

**Examine the role of the latest technology in risk management  
of conserving heritage buildings in Egypt  
A Literature Review**

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**ABSTRACT**

Conservation is essential for understanding the country's background. Besides, Sustainable development is a way to improve sustainability through heritage buildings. The diversity of sustainability perspectives presents a challenge to the design of these types of buildings. Facilities management provides a mechanism for ongoing and lasting development, allowing efficient facilities to be managed and maintained. Concerning other sustainability challenges, the operating phase of a building is essential not only for energy but also for other sustainability challenges. The main problem of this paper is that Existing buildings have higher energy consumption and that risk assessment deliberated that there are critical risk factors. Most of the current practices concerning sustainable retrofitting and facility management of heritage buildings, particularly in Egypt, are lead through neither strategic management plans nor policies. Consequently, the main objective of this research is to examine the latest technology that facilitates risk management and evaluate the risks associated with sustainable retrofitting facility managers in heritage buildings. The methods of this paper followed qualitative analysis through the literature review was implemented to document the approaches to managing risks of heritage building retrofit through literature. This paper will raise awareness of heritage's sustainable retrofit and manage risks with the latest information visualization trends. Finally, it will influence decision-makers and facility managers in future heritage retrofit projects.

**KEYWORDS:**

Sustainable Retrofitting, Facility Management, Stakeholders Engagement, and Risk management.

## 1. INTRODUCTION

Heritage buildings inherit the past and influencing the future with a significant value that represents a sense of identity of a place, that assists in forming identity cognition for citizens through the physical structure. Those buildings are a tourism resource that generated an economic benefit to support their maintenance and operation (Wu & Hou, 2019). Moreover, Heritage buildings represent a significant part of the identity of any country. In 2013, Central Public Works Department (CPWD) stated that heritage buildings are records of nature and how a country expresses or reflects a society's cultural identity at a specific time. It links the history with the communities (Othman & Mahmoud, 2020). In Egypt, the urban landscape and infrastructure of the country are continuously restructured and reorganized, Since the country's new administrative capital launched in 2015. The urban development strategies have led the debate on the conservation of heritage to the front. However, many stakeholders have argued for the loss of historical monuments and buildings and the intangible values of the country's cultural heritage. Furthermore, there is an ongoing debate and attempts to bridge the technology gap with obvious contradictory objectives for conservation and development (Abdelwahab, 2019).

## 2. PROBLEM STATEMENT

The main problem of this paper is that most of the current practices concerning sustainable retrofitting and facility management of heritage buildings, particularly in Egypt, are lead through neither strategic management plans nor policies as well; there is a technological gap to manage this risk in Egypt. The following points are evidence of the current issues: Heritage Building demolition is an issue neglected for years due to several reasons: lack of policy and strict legislative actions to avoid demolition, misusing, and significant changes of heritage buildings. (Othman & Mahmoud, 2020). Egypt has faced several heritage threats. There were various issues, including social, legal, economic, environmental and technology, (Said & Borg, 2017). Throughout centuries, the constant debate is about what makes architecture worth it in different times. The conservation of heritage is essential to recognize as a synthetic, complex subject open to interpretation and discernment (Hamdy & Ibrahim, 2019). In governmental and rhetorical terms, the theory of sustainability is widely accepted and seen from various perspectives. Thus, the variety of sustainability points of view poses a threat for the design— besides, the rising of technologies for managing data through different applications and techniques.

### 3. RESEARCH OBJECTIVE

This research examines the latest technology that facilitates risk management and evaluates the risks of sustainable retrofitting facility managers in heritage buildings. As well as produce a preliminary theoretical framework for the integration between sustainable retrofitting risk management, facility management, and HBIM.

### 4. METHODOLOGY

This study examines sustainable retrofitting and the latest technology of risk management in heritage buildings. A qualitative analysis through an in-depth literature review from books, conferences, journals, publications, academic reports, government websites, and newspapers. In order to document the nature of heritage building reused, characteristics, applications, technology, and Methods of facility managers for mitigating risks of Sustainable retrofitting of heritage building through literature.

### 5. SECTION ONE: HERITAGE AND SUSTAINABILITY

As stated in the Oxford dictionary, heritage is an inherited asset, or already an inheritance passed down from one generation to another (Harrison R. , 2009). Heritage buildings help in establishing identity cognition from the physical structure, inheriting the past, and affecting the future with a significant value that represents a sense of identity of the place. These buildings are known as tourism resources that have provided an economic advantage for maintaining and operating them (Wu & Hou, 2019). The most recognizable part of the country's history is historical buildings that embody cultural values that transferred over time (Prieto, Macías- Bernal, Silva, & Ortiz, 2019). A historical building possesses architectural, aesthetic, historical, documented, archaeological, social, environmental, economic, and even political and spiritual values. The first impression is often emotional since it symbolizes our cultural identity and continuity. If it lasted the dangers of 100 years of utility, it is considered historical (Kalil, Ahmed Mohamed Rafik, 2015). According to UNESCO, the categorization of World Heritage is Natural, Cultural, and Underwater Heritage, as shown in figure 1 below.

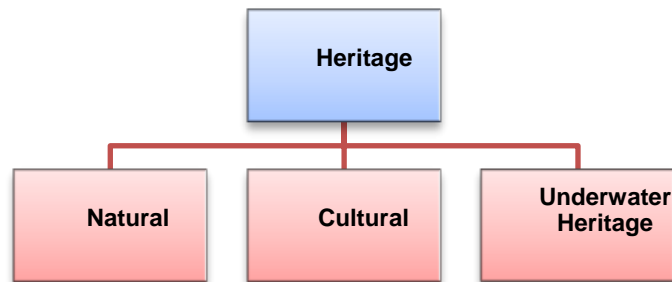


Figure 1: Heritage classification.

Developed by authors based on, (López, Lerones, Llamas, Bermejo, & Zalama, 2018)

Consequently, Heritage buildings embody a significant resource on economic, environmental, cultural, and social levels to any country. Therefore, heritage buildings require a particular contextual approach as it constructed with different materials and structural shapes at different times; accordingly, it performs relatively differently from any modern building nowadays, (Othman & Mahmoud, 2020).

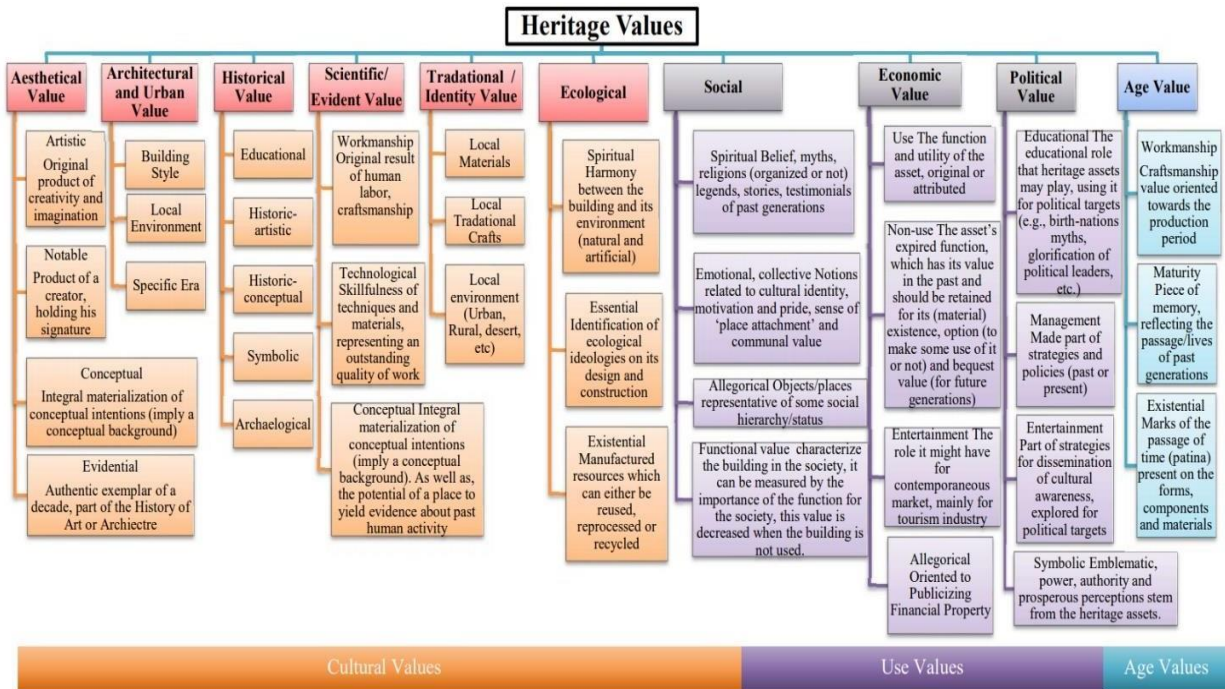
### 5.1 BUILT CULTURE HERITAGE

Cultural Heritage (CH) is composed of a historic or built environment concerning monuments, sites, and the value of heritage buildings divides into two significant groups: tangible and intangible. Tangible CH refers to the physical structure and site architectural fabric such as; landscapes, museums, art galleries, historical buildings, shipwrecks underwater, Natural sacred sites, memorials, religious-secular architecture heritage, etc. On the other hand, Intangible CH refers to cultural heritage Information concerning non-physical buildings and sites which is not physical such as; rituals and religious beliefs, people languages same as in Siwa in Egypt, documentaries, art crafts, festival events as Mooled of Sayda Nafisa in Egypt, music, drama, dance, food types, etc. Based on (Hribara, Bolea, & Pipana, 2015), (Harrison R., 2010), (Shaheen, Othman, & Ismail, 2019), and (Hafez, 2019). Over the centuries, the concept of cultural heritage expanded. Several professionals with different backgrounds and expertise collaborate to preserve heritage tangible and

intangible assets. This complexity poses more challenges when collaborative work is organized (Hirsengergera, Ranogajecb, Vuceticb, Lalic, & Gracanin, 2019). Each tangible type of heritage covered by an intangible heritage arises in community engagement, described in a specific religious practice or language. The protection of BCH is fundamental to the development of the cultural identity of communities for giving the place a character to be enjoyed by present generative groups and passed on to future generations. (Shaheen, Othman, & Ismail, 2019).

### 5.2 VALUE CLASSIFICATION

The Heritage value is culturally determined not within the stonework of historical buildings; the actual value of heritage exists inside the engagement of the community (Shaheen, Othman, & Ismail, 2019). To understand the nature of Heritage values and review it, figure 2 below shows the hierarchy of values and their classification according to several previous resources in figure 2:



**Figure 2: Value Classification.**

Developed by the authors based on (Woodward & Heesom, 2019), (Kalil, Ahmed Mohamed Rafik, 2015), (Khodeir, Aly, & Tarek, 2016) and (Hasbollah H. , 2014)



In addition to their aesthetic, architectural, and scientific value, cultural heritage buildings are a treasure because it integrates a specific society's intangible cultural values. CH is introducing the past and continuing to develop culture, knowledge, and other aspects. Thus, conserving cultural heritage supports sustainable human development further (Prieto, Macías-Bernal, Silva, & Ortiz, 2019).

### **5.3 EGYPTIAN LAWS FOR HERITAGE BUILDING**

Heritage conservation management involves various actors, including GOs (Governmental organizations) and NGOs (Non-governmental organizations). The non-democratic heritage preservation system in Egypt reveals the importance of the Ministry of State for Antiquities. That is the only authority that controls valuable areas of policy and strategy. Make decisions, assign, consult, funding, and follow up for continuous maintenance (Osman, 2018). Several essential laws and documents define, clarify and guide this process where is no single organization regulating or defining the building process for conservation (Woodward & Heesom, 2019).

### **5.4 SUSTAINABLE DEVELOPMENT**

In 1987, the Brundtland Commission defined sustainable development as a development that meets today's needs without compromising future generations' ability to meet their demands (Wang, Wang, Wu, & Li, 2020). In the development strategies of the countries, sustainability at all levels is a crucial concept. The world has begun to act in the past two decades as a single system with widely known development goals (El-Shazly, 2018). Managing the building environment that promotes human activities is essential (Francesc Pardo-Bosch, 2019). The 2030 agenda of the UN (United Nations) provides an integrated strategy towards sustainable development towards the balance between the four pillars culture, economic, social, and environmental dimensions (El-Shazly, 2018) and (Elsaay & Othman, 2018). As a work plan in line with the SDGs of 2030, Egypt's 2030 vision initiates (MPMAR, 2016). The plan to develop and restore archaeological areas, museums, and mosques. In order to maintain the historical heritage, increase income, and spread cultural and archaeological awareness (Ministry of Antiquities, 2020).

## 5.5 HERITAGE CONSERVATION

Conservation of buildings is a complex and multi-layered process that requires cooperation between the various experts (Pocobelli, Boehm, Bryan, Still, & Bové, 2018). Adaptation of the building made over a long period. It aims to enhance, modify, and improve the building performance and value, which involve modifications, adjustments, and improvements. In comparison, maintenance is done continuously or regularly for repairing and preserving the physical condition of the building, usually on a small working scale (Harrison R. , 2009). Cultural heritage sites increasingly threaten to develop preservative strategies and methods to have a safe and sustainable heritage. In contrast, the intangible heritage is being increasingly concerned with and essential to the built and tangible. With the emergence of green and sustainable principles and rating systems, climate change has become apparent; the principles and approaches for conservation have begun to change and use available technologies to adapt to these needs, reduce currencies, and meet them (Hassan & Xie, 2020.)

The reuse intervention strategy prioritizes improving sustainability in heritage buildings. Reusing a building is one process of preserving heritage buildings by changing the building to work—either its original role or a new function. This degree of intervention is either rehabilitation or adaptive reuse. Adaptive reuse to adopt a new function distinct from the building's original function requires more implementation measures to make the building suitable for the new function. Therefore, as shown in figure 4 below, Retrofitting is designed to modernize the building to consider energy efficiency. However, retrofitting can be done, whether in its old function or a completely different function, within the building's adaptive reuse (Kalil, Ahmed Mohamed Rafik, 2015) and (Okba & Embaby, 2013).

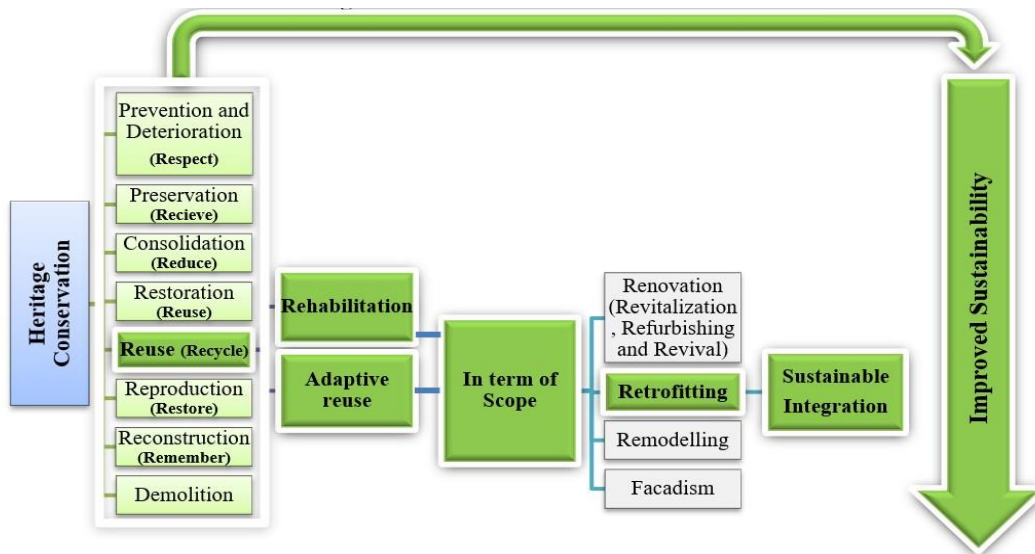


Figure 3: Heritage Conservation Stages.

Developed by the authors based on (Kalil, Ahmed Mohamed Rafik, 2015) and (Okba & Embaby, 2013)

### 5.5.1 PRINCIPLES OF CONSERVATION

The principle of conservation is research and recording as it needs complete analysis, compatibility of use, which refers to disallowing the change of character after the reuse. Minimum intervention so a level of sensitivity must exercise reversibility as the process must be repeatable and reversible. Minimum loss of fabric that historical evidence must destroy or remove because it is lost is complex and impossible to rectify. Other principles are appropriatetechniques and materials, identification of new work, and continued maintenance (Kalil, AhmedMohamed Rafik, 2015).

### 5.5.2 SUSTAINABLE RETROFITTING

Retrofitting is an economically viable new usage process for the conversion of historic buildings. This process is known at the micro-level as adaptive reuse in the conservation as mentioned above in heritage conservation types. Accommodation reuse known by historical expertsand specialists concerned with environmental sustainability as the principal approach to heritage building reuse. The contribution of adaptive reuse to the delivery of economic, social, and environmental benefits agreed in academic speeches for adaptive reuse projects; however, it is stillquestionable whether adaptive reuse of heritage structures leads to urbanization and reduced social inclusion. Discussions of the new use of and implications for the communities of heritage buildingsin the past decade have been



frequent and intense (Wu & Hou, 2019). Building retrofitting is crucial to tackling energy poverty as a significant social issue facing our society (Francesc Pardo-Bosch, 2019). Table 1 below represents some of the definitions of Sustainable retrofitting.

**Table 1: Sustainable retrofitting definitions. It develops by the authors based on the mentioned resources.**

Sustainable Retrofitting	
Sources	Definition
(Mawed, Tilani, & Hamani, 2019) and (Chattaraj & Koner, n.d).	Any improvement on the existing facility to improve energy and environmental efficiency provides the investor with financial incentives.
(Tookey, Ghaffarianhoseini, Okakpu, Rehman, & Haar, 2018) Moreover, (Wilkinson, 2011)	Retrofit initiatives are mainly considered to promote energy efficiency and sustainability as conservation measures. Retrofit complete building or a part of the building.
(Khodeir, Aly, & Tarek, 2016), (Kalil, Ahmed Mohamed Rafik, 2015) Moreover, (Nazria, et al., 2015)	"Retrofitting" is usually associated with building services because the lifespan of the structure and fabric is much longer than that of the services installed. Retrofit refers to "any work on a building, in order to modify its capacity, function or performance with maintenance."

According to the definitions in the table, sustainable retrofitting is any intervention in which part of the whole building is adjusted, reused, or updated in a building to meet new requirements or conditions. It defined it as fitting in an existing building new and more sustainable modern system that reduce energy. The following is the factors that affect the decision-making of adaptive reuse (Retrofitting aspect) of historic buildings: The importance of culture, Assessment of the life cycle, Importance of Heritage, Meeting the benchmarks for sustainability, sustainability of, economy, Sustainability in the environment, Sustainability of society, Local community value, Building orientation, Local Economic Impact, Building capacity to adjust and Stakeholder insights (Elsaay & Othman, 2018). Existing buildings retrofitting interventions are two design strategies, as shown in figure 5, for the sustainable project that affects the comfort ability of building residents. One is architectural passive, and the other is mechanical or active.

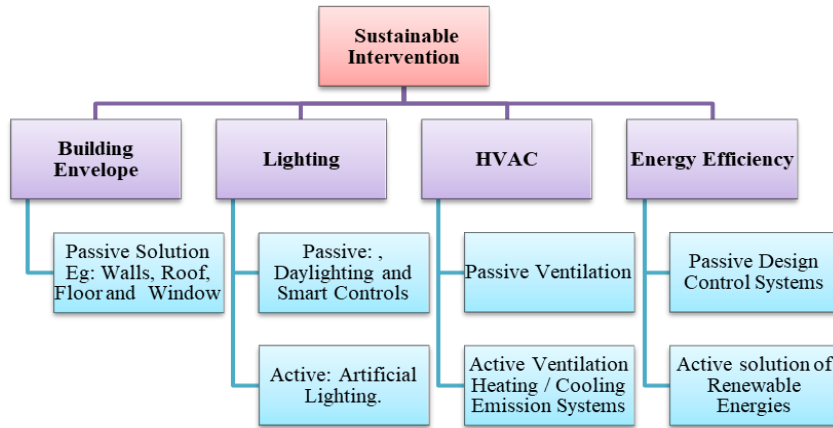


Figure 5: Sustainable Retrofitting Intervention.

Developed by authors based on, (Kalil, Ahmed Mohamed Rafik, 2015)

### 5.5.3 OBSTACLES FOR SUSTAINABLE RETROFITTING

Although this is a positive factor for effective populations in identifying risks in detail and breaking them down, this characterization provides people with a better understanding of potential damage on different levels. In combination with traditional risk preparation methods before, during, and after an event, a value can be given and clear boundaries and risk management priority (Sharifi, 2019) and (Mallawaarachchi, Hansamali, Perera, & Karunasena, 2018). Figure 6 below represents the obstacles to sustainable retrofitting of heritage buildings.

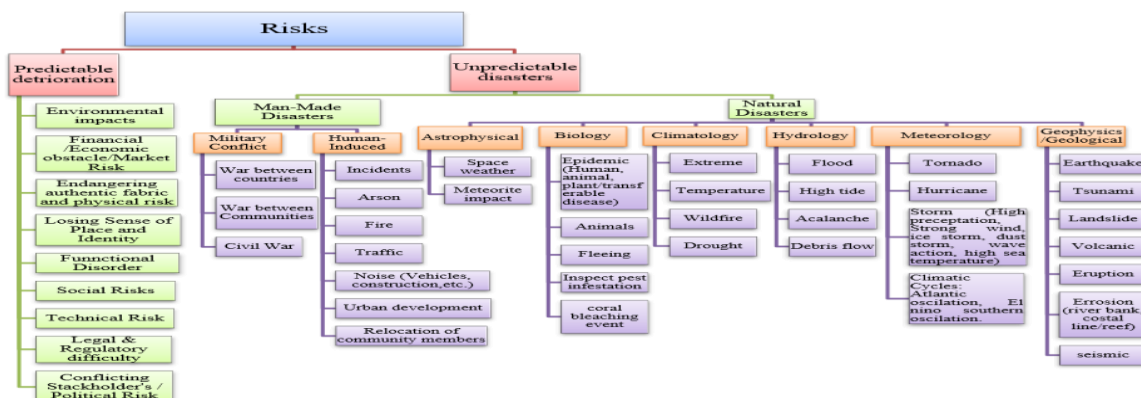


Figure 6: Schematic diagram of common disasters and risks to cultural heritage.

The authors develop it (UNESCO, ICCROM, ICOMOS, IUCN, 2010) and (Laterza, D'amato, & Laguna, 2016), (Mawed, Tilani, & Hamani, 2019), (Spigliantini, Fabi, Schweiker, & Corgnati, 2018), (Tokede, Udawatta, & Luther, 2018), (Shehata, 2014), (Zou, Sanjayan, Alam, & Wilson, 2016), (Alam, Sanjayan, Zou, & Stewart, 2016), (Othman & Mahmoud, 2020), (Wang, Wang, Wu, & Li, 2020), (Mansir, Kasim, & Raszuan, 2018), and (Khalil H. B., 2017).

Old cities, which have numerous historic buildings and monuments, are a core touristic attraction, livable areas that identify and value citizens' identity. Some historic buildings have become uncomfortable over centuries and have become in no way energy efficient. It ensures that the historic building retrofits so that modern versions and facilities can make this building come back to life (Hassan & Xie, 2020) and (Hassan, Elsaay, & Othman, 2019).

#### 5.5.4 BENEFITS FOR SUSTAINABLE RETROFITTING

The engagement of sustainable retrofitting with the sustainability pillars in the following points below: (VHF, 2020) and (Kalil, Ahmed Mohamed Rafik, 2015). (El-Shazly, 2018), (Elsaay & Othman, 2018) and (Wu & Hou, 2019). Culture: Heritage building contributes to maintaining identity, preserving ideas from history, engagement, and providing a sense of place to the future. Social: Standard of living, education, community, and equal opportunity. Environmental: Natural resources, Pollution prevention, saving of land, air, waste, and water. Economic: cost saving of demolition, technological innovations, economic growth, and research and development.

### 6. SECTION TWO: LIFECYCLE OF HERITAGE BUILDING

Definition of IFMA: "A profession covers several disciplines that ensure the functionality of built environment through the integration of people, places, processes, and technology" International Facilities Management Association (Hafez, 2019) and (Ahrens & Norrstorm, 2017). Based on, IFMA the management of facilities covers commercial property, planning (including organizing) and budgeting, spatial planning, interior design, and interior installation, architecture, engineering services, maintenance and operation (El-Motasem, Khodier, & Abdel Kader, 2015), (Wu & Hou, 2019) and (Ashraf & Khodeir, 2016). Furthermore, it is a discipline that comprises strategic and tactical operations (Asbollah, Isa, & Kamaruzzaman, 2016). In terms of technical competence, FM can improve the sustainability of existing buildings and reduce their environmental impact through a 'green retrofit' process (Mawed, Mahmoud; Tilani, Vinay; Hamani, Karima, 2019). Asia & Africa is still seen as a newcomer in the sector, compared to Europe and the USA, in facilities management (Sari, 2018). The three P model describes how FM integrates into an organization in the following figure: The Equation of FM = People (building users) + place (efficiency of building space) + Process (Operating the building based on the users' requirements successfully). according to (El-Motasem, Khodier, & Abdel Kader, 2015).

Facility management covers multiple disciplines to guarantee efficiency through the combination of people, location, technology, and environmental processes. Moreover, it combines the procedures in an association to maintain the approved services and increase its main activities; (Wasfy & Khodeir, 2017).



Figure 8: Three Ps diagram. Developed by authors, based on (Ahrens & Norrstorm, 2017)

In terms of environmental sustainability, Proper skills and services for facility managers can help implement the sustainability agenda in the FM field successfully (Shah, 2007). It is still affecting b the ability to implement sustainability in their routines and their inconsistency. Moreover, problems like the lack of knowledge and knowledge about sustainability add to the problem. Sustainability transition will not occur until the facility manager has the necessary knowledge and capability to meet the challenges of sustainability (Sarpin, Kasim, Zainal, & Noh, 2018) and (Booty, 2009).

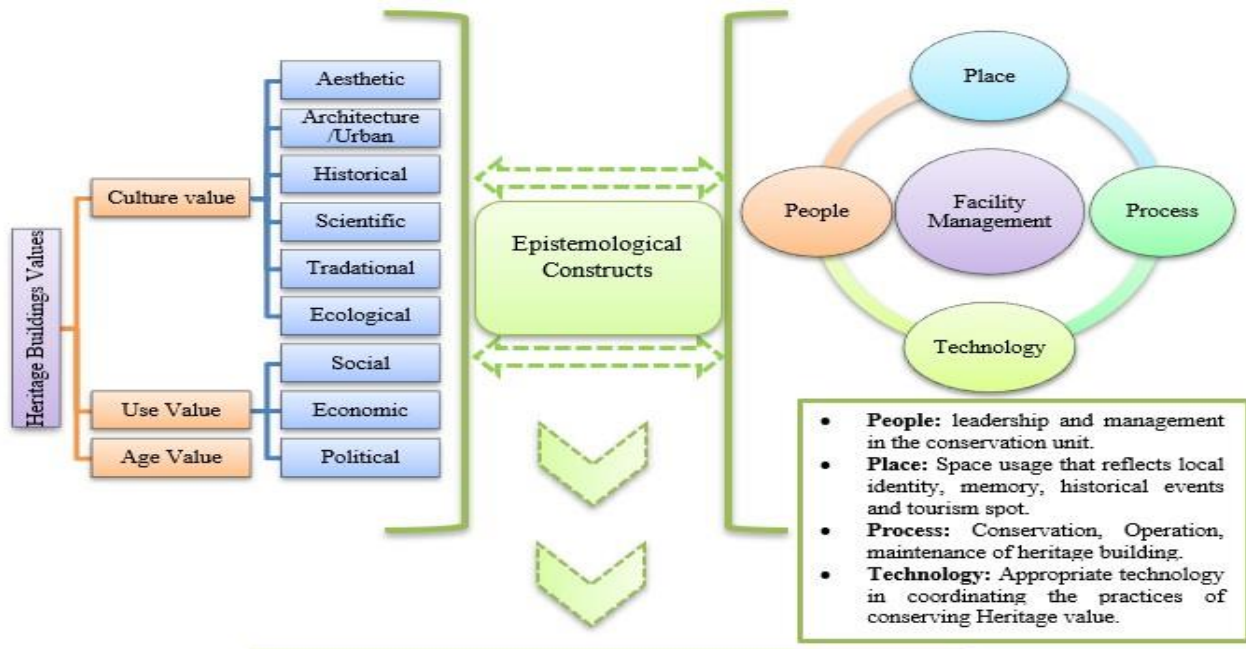


Figure 9: Relationship between Heritage value and FM.

Based on (Hasbollah H. R., 2015), (Francis, Geens, & Littlewood, 2010). and (Abbotsford convent, 2017).

In the last decade, retrofitting heritage buildings have become common. However, the role of FM in the management of heritage buildings is rarely studied. FM contributions are neglected to the sustainability of heritage buildings. Also, many stakeholders' views on the retrofit reflect their different needs and expectations for retrofitting Heritage projects (Wu & Hou, 2019). The Facility Manager has developed the intermediary function of combining operational activities and strategic decisions to ensure that the facility's operations align with the organization's strategy. The role of the facility includes an understanding of all aspects of initial drawings passing by HVAC and lighting systems, etc. FM can add value through social and environmental benefits and increased economic viability (Wu & Hou, 2019) and (Hosseini, Roelvink, Papadonik, Edwards, & Pärn, 2018). Increased awareness in the lifetime of the building heritage actively promotes by facility managers (Douglas & Roders, 2008).

## 6.1 CONFLICT FACTORS OF FACILITY MANAGEMENT

The following points below represent the risk for managing sustainable retrofitting of heritage building from the perspective of facility management: Based on the following sources: (Marit Støre-Valen, 2018), (Buser & Valen, 2017), (Nielsen, Sarasoja, & Ramskov Galamba, 2016) and (Francis, Geens, & Littlewood, 2010). Organization barriers, Technology, Users, Managing Controls, Neighbors and Natural Features, Visitors/Staff, Heating and Cooling, Consequences of Climate change, Environment, Energy and Carbon Emissions, Fire and Security Precautions.

## 7. SECTION THREE: RISK MANAGEMENT

Project Risk Management includes risk management, detection, analysis, response planning, control, and monitoring processes. Project Risk Manager aims to increase the likelihood and impact of positive developments and reduce the likelihood and impact of adverse project events (PMBOK, 2008). Disasters occur, so it is best to be prepared to deal with these inevitable events. As mentioned in section one, natural and unpredictable disasters cannot prevent entirely, but mitigation measures can effectively reduce the risk (UNESCO, ICCROM, ICOMOS, IUCN, 2010). Disasters can have excessive financial consequences: investment in preventive risk management planning is much more cost-effective than spending heavily on post-disaster management when thinking about all that could distract a project from its purposes (CIOB, 2020). Risk management is a risk source identification procedure, an analysis of its effects, and a definition of an appropriate solution for responding to risk items. On the other hand, risk assessment is a critical component of risk management, assisting project managers in identifying and assessing risk events (Karamoozian, Wu, & Abbasnejad, 2020).



As discussed previously in obstacles of sustainable retrofitting through the predicted risks and the unpredicted that may happen. In addition, the hazard is the possibility of a destructive event of risk incidence through vulnerability the injuries or else the harm done as a consequence to the risk that occurred besides the capability toward delivering defense against it (Shaheen, Othman, & Ismail, 2019) and (López P. J., 2016). The production of hazards and vulnerability is a disaster risk (UNESCO, ICCROM, ICOMOS, IUCN, 2010). Research shows that disasters risk categories of cultural heritage assets as identified by the author in 2018. It is a collective interaction of the three variables: hazards; vulnerability (losses or damages to building a heritage); capacity (capacity identify as a community-based asset, resources and skills, a society fundamental and used to mitigate risk in a disaster) (exposure refers to people, property, other assets or systems exposed to hazards) (Mansir, Kasim, & Raszuan, 2018).

### 7.1. RISK MANAGEMENT CYCLE

The following figure 11 outlines the risk management cycle in order to understand the properway to manage it:

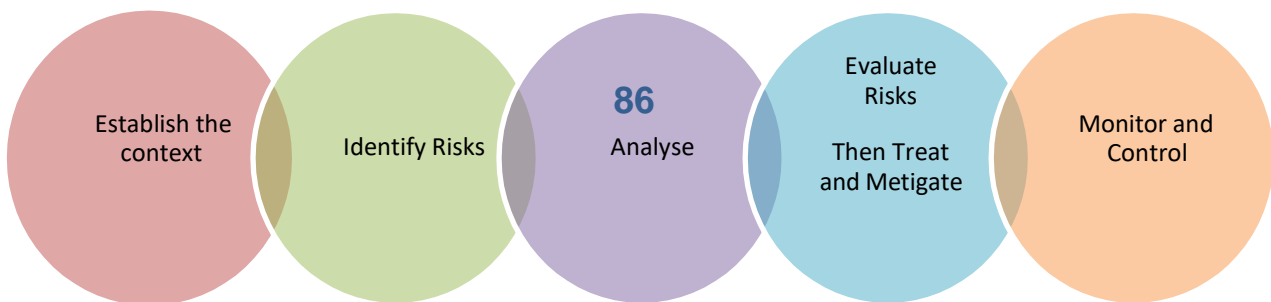


Figure 11: Risk management cycle.  
Developed by author based on, (Karamoozian, Wu, & Abbasnejad, 2020), (CIOB, 2020), (Sharifi, 2019) and (El-Motasem, Khodier, & Abdel Kader, 2015)

The main aims of risk management explain in the following: (CIOB, 2020), (Sharifi, 2019), (El-Motasem, Khodier, & Abdel Kader, 2015), and (Michalski & Pedersoli, 2016).

- **Establish the context:** Measure a variable value outside of the property, the position of the values and their vulnerability. The facility manager decides what is best in Risk Management and ensures that these decisions are not isolated from the goals and aims.
- **Identify potential risks:** (What are potential dangers for our Sustained retrofitted heritage building?) Rapid (e.g., earthquake or war) and slow (e.g., erosion or oxidation)
- **Analyze** Evaluation of the impact Hazard evaluation for losing the value of the environment. Identifies alternative actions which can prevent (avoid) or improve (reduce) impact or provide a strategy to address the accepted effects (acceptance).
- **Evaluate Risks:** Examine and refine the accepted value codes based on analyses. It assesses national and international options and standards (conventions and laws). **Treat/Mitigate:** Implement and monitor the cost-effective actions required to achieve the project objectives successfully: treatment decisions and implementation.
- **Monitor and Review:** The risk management process is vital and enables the facility manager to identify and monitor risks to ensure that the treatment plan positively impacts risk management. That is why the facility manager regularly repeats the "Monitor and Review" process to avoid changes in circumstances or the evolution of new risks that may affect the work progress.

#### 8. SECTION FOUR: LATEST TECHNOLOGY IN HERITAGE BUILDING

BIM is a new technology where digital information models facilitate building management during the entire project life cycle. In general, multiple risks are impressive for projects. A risk management plan must therefore identify through the adoption of BIM. (Karamoozian, Wu, & Abbasnejad, 2020). It can also be adopted and applied in many ways but is primarily a compatible software process used by architects, engineers, and building contractors, which allow the various stakeholders to collaborate as a team in various phases (Fountain & Langara, 2018) and (Hossam, Eid, & Khodeir, 2019). The BIM process involves the assembly into a virtual representation of a building or facility of "intelligent" objects,

building components, and spaces (Ali, Ismail, Hashim, Suhaimi, & Mustafa, 2018). The role of the facility manager progress, including management and ineffective procedures of different time-consuming activities. Figure 4 below represents the BIM dimension which expands in the last couple of years, and it is an expectation to have further dimensions.

Conservation of the heritage is a sensitive task since many problems must address. Many information, for example, the history of the building, its historical layers, the characterization of materials and properties, damages, and temporal decay, must be investigated during the analysis stage. The first step to a successful conservation project is to maintain the correct data. (Pocobelli, Danae Phaedra, n.d). It starts from conceptual design, detailed design, analysis, documentation, fabrication, construction, logistics, operation and maintenance, demolition, renovation, and programming in an ongoing cycle starting with conceptual design. BIM adoption in the Middle East is not satisfying because only 20% of AEC organizations, or in whatever capacity, use BIM or participate in the BIM adoption process. The other 80% are not using BIM nor participating in the BIM process (Gerges, et al., 2017). The perspective of facility managers: BIM provides all the required data to carry out the post-occupancy and demolition project (El-Shazly, 2018) .

In contrast to the newly-built construction sector, where BIM has been applied widely at an international level for several years with numerous publications and online content, BIM is a relatively new field of academic research and seems less popular for heritage professionals (Bryan, 2017) and (Nieto, Moyano, Rico , & Antón, 2016). Egypt has a rich history that has many problems. It is an Egyptian context to protect these valuable resources, new and innovative tools, and strategies in need. The sustainable redevelopment of historic buildings is one of the most extensive conservation opportunities for these buildings while considering all aspects of sustainability. Sustainable upgrades design to increase energy efficiency, optimize building results, increase residence satisfaction and improve return without compromising heritage values.

Historic England defines Heritage Building Information Modeling (HBIM) as the "multi-disciplinary process that requires professional involvement with very different skills in 2017. It is also an area of research, official guidance, standards, and professional practice rapidly developing.' (Khalil & Stravoravdis, 2019). on the contrary, HBIM tools use as a comprehensive data package for all disciplines, particularly concerning the preservation of valuable buildings. Besides, the geometric accuracy of HBIM models ensures reliable outputs for visualization to

improve the retrofitting (Khodeir, Aly, & Tarek, 2016). BIM brings processes, technology, places, and policies together; further expand this to include another "pillar" as a critical factor in the process, people (stakeholders) (Heesom, et al., 2020). There is proof that most existing buildings are not yet in maintenance, renovation, or deconstruction with BIM and other work supporting this viewpoint (Tookey, Ghaffarianhoseini, Okakpu, Rehman, & Haar, 2018). The table below shows the difference between BIM and HBIM.

Table 2: Comparative table between BIM and HBIM. Based on (Littlefield, 2017)

BIM	HBIM
<ul style="list-style-type: none"> <li>• Captures the building as intended to be in order to visualize and test it.</li> <li>• A resource that ensures a new structure conforms to codes and other parameters. A tool that tests and simulates a building before its built.</li> </ul>	<ul style="list-style-type: none"> <li>• Captures the building like it is.</li> <li>• A resource is describing the building which has already in existence. A tool that captures and records building before its loss or damage to conserve it.</li> </ul>
<ul style="list-style-type: none"> <li>• Offsite assembly to predict how a site will perform once changed.</li> <li>• Produce models with precision, predictability, and perfection.</li> <li>• Site Testing to enable site as designed to match site as built.</li> <li>• Directed and ownership is defined.</li> </ul>	<ul style="list-style-type: none"> <li>• Will incorporate many strange things, including competitive and evolving ideas.</li> <li>• On-site- a response to the site as found.</li> <li>• Models may not be precise due to a lack of data.</li> <li>• Site comparison between design, existing, and conservation.</li> <li>• Negotiated, and ownership is loose.</li> </ul>

Table 3: HBIM possibilities of sustainable retrofitting.

The table below represents these HBIM potentials through addressing sustainability core. From the research point of view, this sustainable approach is suitable for retrofitting heritage buildings in Egypt. It is also a nomination for similar projects worldwide (Salam, 2020)(Leea, Kimb, Ahna, & Woa, 2019).

Building information modeling or Heritage-BIM, in particular, is the most significant trend in conservation recently. Fundamentally, it is an intelligent 3D model, as explained previously, which gives experts the tools and insights for planning, construction, designing, and managing risks that might happen. To make it clear, one planner could do several planners that do not use the BIM system and have complete control over the design changes and their impact on the physical buildings from every point of view. Besides, this is more efficient and precise in communicating with other project planners (Pan & Zhang, 2021). The question here is it an intelligent method; researchers agreed that it is productive and certainly helps create a process that contains minor errors and accelerates design and documentation. It still does not mean it is smart or, in other words, intelligent. This method still allows insufficient buildings to be built and designed. Insufficient buildings are the context of creating the project, and BIM cannot utilize a parameter. Our objective always to have a sufficient building, so what could assist us to achieve this goal in a sustainable heritage retrofitting project. It is not even an attempt to tackle the concept of "better." (Lazovski, 2018). Nevertheless, it argues that the particular time we determine what better means, the race is to bring it to completion, but without bankrupting the project, that would be difficult. So consequently, it raised a question could AI (Artificial intelligence) be used to manage the risks of sustainable heritage retrofitting without impacting conservation principles, heritage values, or sustainable principles.

AI is about devices that somehow exhibit human intelligence. AI's many techniques, but machine learning is a subset of this more extensive list letting the algorithms learn from the data. At the same time, deep learning is a computer learning subset that uses multiple layering neural networks to solve the most challenging computer problems. The solution turned out to be mimicking human behavior (AI) and mimicking how humans learn (Tamke & Krijnen, 2015). For example. For future generations, AI even can conserve architectural heritage. The Grand Wall of China extends over 20,000 kilometers, presenting architects and historians to preserve it with a tremendous challenge. Technical risks as areas that are hard to reach, and a manual wall inspection is very tedious. Intel recently worked together to collect lots of photos from the China Foundation for the Conservation of Cultural Heritage, using the latest Drone Technology, and analyzes the AI data to identify areas of the Wall that need restoration.

"Developers could indeed work much faster, more efficient and cost-effective with accurate information about where repairs are needed and what is required." (Ibaraki, 2019).

Could perhaps developers, however, optimize a heritage building drawing? Even so, it is a vector mess that only humans understand. How could researchers convert it into a numerically reading format for processing as well as solving the algorithm? The design turns into a parametric model – this means managed by the code taking values and transformed into a 3D building model through a process. Algorithms can read this pattern that determines the best values for the code, conferring to what the designer predefined optimally after a re-enhanced learning process. Algorithms through the technology of HBIM could solve the implementation difficulties of sustainable retrofitting and process the action to mitigate risks faster through data learning from various similar heritage buildings with artificial intelligence predictions. Prediction task, which learns from given historical data sets, makes precise predictions for new observations to avoid and mitigate risks. (Pan & Zhang, 2021). For example, this method can be carried out in various CAD software types, such as Rhinoceros 3D (combined with Grasshopper plug-in), and requires a parametric specialist or a scripting planner. So hopefully, that definition of AI states to plans exhibiting human-like intelligence in some way (Lazovski, 2018). The following figure 13 represents the latest trend of integrating with HBIM as a technology.





Figure 13 HBIM Integration Trends based on the study made by (Khalid A. Hussein, 2020).

Cultural heritage digitalization helped pave the way towards a variety of applications, even in their physical shape. Hence, in order to explore their potential benefits ultimately. Various digital heritage technologies were devoted to helping cultural assets and addressing the challenges associated with the restoration or, otherwise, the curation, both as metadata or a visual copy (Bouras, Belhi, Al-Ali, & Foufou, 2020). Heritage Building conservation and management undergoes a rapid digital transformation with the extensive adoption of artificial intelligence (AI). Since Construction engineering management solutions based on AI have become the current research focus, it must be fully understood. In this regard, this author presents the current status of the latest technology adoption as a context of the literature review of sustainable retrofitting of heritage risk management. In addition to the classification of these studies by trend and purpose, the Studies adopted an analytical study on a range of studies that focused on historic building

information modeling (HBIM) in the building heritage. Previously, there was a short understanding of heritage and sustainability, facility management, and risk management, which could take advantage of automation, risk mitigation, high efficiency, digitization, and computer vision of the emerging trend of AI (Pan & Zhang, 2021).

## 9. DISCUSSION AND CONCLUDING REMARKS

According to the literature review analysis presented above, In Cairo, Egypt, existing/heritage buildings are the primary consumers of electrical energy. This paper concentrates on the risks associated with retrofitting heritage buildings to enhance energy efficiency and ensure that facility managers advocate for the operation and maintenance of the retrofitted buildings. Retrofitting and providing new life to historic buildings reduces energy consumption and is inherently sustainable. Furthermore, The Egyptian policies are centralized, uncertain, without a reliable direction for retrofitting, and instead dedicate to preservation to control deterioration and overriding scarcity of maintenance.

Sustainable retrofitting of the architectural heritage characterizes by the intervention of various technicians who disagree on decision-making criteria. H-BIM methodology for managing these structures has emerged in recent years, although decision-making risk management is challenging for the facility management multi-disciplinary technical staff. Artificial intelligence can therefore serve as an opportunity for automatic reactions to optimize the process and reduce risks. AI methodology automates decision-making, decreases evaluation times, visualizes and manages the H-BIM model's tangible and intangible data (Huertas, NIETO, Moyano, & Castro, 2020). So, this needs more attention and a framework to ensure the proper retrofitting and post retrofitting actions are established and raise awareness to issue new laws applicable to facility managers for managing sustainable retrofitting in heritage buildings. HBIM uses digital heritage during the different phases of the historic building life cycle, which is crucial for the conservation process; it provides the necessary data to different stakeholders. Despite the significant clutters and occlusions, algorithms efficiently extract the major structural components such as floors, ceilings, roofs, walls, and beams. The algorithm assesses with actual data from a variety of heritage buildings previously retrofitted. The results demonstrate that the classifier used accurately and reminiscently recognizes the objects. In this way, complete data sets labels at once reliably. Experts can

improve the documentation, processing, and managing risks of heritage. In conclusion, according to the research, a machine learning suspect merging an intelligent agent's power and overseen by all project planners with efficient software. However, using the AI concept for risk mitigation of sustainable retrofitting through algorithms constitutes one of the leading knowledge gaps.

## 10. CONCEPTUAL FRAMEWORK

The finding took the form of a preliminary conceptual framework with the steps of project heritage retrofitting and the potential of facility management as an advocate for retrofitting risk management using HBIM as a technology.

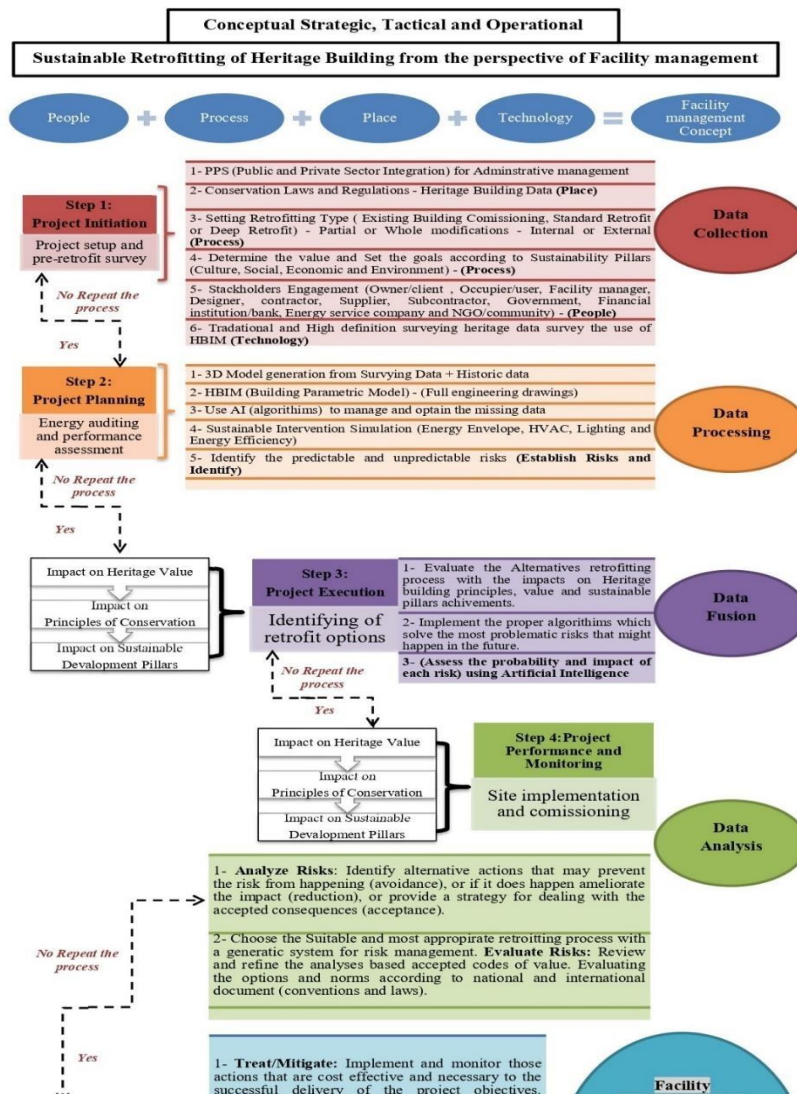


Figure 14: Preliminary framework developed by authors.

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