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Climate Risk Management in Cultural Heritage for Inclusive Adaptation Actions in Nigeria

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Abstract: Different regions around the world are experiencing climate risks, including increasing temperatures, rapid changes in rainfall patterns, loss of biodiversity and extreme weather events. Within the last decade, Nigeria has experienced a series of localised and regional drought and flooding events affecting not only arable farmlands but also cultural heritage, including heritage buildings and cultural landscapes. This study assesses climate-related risks affecting cultural heritage using the ABC risk assessment method to understand the impacts of key climate drivers. The assessment method was applied to five cultural heritage sites with different values and functions. The findings revealed that changes in precipitation and wind speed and direction induce most of the sudden-onset impacts, such as bushfires, flooding and physical collapse. A sense of community connection and attachment to the built heritage remain strong but there have been limited efforts to implement actions that address climate risks to the built heritage and its surrounding spaces. The output of the assessment contributes to risk prioritisation and informs decision making for developing the needed adaptive actions. The study demonstrates the need to leverage climate information collected by different national and international organisations not to only assess climate risks to heritage but also to improve the involvement of local communities and non-heritage professionals in developing adaptation actions for built heritage.

Keywords: climate hazard; community involvement; decision making; extreme weather events; heritage value; climate action

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1. Introduction

Built heritage in different locations around the world faces increasing threats from climate change, such as sea-level rise, extreme temperatures, precipitation changes and other extreme weather events. Previous studies have agreed on the need to assess the scope and manage the nature of climate risks to built heritage by identifying vulnerabilities to inform decision making, prioritisation and allocation of resources, adaptation planning, and initiation of community awareness and engagement strategies [1–3]. Climate risk management, in essence, involves integrating knowledge and information about climate-induced events into planning and decision making for adaptation to potential harm and/or loss [2,4]. Integrating climate risk management into conservation of built heritage requires understanding the trends of local climate and the characteristics of the built heritage. For example, aside from understanding the local climate scenario, site-specific information about the values, unique features and vulnerabilities of a heritage site is collected and analysed.

Different approaches to climate risk management have been implemented, from the identification and assessment of different forms of climate risks to the implementation of climate actions and decisions. Risk assessment mapping using Geographic Information Systems (GISs), for instance, was adopted by Rangel-Buitrago et al. [5] to evaluate risks affecting coastal areas in Cartegena City in Colombia, while Sesana et al. [6] interviewed academics and heritage professionals to assess the vulnerability of World Heritage Sites to climate change impacts in Europe. Scholars have adopted wide-ranging approaches and methods for the management of climate risks to cultural heritage due to factors such as the availability and quality of data, the nature and scope of the risks, and time and financial resources [7,8].

Climate change impacts on cultural heritage vary due to differences in geographical, meteorological and socio-economic factors. Heritage sites located in different geographical zones experience varying weather and climate conditions which are influenced by the presence of geographical features such as water bodies and mountains. Heritage sites in coastal areas are impacted by sea-level rise, ocean surges and coastal floods [9–11], while those in arid areas experience droughts, sandstorms and heatwaves [12,13]. Cultural heritage sites have always experienced loss of value due to natural causes (such as earthquakes and landslides), human activities, neglect and ignorance [14]. Causes of heritage deterioration can also be economic (such as construction development or inadequate funding), social (population growth and urbanisation) and institutional [15]. In certain instances, organisations managing heritage sites are not adequately equipped due to weak policies and regulations, lack of political willingness, and inadequate skilled tradesmen [16,17]. Studies agree that climate change both contributes to the creation of new threats (such as ocean surges and sea-level rise) as well as increasing the intensity of non-climate change threats [18,19]. In Nigeria, for instance, the impacts of localised flooding on heritage sites in the south are largely due to storm-surge river overflow, inefficient drainage systems and uncontrolled urbanisation, while in the north, Sokoto, Kaduna and Gusau are threatened by increasing desertification, droughts and sandstorms [20–22].

However, climate change threatens cultural heritage as well as exacerbating non-climate-related impacts, resulting in damage and eventual loss of heritage, history and connections. The 2022 State of Climate Report for Nigeria identified observed changes in temperature and rainfall as key climate drivers but did not highlight the impacts of changes in climate on different sectors [23]. Recent studies identified rapid soil erosion, intense flooding, insect attacks and extreme weather events as some of the impacts attributed to climate change that are affecting communities in Nigeria [14,24]. The current study investigates climate-related impacts at site level, taking into consideration microclimatic characteristics. In the next section, the methods adopted for the study and a detailed description of the values and microclimatic features of the heritage sites are discussed. Section 3 investigates the (i) values and attributes of the heritage sites, (ii) the climate risks affecting the sites and (iii) the adaptation actions that can be implemented to address the impacts.

2. Materials and Methods

The authors adopted a qualitative approach involving multiple case studies, field observations and stakeholder dialogue with heritage professionals, researchers, community leaders, and government and non-government organisations. An initial desk-based review of relevant reports and publications was undertaken to understand the histories and values of the selected heritage sites. A case study approach was adopted as it was considered most effective for understanding the vulnerabilities of cultural heritage to climate-induced impacts and deterioration [17,25–27].

2.1. Stakeholder Dialogue

Climate change is a global challenge requiring the inclusion and collaboration of various stakeholders. Insights from key studies revealed that conducting stakeholder dialogue for climate change adaptation enhances sense of responsibility and improves connection to the environment and the coordination and implementation of adaptation actions, as well as building resilience to climate change impacts [28,29]. Stakeholder dialogue also enables sharing of insights and perspectives, the co-production of knowledge and the creation of common goals in addressing climate change impacts, protecting values and shared connections with the heritage site. The stakeholder dialogue implemented included employees of government organisations managing the heritage sites, non-government organisations and community leaders (Figure 1). The participants in the stakeholder dialogue were selected based on (i) involvement in decision making and conservation of the heritage site and (ii) consent and availability to participate.

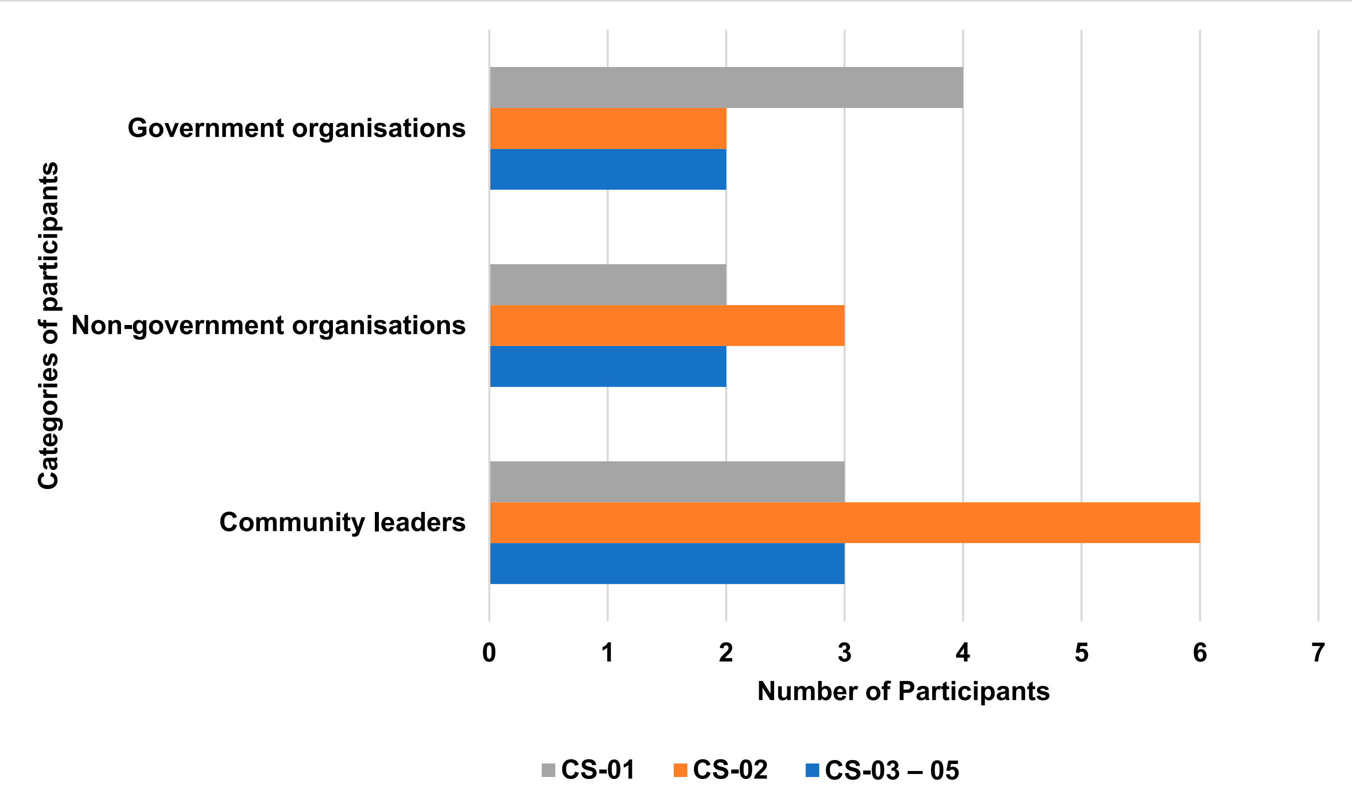

Figure 1. Participants in stakeholder dialogue in categories (prepared by the authors).

The research team facilitated the stakeholder dialogues and supported the participants to identify and prioritise key climate-related impacts, discuss potential actions and develop inclusive strategies for climate change adaptation. The stakeholder dialogue helped to demonstrate the possibility of integrating top-down and bottom-up pathways to address the challenges of climate change for cultural heritage in Nigeria compared to past interventions that have been largely top-down and government-driven.

2.2. Risk Analysis

As noted by McIntyre-Tamwoy [19] and Adetunji et al. [30], management of climate risks to cultural heritage requires the involvement of non-government stakeholders and local community members not only to address the risks but also to build a sense of responsibility and empower local communities to participate in climate action. Participatory approaches to climate risk management are recommended in different studies, such as Masini et al.'s [31] and Hall et al.'s [32], but, in many cases, community members are not involved at the inception of planning the interventions. The emerging literature on managing climate risks to cultural heritage recommends adopting approaches that are easy to implement and understandable to members of local communities [33,34]. However, experts in heritage and climate adaptation can contribute to the development and implementation of adaptive actions and strategies as co-producers with the local community [35]. The co-production of actions for climate adaptation between local communities and experts helps in leveraging the specialised knowledge of the experts in understanding the science of climate change and assessing the risks and vulnerability, while local community members provide the local knowledge needed to develop inclusive adaptation actions. Collaboration between local community and experts provides valuable insights for policymakers and government organisations in developing evidence-based policies to address the impacts of present and future changes in climate on cultural heritage [36,37].

To analyse climate risk to cultural heritage, approaches adopted by scholars range from requiring highly complex to basic-level technical skills. Krus and Seidler [38], for instance, adopted a modelling approach to address intense mould growth which is attributed to climate change, while McClelland et al. [39] and Daly [40] implemented value-based approaches to assess climate risk and vulnerability and raise public awareness to climate change impacts on cultural heritage. A recent review by Adetunji and MacKee [8] classified 22 different approaches into three groups: Group 1 approaches integrate heritage as part of the broad multi-sectoral scope for assessing climate risk, Group 2 approaches are specifically developed for heritage, while Group 3 approaches are developed for other sectors, such as agriculture and infrastructure development, but are adaptable to include heritage [8,41]. The present study considered approaches in Group 2, which include CRiSTAL (the Community-based Risk Screening Tool—Adaptation and Livelihoods), ABCCH (the ABC Risk Management Approach in Cultural Heritage) and CVI (the Climate Vulnerability Index).

CRiSTAL is characterised as community-based and helps local communities to identify and prioritise climate risks, focusing on improving adaptation and livelihoods [42], but it has been largely adopted as a planning tool for risk management interventions. While CRiSTAL does not provide ways to assess climate risk, it helps local communities to (i) understand the interconnectivities between livelihood and climate risks, (ii) evaluate the implications of climate actions and (iii) support the monitoring and evaluation of adaptation actions [41]. CVI, on the other hand, is a tool for assessing the vulnerability of the local community and outstanding universal values (OUVs) of world heritage [43]. It was developed at James Cook University (Australia) in 2020 and has been implemented at sites in several countries. Recently, the Climate Vulnerability Index [44] was applied at Sukur Cultural Landscape, a world heritage site, to assess and prioritise climate risks to inform decision making on adaptive actions to improve preparedness and resilience. The approach, as implemented by Megarry et al. [45] and Jones et al. [46], requires the use of climate models and risk matrices which require a high-level of climate literacy and technical skill to apply.

The ABC risk management method was developed—a modification of Robert Waller's Cultural Property Risk Analysis Model (CPRAM)—in 2016 by the Canadian Conservation Institute (CCI) and ICCROM to support decision making in managing risks and deterioration processes in museums. The method has been adapted to manage risks affecting other forms of heritage. For instance, Paolini et al. [47] adapted the ABC risk assessment method to manage natural and human-induced risks affecting Petra World Heritage Sites in Jordan, and Previtali et al. [48] utilised the ABC risk management method to assess the magnitude of water-related risks affecting San Clemente Church in Albenga (Italy). The ABCCH approach (Figure 2) is a heritage-centred, inclusive and comprehensive decision-making method that includes stakeholders in creating an understanding of the context of the cultural heritage in order to identify, analyse, evaluate and treat risks [8,49]. As with the CVI, ABCCH enables assessment of risks using basic-level technical skills that are available to local communities and non-climate experts [49]. ABCCH, through the integration of risk vulnerability and likelihood and active inclusion of local community members, offers an alternative to risk modelling and the use of geospatial analysis tools, which require high-level technical capacities. ABCCH offers an integrated view of climate risks affecting cultural heritage using easy-to-understand steps, simple mathematical processes, spatial maps and a transparent ranking procedure [47]. CVI also addresses the vulnerability of heritage to climate risks but not the likelihood of the risks occurring. Crowley et al. [50] advise the adoption of a climate risk assessment method that allows active participation of local community members to address the top-down approaches that are prevalent in managing climate risks to heritage. These characteristics of ABCCH made it ideal for the current study, enabling maximum inclusion and active participation of non-climate experts and members of local communities in all phases of the process, i.e., from the planning to the monitoring and evaluation phases.

Figure 2. Systematic process of implementing ABCCH, which is an adaptation of the ABC risk management method for preservation of cultural heritage developed by Michalski and Pedersoli [49].

ABCCH was adopted in the current study in five case studies to (i) identify and assess climate risks and (ii) develop adaptation actions. The approach was implemented with experts as co-producers with members of local communities with connections to the case studies. The role of the experts included facilitating the dialogue, knowledge sharing and integration of scientific knowledge during the stakeholder forum. The involvement of local community members contributed to the integration of local knowledge during the stakeholder forum to understand the values and attributes of the heritage sites.

The climate risks were quantified using data collected in maps, charts and tables about the climate and weather patterns of Lagos State. While the climate data were insufficient to understand the impacts on the cultural heritage sites, local knowledge about the values and attributes of the heritage sites was collected to understand the trends in changes in values and the social, economic and environmental context. Relevant documents, such as conservation reports and historical images of the heritage sites, were also collected and analysed to understand the possible sources of hazards, contributing factors influencing climate risks and past changes to the heritage sites. The risks were further quantified into MR (magnitude of risk) as an aggregate of three component scores (Equation (1)): (i) Component A (frequency of event), (ii) Component B (fraction of value lost due to the event) and (iii) Component C (percentage of the attribute affected by the event). Here, attributes refer to the features of the heritage site affected by the event, for instance, an event of insect infestation might affect ceilings (attribute) at a heritage site. The risks were further evaluated and compared using the ABC scales developed by Pedersoli Jr. et al. [51] to quantify the frequency of risk occurrence and the expected loss in value for the heritage (Table 1). The component scores were determined through collective discussion by the participants. The processes adopted for the component scoring were:

i Development of a list of climate-related impacts on the heritage site with a detailed description of the impacts to the participants;
ii Identification of the attributes of the heritage sites that are affected by the impacts;
iii Identification of the climate drivers influencing the impacts;
iv Collective dialogue on questions and quantification of the component scores using Table 1:
- For Component score A, how often does the impact occur?
- For Component score B, how much value is lost/affected by the impact?
- For Component C, what is the percentage of the attributes that are affected by the impacts?;

v Calculation of the MR value using Equation (1) and prioritisation of the impacts using Table 2 for adaptation action.

$$MR = \text{Component A} + \text{Component B} + \text{Component C} \quad (1)$$

Table 1. Quantification of Component A, B and C scores.

A-Score	Frequency of Event	B-Score	Fraction of Value Lost due to the Event	C-Score	Percentage of Attribute Affected by the Event
5.00	Less than 1 year	5.00	Up to the entire value	5.00	Up to 100%
4.50	More than 1 year to 3 years	4.50	Up to $\frac{3}{10}$th of the entire value	4.50	Up to 30%
4.00	More than 3 to 10 years	4.00	Up to $\frac{1}{10}$th of the entire value	4.00	Up to 10%
3.50	More than 10 to 30 years	3.50	Up to $\frac{3}{100}$th of the entire value	3.50	Up to 3%
3.00	More than 30 to 100 years	3.00	Up to $\frac{1}{100}$th of the entire value	3.00	Up to 1%
2.50	More than 100 to 300 years	2.50	Up to $\frac{3}{1000}$th of the entire value	2.50	Up to 0.3%
2.00	More than 300 to 1000 years	2.00	Up to $\frac{1}{1000}$th of the entire value	2.00	Up to 0.1%
1.50	More than 1000 to 3000 years	1.50	Up to $\frac{3}{10,000}$th of the entire value	1.50	Up to 0.03%
1.00	More than 3000 to 10,000 years	1.00	Up to $\frac{1}{10,000}$th of the entire value	1.00	Up to 0.01%
0.50	More than 10,000 years	0.50	Up to $\frac{3}{100,000}$th of the entire value	0.50	Up to 0.003%

Source: Adapted from Pedersoli Jr., Antomarchi and Michalski [51] and Michalski and Pedersoli [49].

During the stakeholder dialogue, participants responded to questions (Table 2) for each component, and where there was no consensus, the experts provided more insights about the risk to support collective agreement about the component score for the risk. For instance, the participants' responses were split about the fraction of the values of Christ Church Cathedral in Marina affected by mould growth. At this stage, the experts provided more insight into factors influencing mould growth and the difficulties in addressing the risk. The additional insights helped the participants to agree that up to $\frac{1}{100}$th of the entire value is affected by mould growth. The risks were further prioritised for decision making by comparing the magnitude of the risk (MR) score for each of the risks (Table 2). Catastrophic risks were considered as highest priority requiring immediate actions, while medium and low-priority risks were considered as just beyond acceptable and acceptable respectively.

Table 2. Risk prioritisation scale.

MR-Value	Level of Priority	Expected Loss of Value to the Heritage Asset
15.00 14.50 14.00 13.50	Catastrophic priority—All or most of the heritage asset value is likely to be lost in a few years	Up to 100% in 1 year Up to 30% per year Up to 10% per year = 100% in 10 years Up to 3% per year = 30% every 10 years
13.00 12.50 12.00 11.50	Extreme priority—Significant damage to the heritage asset, or total loss of a significant fraction of the heritage asset, is possible in approximately one decade. All or most of the heritage asset value can be lost in one century	10% every 10 years = 100% in 100 years 3% every 10 years = 30% every 100 years 1% every 10 years = 10% every 100 years 0.3% every 10 years = 3% every 100 years
11.00 10.50 10.00 9.50	High priority—Significant loss of value to a small fraction of the heritage asset, or a small loss of value in most or a significant fraction of the heritage asset in one century	1% every 100 years 0.3% every 100 years 0.1% every 100 years = 1% every 1000 years 0.03% every 100 years = 0.3% every 1000 years
9.00 8.50 8.00 7.50	Medium priority—Small damage or loss of value to the heritage asset over many centuries. Significant loss to a significant fraction of the heritage asset over many millennia	0.1% every 1000 years = 1% every 10,000 years 0.01% every 1000 years = 0.1% every 10,000 years
7.00 6.50 6.00 5.50 5.00	Low priority (7 and below)—Minimal or insignificant damage or loss of value to the heritage asset over many millennia	0.001% every 1000 years = 0.01% every 10,000 years 0.0001% every 1000 years = 0.001% every 10,000 years 0.00001% every 1000 years = 0.001% every 10,000 years

Source: Adapted from Pedersoli Jr., Antomarchi and Michalski [51].

2.3. Study Area

To assess climate risks and develop adaptation actions, five cultural heritage properties listed on the Nigeria heritage register were selected based on four criteria (Table 3): Criterion 1 (condition of the materials and components), Criterion 2 (involvement of local community in conservation), Criterion 3 (ownership/custodianship of the heritage site) and Criterion 4 (age, rarity and history).

Table 3. Selected cultural heritage sites.

Case Study	Description	Geographical Location		Criterion 1	Criterion 2	Criterion 3	Criterion 4
		Latitude	Longitude	Condition of Materials and Components	Involvement of Local Community in Conservation	Ownership/ Custodianship	Age, Rarity and History
CS-01	The National Theatre Complex in Iganmu (Figure 3)	6.476447	3.369542	A modern architectural masterpiece built with concrete, sandcrete bricks, aluminium sheets for flat roofing, and glass for windows, doors and some parts of the walls	Local community members are not involved in conservation intervention, but trade unions, such as RATTAWU [1], AGN [2] and SNA [3], may be involved in a minimal way	Fully owned and managed by the national government	Built in 1973, a building of national significance and historical influence, a unique building in the whole of Nigeria
CS-02	Christ Church Cathedral in Marina (Figure 4)	6.450903	3.390203	Late 18th century European Gothic architecture, built with white marble, concrete, sandcrete plaster, stained glass, oak wood and aluminium sheets for gable roofing	Conservation interventions are implemented by the community of parishioners with minimal funding support from Lagos State Government	Fully owned and managed by the Anglican Diocese of Lagos	Construction started on 29 March 1867, and it was dedicated in 1869, the oldest Anglican cathedral in Nigeria, significant to colonial history in Nigeria

Table 3. *Cont.*

Case Study	Description	Geographical Location		Criterion 1	Criterion 2	Criterion 3	Criterion 4
		Latitude	Longitude	Condition of Materials and Components	Involvement of Local Community in Conservation	Ownership/ Custodianship	Age, Rarity and History
CS-03	First two-floor building in Nigeria, Badagry (Figure 5)	6.412228	2.887158	Brazilian-style residential building, built with sandcrete-plastered mud brick walls and aluminium sheets for gable roofing	Local community members and parishioners of Anglican Churches in Badagry are involved in the conservation	Fully owned and managed by the Anglican Church in Badagry	Constructed by Anglican missionaries led by Reverend C.A. Gollmer in 1845, significant to slave history and the experiences of slave returnees
CS-04	Brazilian Barracoon Museum, Badagry (Figure 6)	6.413631	2.879853	Residential building built with cells for captured slaves, built with adobe bricks with sandcrete plastering	Conservation interventions carried out by the family members of Seriki Abass William receive support from the national government, the building having been declared a national monument	Fully owned by the family members of Seriki Abass William	Built in the early 1840s, contains relics, artefacts and handwritten documents of Chief Seriki Abass William, a former slave turned merchant
CS-05	Gberefu Island (Figures 7 and 8)	6.393896	2.879551	Open area with symbols representing the last point for the slaves before boarding the merchant ships and the attenuation well, the source of water where slaves were made to drink their final water before heading onto the merchant ship	Conservation interventions are carried out with support from the national and Lagos State Government	Owned by the local community	Opened in 1473 during the trans-Atlantic slave trade, significant to the history and experiences of the slave trade

Source: Prepared by the authors. [1] Radio, Television, Theatre and Arts Workers' Union of Nigeria. [2] Actors Guild of Nigeria. [3] Society of Nigeria Artists.

Case Study 1 ("CS-01") (the National Theatre Complex in Iganmu) is located within a network of roads connecting various parts of Lagos, at the centre of the Orile-Iganmu, Abule-nla and Ebute-meta areas of Lagos (Figure 9). CS-01 was built between 1973 and 1975 as an exemplar centre (Figure 3), not only for culture and art activities but as a symbol of peace and unity in Nigeria, a country emerging from civil war [52]. The architectural morphology of the theatre complex was adapted from the Palace of Culture and Sports in Varna, Bulgaria, and was built by Technoexportstroy, a Bulgarian Contractor and Consulting Company [53]. The theatre complex built with concrete, sandcrete bricks and aluminium sheets and has a 5000-seat main hall equipped with a collapsible stage, five break-out rooms, four entrances (Gates A–D), a 500-car basement car park and parking for more than 2000 cars outdoors (Table 3). Other facilities within the theatre complex include a banquet hall, a V.I.P. lounge, a press conference hall and a roof garden [54]. The activities hosted within the theatre complex include cultural festivals, marriage ceremonies, stage plays, cultural and artistic exhibitions, films and shows.

Case Study 2 ("CS-02") (the Cathedral Church of Christ in Marina) was designed by the architect Began Benjamin. Its foundation was laid by the Prince of Wales, later King Edward V of England, in November 1924, and it was completed in 1946 (Figure 4). The Cathedral, of late 18th century European Gothic style, is located at the intersection of Marina and Odunlami Streets on Lagos Island, Nigeria (Table 3). It was the first cathedral building in Nigeria and is listed on the heritage lists of the Federal Government of Nigeria, as well as that of Lagos State. The Cathedral embodies the rich and peculiar history of Christianity in Nigeria and the influence of Gothic architecture on the early church buildings. It is located within the dense commercial area of Lagos and is bounded by the Church House and the Niger House in the east and west, respectively.

Figure 3. Aerial view of the National Theatre Complex in Iganmu. Source: Photograph taken by the authors.

Figure 4. Perspective view of Christ Church Cathedral in Marina. Source: Photograph taken by the authors.

Case Studies 3–5 ("CS-03, CS-04 and CS-05") are components of the trans-Atlantic slave heritage sites in Badagry, a rapidly growing community in southwest Nigeria (Figures 5–8). Badagry is located close to the border areas between Nigeria and the Republic of Benin. In the 1660s, the community served as a transit port during the trans-Atlantic slave trade for about 350 years. During this period, approximately 12.4 million Africans were forcibly transported to various parts of the world (Table 3). The Badagry community was founded around 1425. It was dominated by the Egun ethnic group [56] and reputed for its salt trade before starting slave trading in the 1660s, which then lasted for about two hundred years. In the compilation for the Badagry Festival (year unknown), Mesewaku [57] reveals that the expedition of the European slave traders led by George Freemingo, a Portuguese slave merchant, landed at Badagry around the 1660s and practised slave trading in conjunction with slave traders from other countries. CS-03 is claimed to be the first two-floor building in Nigeria built as a Brazilian-style residence used by the early church missionaries in

Badagry from Sierra Leone (Figure 5). CS-04 was built by Late Seriki Abass William, a slave returnee turned slave merchant for residential and slave confinement purposes until the abolishment of the slave trade (Figure 6). The dual-purpose building has 40-room barracoons, temporary holding places for captured slaves. CS-05 is a historic island which was the last place for the captured slaves before boarding slave merchant ships to leave Africa (Figures 7 and 8). An attenuation well is also located on the island, where the slaves were made to drink water before embarking on a 1 km trek with chains and shackles to the Point-of-No-Return [57].

The selected cultural heritage sites are managed partly or entirely by the government (federal and state). CS-01, for instance, is managed entirely by the National Theatre Agency, which is part of the Federal Government, while CS-02 is managed largely by the parishioners of the Anglican Communion, though with support from the Lagos State Government (Table 3). The three heritage sites in Badagry are owned by the local communities, but agencies of federal and state governments are involved in their conservation and protection.

Figure 5. First two-floor building in Nigeria, located in Badagry. Source: Photograph taken by the authors.

Figure 6. Brazilian Barracoon Museum in Badagry. Source: Photograph taken by the authors.

Figure 7. Attenuation well on Gberefu Island. Source: Photograph taken by the authors.

Figure 8. Gberefu Island with remodelled tourist attraction. Source: Photograph taken by the authors.

The case studies are located in Lagos, a state associated with a tropical savanna climate (Figure 10) characterised by tropical wet and dry seasons [58]. The mean annual rainfall is about 1200 mm or below, while the monthly mean temperatures for daytime and night-time are 33 °C and 22 °C, respectively. In 2022, Lagos recorded an average incident of solar radiation of 160–210 W/m^2 per day largely due to the influence of the Atlantic Ocean and other water bodies within and around the state. The weather conditions in Lagos are also influenced by the air masses from the southwest and northeast, with an annual rainfall period of 7–9 months [59]. The annual temperature is moderately stable with minimal variations, which are a result of the location of Lagos being close to the equator. Based on historic climatic readings, February is the hottest month, with a peak temperature of 33 °C on average. The humidity is relatively high, with an average of 80% per month.

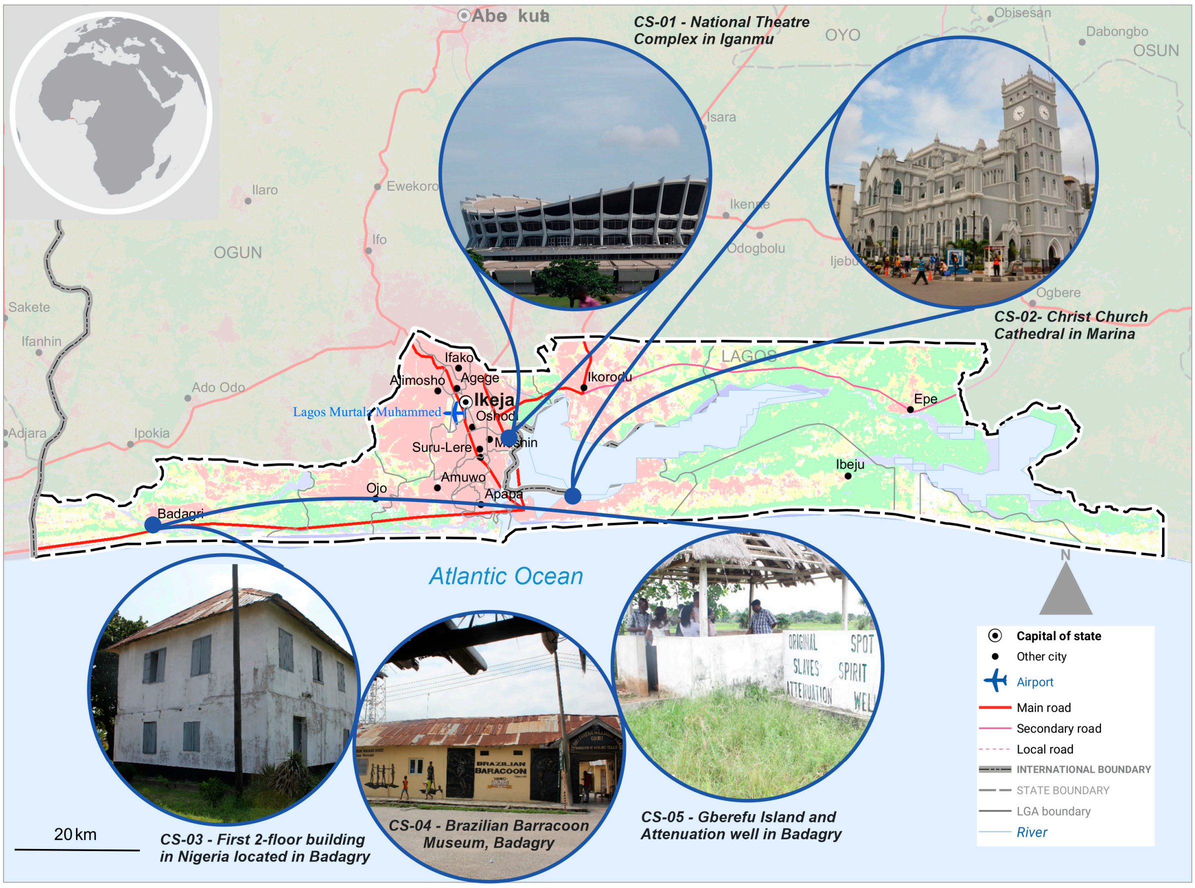

Figure 9. Map of Lagos showing selected cultural heritage sites with insets of the National Theatre Complex in Iganmu (CS-01); Christ Church Cathedral (CS-02); the first two-floor building in Nigeria, Badagry (CS-03); the Brazilian Barracoon Museum in Badagry (CS-04); and Gberefu Island with its attenuation well (CS-05) (prepared by the authors; map of Lagos underlay sourced from [55]).

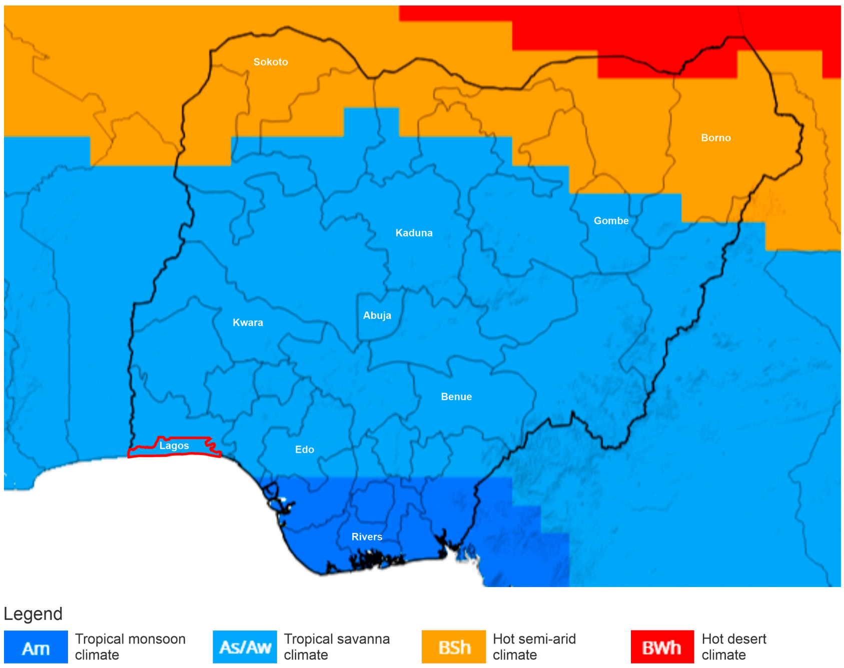

Figure 10. Koppen–Geiger climate classification for Nigeria showing the location of Lagos (in red boundary) in the tropical savanna climate zone [60].

3. Results

3.1. Step 1—Establish the Context

In Step 1, we examined the (i) actors and stakeholders involved with shared responsibility of care for the heritage sites, (ii) policies and regulations influencing conservation of the heritage sites, (iii) microclimatic conditions of the heritage sites and (iv) values and attributes of the heritage sites. The values assigned to heritage by individuals and communities define their attachment to the place, sense of responsibility and ownership [61].

Table 4 describes the key values defined for the case studies during the stakeholder dialogue. The sense of belonging and connection to the heritage sites through which they are connected to experiences of past generations was described by the participants as priceless and unique. One participant reflected that:

> ". . .the theatre complex houses lots of priceless treasures of renowned artists and sculptors such as Fakeye, Grillo and other past carvers and sculptors" (Participant CS1-06, a renowned artist and poet in Nigeria)

Moreover, the values attributed to the heritage sites were categorised into 10 themes: age and history, authenticity and symbolism, educational, use and function, culture and identity, architectural, environmental, aesthetics, and religious (Table 4). The influence of the heritage sites on social, economic and environmental livelihood within the local communities, however, transcends individuals and community groups within the local communities to include people outside the communities, especially students from academic institutions. A theatre art professional recounted that:

> ". . .while in the university, around 1992/1993, I was involved directly with the National Theatre, as part of the cast for a play titled 'The Importance of being Earnest' directed by Prof. Sola Fosudo. It is going to be very difficult for me to forget that experience. Acting on [the stage in the theatre complex] had a [positive] impact on me" (Participant CS1-11)

Furthermore, the values and connections are related to tangible and intangible attributes of the heritage sites. For instance, the participants often mentioned different spaces, materials, forms and shapes, design styles, functions, locations and construction techniques adopted for the sites. One participant, who is an indigenous resident of Badagry, noted that:

> ". . .my relationship with the slave heritage sites (CS 03–05) in Badagry dated to my childhood days, about 40 years ago. The compound (CS-03) is known for the small holding cells built for 40 captured slaves" (Participants CS3-03)

The heritage sites are places of attraction for tourists from within and outside Nigeria. The participants agreed that tourists visit to experience the ambience and beauty of the heritage sites. However, tourists' visitation to the sites may generate some form of dissonance and provoke intense emotions and discomfort, especially among descendants of survivors of the trans-Atlantic slave trade. One of the tour operators in Badagry recounts his experience while guiding tourists through the slave heritage sites:

> ". . .three tourists—a Brazilian black girl and a European man with his daughter visited the heritage sites in 2018, when the Brazilian girl set her eyes on the European man [and his daughter], she started accusing him that they [Europeans] were the ones that enslaved them and [asked] what are they doing here. But I as the tour guide, had to educate the tourists on the purpose of the heritage sites and the need to [encourage remission, restitution and peaceful coexistence across races, ethnicity, regions and countries]" (Participant CS3-01)

Table 4. Values of five national monuments in Nigeria.

	Categories of Key Values	Description of Values
CS-01—The National Theatre Complex in Iganmu	Age and History	• Age and year that the theatre building was constructed • Historical legacy of the building with Festival of Arts and Culture (FESTAC) hosted in 1977 • Historical items and materials archived within the building • Represents the identity and conveys the histories of Nigerian communities
	Authenticity and Symbolism	• Materials used in the construction of the theatre building • Unique and iconic view within its environment • Symbolism of the building of unity and peace in Nigeria • Represents a symbol of Nigerian architecture
	Educational	• An educational place to learn and acquire local knowledge
	Use	• Capacity of the main hall, collapsible stage and auditorium • Events and activities that the building is used for, e.g., musical concerts, dramas, exhibitions etc. • Use of the building by government agencies, such as the National Gallery of Art, National Council for Arts and Culture etc. • A place for hosting cultural and art events • Ancillary spaces within the theatre building, such as restaurants, art and craft shops etc.
	Economic	• Promotion of cultural and creative development in Nigeria • Ability to generate revenue and job creation
	Cultural and Identity	• Promotion of a sense of identity and community • Promotion of cultural festivities of different ethnic groups in Nigeria
	Architectural	• Size and shape of the openings (doors, windows etc.) • Shape and form of the theatre building • The type and style of the roof • Quality of the surrounding environment, including the park chairs, garden and the statue • Construction technology and techniques exhibited by the building • Facilities and equipment within the building
	Environmental	• Surrounding environment used for recreation purposes • Location of National Theatre building
	Aesthetic	• Aesthetic quality of the building • Artistic works and ornamentations on the theatre building • Beauty of the interior spaces
CS-02—Christ Church Cathedral in Marina	Aesthetics	• Aesthetic quality of the cathedral building • Artistic works and ornamentations on the cathedral building • Beauty of the interior spaces
	Authenticity	• Finishes and style of the external walls • Finishes and style of the internal walls • Finishes and style of the pews and the interior features • Materials used in the construction of the cathedral building • Historical materials archived within the building, such as the cenotaph for late Rev. Dr Samuel Ajayi Crowther • Unique and iconic view within its environment
	Religious	• Being the headquarters of the Anglican Communion of Nigeria • Symbolism and meanings the building portrays relating to sacredness and crucifixion in Christianity • Promotion of spiritual festivities of Christianity in Nigeria
	Architectural	• Size and shape of the openings (doors, windows etc.) • Shape and form of the cathedral building • The type and style of the roof • Construction technology and techniques exhibited by the building • Facilities and equipment within the building

Table 4. *Cont.*

	Categories of Key Values	Description of Values
CS-02—Christ Church Cathedral in Marina	Historical and Identity	• Age and year that the cathedral building was constructed • Represents the identity and conveys histories of the Anglican communion in Nigeria • Promotion of a sense of identity and community • Represents a symbol of early church architecture in Nigeria
	Educational	• An educational place to learn and acquire local knowledge
	Environmental	• Quality of the surrounding environment • Location of Cathedral Church of Christ
	Uses and function	• Capacity of the main auditorium in the cathedral • Events and activities that the building is used for, e.g., Church services, Holy Communion etc. • Ancillary spaces within the cathedral building, such as chapel, chancel, pulpit • Surrounding environment is used for religious and recreational purposes
	Economic	• Ability to generate revenue and job creation • Promotion of cultural and creative development in Nigeria
CS-03-05—Slave Heritage Sites in Badagry	Age	• Age and year that the museum building was constructed
	Authenticity and cultural	• Materials used in the construction of the museum building • Historical items and materials archived within the building, such as slave chains • Unique and iconic view within its environment • Promotion of cultural festivities of the ethnic groups in Badagry, Nigeria
	Historical and identity	• Historical legacy of the building with the slave trade in Nigeria • Represents the identity and conveys colonial histories of Nigerians • Promotion of a sense of identity and community • Represents a symbol of colonial architecture in Nigeria • Symbolism of the building to colonisation, freedom and independence of Nigeria
	Economic	• Ability to generate revenue and job creation • Promotion of cultural and creative development in Badagry and Nigeria as a whole
	Aesthetic	• Aesthetic quality of the building • Artistic works and ornamentations on the museum building • Beauty of the interior spaces
	Educational	• Construction technology and techniques exhibited by the building • An educational place for learning and acquisition of historical knowledge
	Environmental	• Quality of the surrounding environment • Location of Badagry Heritage Museum
	Use	• Capacity of the exhibition spaces • Events and activities that the building is used for, e.g., exhibitions, tourist tours etc. • A place for hosting culture and art events • Ancillary spaces within the museum building, such as restaurants, art and craft shops etc. • Surrounding environment used for recreation purposes
	Architectural	• Size and shape of the openings (doors, windows etc.) • Shape and form of the museum building • The type and style of the roof • Facilities and equipment within the building

Source: Prepared by the authors.

The connections between the values, attributes, actors and stakeholders involved in the conservation and management of the heritage sites were mapped (Figure 11). The connections highlight how heritage changes over time due to alterations in ownership, policy and environmental conditions. Climate change, for instance, contributes to the intensification of flooding events in Lagos, resulting in partially or wholly destroyed heritage sites and ensuing changes in the values and attributes. Participants further revealed that changes in values and attributes of heritage are largely caused by poor conservation practices, deterioration of aesthetic features, inadequate awareness, loss of community interests, policy instability and disregard for art and culture, lack of sustainable planning, and insecurity.

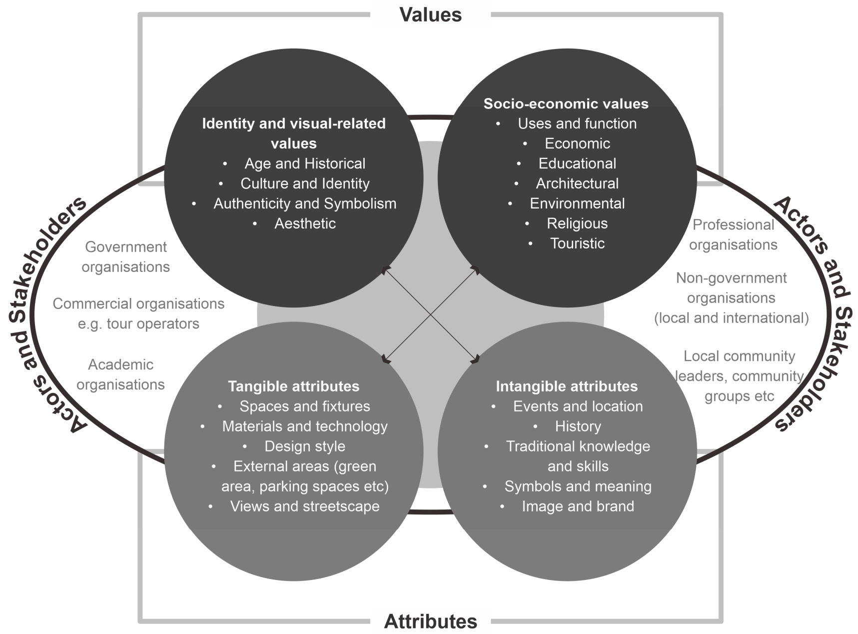

Figure 11. Connections between values, attributes and actors and stakeholders (prepared by the authors).

3.2. Step 2—Identify Climate Risk

The effects of climate change are varied and challenging to predict due to the increase in frequent weather events and the multiple interactions of different values which need to be protected. Perception of impacts resulting from climate change can depend on individual perspectives, making it difficult to anticipate which changes will result in the loss of valued cultural assets [62]. This explains why participants generally find it harder to identify and interpret the impacts. In Step 2, we identified the (i) climate-related impacts affecting the values and attributes of the heritage sites, (ii) key climate drivers for the risks and (iii) impacts based on frequency of occurrence and speed of impact.

Overall, we identified changes in temperature, precipitation and wind as the key drivers of the climate-related impacts on the heritage sites. For CS-01, we identified 11 climate-related impacts, including flooding, rainwater intrusion and subsidence, affecting the values and attributes of the heritage sites (Figure 12). Some impacts, such as the destabilisation of foundations and rising damp, were classified as slow-onset, while rainwater intrusion and partial/whole collapse were regarded as sudden-onset impacts. Four participants reflected that:

> "...parts of the art works on the theatre complex are affected especially when there is strong wind" (Participant CS1-01, an employee working in the theatre complex) "...whenever there is heavy rain or wind, the [theatre] complex needs to be checked to know the parts that were affected" (Participant CS1-06, a renowned artist and poet in Nigeria) "...The premises experiences flooding because the rain is heavier nowadays ..... exacerbated because of blocked drainages and reclaimed quality of the land" (Participant CS1-03, a community leader in Iganmu) "...the surrounding environment of the National Theatre is facing immense impact from the ocean causing flooding and lots of damage" (Participant CS1-05, a volunteer for an NGO involved in conservation of heritage sites)

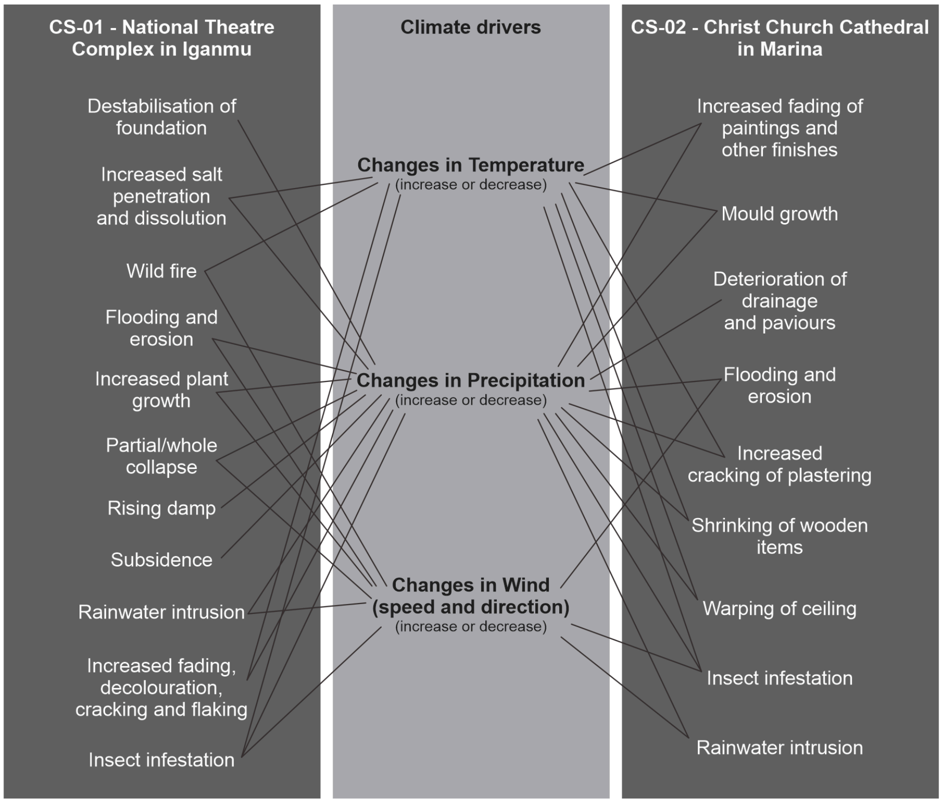

Figure 12. Cumulative physical impacts for CS-01 and CS-02 induced by climate drivers (prepared by the authors).

The participants also identified nine climate-related risks affecting the values and attributes of CS-02, including mould growth, increased cracking of plaster and warping of the ceiling (Figure 12). All the climate-related impacts, except rainwater intrusion, were classified as slow-onset. Two participants revealed that:

> "...the cathedral experiences light flooding as a result of the surrounding areas becoming waterlogged and it lasts for 4–6 h after rainfall" (Participant CS2-07, a director-level employee working in the theatre complex) "this [flooding] is a common issue affecting lots of the neighbouring communities" (Participant CS2-11, a community leader in Marina)

The climate-related impacts affecting slave heritage sites (CS-03–05) in Badagry are similar to those of CS-01 and CS-02, but CS-05 is affected by coastal erosion, ocean surges and heavier storms due to its closeness to the Atlantic Ocean and Lagos Lagoon. The participants recounted their experience during the 2021 and 2022 flooding events, where many farmlands, houses and other properties were exposed to long periods of intense rainfall. Two participants who are community leaders in Badagry explained that:

> "...Badagry is facing intense disaster whenever the ocean overflows. Also, many buildings are affected due to the materials used in building them" (Participant CS3-01) "...when rain falls, everybody feels the impacts. You have to be on your knees because there is a high tendency for water to flood the buildings and destroy our farmlands" (Participant CS3-05)

3.3. Step 3—Analyse Climate Risk

To understand how climate hazards affect cultural heritage, it is vital to quantify the risks within the context of the heritage sites, considering the frequency and likelihood of exposure and the impact on the values and attributes, thereby enabling prioritisation for decision making. In Step 3, we quantified the component scores for each of the risks

(Component scores A, B, C and MR), informed by the regional climate information for temperature, precipitation and wind.

In Lagos, daily rainfall continues to be extreme, ranging from 151.2 to 186.2 mm, with many areas, including Marina, Lagos Island and Badagry, experiencing intense flooding and windstorms [23]. Temperatures also vary depending on the seasons; in 2022, the temperature during the dry season was 0.7–0.9 °C higher than in the previous year, while temperature during the rainy season also increased by 1.7 °C (Figure 13).

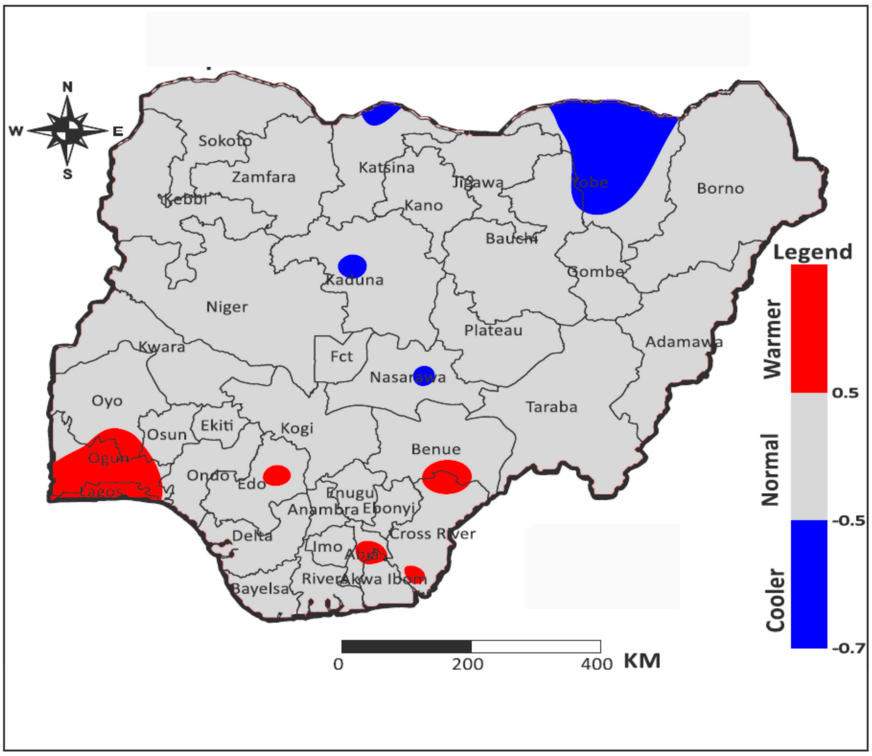

Figure 13. Annual mean maximum temperature for 2022 with departure from 1991–2020 (adapted from [23]).

Furthermore, the component scores revealed that wildfires, flooding and erosion, rainwater intrusion, and destabilisation of foundations are of high priority for the protection of values and attributes of the heritage sites, while insect infestation and cracking of plastering have the lowest priority (Figure 14). Participants generally agreed that values and attributes of the heritage sites are threatened by climate-related risks associated with potential loss of traditional knowledge, memory, identity and connections.

Participants also agreed that walls, windows, doors (especially external doors), roofs and foundations were attributes of the heritage sites that were most at risk. Interestingly, four participants added that cultural skills and practices, traditions, and knowledge systems were being lost due to the continuous impacts of climate-related risks. Two participants highlighted that:

> "…lots of the windows are either deteriorated or have fallen off the openings due to strong wind or rain" (Participant CS3-02, a heritage site manager) "…we experience this often during the wet season due to the wetness of the wooden windows making the management to contemplate changing into other types of windows" (Participant CS3-06, an employee of a heritage organisation)

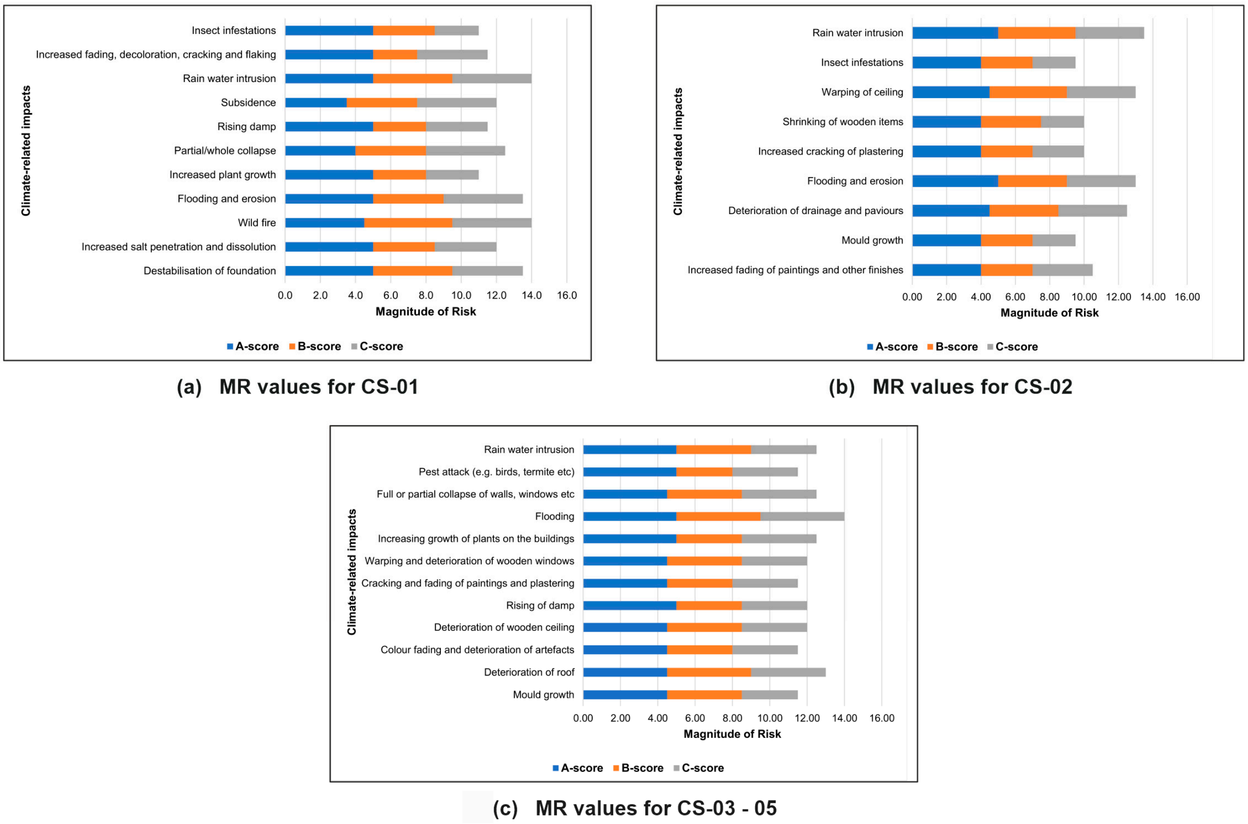

Figure 14. Magnitude of risk values for CS-01–05 (prepared by the authors).

3.4. Step 4—Evaluate Climate Risk

To determine adaptation actions needed to address the risks, we compared the impacts using a prioritisation scale (Table 2). CS-01, for instance, is affected by wildfires and insect infestations, which were determined as catastrophic and a high priority for adaptation action, respectively. The risks affecting CS-01–05 were ranked in the top three levels (catastrophic, extreme and high) of priority (Figure 15), indicating that all the risks are potentially of great concern, requiring immediate adaptation actions, while the risks affecting the slave heritage sites (CS-03–05) were ranked as of extreme priority, except for flooding.

Two participants, however, agreed that the impacts of the risks on CS-01 and the slave heritage sites (CS-03–05) are immense due to years of neglect, poor conservation practices and inadequate funding by the government organisations managing the sites. While the rate of occurrence of the impacts varies, both participants reflected that:

> "...this is a great risk facing the historical buildings because the materials are old and have not been appropriately repaired" (Participant C3-01, a volunteer with an NGO involved in heritage management) "...the roof of the first two-floor building (CS-03) was changed in 2017 but has deteriorated making conservation of the historic building costly" (Participant C3-04, a religious leader in Badagry)

Participants also agreed that wildfires and partial/whole collapse occur rarely, but the extent of loss of heritage value is enormous. In contrast, flooding and erosion, warping of ceilings and rising damp are common events affecting the heritage sites (Figure 16). Other participants added that increased plant growth and cracking of plastering are cumulative events that occur continuously for years. Concerning CS-01, two participants noted that:

> "... flooding is very common and has contributed to various disasters affecting the theatre complex (CS-01)" (Participant C1-05) "... the main challenge affecting Onikan, Ebute-metta, Apapa and other neighbouring communities is flooding because those areas are wetland" (Participant C1-08)

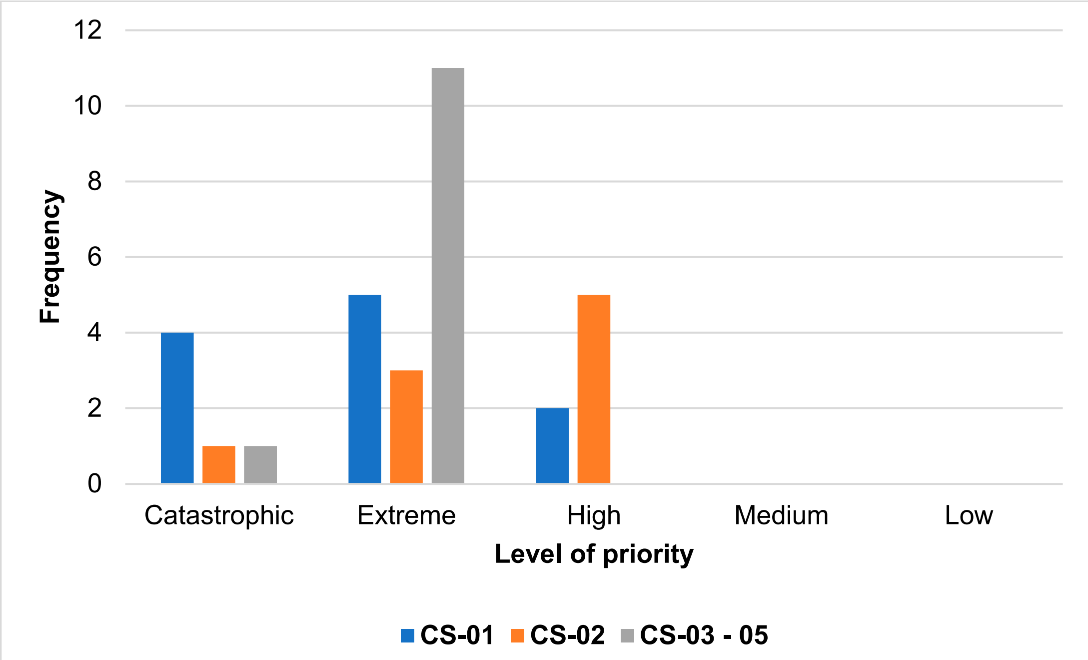

Figure 15. Prioritisation of risks for adaptation actions (prepared by the authors).

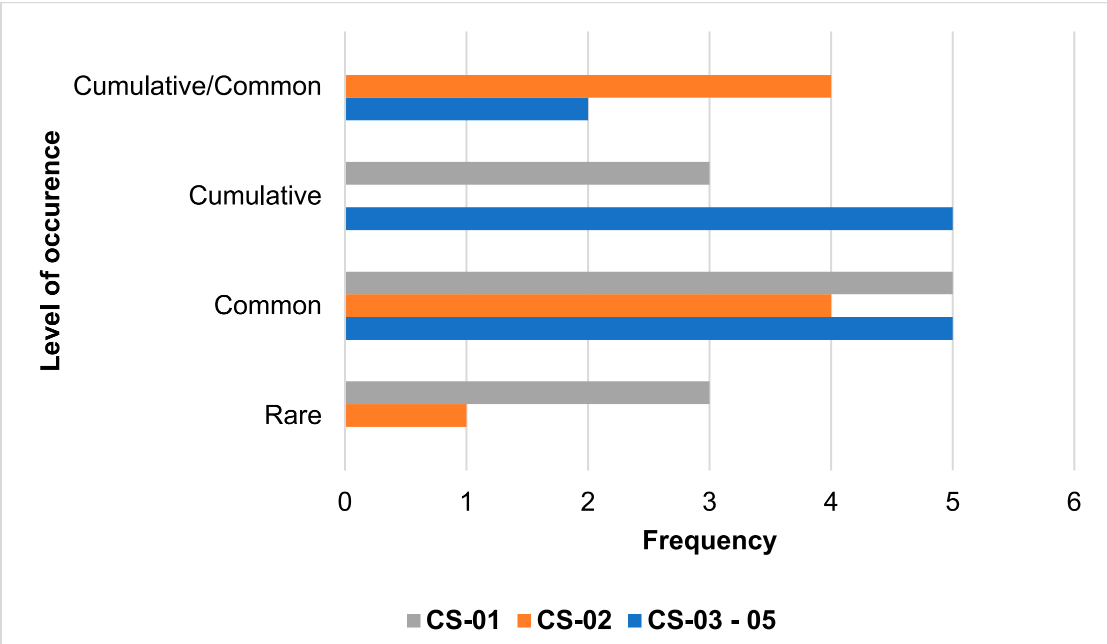

Figure 16. Occurrence of risks affecting heritage sites (prepared by the authors).

However, increased fading of paintings and other finishes, mould growth, deterioration of drainage and paviours, and shrinking of wooden items were regarded as cumulative and common events affecting CS-02. A participant who is a religious leader noted that:

> "... light flooding is common within the cathedral while heavy flooding is common within the neighbourhood" (Participant C2-11)

3.5. Step 5—Treat Climate Risk

By evaluating the risks, we were able to understand the vulnerability of the heritage sites and, as a result, to develop appropriate strategies for conservation and protection. Treating climate-related risks to cultural heritage goes beyond maintaining the tangible heritage to include the intangible aspects of the heritage, such as traditional knowledge, beliefs, practices and connections. Addressing climate risks affecting cultural heritage is vital to preserving the values and attributes of the heritage as well as for enhancing the sustainability and resilience of communities [63,64]. The risks can be treated by a combination of strategies relating to policy and governance, design and construction techniques, building maintenance and land care, public education and awareness, and integration of cultural heritage into climate policy and initiatives (Table 5).

Table 5. Strategies for treating climate-related risks to cultural heritage.

Categories	Adaptation Actions and Strategies
Building maintenance and land care	- Shore up foundation base to resist shakes and settlement - Implement traditional and innovative surface treatments on walls and other external surfaces - Use of climate-resistant materials - Install functional fire emergency equipment and continuous maintenance of the equipment - Repair deteriorated paviours and drainages - Install embankments, retaining walls and seawalls around nearby water bodies - Removal of root systems of trees and shrubs growing in unwanted places, e.g., roof gutters, etc. - Implement passive treatment techniques for salt damage - Prompt repair of damaged parts of heritage sites, sewers and drainages - Installation of protective frames around vulnerable sides of heritage sites - Insertion of damp-proof courses into heritage buildings - Installing water-redirection pavements around external walls - Reconstruction of sewers and drainages for intense water run-off - Installation of ceiling ventilators to keep the ceilings dry - Installation of protective glazing and screens for the windows - Prompt cleaning of stained glass using appropriate cleaning agents - Installation of roof insulation - Ensuring roofs are well-drained - Use of well-seasoned timber to replace deteriorated wooden windows - Control of clay and silt deposits around coastal areas - Proper monitoring of climate and pest colonies
Policy and governance	- Develop and implement conservation plans to preserve and promote the heritage sites - Develop and implement a fire management plan - Implementation of holistic conservation plans for the sites
Early warning and indoor environment monitoring systems	- Introduce early warning systems for weather changes, floods and storms - Installation of active systems to monitor indoor environmental quality
Material selection	- Use of climate-resistant plastering materials - Use of mould-resistant products - Use of climate-resistant finishes on walls and artefacts
Use of nature-based strategies and traditional knowledge	- Introduction of traditional methods of controlling growth of weeds and other pests - Strategic planting of trees to serve as wind breakers - Repair and nourishment of coastal areas around the water bodies with native trees and shrubs - Implementation of traditional means of preservation of wood

Source: Prepared by the authors.

Participants also emphasised the importance of adopting digital preservation for heritage, not only to document the values and attributes but also to improve the access, usability and interpretation of the history and the meaning of the heritage. Moreover, treating climate risks to cultural heritage requires the development and implementation of heritage policies to regulate the activities of stakeholders and support interorganisational and interdisciplinary collaboration. A participant who is a community leader in Badagry highlighted the significance of the heritage site to the socio-economic livelihoods of the communities, noting that:

"...over years, the community was responsible for the protection of the slave heritage sites because many people depend on the sites for their livelihood" (Participant C3-05)

Other participants, especially those from Badagry, also argued that government organisations involved in managing the heritage sites have been reactive to climate risks threatening the site. However, participants connected to CS-02 established the importance of community ownership of heritage, noting that:

"...the cathedral (CS-02) is maintained by the parishioners with minimal support from the government, especially the Lagos State Government. However, the federal government nominated the cathedral (CS-02) as a national monument with no plan to support its conservation" (Participant C2-04)

Table 5 shows the adaptation actions and strategies discussed by the participants to address the identified climate-related impacts. CS-01, a cultural heritage site located in the tropical savanna climate zone is affected by the destabilisation of foundations causing the destruction of walls, perimeter fences and pedestrian walkways in different parts of the site. To address the impacts, participants agreed that the perimeter fences and external walls should be shored up using retaining walls, stabilisation of the underlining soil and repair of deteriorated portions of the pedestrian walkways. The participants connected the wetland nature of Iganmu and neighbouring communities to the intensity of flooding, subsidence, and salt penetration and dissolution. It is therefore advisable to maintain CS-01 using materials that are climate-resilient and adapted appropriately to corrosion and salt damage.

CS-02, a historic cathedral with various wooden artefacts, is exposed to insect infestation, mould growth, shrinking and warping. Therefore, the participants agreed that the indoor climate needs to be monitored and controlled to prevent mould growth and enhance thermal comfort. Two participants who are part of the parishioners' leadership revealed that poor access to power is a key challenge to the installation of active environmental monitoring systems. However, one participant noted that ventilation within the interior spaces can be improved using operable windows and openings. The slave heritage sites in Badagry (CS-03–05) are affected by coastal storms and surges causing deposition of clay around the sites, termite attacks and destruction of the plumbing systems. The participants, therefore, agreed on the development and implementation of a holistic conservation management plan for the slave heritage sites. A participant noted that:

"...the slave heritage sites have been neglected for a long time by the federal and state governments, no regular maintenance of the sites causing lots of the walls, roofs and ceiling to be destroyed and looting of the slave relics within the sites is increasing as well" (Participant C3-02, a community leader in Badagry)

Prioritisation for adaptation actions was determined using the risk prioritisation scale (Table 2), indicating that the impacts were to be treated by implementing the adaptation actions and strategies to avoid, block, detect and respond to them and recover the heritage sites [51]. Factors increasing the intensity of the impacts can be avoided through the installation of early warning systems to monitor changes in weather conditions and inform heritage managers to protect the sites against extreme and catastrophic impacts, such as flooding and wildfires. Also, factors influencing the climate-related impacts can be blocked from affecting the heritage sites. Examples of actions to block the climate-related impacts include shoring up the wall foundations of the heritage sites, the erection of protective frames around vulnerable parts of the sites and the installation of water-proof roof insulation. Moreover, slow-onset factors (such as increases in indoor temperature and humidity influencing the shrinkage of wooden items and warping of ceilings) can be detected in other to implement actions in response. For instance, an increase in humidity can be detected quickly using indoor environment monitoring systems, which would allow heritage managers to improve ventilation rates and maintain humidity at appropriate levels. Dealing with climate-related risks is complex, however, and not all risks can be avoided or prevented from occurring [33,65]. Therefore, to reduce the negative consequences of climate-related impacts, heritage managers also need to be prepared to recover heritage from loss and damage. Heritage sites affected by climate-related impacts can be recovered by reconstructing the destroyed attributes, digital documentation of the heritage sites, and collecting community stories and narratives about destroyed sites to preserve the experiences and connections of community members with respect to the sites.

4. Discussion

Climate change poses a significant threat to Nigeria's cultural heritage, highlighting the importance of inclusive adaptation actions and effective climate risk management strategies. The values and attributes of cultural heritage that are vulnerable to climate risk are also of immeasurable significance to the social, economic and environmental livelihoods of communities [41]. Across the five case studies, it is evident that communities are motivated to participate in managing climate risks affecting cultural heritage but require the specialised knowledge and insights of heritage and climate experts to do so [8,33,66]. Engaging experts in interventions for climate change adaptation ensures that strategies are based on verified and current scientific evidence and that actions are tailored to key challenges and opportunities.

This study demonstrates the co-production of climate change adaptation actions from Step 1 (establish the context) to Step 5 (treat the climate risk) by not only providing a platform for local stakeholders to participate but also by creating a supportive environment for collaboration between government, policymakers, experts (heritage and climate), non-government organisations and community members. The stakeholders were an integral component of the process as holders of local knowledge on the heritage and its environment. Involving local communities in climate adaptation interventions also addresses the challenges to equity and power imbalance between government and non-government stakeholders. Over the past decades, conservation of cultural heritage and addressing the impacts of climate change, especially in developing countries, has largely been government-driven with limited involvement of local communities [35], resulting in a disconnection between the stakeholders. Involving local stakeholders in climate change adaptation intervention may require more resources and time but can help to mobilise political will and community awareness for the intervention.

While collaborating with local actors and stakeholders to understand the context of the heritage sites, we came to realise that awareness about the values and significance of heritage is often limited. Many members of the local communities also have insufficient understanding of climate change and its impacts, making it difficult to recognise the need for adaptation and active engagement in adaptation action [63,67]. The local communities generally have limited access to scientific knowledge about climate change and human, financial and technical resources, reducing their ability to effectively participate in adaptation interventions.

In addressing the challenges, we relied on participating in community meetings and social events to engage with local community members to understand their connections with the heritage and experience of climate change impacts. Heritage embodies traditional practices and knowledge transferred across generations connected to different attributes of heritage sites. While heritage values and attributes are interconnected, Christoff [68] noted that climate change threatens the sense of responsibility of communities to care for the heritage. We, therefore, identified the values connected to attributes such as spaces, features, location, events, age and history. For instance, the authenticity and symbolism of CS-01 are derived from the materials used for the walls and roof, the building's form and the external finishes. The current study revealed that the social, cultural, environmental and economic significance of the heritage sites are being affected by changes in temperature, precipitation and wind, which are the key climate drivers. Climate change impacts have intensified, causing the subsidence, deterioration of roofs, walls and ceilings, and partial or total collapse of heritage sites [54,69]. Findings indicate that the impacts stem from changes in the climate drivers resulting in rare (occurring less often, about once in 100 years), common (occurring many times in 100 years) or cumulative (occurring intermittently for years) events [49]. Additionally, van der Geest and van den Berg [70] noted that climate change impacts may occur suddenly (sudden-onset) or gradually (slow-onset). Examples of sudden-onset impacts include wildfires and collapse of heritage sites, while mould growth and rising damp are regarded as slow-onset. Gradual changes are described as lasting, progressive, manageable and less destructive, while sudden events are brief, intense, highly destructive and beyond control [71].

Brown, Dayal and del Rio [29] suggest that slow-onset events can be addressed by taking measures and implementing conservation techniques, while sudden-onset events may require the installation of early warning systems and the construction of retaining walls. To determine the appropriate adaptation action, it is vital to prioritise climate risks and develop targeted adaptation actions and strategies. By identifying and prioritising the most pressing climate risks, policymakers and key stakeholders can allocate resources and efforts to address the climate risks that may cause immense damage or loss to the heritage and the community. Findings revealed that destabilisation of foundations and rainwater intrusion are rare events but cause catastrophic impacts to heritage, while insect infestations and mould growth are common events causing high impacts. Other common events, such as warping of ceilings, shrinking of wooden items and cracking of plaster, occur gradually, resulting in extreme adverse impacts on the values and attributes of heritage sites. Therefore, it may be beneficial to protect heritage against rare events with catastrophic impacts rather than using up the available resources to address common events with low or medium impacts.

5. Conclusions

Climate change presents risks to cultural heritage sites worldwide, including those in Nigeria. These sites hold value in terms of culture, history and archaeology. Addressing these risks necessitates the implementation of climate risk management strategies that prioritise inclusive adaptation actions in Nigeria. Such strategies should involve cooperation between agencies, local communities and international organisations to create policies and initiatives that safeguard and preserve heritage amidst the challenges posed by climate change. By incorporating traditional knowledge and practices, adaptation actions may be rooted in the wisdom of the past while effectively addressing the threats presented by a changing climate. It is also crucial to prioritise the involvement of local community members and stakeholders because they possess valuable insights that can inform adaptation measures.

Additionally, it is important to co-produce adaptation actions with heritage and climate experts in analysing potential approaches to address climate risk, enhance resilience and strengthen adaptive capacity. To summarise, managing climate risks associated with heritage for inclusive adaptation actions in Nigeria demands an interdisciplinary approach to include local communities while incorporating traditional knowledge. The ABC method adopted in the study allows the engagement of members of local communities in climate risk management without the complexities of integrating advanced technical skills that may be difficult for local communities to acquire. Climate adaptation requires integrated planning and holistic consideration of all forms of climate risk and inclusion of researchers, community members, policymakers and other stakeholders. Inclusive planning offers a multifaceted view and consideration of the social, economic and environmental dimensions of climate risks. Incorporating indigenous knowledge and practices enhances the inclusiveness and effectiveness of climate change adaptation at the community level as well as improving intergenerational knowledge transfer [14].

This process will not only safeguard cultural heritage sites but also contribute to the resilience of local communities, ensuring a sustainable future. It is crucial to adopt climate risk management strategies for protecting and preserving sites in the face of climate change impacts. Such strategies should be based on an understanding of how climate change affects heritage, including vulnerabilities, as well as available options for adaptation. Managing climate risks to cultural heritage through inclusive adaptation actions will contribute significantly to safeguarding historical assets from the effects of climate change. This will ensure their long-term sustainability for the benefit of future generations.

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