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The Conservation Imperative: Developing a Framework for Climate Change Adaptation in Coastal Heritage Conservation—A Study of Monuments in Kenya

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Abstract

Kenya's coastal monuments, crucial for its cultural heritage, face increasing threats from climate change, including sea-level rise and erosion. This research investigated the conditions of the monuments as impacted by climate change and the need for adaptation strategies to protect these sites. Employing a mixed-methods approach, including literature reviews, on-site observations, and interviews with professionals and locals, the study documented significant climate-related damages, such as wall flaking, erosion, and structural decay. The findings revealed a critical gap in current conservation practices, highlighting the necessity for a holistic adaptation framework. This framework comprises four key components: vulnerability assessment, risk management, community engagement, and policy integration. Vulnerability assessment involves mapping climate risks, while risk management integrates engineering solutions with traditional conservation methods. Community engagement ensures local participation in decision-making, and policy integration necessitates incorporating climate adaptation into heritage management plans. The proposed framework aims to enhance the resilience of these monuments, ensuring their preservation for future generations. This research contributes to the knowledge base on climate change adaptation in heritage conservation, providing a practical,

context-specific approach for safeguarding cultural heritage in vulnerable coastal environments.

Keywords

Climate Change Adaptation, Coastal Monuments, Vulnerability Assessment, Community Engagement, Risk Management

1. Introduction

The Kenyan littoral zone harbors a significant corpus of historic monuments, frequently characterized by vernacular construction materials (Ralwala, 2023; Njoroge & Wanyama, 2020). These culturally and historically significant assets are experiencing accelerated material degradation due to the intensifying exogenous pressures of anthropogenic climate change, most notably, sea-level rise and the increased frequency of extreme weather events (Musyoka, Muchiri, & Njoroge, 2021; Muthoni, 2020; Orr, Richards, & Fatorić, 2021).

Addressing such climate-induced challenges necessitates the implementation of effective heritage conservation strategies (Sesana, Bertolin, Gagnon, & Hughes, 2020). However, this research acknowledges that contemporary conservation practice is hindered by numerous constraints, including the absence of climate-adaptive conservation approaches; disjointed organizational structures; constrained financial resources; underutilization of technological advancements and innovations; and inadequate fiscal apportionment. Moreover, these shortcomings are further exacerbated by a lack of policy support and enforcement, insufficient hazard and vulnerability assessments, as well as the weak integration of indigenous knowledge and communal participation.

Consequently, as detailed by UNEP (2021), and the IPCC (IPCC, 2022, Working Group II report, Chapter 9, Section 9.6.2), extreme weather events have significantly impacted the Kenyan coastline, leading to increased flooding, accelerated coastal erosion, intense precipitation, elevated relative humidity, salt weathering, tropical storms, and high-velocity winds. A joint report by UNESCO and IPCC (2023) emphasizes that these climate stressors pose an escalating threat to coastal cultural heritage.

For the purposes of this research, Kenyan coastal cultural heritage is defined as "monuments," consistent with the definition outlined in the National Museums and Heritage Act (NMHA) of 2006, which encompasses places or immovable structures of historical, cultural, scientific, architectural, technological, or other human interest. The imperative to safeguard these monuments from the deleterious impacts of anthropogenic climate change has thus emerged as a critical global exigency (UNESCO, 2021; IPCC, 2023; Chemeli, Njoroge, & Agufana, 2021).

For instance, the United Nations Framework Convention on Climate Change (UNFCCC, 2022) acknowledges the increasing vulnerability of cultural monu-

ments, particularly those situated within ecologically sensitive coastal environments, to the intensifying impacts of climate change. Specifically, the Warsaw International Mechanism for Loss and Damage (WIM), under the UNFCCC framework, formally recognizes the deterioration and potential irretrievability of cultural monuments as a significant non-economic loss resulting from climate change (UNFCCC, 2022).

Similarly, the Intergovernmental Panel on Climate Change (IPCC, 2022) asserts that the need to protect monuments from the effects of climate change is grounded in their demonstrated susceptibility to climatic vulnerabilities. The IPCC reiterates that climate change manifests through phenomena such as eustatic sea-level rise, increased erosion, inundation, ocean acidification, and intensified extreme weather events; factors that collectively accelerate the deterioration of cultural monuments and exacerbate their inherent vulnerabilities.

Vulnerability, as defined by the IPCC (2022), refers to the propensity or predisposition of a system to be adversely affected. It encompasses a range of concepts, including sensitivity or susceptibility to harm, and the lack of capacity to cope and adapt. Thus, vulnerability transcends a singular dependence on climatic variables and instead emerges as a complex interplay modulated by both the intrinsic characteristics and contextual conditions of the exposed system (IPCC, 2022; UNEP, 2021).

As supported by a growing body of scholarship, coastal monuments exhibit pronounced vulnerability, undergoing physical, environmental, and social transformations that threaten their Outstanding Universal Value (Fatorić & Seekamp, 2023; Dawson, Hambly, Kelley, Lees, & Miller, 2020). This susceptibility is further compounded by the nascent state of vulnerability and risk assessment methodologies, which currently lack standardized frameworks and harmonized indicators, thereby impeding the formulation and implementation of effective mitigation strategies (UNESCO, 2023; Claudia, Yan, & Brian, 2021).

Ergo, this study strategically situates itself within the established paradigms of the IPCC vulnerability framework (IPCC, 2022: WG II), which conceptualizes vulnerability as a function of a system's sensitivity, exposure to hazards, and adaptive capacity. The IPCC defines "exposure" as the presence of people, assets, or systems in places that could be adversely affected by climate-related hazards. This research demonstrates that the Kenyan littoral zone exhibits high exposure to multiple climatological threats, including sea-level rise, coastal erosion, saltwater intrusion, flooding, storm surges, and high-intensity tropical storms; all of which challenge the resilience of both natural ecosystems and cultural heritage sites (IPCC, 2022: Chapter 9).

"Sensitivity" is defined as the degree to which a system is affected by climatic stimuli, either positively or negatively. Empirically, this study reveals that Kenyan coastal monuments are highly sensitive due to the nature of their construction materials. Structures such as Mombasa Old Town, Gede Ruins, Jumba la Mtwana, and the Vasco da Gama Pillar exhibit heightened susceptibility to climate-induced

degradation. Built primarily from porous coralline limestone (coral rag), lime-based mortars, timber, and metallic elements, these monuments are particularly vulnerable to thermal stress, hygric fluctuations, and saline intrusion (Karanja & Njiru, 2020).

"Adaptive capacity" refers to the ability of systems, institutions, and communities to adjust to potential damage, exploit opportunities, or respond effectively to climatic threats (IPCC, 2022). According to Karanja and Njiru (2020) and UNESCO (2021), Kenya's adaptive capacity is constrained by financial limitations, inadequate institutional frameworks, and a lack of localized expertise in heritage conservation under climate stress.

To empirically assess the vulnerability of Kenyan coastal monuments within the IPCC framework, this study conducted an exposure and sensitivity assessment of four key sites: Mombasa Old Town (including Fort Jesus), Gede Ruins, Jumba la Mtwana, and the Vasco da Gama Pillar. The assessment involved structured physical inspections using observational checklists to document the current material conditions of the monuments, along with an interpretation of climate-related degradation.

Furthermore, a survey employing closed-ended questionnaires and semi-structured interviews was conducted with heritage professionals, community members, and government officials. These interviews aimed to elicit qualitative insights into climate change impacts and perceptions, which were thematically analyzed and triangulated with the observational data.

Accordingly, the findings underscore the urgent need for pragmatic, context-specific strategies to safeguard Kenya's invaluable littoral cultural heritage. To this end, this study proposes a comprehensive climate change adaptation framework aimed at enhancing the adaptive capacity and resilience of coastal monuments. Prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

2. Methodology

This research employed a convergent mixed-methods design, incorporating physical observations of the state of monuments using an observational checklist, as well as a survey method with closed-ended questionnaires. Initially, a comprehensive review of extant literature pertaining to climate change and cultural heritage, alongside archival records concerning listed monuments along the Kenyan Coast sourced from the National Museums of Kenya (NMK) Database, was undertaken. Subsequently, *in situ* observations and photographic documentation were conducted on the coastal monuments selected via purposive sampling. These observations systematically recorded the physical conditions of the monuments, concurrently identifying indicators of climate-related degradation. Finally, semi-structured interviews were administered to heritage professionals, local community members, and government officials to elicit qualitative Data regarding perceptions and experiences of climate change impacts. The resultant information was thematically analyzed and employed as a triangulation mechanism to validate the observed Data.

3. Beyond the Statutes: A Critical Analysis of Legal Effectiveness and Implementation Gaps in Climate Change Adaptation and Mitigation Mandates

This paper undertakes a critical analysis of Kenya's climate change mandates, focusing on their articulation within six pivotal legislative and policy documents: the Constitution of Kenya of 2010 (Republic of Kenya, 2010); the Climate Change Act of 2016 (Republic of Kenya, 2016b); the National Museums and Heritage Act of 2006 (Republic of Kenya, 2006); Kenya's Vision 2030 (Republic of Kenya, 2007); Kenya's National Policy on Culture and Heritage of 2009 (Republic of Kenya, 2009) and Protection of Traditional Knowledge and Cultural Expressions Act of 2016 (Republic of Kenya, 2016a). This examination seeks to elucidate how these frameworks address the multi-faceted challenges posed by climate change.

The Constitution of Kenya of 2010: Despite the absence of explicit nomenclature designating "climate change" within its articles, the Constitution of Kenya furnishes a robust legal framework conducive to environmental stewardship and sustainable development, both intrinsically linked to climate change mitigation and adaptation. The document enshrines the principles of sustainable development, mandating intergenerational equity in resource utilization and providing a foundational normative basis for climate action. Furthermore, the constitution articulates environmental rights, granting citizens legal standing to hold state and non-state actors accountable for environmental degradation, including climate change exacerbation. The establishment of the public trust doctrine mandates that the state manages natural resources as a fiduciary, necessitating sustainable resource governance and protection against climate change impacts. The devolved governance structure facilitates localized climate action, enabling the tailoring of interventions to regional vulnerabilities. Collectively, these constitutional provisions provide a legal armature for environmental protection, sustainable resource management, and the assertion of citizens' environmental rights, thereby establishing a jurisprudential foundation for climate change-related legislation and policy, exemplified by the Climate Change Act.

Notwithstanding Kenya's progressive constitutional framework promoting environmental stewardship and intergenerational equity, significant impediments persist in the effective protection of cultural heritage from the pervasive impacts of climate change. Key among these is institutional fragmentation, with weak coordination between environmental, cultural, and climate change sectors. Although the devolved governance system offers potential for context-specific solutions, disparities in resources and expertise among counties hinder effective local responses. Many county governments lack the capacity and funding needed to integrate cultural heritage into climate adaptation efforts, leaving heritage sites, especially in vulnerable regions, exposed to climate threats. Another critical issue is the absence of explicit legal recognition of cultural heritage within climate change legislation and policy. While the Constitution guarantees environmental rights and sustainable development, it lacks specific provisions for protecting cultural heritage

from climate-related risks such as sea-level rise and extreme weather. This gap is reflected in national climate policies, where cultural heritage often remains a low priority, overshadowed by more immediate socio-economic concerns.

This neglect is exacerbated by a shortage of empirical data and research on the effects of climate change on Kenya's diverse tangible and intangible heritage. The lack of evidence-based insights hampers the development of targeted, effective interventions. Additionally, financial constraints limit access to climate funds that could support heritage conservation, while weak enforcement of existing laws further undermines protection efforts.

The Climate Change Act of 2016 stands as a cornerstone of Kenya's climate action, establishing a legal framework for coordinating and implementing climate change responses. It mandates the development of national and county-level climate action plans, emphasizing both mitigation and adaptation strategies. This act underscores Kenya's commitment to building resilience and fostering a low-carbon development pathway. Despite the progressive legal foundation offered by Kenya's Climate Change Act of 2016, its effective implementation in protecting cultural heritage from climate change impacts faces significant challenges. One of the primary limitations is the Act's minimal explicit reference to cultural heritage within its mitigation and adaptation frameworks. While the Act promotes climate resilience, it does not adequately address the unique vulnerabilities faced by heritage assets, which are increasingly threatened by rising sea levels, extreme weather events, and other climate-induced hazards. At both national and county levels, implementation is hindered by limited technical capacity, financial constraints, and weak institutional support. Many County Climate Change Action Plans (CCCAPs) prioritize sectors such as agriculture, water, and infrastructure, often neglecting cultural heritage, despite its importance to national identity, tourism, and community cohesion. Additionally, the absence of heritage-focused strategies in climate action reflects a broader marginalization of the sector. Further complicating the issue is poor coordination between institutions responsible for climate change policy and those tasked with heritage protection, such as the National Museums of Kenya (NMK). This institutional disconnect results in fragmented planning and leaves cultural sites under protected and poorly monitored for climate risks. A lack of data and research on the specific impacts of climate change on cultural heritage further impedes evidence-based intervention. Moreover, heritage-related projects often struggle to access climate finance, as funding tends to favor other sectors.

Conversely, the National Museums and Heritage (NMK) Act of 2006, while primarily focused on cultural preservation, holds significant relevance in the context of climate change. Heritage sites and cultural practices are increasingly vulnerable to climate-related impacts, such as sea-level rise, extreme weather events, and altered ecological conditions. Therefore, this act's provisions for safeguarding cultural heritage are intrinsically linked to climate change adaptation efforts. In spite of the NMK Act (2006) providing a crucial framework for cultural heritage conservation, its effective application to climate change adaptation is challenged by the lack of explicit climate-specific provisions. This omission limits its capacity to

fully guide responsive strategies for heritage sites increasingly threatened by climate-related hazards. A key impediment is the limited integration between heritage conservation efforts and national climate adaptation strategies. The frequent operational isolation of heritage management institutions from climate change agencies results in fragmented efforts, wherein climate risks to cultural heritage are insufficiently anticipated or addressed within broader environmental planning.

Kenya's Vision 2030, the nation's long-term development blueprint, integrates climate change considerations into its broader sustainable development agenda. This vision acknowledges the inextricable link between environmental sustainability and economic prosperity, emphasizing the need for climate-resilient development across all sectors. By mainstreaming climate change into its strategic objectives, Vision 2030 provides a comprehensive framework for aligning national development priorities with climate action.

Even though Vision 2030 acknowledges environmental sustainability as crucial for protracted economic growth, the explicit articulation of cultural heritage protection within its climate-resilient development framework is conspicuously absent. This omission has contributed to the marginalization of cultural heritage in strategic planning and climate action implementation. Furthermore, Vision 2030 lacks specific policy directives and institutional mechanisms addressing the nexus of climate change and cultural heritage. While sectors like agriculture and infrastructure are prioritized in climate-resilient development, cultural heritage is frequently overlooked, notwithstanding its significance to national identity and social cohesion. This limited salience curtails opportunities for heritage concerns to be integrated into adaptation and mitigation endeavors.

Kenya's National Policy on Culture and Heritage (2009) focuses on the conservation, promotion, and development of both tangible and intangible aspects of the nation's cultural heritage. It aims to safeguard cultural heritage for future generations while emphasizing the importance of indigenous knowledge, values, and symbols, especially in the context of climate change adaptation and mitigation. Indigenous communities often hold traditional environmental knowledge that supports sustainable resource use and resilience to environmental changes. The policy highlights the connection between cultural heritage and sustainable development, recognizing that protecting heritage contributes to climate-resilient development. Community participation is emphasized as essential for understanding local climate impacts and creating culturally relevant adaptation strategies. Additionally, the policy encourages raising public awareness not only of Kenya's cultural heritage but also of the climate-related threats it faces, positioning heritage as a key resource in responding to environmental challenges.

Nevertheless, the policy's efficacy in directly addressing climate change impacts remains limited due to a lack of explicit integration of climate change considerations within heritage management paradigms. While acknowledging indigenous ecological knowledge and hinting at heritage-sustainable development nexus, the policy notably lacks actionable strategies for climate risk assessment, adaptation

planning, and resource allocation for climate-induced threats. Predating the current climate crisis exigency, it inadequately reflects evolving risks, particularly for vulnerable coastal and archaeological sites. Furthermore, the absence of delineated inter-institutional coordination between environmental and heritage sectors impedes the cultivation of climate-resilient heritage conservation.

Kenya's Protection of Traditional Knowledge and Cultural Expressions Act of 2016, though not a climate-focused law, exhibits salient implications for both climate change adaptation and, to a lesser extent, mitigation. The Act's provisions, centered on the protection of indigenous epistemologies, directly bolster adaptive capacity. It safeguards Indigenous ecological knowledge, enhancing resilience to climate impacts like droughts. This knowledge, related to agriculture, resource management, and weather prediction, strengthens community adaptation. The Act also protects biodiversity and genetic resources, crucial for climate-resilient agriculture. Furthermore, it indirectly supports mitigation by preserving sustainable practices, such as traditional agriculture, which reduces emissions. It promotes cultural values that encourage responsible consumption. While primarily focused on intellectual property, the Act's protection of Indigenous knowledge is essential for building climate resilience in Kenya, making its provisions indispensable for national adaptation strategies.

The Act, primarily focusing on intellectual property rights and benefit-sharing for traditional knowledge and cultural expressions, exhibits a gap regarding environmental and climate-related dimensions. Consequently, it lacks a clear framework for the integration of traditional ecological knowledge into climate change adaptation and mitigation strategies. It also neglects the existential threats posed by environmental change to traditional practices and knowledge systems. The absence of provisions for assessing climate change impacts on tangible and intangible cultural heritage held by indigenous communities curtails the policy's capacity to foster resilience and continuity of traditional knowledge amidst environmental disruption. Furthermore, the Act's deficiency in establishing inter-institutional linkages between heritage management authorities and climate change actors impedes the utilization of traditional knowledge for sustainable and climate-resilient development. Constrained by limited community awareness, inadequate funding, and weak enforcement mechanisms, the Act's practical implementation, particularly in marginalized regions where traditional knowledge is most susceptible to climatic effects, remains challenging.

4. Quantifying Vulnerability: A Multi-Scalar Analysis of Climate Change Impacts on the Coastal Monuments

Empirical research revealed that Kenya's coastal monuments face severe threats from climate change. Specifically, as KIPPRA (2024) explains, this research confirms that rising sea levels risk submerging these heritage sites, while intensified storms and rainfall accelerate erosion and structural damage. Furthermore, changing temperatures and humidity have contributed to material decay, leading

to cracks, corrosion, and biological growth. The subsequent sections provide site-specific analyses of their morphology and climate change impacts.

Mombasa Old Town (MOT), a 72-hectare historical enclave on Mombasa Island, stands as a pivotal cultural heritage site in Kenya. Its origins as a Swahili Islamic port, dating from the 13th to 15th centuries, have fostered a rich cultural amalgamation, evidenced by Arab, Portuguese, Asian, British, and local Swahili influences (UNESCO, 2021). This diverse heritage is manifest in the town's distinctive architecture, characterized by protruding balconies and curved doorways that synthesize European, Indian, and Arab stylistic elements. Recognizing its cultural significance, MOT is both a Kenyan national monument and a tentative UNESCO World Heritage site, affirming its potential for outstanding universal value. This research posits that safeguarding Kenya's coastal cultural legacy can be achieved through the conservation of MOT's historical monuments and open spaces. **Map 1** illustrates specific areas within Mombasa Old Town (MOT) experiencing fabric deterioration due to the effects of climate change. These areas, numbered 1 through 24 on the map and cross-referenced with the details in **Table 1**, underscore the urgent need for targeted interventions.

Source: Author (Jan. 2025).

Map 1. Mombasa Old Town (MOT) showing significant monuments.

Table 1. Significant monuments within the Mombasa Old Town (MOT) showing conditions of their fabric.

S/No	Heritage Place	Heritage Description	Conditions of their Fabric
1	Africa Hotel	Mombasa's first hotel, built around 1904, featured ocean-facing balconies and curved entrances. Owned by Indians, Goans, and Junior, it also housed the Portuguese Consul.	-Brown coloration of original white paint on some parts -Decay on some timber portions on balcony and fascia boards -Visible fissures on some upper walls -Timber decay on some parts
2	Ali's Curio Market	The place was the first police station in Mombasa, built in around 1898.	-Shattering of roof sheets -Brown coloration of original white paint on walls
3	Alien Registration Building	The structure was occupied by the first Imperial British East Africa Company legislators between 1888 and 1895.	-Walls' paints' oxidizing -Corrosion of metallic bars -Decay on some timber -Visible fissures on some walls' parts
4	Basheikh Mosque	The mosque displays Swahili architecture with elongated windows and curved doors, and minimal decorations. Its notable feature is unique minaret.	-Discoloration on some wall paints -Visible fissures on some walls' parts
5	Bohra Mosque	It is dominant mosque built in 1982 and replaced the original one built by A.M Jevanjee in 1901. It belongs to Bohra, an Indian Muslim community in the town.	-Discoloration on some wall paints -Repainting indicates some previous plaster's withering
6	Datoo's Sale Rooms	It was built in around 1920 as a sales place. Up to now, it acts as sales room for household and furniture items.	-Visible superficial lesions -Tarnishing of white paints -Corrosion of metallic bars
7	Fort Jesus	A masterpiece heritage place and a national museum in the town, it was built by Portuguese in 16th Century. It is listed as a World Heritage Site by UNESCO and National Museums of Kenya.	-Measurable breakdown and loss of wall's materials; cracks, erosion and flaking -Loss of material shape in some parts
8	Jubilee Hall	The hall was built in 1897 to commemorate diamond jubilee for Queen Victoria.	-Superficial paints yellowing and brown patches -Roof's bricks red color tarnishing and disintegrations -Decay on fascia timber -Swelling of timber and decay
9	Leven House and Steps	Named after HMS Leven, a British Naval Survey Ship touring Mombasa in 1824. The ship officers operated anti-slaving functions from there. Later it was occupied by the first British Vice-Consul, the missionary Dr. Krapf, and a German Shipping Company, Oswald & Company.	-Slight degradation of material -Collapse of skirting roof and timber; timber swelling and decay -Visible small fissures on walls -Withering of roof sheets -Corrosion of metallic bars
10	Lookmanji Curio Shop	The house has protruding balconies with curved brackets, and its windows and doors have curved arches on top. Aesthetic is also enhanced by decorative moldings and carvings around the windows and walls' corners.	-Balcony timber stains, decay and dislocations -Walls discoloration
11	Mandhry Mosque	It is one of the oldest mosques in the Coast of Kenya,	-Slight paint tarnishing

		built around 1570. Its north wall has an apse-like quibla facing direction of Mecca. It has no decorative elements.	-Repainting indicates some previous plaster's withering
12	Mazrui Graveyard	The place is an open landscape with a graveyard for a renowned scholar Prof. Ali Mazrui. The land is owned by the famous Mazrui family whose dominance in Mombasa dates back to 18th Century.	-Uneven grass growth on soft spaces -Presence of insects' invasions
13	Mombasa Club	The club was constructed in 1897 and is the oldest club in Kenya. It borders and overlooks the Indian Ocean.	-Slight paint tarnishing; there is visible effort of renovations indicating previous dilapidations
14	Mombasa House	It is regarded as one of the oldest town houses in Mombasa. It was built by a master of customs, working for a Sultan of Zanzibar in 1880 Century.	-Molds growth on some walls and timber -Visible superficial lesions -Shattering of roof sheets -Discoloration on wall paints -Timber decay on some parts
15	Old Law Courts	It was founded in around 1902 and opened by the then Governor of Kenya, a British native Sir. Charles Eliot. In 1983, new law courts were established there; currently the building has archeological materials for the National Museums of Kenya (NMK), a library, offices and a gallery on the ground floor.	-Presence of insects' invasions on the landscape -Slight paint tarnishing; there is visible effort of renovations indicating previous corrosions
16	Old Portuguese Church Site	The site is thought to have belonged to the Portuguese Church of Misericordia. In 1857, it was found by Richard Bulton and was being used as cattle shed.	-Top layer withering and tarnishing of roof iron sheets -Walls' paints discoloration and flaking -Visible superficial lesions -Funguses growth on walls and timber; timber decay -Corrosion of metallic bars -Presence of insects' invasions
17	Piggott Place	The place was named after an official of the Imperial British East Africa Company, Mr. Piggott. It was a market place.	-Tarnishing of paints -Visible fissures on walls -Plaster flaking
18	Reitz House	It was a Portuguese warehouse for Lieutenant Reitz. He was a British naval officer who took part against slave trade. He lived in the house until he died in 1824.	-Peeling off of plaster -Paints discoloration -Withering of masonry walls -Timber flaking -Iron sheets tarnishing
19	Swahili Cultural Centre	The center consists of two colonial buildings, which are currently used as a training facility for Swahili Cultural Craftsmanship. It attracts local and international tourists.	-Paints discoloration -Presence of insects on the soft grounds and floors
20	The Old Port / Government Square	It is the oldest port in Mombasa where the triangular-like dhows trade operated. It connected Mombasa and the Arabian Gulf through the Indian Ocean. It has enhanced the inventory of the history of dhows craftsmanship, a practice that is hitherto carried out.	-High water mark on sea bed due to frequent high-water levels -Disintegration of rocks on the dock and pier -Visible cracks on the hard concreted parts
21	The Old Post	The place was established in 1899 as the main post	-Dampness and collapse of ceiling boards

	Office	office, for the Indian railway construction workers to send money to their families in India.	-Decay of truss and balcony timber -Presence of fungus on timber and walls -Discoloration of wall paints -Tarnishing and waning of iron sheets -Presence of insects on soft grounds and concrete floors
22	The Sanaa Gallery	It belonged to a philanthropist Allidina Visram, an Ismaili merchant in around 1898. He successfully established commercial outlets in Kenya. His son Abdul Rasul later established Allidina Visram School in Mombasa as a monument for commemorating him.	-Discoloration of wall paints -Decay of truss and balcony timber -Presence of fungus on timber and walls -Visible superficial lesions -Disintegration of some plaster parts -Tarnishing and waning of iron sheets
23	The White House	The house was constructed in 19th Century and was rented by the Church Missionary Society for the unmarried missionary ladies. It later became the initial American Consulate in Mombasa.	-Discoloration of the white wall paints -Tarnishing of iron sheets -Withering of some wall's patches
24	The Treasury Square	It is a soft landscaped garden consisting of various tree species. It was opened in 1901 and consisted of Sir. William MacKinnon's statue; he lived between 1823 and 1893 and was a founder of British East Africa. After independence, the statue was removed. Around the square can be found some colonial-built style structures dating back to 18th Century, like the current municipal offices and the Kenya Commercial Bank.	-Invasion of insects on the grounds and on trees -Irregular and stunted growth of vegetation -Cracking of concreted floors -Great swaying of trees due to high wind speeds

Source: Author (2025).

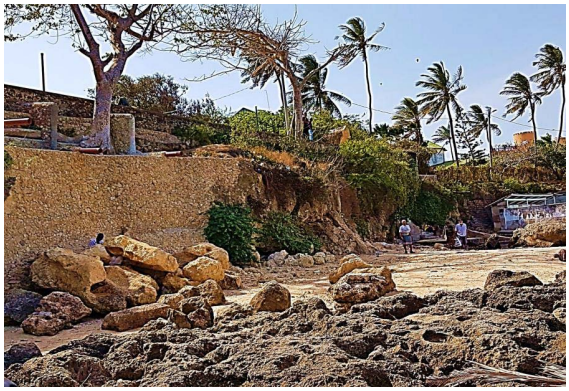
Figure 1 and Figure 2 illustrate the visible deterioration of buildings in Mombasa Old Town. Coral stone walls and limestone mortar plaster show extensive weathering, with flaking and discolored paint. Decorated surfaces are damaged, and ceilings and roofing are detaching. Timber elements, such as balconies, roof supports, window frames, and security bars, display decay and fungal growth.

Source: Author, 2024.

Figure 1. Building with flake walls.

Source: Author, 2024.

Figure 2. Building with detaching roof.



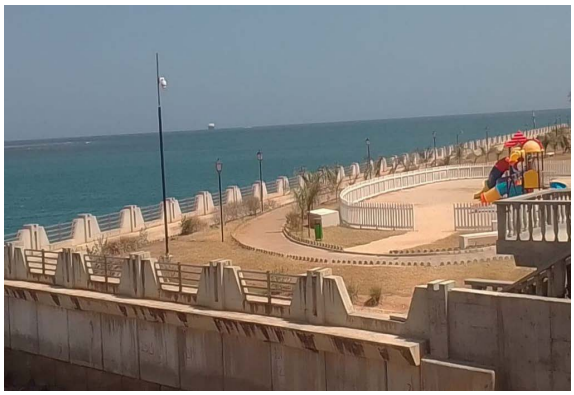
Source: Author, 2012.

Figure 3. The Fort Jesus Shoreline in 2012.

A 2012 **Figure 3** of Fort Jesus within MOT reveals significant deterioration along its sea-facing section, with rock disintegration, cliff slumping, and visible cracks containing salt crystals as a result of change of sea level rise and temperature variations. The rapid erosion of these cliffs poses a serious threat to the fort's foundations. In response, the Kenyan government, in collaboration with local and international organizations, constructed a protective barrier wall along the shoreline. The resulting area between the fort and the barrier has been transformed into a recreational space, as shown by **Figure 4**. This intervention has effectively created a buffer zone, preserving the authenticity and visual integrity of Fort Jesus against the encroaching ocean.

The Gede Ruins, a vestige of a 12th-century Swahili urban settlement situated within the Arabuko Sokoke Forest in Kilifi County, constitute a national monument under the stewardship of the National Museums of Kenya (NMK, 2024). Furthermore, this archaeological site is integrated within Kenya's UNESCO Tentative List as a component of the Sacred Mijikenda Kaya Forests. It holds significant economic, historical, socio-cultural, spiritual, and natural values (UNESCO

World Heritage Centre, 2023). Rebuilt in the 15th and 16th centuries, the ruins have suffered significant dilapidation, largely attributed to climate change, including a dwindling water table as evidenced by the deepened well near the Great Mosque. Walls have collapsed and disintegrated, with existing structures exhibiting major cracks. **Figure 5** shows a section of the ruins.



Source: Author, 2024.

Figure 4. Fort Jesus Shoreline in 2024.

Source: Author, 2025.

Figure 5. The Gede Ruins.

The coral-built Vasco da Gama Pillar is located in Malindi, Kilifi County. Erected in 1498 CE, the Vasco da Gama Pillar stands as an early European monument in East Africa. Commissioned by Portuguese explorers led by Vasco da Gama during his initial voyage to India, it served as a navigational marker and a symbolic representation of Portuguese presence in the region (NMK, 2023). As depicted in **Figure 6**, it exhibits several significant cracks, rock deterioration, and soil erosion. Insects are prevalent, and some have created dune-like formations. Visible renovations suggest previous structural damage to the pillar.

Jumba la Mtwana, an archaeological Kenyan National Monument since 1982 (NMK, 2023), is depicted in **Figure 7**. This historic site features a tomb, four mosques, and four distinct houses: the Great Mosque, the House of the Cylinder, the House of the Many Pools, and the House of the Kitchen. Climate change im-

pacts are evident in the deterioration of its structures, including soil and rock erosion, cracking, and wall disintegration, resulting in its ruined state. The site holds significant economic, historical, social, archaeological, and natural value.

Source: Author, 2023.

Figure 6. Vasco da Gama Pillar.

Source: Author, 2023.

Figure 7. Jumba La Mtwana.

5. Climate Change Factors Contributing to the Degradation of Kenyan Coastal Monuments

Salient findings from *in-situ* physical investigations into the material state and inherent vulnerabilities of Kenyan coastal monuments evince a pattern of extensive and accelerating degradations. Furthermore, insights gleaned from extant literature concerning the generalized influence of climate change effects on such degradations were corroborated by empirical data elicited from local respondents, encompassing both residents and subject matter experts. Consequently, this deterioration is predominantly attributable to the compounding impacts of anthropogenic climate change and pervasive environmental degradation as discussed below:

In Mombasa Old Town (MOT), edifices constructed with coralline and calcareous mortar manifest pervasive weathering, characterized by plaster delamina-

tion, chromatic alteration of applied coatings, and the progressive tarnishing of previously pristine surfaces. Ornate façades exhibit notable degradation, while overhead and roofing assemblies demonstrate detachment. Ligneous structural components, including cantilevered balconies, fascia boards, roof supports, and fenestration frames, display discernible decay, fungal proliferation, and, in certain instances, volumetric expansion, exfoliation, or complete structural failure. These deteriorations are compounded by the corrosive degradation of metallic reinforcement bars, superficial fissuring of upper wall surfaces, plaster exfoliation, and visible repainting interventions indicative of prior dilapidation.

This discernible degradation of edifices is inextricably linked to the escalating ramifications of anthropogenic climate change along the Kenyan coastline. The region's inherently warm and humid climatic regime has undergone exacerbation in recent periods, attributable to the inexorable ascent of global mean temperatures. This situation creates protracted periods of moisture exposure that catalyze the accelerated weathering of coralline and calcareous mortar. The lithological constituents, intrinsically porous and susceptible to environmental perturbations, exhibit marked vulnerability to salt crystallization and moisture retention. Moreover, the transgression of sea levels, coupled with the amplified aeolian transport of saline particulates inland, precipitates salt efflorescence within structural walls, culminating in plaster delamination, chromatic alteration of applied coatings, and the progressive tarnishing of previously pristine surfaces. Concomitantly, heightened atmospheric humidity and oscillating thermal amplitudes engender propitious microclimatic conditions for biodeterioration.

Ligneous structural elements, such as cantilevered balconies, fascia boards, and fenestration frames, succumb to protracted dampness, fostering fungal infestations, volumetric expansion, and eventual structural decay. The hygroscopic nature of these timber components facilitates moisture absorption, leading to internal material breakdown, warping, and, in extreme instances, complete disintegration. The detachment of overhead and roofing assemblies is similarly correlated with the attenuation of load-bearing materials under the cyclical stress induced by alternating hydric and desiccative phases, which instigates the progressive loosening of structural cohesion over temporal scales.

Furthermore, the corrosive degradation of metallic reinforcement bars is directly mediated by the elevated atmospheric salinity and augmented condensation on metallic interfaces. This phenomenon compromises the structural integrity of the masonry, contributing to the genesis of wall fissures, fractures, and insidious structural instability. Superficial cracking and plaster exfoliation serve as symptomatic indicators of protracted material fatigue, frequently exacerbated by recurrent exposure to torrential precipitation and potent coastal winds; both of which are exhibiting increased frequency and intensity under the aegis of evolving climatological paradigms.

Fort Jesus evinces critical structural compromise, particularly along its oceanic façade. The synergistic effects of eustatic sea-level rise and fluctuating thermal

amplitudes have instigated the accumulation of salty crystals within visible wall fissures, cliff slumping, and accelerated rocks disintegration, thereby jeopardizing the structural integrity of this UNESCO World Heritage site. The phenomenon of eustatic sea-level rise, a direct consequence of global thermal augmentation, has intensified hydrodynamic forces and saline water intrusion. This has precipitated the accretion of salt crystals within pre-existing wall fissures, thereby contributing to plaster exfoliation and a visible diminution of structural cohesion. Furthermore, the cyclical wetting and drying cycles engendered by fluctuating thermal amplitudes, another salient manifestation of climate change, exert significant stress on the constituent building materials, culminating in cliff slumping and an accelerated rate of rock disintegration along the fort's exposed maritime flank.

The Vasco da Gama Pillar exhibits structural fracturing, lithic decay, pedological erosion, and entomological infestation, with aeolian dune accretion around its base, indicative of prior damage and extant vulnerabilities. Equally, these deleterious environmental dynamics are analogously impacting this cultural heritage. The structural fracturing, lithic decay, and pedological erosion are being exacerbated by the increasing intensity of coastal winds and the variability of precipitation patterns, both demonstrably influenced by shifting climatological conditions. The accumulation of aeolian sand deposits at its base suggests an intensification of wind-driven erosion and subsequent sediment displacement. The elevated ambient temperatures and increased atmospheric humidity also foster entomological infestations that further compromise the monument's structural integrity and material stability.

Similarly, the Gede Ruins, an archaeological site, has undergone substantial structural degradation, characterized by collapsed walls, disintegrated coralline stone, and significant fracturing. A deepened well proximate to the Great Mosque signifies a declining phreatic surface. This is an indicator of shifting climatological patterns, reflecting prolonged periods of drought and inconsistent rainfall patterns. These hydroclimatic shifts weaken the underlying substrate and undermine the structural foundations of the site, contributing to the collapse of extant walls and the fracturing of the coralline stone fabric. The ruins, which once benefited from the relative stability of the forest's microclimate, now face heightened exposure to the vagaries of changing regional climatic patterns.

Correspondingly, Jumba la Mtwana is deteriorating due to erosional processes, pedo-logical instability, an increased prevalence of structural fracturing, and progressive walls disintegration, leaving key architectural elements such as its mosques and domestic structures in a state of ruin. Coastal erosion, driven by the synergistic effects of rising tidal levels and intensified seasonal precipitation, has destabilized the monument's structural materials. Moreover, fluctuations in ambient temperature have accelerated the degradation of its plaster and mural surfaces. The cumulative impact of these environmental stressors is the progressive ruin of its mosques and other architectural elements that once held significant historical and cultural values.

6. Conclusion: The Lacunae and the Urgent Imperative for Conservation Paradigm Shifts in Kenya's Coastal Monuments

This research concludes that climate change is significantly accelerating the degradation of Kenya's coastal monuments through the compounded effects of sea-level rise, extreme weather events, and ongoing environmental degradation. These impacts critically undermine the structural integrity of heritage sites, exposing the limitations of existing conservation frameworks. The findings underscore the urgent need to reform national policies by explicitly integrating cultural heritage conservation within broader climate resilience and adaptation strategies.

The analysis reveals that current policy and legislative responses are markedly inadequate, characterized by limited site-specific adaptation measures, underdeveloped early warning systems, and insufficient incorporation of scientific research and Indigenous knowledge systems. Effective conservation, therefore, necessitates a transition from reactive, isolated interventions toward proactive, multi-stakeholder, and interdisciplinary approaches.

A robust, multi-dimensional adaptation framework is essential, encompassing detailed risk assessments, inclusive community engagement, targeted capacity-building initiatives, and sustained monitoring protocols. Additionally, enhanced inter-agency coordination and the establishment of sustainable, dedicated funding mechanisms are critical to strengthening the resilience of heritage conservation efforts.

In conclusion, the preservation of Kenya's irreplaceable coastal monuments demands urgent, coordinated action that aligns cultural heritage protection with national climate resilience goals. By embracing integrated, inclusive, and forward-looking strategies, Kenya can mitigate the escalating risks posed by climate change and ensure the enduring protection of its invaluable coastal heritage.

7. A Framework for Climate Change Adaptation of Coastal Monuments: A Multi-Faceted Strategy for Resilience

Building upon the foundational elements of risk assessment, community engagement, and targeted adaptation, a comprehensive framework for adapting Kenya's coastal monuments to climate change must address the identified legislative and policy gaps.

Firstly, to bridge the planning deficit, the framework necessitates the development of site-specific Integrated Coastal Heritage Climate Adaptation Plans (ICHCAPs). These plans must be mandated by national policy and integrated into county-level development strategies to ensure legal enforceability. They should outline actionable strategies for each monument, informed by a robust risk assessment and data collection process, and must specify timelines, responsibilities, and key performance indicators (KPIs).

Secondly, the establishment of a National Coastal Heritage Climate Adaptation Task Force (NCHCATF) will address the current lack of inter-agency coordina-

tion. This task force will comprise representatives from national and county governments, heritage institutions, climate change agencies, and coastal zone management authorities. It will facilitate seamless collaboration and ensure alignment of policies and implementation strategies. It will also be empowered to create and enforce inter-agency agreements and monitor the implementation of adaptation initiatives.

Thirdly, to transition from reactive to proactive approaches, the framework advocates for the implementation of Climate-Based Heritage Impact Assessments (CBHIA) as a mandatory prerequisite for any development or conservation activity near coastal monuments. These assessments will employ predictive models and early warning systems to anticipate climate impacts, thereby informing preventive measures and long-term planning.

Fourthly, the creation of a National Coastal Heritage Climate Adaptation Fund (NCHCAF) will address financial and resource allocation gaps. This fund, supported by national budget allocations, international grants, and private sector contributions, will provide dedicated financial resources for adaptation projects. It will be governed by transparent criteria and procedures to ensure equitable distribution and efficient utilization. Additionally, the framework calls for the development of a National Strategy for Climate Change Adaptation Funding (NSCCAF) for cultural heritage, which will be incorporated into the National Climate Change Adaptation Plan (NCCAP).

Fifthly, to enhance the integration of scientific data and local knowledge, the framework proposes the establishment of a National Coastal Heritage Climate Data and Knowledge Hub. This hub will serve as a centralized repository for climate data, scientific research, and traditional knowledge, improving access for researchers, heritage managers, and community members alike. Furthermore, this integrated approach will support collaborative research initiatives and knowledge-sharing platforms. In situations where systematic scientific data collection is limited, local knowledge and observations will be crucial in filling critical information gaps, offering insights into past climate variability and its diverse impacts.

Sixthly, to strengthen enforcement and monitoring, the framework recommends the development of legally binding Performance Standards and Compliance Mechanisms (PSCM) for climate adaptation measures at coastal heritage sites. Regular audits conducted by independent experts will assess compliance and evaluate the effectiveness of adaptation strategies. Moreover, the creation of a publicly accessible Online Dashboard will enable real-time monitoring of progress and promote transparency. Strengthening legal penalties for non-compliance, alongside the development of a National Certification System for Heritage Professionals in climate change adaptation, is also essential.

Seventhly, the creation of Heritage-Based Livelihood Diversification Programs (HBLDPs) will address economic vulnerabilities in communities near coastal monuments. These initiatives connect heritage conservation with income-generating activities such as eco-tourism, traditional crafts, and guided tours. By train-

ing locals and involving them in the heritage economy, the program not only enhances financial stability but also fosters a strong sense of responsibility and care for heritage sites.

Additionally, the development of Public-Private Partnerships (PPPs) for Heritage Investment will enhance mobilization of financial and technical resources for heritage conservation. Offering incentives, such as tax breaks, branding opportunities, and land-use concessions, to companies investing in cultural heritage can drive sustainable private sector involvement. These partnerships can fund site upgrades, digital innovations, and adaptive reuse projects, with mechanisms in place to ensure that a portion of the profits is reinvested locally.

To resolve conflicting regulations and fragmented jurisdiction, the framework should introduce a Legislative Harmonization and Capacity Building Program (LHCBD). This program will align laws across key sectors, including heritage, environmental management, and urban planning, and provide capacity-building training for officials at both the county and national levels. Specialized training will ensure consistent policy interpretation and effective enforcement across governance structures.

Finally, the framework should support Decentralized Heritage Governance (DHG) by empowering county governments and establishing local heritage boards with greater autonomy in decision-making and budget allocation. In parallel, Policy Accountability Mechanisms (PAMs), such as public performance scorecards and local heritage oversight councils, should be introduced. These measures will increase transparency, foster political commitment, and reduce the risks of corruption or neglect in heritage protection.

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Ethics Statement

The authors confirm adherence to all ethical and regulatory protocols, including the acquisition of necessary permissions for research conduct and site access.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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