Open Access

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

Adaptation to Climate Change and the Financial/Technical Feasibility of Conservation in Heritage Buildings: A Nexus of Ideological Divergence in Post-Flood Disaster Reconstruction

Amadi Alolote Ibim

Department of Quantity Surveying, Rivers State University, Port Harcourt, Nigeria

amadialolote@yahoo.com

Article Information

Manuscript Received 2024-12-05
Manuscript Revised 2024-12-31
Manuscript Accepted 2024-12-31
Manuscript Online 2025-01-01

ABSTRACT

Reconstruction following climate change induced disasters is often required after possible destruction of the built heritage. Achieving greater disaster resilience and reducing disaster risk due to climate change requires that such reconstruction must be balanced with financial and technical feasibility while conserving the historic character of the heritage building. The 'Build-Back-Better' mantra is mostly embraced during disaster induced reconstruction, and seeks to build safer and more resilient structures, to reduce pre-disaster vulnerabilities. The 'Build-Back-Better' approach assumes that there were vulnerabilities within the pre-disaster built environments that need to be rectified during reconstruction to enhance resilience. As such, achieving building conservation and climate adaptation during reconstruction might at first glance appear completely divergent. Conservation mostly focuses on maintaining the fabric of a place in its existing state, while adaptation may require updating/altering the components of an existing building. However, a more thorough understanding may lead to the conclusion that there is a convergence. This is because the conservation of the built heritage should contribute to resilience, in many ways similar to adaptation, especially in the context of post-disaster recovery. A divergence will result in a fairly unprecedented exposure to natural hazards triggered by climate change, and amplify the performance deficiencies, in terms of functional, technological and normative obsolescence. A convergence is needed due to the increasing requirements of safety, well-being and accessibility of the historic and architectural values, whose conservation is sought. Flooding is the most widely spread climate change induced disaster that affects the built environment globally. This study highlights how heritage conservation can techno-economically align with the resilience agenda, to ensure financial feasibility during reconstruction following flood disasters induced by climate change.

Keywords: *Adaptation, Building Conservation, Climate Change; Disaster, Flooding, Reconstruction, Resilience*

1. INTRODUCTION

The term "weather" as commonly used refers to the short-term (daily) changes in temperature, wind, and/or precipitation of a region [1]. Weather is influenced by the Sun. The Sun heats the Earth's atmosphere and its surface, causing air and water to move around the planet [2]. Weather is thus the patterns in set of meteorological conditions such as wind, rain, snow, sunshine, temperature, etc., at a particular time and place [3, 4]. By contrast, the term climate describes the overall long-term characteristics of the weather experienced at a place. The climate, therefore, can be thought of as a long-term summary of weather conditions, taking account of the average conditions as well as the variability of these conditions [5, 6].

The Earth's weather and climate has varied considerably in the past, as shown by the geological evidence of ice ages and sea level changes over many hundreds of years [6]. The causes of past changes are not always clear but are generally known to be related to changes in ocean currents, solar activity, volcanic eruptions, and other natural factors. The difference now is that global temperatures have risen unusually rapidly over the last few decades [4]. There is strong evidence of an increase in average global air and ocean temperatures, widespread melting of snow and ice, and rising of average global sea levels. The real threat of climate change thus lies in how rapidly the weather change now occurs, with evidence suggesting further future increases in mean global temperature [7].

Climate change is a change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e., decades to millions of years). Climate change may refer to a change in average weather conditions, or in the time variation of weather around longer-term average conditions (i.e., more or fewer extreme weather events). Climate change is caused by factors such

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

as biotic processes, variations in solar radiation received by Earth, plate tectonics, and volcanic eruptions. Global climate change is a change in the long-term weather patterns that characterize the regions of the world [8]. Certain human activities have however been identified as primary causes of ongoing climate change, often referred to as global warming. Climate change can thus be defined climate change as "*the change in climate that can be attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*".

Climate change and variability have implications for disasters. Increase in the severity of extreme disasters such as droughts and floods, cold and heat waves, hurricanes, tropical storms, etc. have all been linked to climate change. An increase in aerosols (atmospheric pollutants) is due to emission of greenhouse gases (GHGs) such as CFCs, HCFCs, HFCs and PFCs [9]. Among the GHGs, CO2 is the predominant gas leading to global warming as it traps long-wave radiation and emits it back to the Earth's surface causing global warming. Such changes in surface air temperature has adverse impact on rainfall. Ozone depletion and UV-B-filtered radiation, associated with global warming are further exacerbated by deforestation and loss of wet lands. The loss of forest cover, which normally intercepts rainfall and allows it to be absorbed by the soil, causes precipitation to erode top soil, causing floods and erosion. Paradoxically, a lack of trees also exacerbates drought in dry years by making the soil dry more quickly. Climate change has thus had significant implications for the occurrence of disasters [10].

Climate has now become a matter of global concern, transcending national boundaries, with several international bodies, treaties and gatherings seeking to address this menace. Such notable efforts and policies typically include the Rio Declaration, the Montreal Protocol, the United Nations Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Paris Agreement and the Annual Conventions of the Parties to the UNFCCC**.** The Rio Declaration is one major outcome of the Earth Summit, which recognised the right of states to economic and social development, but following the well-known precautionary, which states that lack of full scientific certainty (of cause or effects) should not be used as a reason for inaction, so long as that action is proportionate and the costs and benefits of action versus inaction have been evaluated [11]. The Montreal Protocol was an international agreement facilitated by UNEP, which sought to protect the ozone layer by phasing out the production and consumption of Ozone layer-depleting substances such as CFCs, HCFCs and HFCs. It was agreed upon in 1987 and came into force in 1989. The United Nations Framework Convention on Climate Change (UNFCCC) is the UN process for negotiating an agreement to limit climate change and was adopted in 1992. The convention was focused on anthropogenically induced climate, aimed at preventing dangerous human interferences with the global climate system. The Kyoto Protocol was an extension of the 1992 UNFCCC and was the first legally binding international treaty that required industrialized countries to reduce emissions by 5%. The EU committed to an 8% reduction [12]. It was adopted in 1997 and initially signed by 83 parties, including countries and regional economic integration organisations. It came into force in 2005. The Paris Agreement, replaced the Kyoto Protocol, as it only covered 18% of global emissions. The Paris Agreement was drafted in 2015, and signed in 2016 by 55 UNFCCC countries at the COP21 held in Paris, and covers climate change mitigation, adaptation via the adoption of Nationally Determined Contributions (NDCs) and financing mechanisms. It seeks to minimise the increases in global warming to below 1.5^0C. The Annual Conventions of the Parties to the UNFCCC commonly referred to as COP, are important events, which present opportunities for international collaboration on climate change. The most recent event is the COP29, which is the 29^{th} annual conference, and like its predecessors, seeks to address the Paris Agreement, including efforts to limit global warming and adapt to the impact of climate change [13].

Resilience is in the built environment is needed to compliment global efforts and adapt to the impact of climate change, particularly in post disaster reconstruction that may be unavoidably induced. Resilience refers to the capability of a system, a community or a society exposed to hazards to mitigate, resist, change and recover from the effects in a timely and efficient manner, by keeping its functions and structures [11]. The need for resilience in the face of climate change has gained traction, with increasing attention within the international debate, at institutional, scientific and technical levels**.** This is against the backdrop that for decades, the discourse in disaster risk management (DRM) centered predominantly on reactive measures to disasters [12]. In more recent times, a focus on preemptive measures and preparedness for natural disasters has taken center stage. A paradigm shift has resulted in a focus on vulnerability reduction, disaster preparedness, and hazard mitigation, as opposed to post-disaster relief and management [13]. This is underpinned by the rationalization/theories of DRM that a significant portion of disasters is not unexpected, and therefore the impacts of disasters can be minimized. An emergent theme recurring is the concept of built-in resilience. It is thus an underlying philosophy that to achieve resilience in the built environment, there is a need to learn from the history of past disaster occurrences. Globally, property-level structural adaptation is now considered key to building resilience to climate change related disasters [14]. Achieving structural adaption/mitigation requires that buildings are physically strengthened and protected to withstand hazards, based on their level of exposure or vulnerability. This requires designing new buildings to be less vulnerable as well as reconstructing existing structures to be more resilient. Achieving resilience in post-disaster reconstruction is thus considered a key climate change adaption strategy in the built environment [15]. Against this backdrop, this study highlights how heritage conservation can techno-economically align with the resilience agenda, to ensure

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

financial feasibility during reconstruction particularly following flood disasters induced by climate change.

2. RESEARCH SIGNIFICANCE

The need for the study is pivoted on the irreplaceability of cultural heritage, and the established fact that disasters can disrupt people's cultures, identities, and livelihoods in irreversible ways. Cultural heritage conservation is important in post-disaster management because it can help safeguard a community's identity and resilience, and it can also help with reconstruction: Cultural heritage is a core part of a community's identity, and disasters due to climate change can destroy centuries of it in a short time. Cultural heritage can be a keystone for rebuilding and building resilience to disasters.

The issue of the economic feasibility of heritage preservation is, perhaps more than ever, at the forefront of public which seek for that financing conservation efforts should be more robust and less reliant on government funding. Financial feasibility is important for heritage conservation because it can help ensure that these projects are sustainable and have enough funding. This is because heritage conservation projects can be underfunded and lack financial support from the public and private sectors, considering that the costs of preserving, protecting, and maintaining cultural heritage can be high. Cultural projects need to demonstrate technical and financial sustainability to increase the likelihood of funding.

Reconstruction within the context of disaster impacts in heritage buildings refers to the act or process of depicting, by means of new construction, the form, features, and detailing of a non-surviving site, landscape, building, structure, or object for the purpose of replicating its appearance at a specific period of time and in its historic location. Responsible conservation practices during reconstruction in response to climate change induced disaster is needed to protect irreplaceable cultural features of heritage buildings [15, 16]. This is because, during reconstruction there is very limited scope, since only the few resources that are no longer extant can be recreated to the degree necessary to accurately idealise the property in a manner that conveys its appearance at a particular point in history [16,17,18].

Flooding is the most widely spread climate change induced disaster that affects the built environment globally. Flooding is a hydrological disaster that occurs as a result of large volumes of water submerging built-up areas. Before any mitigation measure is carried out to conserve and adapt a heritage building to be more resilient to potential future flooding during reconstruction, research about the actual flood risk as well as about the heritage building must be undertaken. The proposed flood risk adaptation will need to be adequate to address the identified risk, taking into account the characteristics of the potential flood, and the applicable code requirements and regulation [19]. These flood characteristics include: the direction the water will likely flow, the expected speed and depth of the water, the duration of the flood, whether there will be wave action, the potential for water-borne debris, the water salinity, and the contamination of the flood waters.

Understanding the characteristics of a flood is critical to building. The established flood risk level" should be based upon recognized flood data, past flood events, site-specific reports, and other applicable information, such as local floodplain ordinances and codes. Significant structural damage can re-occur to the building, if these characteristics are not properly mitigated during reconstruction. Typically, fast-moving flood waters can structurally undermine a foundation or scour out land around a building. Waterborne debris can impact walls, which can fail if not adequately reinforced and anchored to withstand flooding forces, including buoyancy and debris impact [16, 20].

Choosing the most appropriate treatment for a building requires careful decision making about a building's historical significance, as well as taking into account other considerations such as the level of significance, physical condition, regulatory requirements and adaptations needed. Typically, National Historic features, designated for their "exceptional significance in history," and other properties important for their interpretive value need to be preserved or restored, to the extent to which is practically tenable and compatible with climate adaptation. The physical condition of the parts of the building will determine the treatment alternative to be adopted during reconstruction [17, 21]. Preservation of the distinctive materials, features, and spaces that are essentially intact is needed following a disaster event. If the building requires more extensive repair and replacement, or if alterations or a new addition are necessary, then Rehabilitation is probably the most appropriate treatment for those parts. Regardless of the treatment, regulatory requirements must be addressed. But without a sensitive conservation approach such work may damage a building's historic materials and negatively impact its character. Adaptations to address natural hazards as well as sustainability is needed during reconstruction of vulnerable heritage buildings. Some necessary modifications have to be carried out to mitigate climate change impacts [18, 22, 23].

However, a balance should be struck to minimise changes that would not preserve the building's historic character. It is thus emphasized that prior to planning or undertaking any adaptation measures, the spaces, features, materials, and finishes of the heritage building or the proposed adaptive measures should be documented. The building existing capacity to sustain and recover from flooding, as well as its physical condition and use, should be evaluated [19, 24]. Those spaces, features, and materials that are important to the historic character and significance of the property should be identified for retention and preservation. Existing materials and features that provide additional resilience to flooding may also be considered for retention, improvement, or enhancement [20, 25].

3. RESEARCH METHODS

In the bid to ensure resilience to climate change in the built environment, Flood risk mitigation measures have been recommended in several institutional guidelines obtainable from government reports and the technical press because the issue of flood risk management is of direct interest to

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

government agencies [26, 27, 28, 29, 30, 31]. Typically, establishing the specific level of risk posed to the heritage guidelines have been developed by the Royal Institute of British Architects (RIBA), American Society of Civil Engineers (ASCE) and the Federal Environmental Management Agency (FEMA) making recommendations on how to adapt buildings to flooding. FEMA offers extensive guidelines to homeowners for retrofitting diverse types of properties. Some other commonly referenced guidelines include the USACE flood proofing matrix, the Hawkesbury-Nepean Australian guide as well as the UK BS85500 guide. The Australian government for example, through the Australian Building Codes Board (ABCB) also published the "Standard for Construction of Buildings in Flood Hazard Areas". The United Nations Economic and Social Commission for Asia and the Pacific (UN ESCAP) sought to integrate environmental sustainability and disaster resilience measures in Building Codes for disaster prone areas. More specific to heritage buildings, in 2021 the United State Department for Interior, pursuant to the National Historic Preservation Act, developed guidelines on flood adaptation for rehabilitating historic buildings, with a view to make them more flood resilient. This study undertakes a systematic analysis of these array of institutional guidelines that have been proposed to mitigate the impact of flooding on the environment to spotlight the technicalities of the various flood risk adaptation strategies and further narrows it down to within the context of heritage adaptation. Further to this, an overview of the key considerations that will impact the financial and technical feasibility of heritage conservation efforts is outlined.

4. RESULTS AND DISCUSSION

The key recommended structural adaptation measures outlined in the various institutional guidelines include temporary protective measures, site and landscape adaptations, protection of utilities, dry floodproofing, wet flood-proofing, elevating the Building on a new foundation and moving the Historic Building.

4.1 Temporary Protective Measures

Temporary or non-permanent protective measures use materials or systems that can be deployed or activated when flooding is predicted and removed or stored when the flood waters have receded. Temporary measures are generally the most affordable options and can have a low impact on the historic character of the property because they rarely involve permanent changes to the property. Temporary measures include sandbags, temporary dams, temporary floodgates, and flood-wrapping systems. Sandbags are the most widely recognized tool used to protect a property from flood water, but there are also synthetic products that function in a similar fashion. Temporary dams are intended to encircle a building or close gaps in floodwalls. Temporary floodgates are removable barriers installed in windows, doorways, and other openings. Flood wrapping systems cover the most vulnerable portion of an existing structure to create a temporary impervious barrier. Wrapping systems do not lend additional strength or stability to a structure, therefore any building using such a system must be able to withstand the forces of the flood. With any of these systems, if custom-sized or special components like a temporary floodgate for a specific-width opening is needed, it is important that they be easy to locate and identify to facilitate timely installation when flooding is predicted. It is important to provide sufficient clearance between the temporary barrier and the walls of a heritage building to ensure that the force of the water against the barrier is not transferred to the building.

Temporary measures have limitations, which must be considered before deployment:

- Temporary protective measures are generally designed for relatively shallow floods of limited duration. They are not well suited for areas subject to frequent flooding
- Deployment takes time and varies depending on the equipment or system and the labor available to put it in place, so they are not a good option in locations where flooding may occur without sufficient warning time.
- Equipment requires storage space, and, if stored off site, the logistics of getting the temporary barrier or system to the site must be factored into deployment time.
- During a flood event, temporary measures must not rely on continual on-site monitoring, as evacuation from the flooded area may be required until emergency personnel allow property owners to return.
- No temporary system is failproof. There can be water seepage with these materials and barrier systems, and they should be used in conjunction with pumps and emergency generators to remove water from behind the barrier

4.2 Site and Landscape Adaptations

A range of site and landscape interventions can be implemented to protect a heritage building from flooding, both on the property itself as well as off-site. The advantage of these options is that the heritage building generally remains unaltered. However, the relationship of a building to the site and setting is important to the preservation of historic character. Changes to the site and landscape should be carefully planned to avoid negatively impacting the property's historic integrity and any historic landscape features, archeological resources, and other cultural or religious features. The different types of site interventions include:

- Basic regrading, large engineered structures, and infrastructure projects that may protect many properties in a neighborhood or district.
- Levees and the restoration of natural flood control systems like living shorelines, dunes, marshes, and wetlands are additional tools for larger-scale interventions.
- Street and sidewalk improvements that including bio-swales or other water retention systems can be effective devices to collect or direct water and alleviate flooding
- Storm-water management systems, berms, and floodwalls can all be used to control water on a single site, and each of these site interventions can also be 'scaled up' to protect multiple properties and larger areas.

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

The deployment of site/landscape adaptations for flood mitigation has drawbacks and limitations, which must be borne in mind when choosing this strategy:

- Site mitigation will change how water moves through and around a property, therefore, alterations to the existing landscape must be done with thoughtful examination of potential impacts to neighboring properties adjacent to and downstream from a property. As such, site or landscape adaptation measures can make flooding worse for other properties, and codes or regulations may not allow their use in certain locations.
- Adding a new site or landscape feature is not possible on-site for properties that are already on fully developed sites, where the building occupies the majority of the plot, although modifications can be made to an existing feature like a site wall.
- Site or landscape adaptation measures can damage or destroy significant historic landscape features, designs, or plantings in order to establish a new site or landscape feature to protect the property from flood risks.

4.3 Protecting Utilities

Utilities and mechanical systems for heritage buildings are often placed in basements to conceal them from sight. Any part of the utilities and mechanical systems for heritage buildings that is in flood-vulnerable locations should be elevated or relocated above the established flood risk level. Utilities and mechanical systems should be relocated to utilitarian or insignificant spaces in historic buildings that are unlikely to flood. Exterior utilities and mechanical systems should similarly be elevated to protect them from flooding and placed in locations that minimize as much as possible their visibility and impact on the historic character and appearance of the building. Furthermore, when planning a project involving mechanical, electrical, plumbing, or fire suppression systems, it is helpful to be aware of the service life of the various features of the systems. Sometimes it may be necessary to keep the systems, in whole or in part, in the existing location even though it is a known flood risk area of the property. This part of the system will need to be placed within a watertight enclosure or be sacrificial/replaced after a flood. Depending on the frequency of expected flooding, the cost of that part of the system, and its expected service life, sacrificing system components may be economically reasonable. It must however be noted that the new location for the equipment must provide adequate space and meet ventilation requirements. The relocated equipment must be accessible for monitoring, servicing, and inspection.

4.4 Dry Floodproofing

Dry floodproofing is an adaptation method designed to keep water out of a building, and requires establishing a watertight seal on the exterior of the foundation and sealing all interior spaces below the established flood risk level. In order to dry floodproof a property, all openings (windows, doors, and any utility penetration) that extend or are completely below the established flood risk level must be designed to be temporarily or permanently sealed. Exterior foundation surfaces must be impervious to water. This can be accomplished with a waterproof coating or membrane. Walls must be reinforced and anchored to withstand flooding forces, including buoyancy and debris impact, and an engineered drainage system must be installed. It is necessary to effectively manage the incoming floodwaters and removing the water from the site and historic building after the flooding to reduce hydrostatic pressure post-flooding by installing a drainage system around the foundation and footings of the historic building, installing a backflow valve to prevent sewer and drain backups and installing one or more sump pumps to control water on the site.

It has however been emphasized that dry floodproofing may involve significant alterations that impact historic spaces, features, and materials affecting the building's historic character and appearance. Such impacts to historic character are likely to be less for buildings where dry floodproofing is only necessary below grade, thus eliminating the visibility of the alterations. The aspect of dry floodproofing that can pose the greatest concern from a preservation perspective is waterproofing. This is because there are numerous products that are available for waterproofing, and each product has different performance standards and the potential to negatively impact the historic materials to which it is applied. Also, because of the strength of flood forces, dry floodproofing is generally not recommended for projected flood inundation levels that are more than three feet, due to structural considerations. Any building component below the established flood risk level, which could include foundations, walls, slab, stair, or sanitary systems, must be able to withstand hydrostatic forces. Furthermore, dry floodproofing will require a high frequency of maintenance when exposed to repeat flooding, as system components such as sealants and membranes can degrade or become damaged.

4.5 Wet Floodproofing

Wet floodproofing allows water to enter a historic building during a flood event and drain out as the flood waters recede. This mode of adaptation requires the water to move in, through and out of the building at a consistent rate, largely controlled by vents. The total number, size, and locations of the vents or openings is based on the square footage of the building and the anticipated performance of the vents. Water must also be able to move through the interior spaces of the flooded portions of the building, such as through doors and other openings.

The building may however require structural reinforcement and anchoring to the foundation to allow it to withstand the force of the flood waters. As such, any building component below the established flood risk level, which could include foundations, walls, slab, stair, or sanitary systems, must be able to withstand hydrostatic forces. All mechanical, electrical, and plumbing systems must be elevated above the established flood risk level or otherwise designed to withstand floodwaters. Where the floodwater may not drain naturally from the lowest levels of the property, a drainage system must also be designed and installed to help remove the water. It is important to retain historic materials, features, and finishes that are flood-damage resistant, and remove non-historic finishes and furnishings that absorb and trap moisture. Substitute materials that are more flood-damage resistant should be used when replacing deteriorated or destroyed historic materials and features that are compatible with the historic character of the building.

Like all types of adaptation measures, wet floodproofing has its drawbacks and limitation. Primarily, the preservation concern about wetproofing is the potential loss of historic materials. Many historic buildings have been altered over time and may no longer retain a high degree of historic interior materials or features (e.g., plaster may have been replaced with drywall).

Wet floodproofing is thus generally not appropriate for a historic building that still retains a high level of historic materials, features, and finishes that are not flood-damage resistant at or below the established flood risk level because it could result in their loss. Wet floodproofing is also not viable for buildings where flooding will likely exceed 24 hours due in part to the potential for damage to historic materials, contamination, and biological growth possible over longer exposures to floodwater. Since wet floodproofing requires a lengthy cleaning process and drying time, and, therefore, it is best selected when flood waters will be limited to non-living spaces (i.e., basements, crawlspaces, garages, etc.) or for nonresidential properties. Keeping in mind that the building has to dry out after a flood, this method is not suitable if there is inadequate ventilation of the flooded area.

4.6 Elevating the Building on a New Foundation

This adaptation method involves raising the height of a building by lifting the building from the existing foundation, constructing a higher foundation, and resetting the building on the new base. Elevating building on a new foundation can generally protect a historic building from any type of flooding if the water does not reach the new first floor after elevation. However, how high a building can be elevated without a major impact on the property's historic character, will depend on appearance of the specific property. Thoughtful design will take into account both the flood risk and the existing historic design. The anticipated flood type will also dictate the foundation treatment. For example, in a fast-moving flood a building that is properly tied to the piers of an open foundation will generally have less damage than a building on a closed foundation. In other circumstances, break-away walls may be the only type of solid infill allowable below the established flood risk level. While this is one of the most common solutions for addressing flood risk, the historic character and appearance of the building can be considerably impacted when the change in height of the new foundation is significantly different from the original height. It has thus been reiterated that in order to maintain the overall historic character and appearance of the building, it is important to consider the all aspects of the site, setting, and design of the property. This include the topography and landscaping, shape and size of the land in relation to the building footprint, placement and Other features such as the building form including the existing overall width to height ratio, height and number of floors, as well as its horizontal or vertical orientation must also be considered. Furthermore, the Property type, Construction type and the relative visibility of the foundation or basement, with the change in height must be considered. The historic building must also be structurally stable and/or temporarily reinforced in order to be raised onto a new foundation. There must also be a structural system that can support the building on temporary cribbing while a new foundation is constructed.

4.7 Moving the Historic Building

Moving a historic building requires separating the building from its foundation and relocating it to a new site and foundation. Relocating a historic building is generally not a recommended preservation practice. In certain situations, however, this method of adaptation may be needed. Moving a historic building is usually considered only when the property is expected to flood repeatedly, succumb to river or shoreline erosion, or is subject to permanent inundation due to sea level rise or subsidence. The primary goal in selecting a new site should be a location that eliminates or reduces the flood risk. The new site should provide as similar a setting as possible to the original. In siting the historic building, consideration should be given to such factors as the original directional orientation of the building and if it had a strong visual relationship to a landscape or other feature, such as a road. The new foundation should match the original in height, design, and materials.

Before a decision is reached to move a historic building, it must be recognized that it is is more challenging, both technically and financially, when the building is masonry construction, and it is not feasible for buildings with shared walls, unless they are moved together. The building must also be strong enough to withstand the travel required in the relocation. Historic buildings that have structural deficiency may require additional reinforcement. It is always preferable that a historic building be moved in one piece. Sometimes, porches or small additions may need to be relocated separately, and reattached to the building after. The various construction periods, additions, and ancillary structures of a property should be considered in determining what needs to be moved to the new location. Moving a building to a new site requires a significant amount of preparation. Typically, routes between the historic location and the new site must be suitable for transporting a building. Furthermore, prior to the move, photographs of the building from all elevations should be taken, and interior finishes should be temporarily protected during the move. Also, depending on the distance and route to the new location, coordination with local highway departments, local permitting agencies, and utility companies may be required.

4.8 Financial and Technical Feasibility of Adaptation Measures

To ensure resilience to climate change in the built environment, the financial and technical feasibility of the

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

aforementioned adaptation strategies must be considered. This is because built heritage conservation, particularly during reconstruction following disasters is a complex issue that involves a number of factors. To verify the financial and technical feasibility of a built heritage conservation project, it is necessary to describe the current state of the building, explore the adaptive reuse potential of the project, assess the initiative costs as well as the initiative revenues and determine the main financial performance indicators.

Cost analysis of heritage conservation can help determine the most cost-effective ways to preserve cultural heritage sites. Some methods used in cost analysis of heritage conservation include Cost-benefit analysis, Hedonic price estimation and Life cycle cost analysis, Cost-benefit analysis is a method that can help identify heritage places that provide a net benefit to the community. It can also help determine the optimal quality of cultural heritage. Hedonic price estimation is a method that assesses the value of heritage properties by breaking them down into their constituent characteristics. It uses an econometric model to calculate the price of each characteristic. Life cycle cost analysis: is a method that can help with the sustainable maintenance of heritage sites. Other considerations in cost analysis of heritage conservation include regular maintenance and major restoration. Regular maintenance can help preserve the value of a heritage site and extend its lifespan, while major restoration can be expensive and disruptive, and may not be the best option for every site.

In terms of financing, it can be difficult to decide how to finance cultural heritage restoration projects. since the benefits of heritage conservation can be difficult to price. The cost of investment and management can be high, and public funds are often limited. Private investors may choose projects with a higher return on investment (ROI) over cultural heritage conservation projects. On the other hand, where public support is needed, there are usually multiple stakeholders with different views on a project's performance. The goal should always be to achieve economic sustainability, via improved financial management to ensure that sites are conserved and maintained for future generations. Commodification may also be considered as an approach to ensure financial feasibility. Commodifying cultural heritage to generate income can compromise other values.

Technical feasibility, should also be carried out as part of the financial feasibility studies. Technical feasibility of heritage conservation is the assessment of whether the available resources and technology can be used to preserve and prolong the life of a heritage building. It is important to verify whether the organization has the technical resources to meet the project's capacity and whether the technical team can convert ideas into working systems. Also the availability of materials, construction techniques, and whether the construction techniques are suitable for the project should be verified. Technical feasibility studies help identify technical challenges and ensure that a project is technically possible.

5. CONCLUSIONS

Planning and Assessment for potential climate change-induced disasters, primarily flooding is necessary during reconstruction of the built heritage, following climate-induced disasters. Temporary protective measures and protecting utilities are adaptation strategies that generally result in minimal changes to heritage buildings. The impacts of the other adaptation strategies to the historic building will vary greatly depending on multiple factors such as the location and site conditions of a property, its historic significance, the level of flood risk, the physical and structural attributes of the building, as well as its features, materials, and architectural style.

Selecting more than adaptation approach or combining measures from different approaches may be necessary to make the building more resilient to flooding and/or to minimize the impacts to the historic character and appearance of the property. In some instances, a certain degree of impact on a building's historic character may be necessary to ensure its retention and continued preservation. In other instances, a proposed treatment may have too great an impact to preserve the historic character of the building. Alternative treatment plans should be sought. Case-specific advice is thus necessary, as the importance of the historic features of heritage buildings vary in terms of how they define the historic character and, therefore, the degree of need for their retention. Nonetheless, in all instances, a building should be maintained in good condition and monitored regularly, and historic documentation should be prepared as a record of the building and to help guide future interventions.

These adaptation measures must be balanced with economic and technical feasibility while minimizing the impacts to the historic character of the building. The potential future impacts of disasters and natural hazards on a heritage building should be carefully evaluated and considered during reconstruction. If foreseeable loss, damage, or destruction to the building or its features can be reasonably anticipated, adaptation should be undertaken to avoid or minimize the impacts and to ensure the continued preservation of the building and its historic character. Some impacts of climate change disasters may be particularly sudden and destructive to a historic building (such as riverine flash flooding, coastal storm surge, or a tornado) and may require adaptive treatments that are more invasive. The goal during reconstruction should always be to minimize the impacts to the building's historic character to the greatest extent possible in adapting the building to be more resilient.

6. ACKNOWLEDGEMENTS

The author would like to thank the rivers State University for the research support.

7. AUTHOR CONTRIBUTIONS

Conception and design: Alolote Amadi
Methodology: Alolote Amadi
Data acquisition: Alolote Amadi
Analysis and interpretation of data: Alolote Amadi
Writing publication: Alolote Amadi

Journal of Evrimata: Engineering and Physics
Vol. 02, No. 02, December, 2024, p.73 – 80 e-ISSN: 3025-1265

Approval of final publication: Alolote Amadi
Resources, technical and material supports: Alolote Amadi
Supervision: Alolote Amadi

8. REFERENCES

[1] Karl, T. R., Meehl, G. A., Miller, C. D., Hassol, S. J., Waple, A. M., & Murray, W. L. (2008). Weather and Climate Extremes in a Changing Climate; Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacifc Islands. A Report by the U.S. Climate Change Science Program and the Subcommittee on Global Change Research. Washington, D.C., USA: Department of Commerce, NOAA's National Climatic Data Center.

[2] National Climatic Data Center. (2010, December). State of the Climate Global Analysis: Annual 2010. Retrieved May19, 2011, from http://1.usa.gov/fxdFai

[3] Ebi, K.L. & Meehl, G.A. (2007). The Heat is On: Climate Change & Heatwaves in the Midwest. In [Gulledge, J. & Smith, J., Eds.] Regional Impacts of Climate Change: Four Case Studies in the United States. Pew Center on Global Climate Change, Arlington, Virginia USA.

[4] Karl, T. R., Melillo, J. M., & Peterson, T. C. (2009). Global Climate Change Impacts in the United States. Cambridge University Press. Available at http://1.usa.gov/7Mcd7Q

[5] Meehl, G. A., Tebaldi, C., Walton, G., Easterling, D., & McDaniel, L. (2009). The relative increase of record high maximum temperatuers compared to record low minimum temperatures in the U.S. Geophysical Research Letters , 36(23), L23701.

[6] Ganguly, A. R., Steinhaeuser, K., Erickson III, D. J., Branstetter, M., Parish, E. S., Singh, N., et al. (2009). Higher trends but larger uncertainty and geographic variability in 21st century temperature and heat waves. PNAS , 106 (37),15555-15559.

[7] Seidel, D. J., Fu, Q., Randel, W. J., & Reichler, T. J. (2007). Widening of the tropical belt in a changing climate. Nature Geoscience , 1, 21-24.

[8] National Climatic Data Center, (2011). U.S. Climate Extremes Index, National Oceanic and Atmospheric Administration.Retrieved November 22, 2023, from: http://1.usa.gov/vAH4Qx

[9] IPCC, (2001). Climate Change 2001: The Scienti#c Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change in Houghton, J.T., Y. Ding, D.J. Griggs, M. Noguer, P.J. van der Linden, X. Dai, K. Maskell, & C.A. Johnson (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

[10] Schar, C., Vidale, P.L., Luthi, D., Frei, C., Haberli, C., Liniger, M.A. & Appenzeller, C. (2004). The Role of Increasing Temperature Variability in European Summer Heatwaves. Nature 427, 332-336.

[11] Stott, P. A., Stone, D., & Allen, M. (2004). Human contribution to the European heatwave of 2003. Nature , 432, 610-614.

[12] Lenderink, G., & van Meijgaard, E. (2008). Increase in hourly precipitation extremes beyond expectations from temperature changes. Nature Geoscience, 1, 511-514.

[13] Pall, P., Aina, T., Stone, D. A., Stott, P. A., Nozawa, T., Hilberts, A. G., et al. (2011). Anthropogenic greenhouse gascontribution to "ood risk in England and Wales in autumn 2000. Nature, 470, 382-385.

[14] B. Isakhan, L. Meskell,. (2019). UNESCO's project to 'Revive the Spirit of Mosul': Iraqi and Syrian opinion on heritage reconstruction after the Islamic State, Int. J. Herit. Stud. 25 (11) 1189–1204, https://doi.org/10.1080/13527258.2019.158988.

[15] N. Munawar. (2022).Reconstructing narratives: the politics of heritage in contemporary Syria, J. Soc. Archaeol. https://doi.org/10.1177/1469605322.073992.

[16] S. Fatoric, E. Seekamp. (2017). Are cultural heritage and resources threatened by climate change? A systematic literature review, Climatic Change 14 227–254.

[17] G. Hambrecht, M. Rockman. (2017). International approaches to climate change and cultural heritage, Am. Antiq. 82 (4) 627–641.

[18] J. Kennedy, J. Ashmore & E., B., I. Kelman. (2008). The meaning of 'build back better': evidence from post-tsunami aceh and Sri Lanka, J. Contingencies Crisis Manag. 16 (1) 24–36, https://doi.org/10.1111/j.1468-5973.2008.00529.x.

[19] S. Mannakkara, S. Wilkinson, (2013) Build back better principles for post-disaster structural improvements, Struct. Surv. 31 (4) 314–327.

[20] J. McCaughey, P. Daly, I. Mindzir, S. Mahdi, A. Patt . (2018). Socio-economic consequences of post-disaster reconstruction in hazard-exposed areas, Nat. Sustain. 1, 38–43.

[21] M. Hall, T. Baird, M. James, Y. Ram. (2015) Climate change and cultural heritage: conservation and heritage tourism in the anthropocene, J. Herit. Tourism 11 (1) 10–24.

[22] H. Kalman. (2017). Destruction, mitigation, and reconciliation of cultural heritage, Int. J. Herit. Stud. 23 (6) 538–555, https://doi.org/10.1080/13527258.2017.1289475.

[23] T. Rico. (2016). Constructing Destruction: Heritage Narratives in the Tsunami City, Routledge, New York.

[24] T. Rico, Reclaiming post-disaster narratives of loss in Indonesia, Int. J. Herit. Stud. 26 (1) (2020), https://doi.org/10.1080/13527258.2018.1552612.

[25] E. Avrami, Creative destruction and the social (Re) construction of heritage, Int. J. Cult. Property 27 (2) (2020) 215–237, https://doi.org/10.1017/S0940739120000120.

[26] United State Department for Interior (2021), Guidelines On Flood Adaptation For Rehabilitating Historic Buildings. Technical Preservation Services Washington, DC.

[27] ASCE (2005), "Flood resistant design and construction", ASCE Standard ASCE 24-05, American Society of Civil Engineers, doi: 10.1061/9780784408186.

[28] DEFRA (2008), Consultation on Policy Options for Promoting Property-level Flood Protection and Resilience, Flood Resilience Consultation, Department for Environment, Food and Rural Affairs, London.

[29] FEMA (2014), P-312 Homeowner's Guide to Retrofitting, 3rd ed., Federal Emergency Management Agency, New York.

[30] RIBA (2009), Climate Change Toolkit: Designing for Flood Risk, Second ed., Royal Institute of British Architects (RIBA), London, available at: https://www.architecture.com/Files/RIBAHoldings/PolicyAndInternationalRelations/Policy/Environment/2Designing_for_floodrisk.pdf (accessed 27 May 2022).

[31] UN ESCAP (2012), Integrating Environmental Sustainability and Disaster Resilience in Building Codes, United Nations Economic and Social Commission for Asia and the Pacific, Bangkok.