JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

A PRELIMINARY RISK MODEL FOR CLIMATE CHANGE RISKS ON BUILT CULTURAL HERITAGE: A SELECTION PROCESS TOOL

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Abstract: The loss of our cultural legacy is significantly rising at an alarming rate due to natural deterioration, climatic and environmental changes, natural disasters as well as human impacts. In order to protect our individual and group identity, its crucial to preserve this non-renewable resource. However, the escalating risks associated with climate change intensifies the frequency and intensity of extreme weather events. Hence, posing additional challenge for managing and conserving of our built cultural heritage. This paper aims to present the development of a preliminary risk management model that serves as a selection tool for assessing the vulnerability of built cultural heritage to existing climate change stressors. The model was designed based on a systematic review of literature related to climate change risks, vulnerabilities, and adaptation strategies for built heritage sites. In addition to investigating the risk assessment processes and practices.

The developed model provides a simple quantitative assessment matrix that offers a valuable robust selection process to proactively assess the growing climate change threats to built cultural heritage. The systematic model serves as practical guide for potential climate change risks evaluation and as a support to the decision-making process for heritage managers and policy makers. Thus, facilitating long term strategies establishment for resilient built heritage. The model shall be furtherly developed and tailored to specific context to provide evidence-based decision making in practical implementation.

IndexTerms - Climate change, Culture heritage, Risk, Risk management

I. INTRODUCTION

Amidst the mounting impacts posed by climate change, our built heritage confronts a series of pressing threats, that demands urgent attention and action. Built heritage refers to physical human made structures and cultural artefacts that are considered of significance in terms of history, culture and architecture. As the impacts of climate change escalates, its detrimental effects on the built heritage vary through several stressors such as rising sea levels, extreme weather events, increased temperatures, and increased humidity levels [1,2].

1.1. Overview of Climate Change and Built Cultural Heritage (BCH)

According to the UNESCO, cultural heritage is defined as the tangible and intangible expressions of the life ways of a community or culture that was passed down through the ages [3,4]. Building, monuments and constructions are all considered a form of tangible heritage, yet the term “architectural heritage” includes both the historic sites and features besides to the traditional buildings and historic quarters in urban and rural areas [5], which emphasizes on the various expressions of heritage, making the risks posed by climate change more challenging.

Although there is no one universal established definition for cultural heritage, however there are some common traits that should be possessed by the building/s that were common among several interpretations [6,7] such as:

- The building/s authenticity and rarity
- The building/s shall be of essential significance in terms of history, art, culture, aesthetics, architecture, and/or science.
- The building/s ability to represent creative humankind's work in artistic, architectural, and technological fields.
- The building/s age is sometimes used as a factor by some of the European union (EU) member states when defining heritage, however it is not a standard requirement in some countries.

Climate stressors are affecting several types of built heritage both ancient and contemporary constructions leading to degrading and loss in some of the assets outstanding universal value (OUV) which is the reason they have been classifies as world heritage assets [8]. In order to assess all those impacts, they have to be characterized either quantitatively or descriptively. According to Court et al. [9], the impacts could be summarized as shown in Figure *1*.

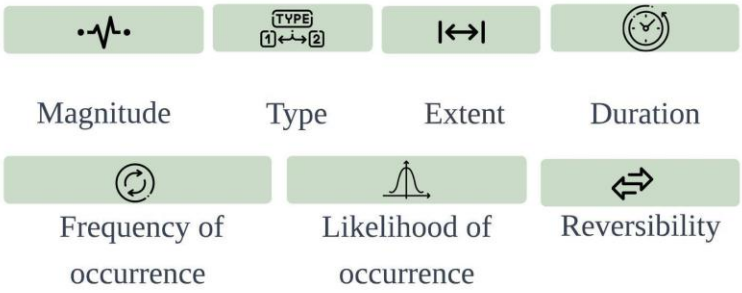

Figure 1 Characteristics of climate change impacts (author,2024)

- Magnitude to measure the occurring change
- Type of impact whether it's positive, negative, or neutral
- The extent of the impacted area
- Duration of the impact whether short, medium, or long term.
- Frequency and likelihood of occurrence
- Whether the impact is naturally reversible or can be influenced by human intervention or irreversible.

1.2. Climate Change as a threat to Built Cultural Heritage

Climate change is the identified alterations in the climate state that could be determined by changes in the mean and/or variability of the climate properties that continues for a period of time (decades or longer) [10]. It is considered a long-term progressive phenomenon that unfolds gradually over time. However, in 2020 ICOMOS declared climate change emergency as many of the systems will not be able to adapt at 2 °C of warming than at 1.5 °C; accordingly, the potential impacts of climate change on the built heritage must be effectively handled at all levels [4,11,12].

In the wake of climate change, Egypt confronts extreme climatic events and aridity change. According to Trisos et al. [13], study, to investigate the climate impact drivers on Africa's regions, Egypt falls into two regions within the African portions: the north Africa and the Sahara regions. It showed a high degree of confidence in the rise of air mean temperature, heat waves, atmospheric CO2 levels, aridity, droughts, and weather fire. Moreover, it manifested that Egypt is highly subjective to high sea level rise, increased water vapor content level, coastal erosion and oceans acidity [14,15], as shown in Figure *2*.

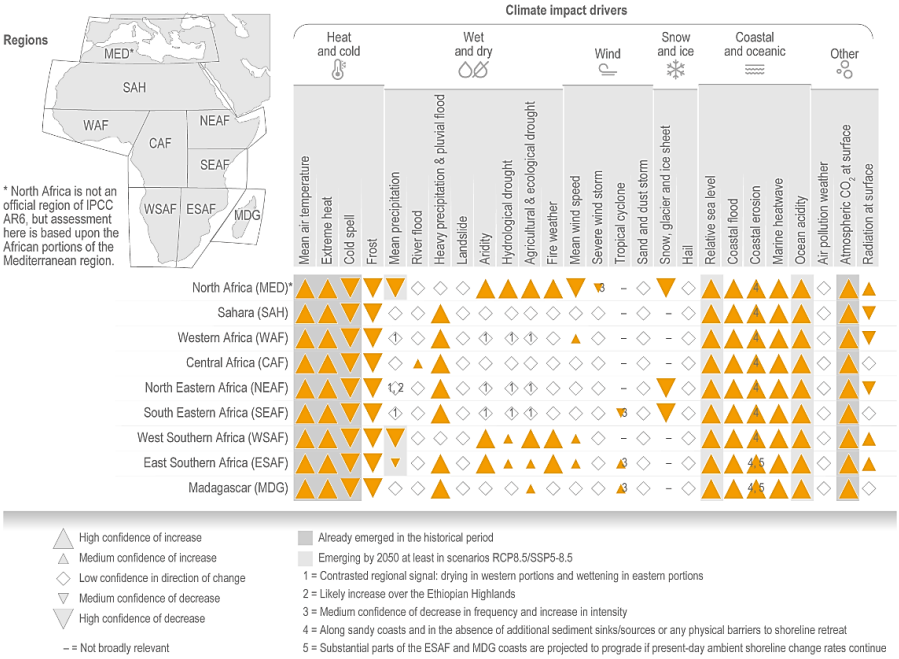

Figure 2 The climate impact drivers on Africa's regions [13]

The potential climate change impacts typologies can be classified into the following categories [16]:

- Atmospheric category that includes changes in the air temperature, wind, humidity, precipitation, extreme temperature events, rise in storms and droughts intensities and frequencies.
- Marine and aquatic that is related to changes in water temperature, sea level, ocean currents, storm flood and oceans acidification.

Figure 3 shows the Climate change impact drivers acknowledged by the IPCC six assessment report where the climate impact drivers are categorized and highlighted according to the duration of the stressors impact on heritage sites [17,18].

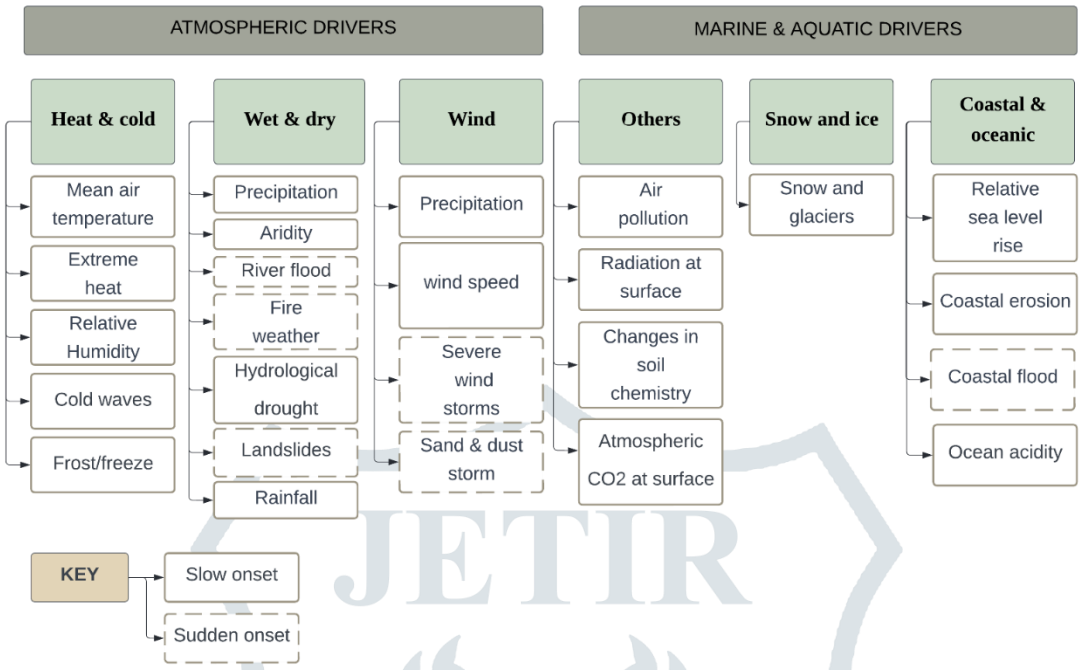

Figure 3 Climate change impact drivers (author,2024)

1.2.1. Climate Change Impacts on Built Cultural Heritage values

The Cultural built heritage authenticity is expressed through attributes from which their significance is derived as illustrated in Figure 4 [19-21].

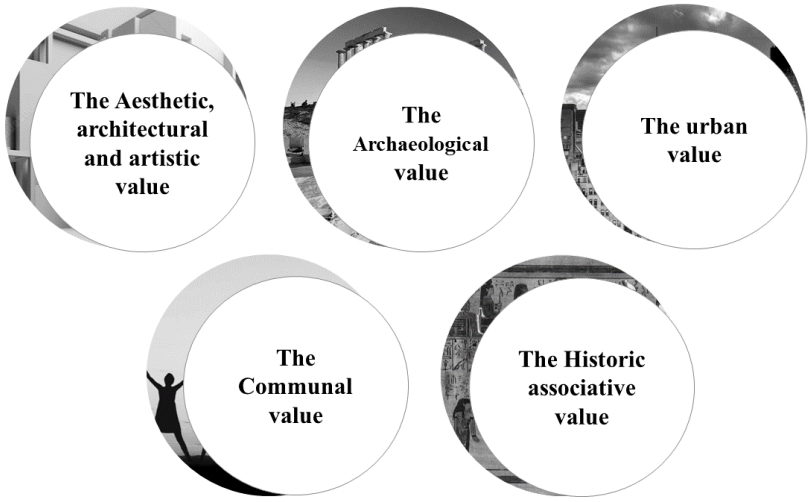

Figure 4 Associated values of built cultural heritage (author,2024)

- The aesthetic, architectural and artistic values entail the site or the buildings, aesthetic, and visually appealing features. It's also concerned with the overall building design, authentic features, decorative details, materials, and buildings finishes.
- The archaeological values are concerned with monuments contextual and cultural significance, the archaeological materials, and physical remains.
- The urban values are concerned with monuments relationship to the surrounding context, location, and its role as landmark.
- The communal values encompass the monument's significance whether its symbolism for cultural identity, its ability to promote social cohesion, or religious value, its attractiveness, and economic benefits.
- The historic associative values that are concerned with the monument's rarity according to the property type and importance.

1.3. Heritage Risk Management

In the heritage context, Risk could be defined as the probability of adverse consequences where a heritage value is at risk and where the possibility of occurrence and the severity of the risk's outcome are uncertain [22,23]. The most significant element of this definition is the where the heritage asset's value may be lost [24]. Accordingly, the heritage risk management process, which is concerned with the process of determining, evaluating, and expecting damage to heritage assets, as well as creating and putting into action mitigation measures to reduce the risk of damage. Hence, providing a mean to respond to the risk consequences in terms of plans, actions, strategies and polices [25].

According to Mahmoud & Pedersoli et al. [24], ICCROM developed a heritage risk management process that merges between the 5 steps international risk management principles and guidelines with the heritage sector concepts and tools as illustrated in Figure 5, where each risk process is stated along with the expected outcome of each phase.

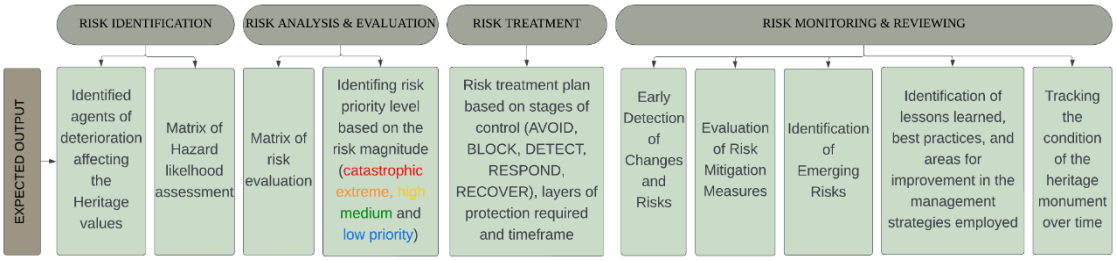

Figure 5 Heritage risk management process & expected outcomes (author,2024)

The Risk identification process involves identifying the hazards, then the Risk analysis which encompasses prioritizing detected hazards according to their impact, probability, and likelihood. The Risk Response/treatment involves developing options to improve positive impacts and decrease negative impacts on the project. Eventually, Monitoring and control which involves the discovery of any new risks, their inclusion in the management process, supervision of the implementation of the risk responses, and evaluation of the effectiveness of the entire procedure [26].

Since climate change has emerged as one of the supreme global challenges, the UNESCO world heritage center declared that the to protect our heritage, preventive efforts, corrective measure and sharing of best knowledge must be followed. Addressing these challenges emphasizes on the necessity of a comprehensive risk assessment that is tailored to each sites' specific vulnerabilities, thus, to preserve our irreplaceable cultural legacies against climate change impacts management [27].

In light of this, this paper focuses on contributing to the corrective measures required through the development of a preliminary heritage risk management model; that would serve as a foundation for the development of a risk assessment tool for the Egyptian heritage community.

II. Research Methodology

The study methodology was conducted through a comprehensive literature review, which encompassed the examination of scientific research papers sourced from scientific electronic database, where the primary sources selected to conduct the study in the area of managing climate change related risks on built cultural heritage included Scopus, Research Gate and Science Direct. The mentioned sites can offer a broad coverage of academic and scientific publications across several academic disciplines.

The study was performed based on a systematic review approach by the PRISMA protocol guidelines to ensure transparency and consistency in recording the methods, results and conclusions of the literature review and meta-analysis as shown in flow chart Figure 6:

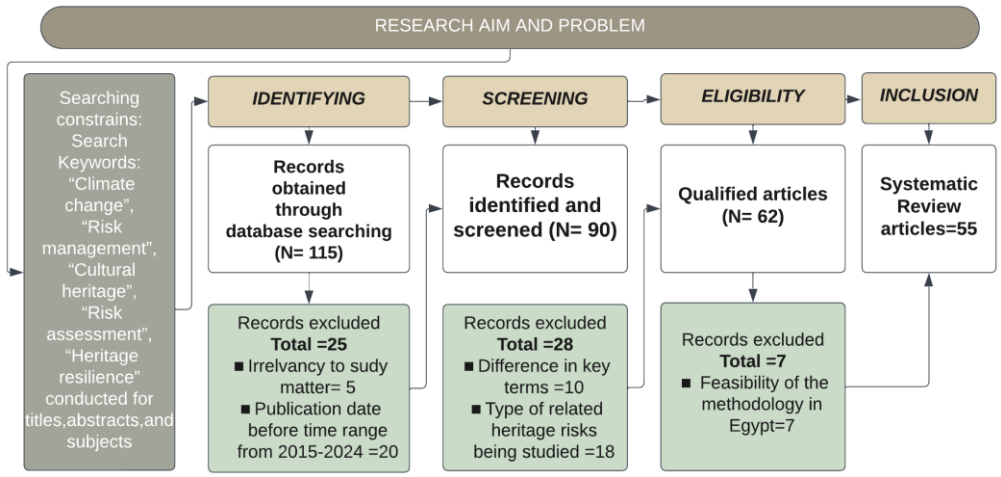

Figure 6 Literature Review diagram constructed upon PRISMA (author,2024)

1) The database search entailed titles, abstracts and subjects using the following keywords "Climate change", "Risk management", "Cultural heritage", "Risk assessment" and "Heritage resilience". A Total of 115 publications were obtained from all sources.
2) The articles collected were identified and filtered according to the publication dates ranging from 2015 to 2024. 25 out of 115 were removed from the study for duplication and irrelevancy to the matter of study.

3) After the initial evaluation of papers, 28 out of 90 of reviewed papers were eliminated. This elimination was based on difference in key terms related to the topic, type of related heritage risks being studied is non-climate-change related risks.
4) After identification and screening, the scholarly articles selected for the study were 62 articles. 7 out of 62 were excluded for the non-feasibility of the methodology of study in Egyptian context.
5) The selection process resulted in 55 research papers. The articles were selected based on the provision of sufficient literature and analysis and relevancy to research aim.

III. RESULTS

The literature findings conducted in this study were analysed in order to synthesize the key heritage themes, climate change drivers and systematic risk management process with the aim to create a preliminary risk management model for assessing the impact of climate change risks on built cultural heritage. This model lays the foundation for the future development of a comprehensive heritage risk assessment tool development.

The developed model is asset-based where heritage assets can be either assessed individually or as a group of monuments. The model consists of four phases:

3.1. Phase 1: Risk identification

This phase entailed categorizing the heritage values under key themes as shown in Figure 7 as “architecture, artistic and aesthetic value”, “the archaeological value”, “the urban value”, “the communal value” and “the heritage associative values”. Those values were mapped against the identified climate change drivers shown in Figure 8, that were grouped under subcategories as “hot and dry drivers”, “wet and dry drivers”, “wind drivers” and “coastal and oceanic drivers”.

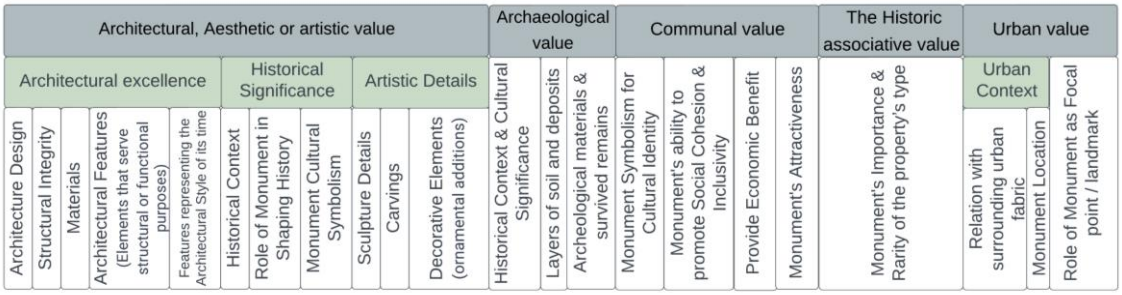

Figure 7 Heritage associated values breakdown (author,2024)

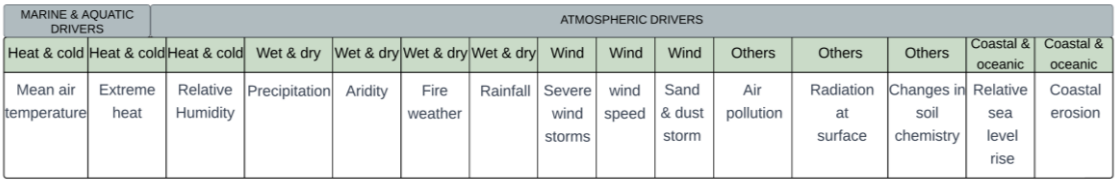

Figure 8 Climate change drivers categorization (author,2024)

This matrix Figure 9 shall result in two crucial outputs:

- The climate stressor’s impact significance, which is colour coded to show catastrophic -red, major-orange, moderate-yellow and insignificant- blue impacts.
- The probability of the climate stressor occurrence which shall be numerically coded from certainly occurring (5) to extremely rare to occur (1).

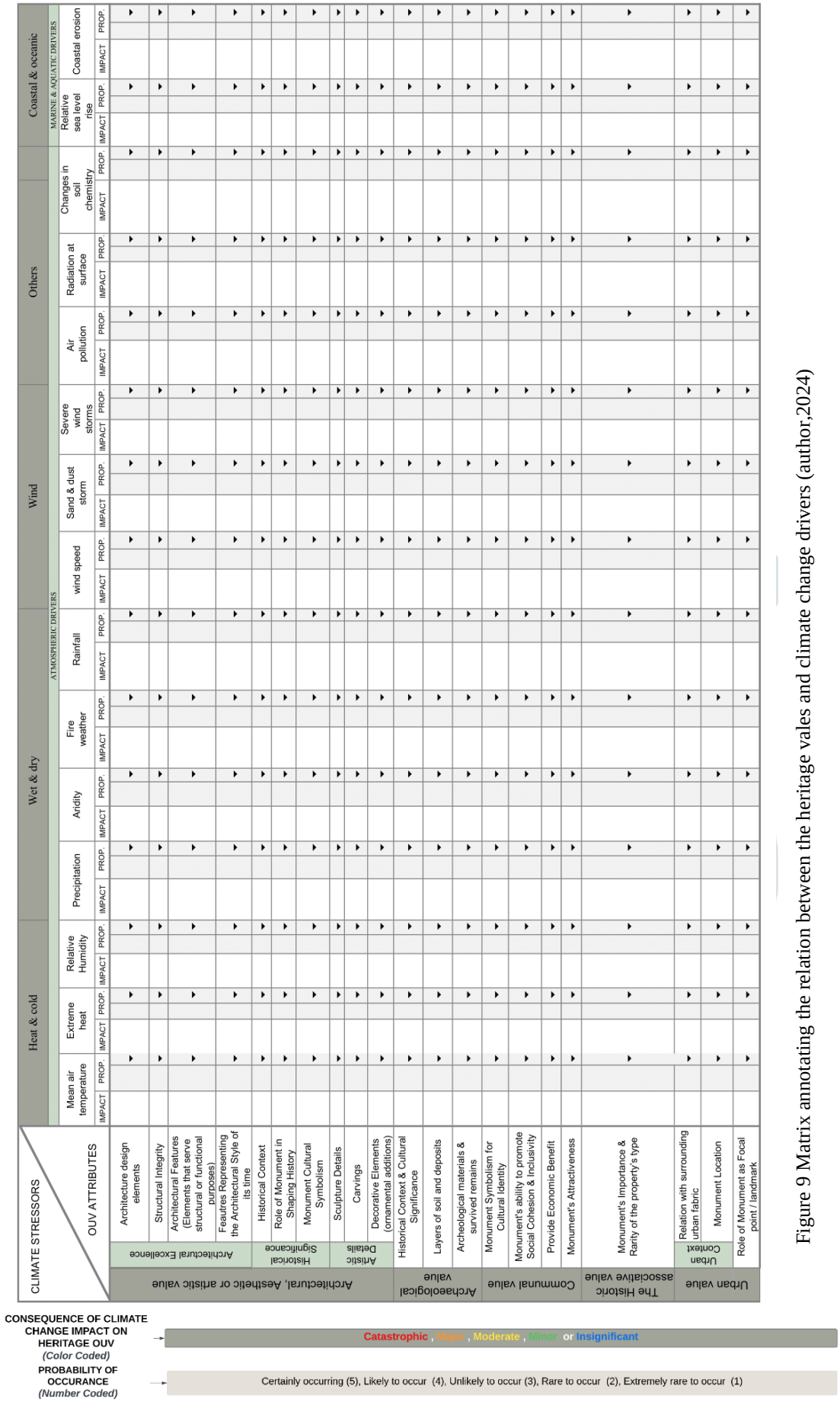

Figure 9 Matrix annotating the relation between the heritage vales and climate change drivers (author,2024)

3.2. Phase 2: Risk Analysis and Evaluation

This phase is concerned with analysing and evaluating the impact of the climate stressor on the heritage values which is assessed based on phase 1 matrix, thus, identifying the priority action level ranging from catastrophic to low priority.

3.3. Phase 3: Risk Treatment

The model suggests five stages of risk control identified as “avoid”, “block”, “detect”, “respond” and “recover”. The tool shall direct the selection of appropriate treatment strategies based on the risks identified.

3.4. Phase 4: Risk Monitoring and Reviewing

This phase entails the development of long-, medium- and short-term solutions to ensure the overall effectiveness of the risk management procedure.

The developed primary model applicability shall be furtherly investigated on selected case study within the Egyptian context to enhance the model, identify the gaps and refine the assessment process, resulting in the development of a comprehensive heritage risk assessment tool.

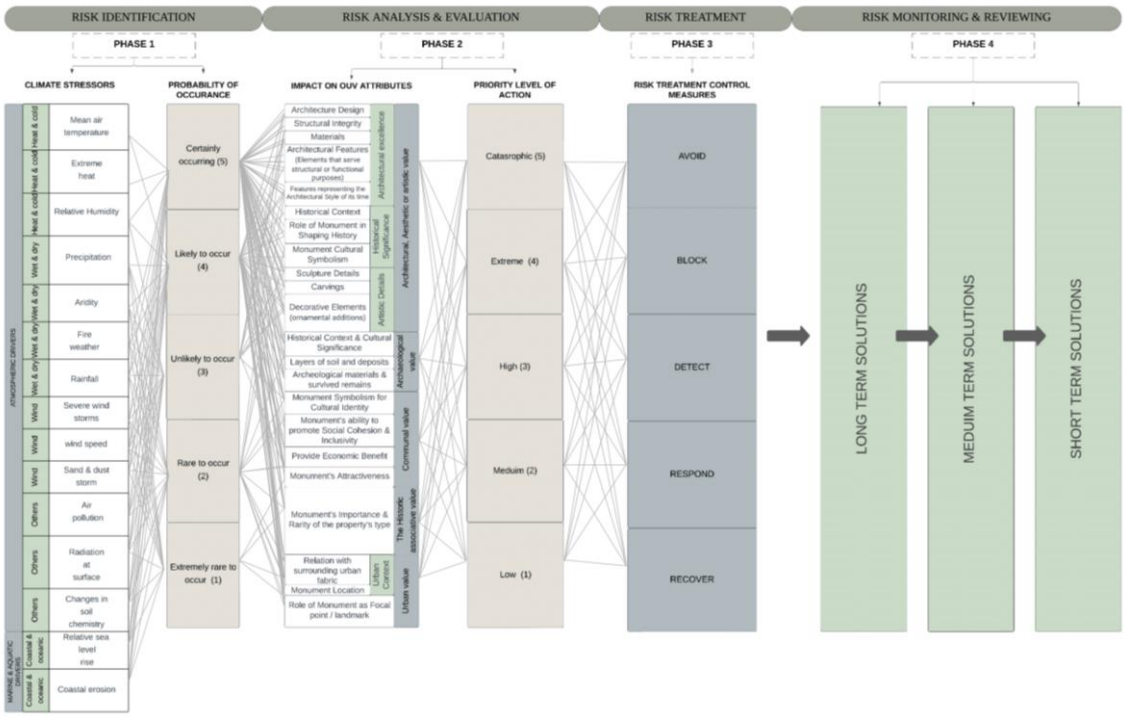

Figure 10 Probability chart showing the various likelihoods between each phase (author,2024)

Figure 10 emphasizes on the various probabilities that are resulting from the climate stressors on the heritage values, which accordingly leads to several chances in the priority action required and the appropriate corresponding treatment plan strategies. Hence, highlighting the lack of comprehensive heritage risk assessment tool.

IV. DISCUSSION

The findings of this review revealed that assessing the climate change impacts on built cultural heritage and the development of risk management protocols remains a highly complex field of research and practice. In addition, the findings also revealed the significant gap in the contextual heritage risk management state of practice where the studies highlighted the paucity of a well-developed, systematically assessing risk management model. In addition to the lack of Egyptian tailored quantitative assessment methodology that would provide the heritage experts and decision makers with quantitative based choices when considering a heritage risk management plan. Since the majority of the studied risk management approaches tend to be reactive, fragmented and dependent on heritage expert's qualitative evaluation methods, its crucial to address such gap to enhance the heritage resiliency towards facing climate change crisis.

The suggested methodology could act as a quick tool in order to generate the priority level for each risk identified, accordingly recognizing the controlling stage required and generate an insight about proposed solutions whether short, medium or long-term plans. Thus, contributing to the heritage conservation efforts amidst the accelerating climate change catastrophe. However, the model lacks to incorporate a post risk management evaluation process which needs to be addressed in further model refinement to improve the assessment process.

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