerability of this coastal record. Already, The Archaeological Society is made up many scientific disciplines, not just archaeologists, and so again, this presents an excellent gateway for pursuing this multidisciplinary approach.

Discussion: Lose, Mitigate, Manage and Adapt

The heritage community and by extent, Jamaica, is at a critical place and time to truly determine how it wishes to approach the protection of its archaeological heritage within the context of a changing climate and develop an applicable management response strategy that is uniquely Jamaican and addresses its particular context and engaged stakeholders. With decades of virtually no actions taken to survey the vast majority of Jamaica's coastal heritage, we are now in a place where the foundation can be laid and much good can be achieved for the protection of this heritage. There will be the usual challenges of limited resources, but we can hardly afford to do nothing while saying that we are managers of this heritage.

Through this research, a four-pronged approach is being proposed to address the threats to our pre-Columbian archaeological record in imminent danger of being lost forever as a result of climate stressors, anchored in an extensive surveying of our pre-Columbian archaeological record through the combined efforts of the JNHT, Archaeological Society of Jamaica (ASJ), and the University of the West Indies or a partnership between of these bodies. Other societies such as the Jamaica Georgian and the Historical Society can also be included in a wider surveying exercise of archaeological heritage which will be key to generating critical baseline data.

Our first step should be the utilization of archaeological and other data and various tools and methodologies to analyze the current and future vulnerability of these sites, utilizing monitoring and assessment data and predictive modeling in order to develop a robust monitoring program. In addition to the partnerships mentioned above, the integration of other scientific disciplines and societies such as the Geographic and Geological Societies will be important, in addition to Land Surveying and Coastal Zone Management agencies among others.

This is followed by the development of critical mitigation and adaptation strategies with a host of partners such as environmental agencies and NGOs for the development of nature-based solutions and the restoration of coastal ecosystems as our second step. This is also a mutually beneficial partnership as these agencies also have the restoration of these areas as part of their mandate, so it will not just be a partnership to benefit from generated data.

Thirdly, the development of a data driven approach for archaeological sites within a wider sector program for heritage will develop strategies for guiding mitigation and adaptation actions based on surveyed information and assessed vulnerabilities.

The final approach envisions the broad-based involvement of local stakeholders through the appropriately termed citizen science initiatives. These initiatives count on the support of communities to bridge the gap between research, management and protection of sites and utilize technologies for surveying, registering, monitoring, preserving and displaying sites that are threatened by climate change. This strategy is being used extensively in many countries in the world. Although the uptake has been slow in the Caribbean, there are interesting projects in Barbuda, Guadeloupe and Puerto Rico (mentioned earlier in this paper). Citizen Science Initiatives are not entirely new to Jamaica. The work done by the ASJ from the 1960s is a form of CSI and should be expanded. This foresees the creation and streamlining of various data collection tools to ensure that data collected is the same throughout.

Another local stakeholder component is the engagement of communities, schools and individuals close to these sites. The use of tools such as simulation maps can prove to be interesting gateways for engaging this 'non-technical' public. Farming and fishing groups and other community-based associations and organizations are another underutilized entry point to build awareness. These gateways also provide opportunities for groups to be involved in developing climate stories and safeguarding initiatives within their or the site's local context and also share local ecological knowledge regarding the landscape and environment.

The actions to be implemented call on the JNHT – as the primary agency for the protection of heritage in Jamaica, to work outside the box with a mix of key partners and stakeholders. The ASJ also has a critical role, calling on its historic involvement in the mapping of Jamaica's archaeological heritage. The approach that is weaved throughout this research and specifically the recommended actions, seek to address this threat to our pre-Columbian archaeological heritage, and by extension all coastal heritage. It is one of

forging key partnerships and integrating stakeholders every step of the way, while working towards the full integration of our cultural heritage in national climate change adaptation strategies.

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