# A Framework for Certified Adaptive Reuse of Heritage Building

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# ABSTRACT

One of the significant tools in conservation is adaptive reuse, which allows the obsolete heritage buildings (HB) to be sustained for new generations. In addition to the already accepted positive contribution of reusing existing buildings to sustainability, a current debate is to propose effective strategies to accomplish green certification of heritage buildings, for both environmental sustainability, and cultural sustainability. In order to make the adaptation of heritage buildings more ecologically sustainable, environmental rating systems propose precise criteria for evaluating the various aspects of a building's environmental impact, including heritage value.

This study examines the effective factors of sustainability concept in conservation of architectural heritage through an examination of different adaptive reuse models and environmental rating systems developed worldwide, where both are related with architectural heritage. Thus, the aim is to prepare a framework that can provide the integration between adaptive reuse of HB and environmental rating systems considering HB. Within this approach, the aim of this research is to enlighten the ecologically sustainable ways of conserving heritage buildings for future generations. In order to reach comprehensive results, qualitative data have been collected by literature survey through grounded theory method. In the following step, the content analysis method as a qualitative research method has been used to extract related criteria and sub-criteria from existing systems and models. The gathered data have been examined in detail, in order to extract criteria and sub-criteria which have been illustrated via related tables and figures. In order to find their effective weights, this quantitative method has been applied through Microsoft Excel© software. These criteria and sub-criteria have been used to develop a holistic framework which is a combination of both qualitative and quantitative strategies. The Prerequisite Criteria Schema (PCS) provides a tool to be used by conservators for the examination of the prerequisite criteria for achieving ecologically certified adaptive reuse projects for heritage buildings. Selected worldwide HB examples, which consider ecologically sustainable approaches, have been examined during the development stage of the framework. 'Boğaziçi University Tarsus-Gözlükule Excavations Research Centre', with LEED Gold certificate, has been selected for testing and verifying the PSC tool.

**Keywords:** heritage building, adaptive reuse model, environmental rating system, cultural sustainability, ecological sustainability.

# ÖZ

Korumadaki önemli araçlardan biri, işlevini yitirmiş miras binalarının (MB) yeni nesiller için sürdürülmesini sağlayan yeniden kullanıma adaptasyondur. Mevcut binaların yeniden kullanıma adaptasyonunun sürdürülebilirliğe halihazırda kabul edilmiş olumlu katkısına ek olarak, güncel tartışma; hem kültürel sürdürülebilirliğe hem de çevresel sürdürülebilirliğe yönelik yeşil sertifikasyonun tarihi binalarda gerçekleştirilmesi için etkili stratejiler önermektir. Miras binalarının adaptasyonunu ekolojik olarak daha sürdürülebilir hale getirmek için çevresel değerlendirme sistemleri, miras değeri de dahil olmak üzere bir binanın çeşitli özelliklerini çevresel etki açısından değerlendirmek için kesin kriterler önermektedir.

Bu çalışma, mimari mirasın korunmasında sürdürülebilirlik kavramında etkili olan etkenleri, mimari mirasa yönelik dünya çapında geliştirilen farklı yeniden kullanıma uyarlama modellerinin ve mimari mirası dikkate alan çevresel değerlendirme sistemlerinin değerlendirilmesi yoluyla incelemektedir. Bu nedenle amaç, MB'nın yeniden kullanıma uyarlanması ile MB'nı dikkate alan çevresel değerlendirme sistemleri arasında bütünleşme sağlayabilecek bir çerçeve hazırlamaktır. Bu yaklaşımla, bu araştırmanın amacı gelecek nesiller için miras binalarını korumanın ekolojik olarak sürdürülebilir yollarını açıklığa kavuşturmaktır. Kapsamlı sonuçlara ulaşmak için, temellendirilmiş kuram yöntemiyle yürütülen literatür araştırması ile nicel veriler toplanmıştır. Sonraki adımda nitel bir araştırma yöntemi olan içerik çözümlemesi yöntemi kullanılarak, mevcut sistemlerden ve modellerden ilgili kriterler ile alt kriterler çıkarılmıştır. Toplanan veriler ayrıntılı olarak incelenmiş ve ilgili tablolar ve rakamlar ile gösterilen kriterler ve alt kriterler çıkarılmıştır. Etkin ağırlıkları bulmak için bu nitel yöntem Microsoft Excel© yazılımı ile uygulanmıştır. Bu kriterler ve alt kriterler, her iki stratejinin bir kombinasyonu olan bütüncül bir çerçeve geliştirmek için kullanılmıştır. Önerilen Ön Koşul Kriterleri Şeması (PCS), miras binaları için ekolojik olarak sertifikalandırılmış yeniden kullanıma uyarlama projelerine yönelik ön koşul kriterlerinin incelenmesi için korumacılar tarafından kullanılacak bir araç sağlamaktadır. Ekolojik olarak sürdürülebilir yaklaşımları dikkate alarak günümüze adapte edilmiş MB örnekleri, çerçevenin geliştirme aşamasında incelenmiştir. PCS aracının test edilmesi ve doğrulanması için LEED Gold sertifikası olan Boğaziçi Üniversitesi Tarsus-Gözlükule Kazıları Araştırma Merkezi Boğaziçi seçilmiştir.

**Anahtar Kelimeler:** miras binaları, yeniden kullanıma adaptasyon modeli, çevresel değerlendirme sistemi, kültürel sürdürülebilirlik, ekolojik sürdürülebilirlik.

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# Chapter 1

# INTRODUCTION

This chapter is about a comprehensive background collection in order to clarify the purpose and objective of the research which is the integration of both cultural and environmental sustainability on heritage buildings. In this manner, a theoretical background of the cultural heritage, adaptive reuse concept, the innovation of cultral sustainability and its relation to environmental sustainability have been investigated. Therefore, based on the aim and scope and suitable method selection, the thesis structure has been evolved in order to provide a platform to create a unique alignment schema for certified adaptation of heritage buildings for improving cultural and ecological sustainability of HB.

## 1.1 Theoretical background

As for the importance of this research which is the examination of both cultural and ecological sustainability features for HB for fulfilling a gap in the scientific knowledge, the following paragraphs have been provided to express the vital role of green conservation through the history and how this study has responded to the gap by proposing the particular framework.

Cultural heritage depicts lifestyles that have shaped societies as time passed and were transferred from ancestors to descendants by practical customs (ICOMOS, 2000, Doğan, 2019). Historic buildings have several values such as: documentary, architectural, economic, historic, aesthetic, political, symbolic or spiritual and social, but the most effective factor is emotional which refers to the continuity and cultural identity of our heritage (Tam et al., 2016; Feilden, 2007; Rahman, 2013). Conserving immovable heritage, such as preservation or restoration of architectural sites, needs close attention because of the congenital nature of cultural heritage as a system (Blundo et al., 2018). Heritage conservation is creating a memory collection which delivers the belonging and continuity sense and aids to express our cultural identity, as well as raising respect for human creativity and cultural diversity in communities and groups (UNESCO, 2003; Feilden 2007; Rahman, 2013; Tam et al., 2016).

Recently, many buildings are encountered with various threats including earthquake, widening roads, global climate changes, increase of land-value, etc. and the problem appears with the lack of financial issue for improvement. This phenomena have impact also on heritage buildings and community which directs the result through demolition or abandonment of buildings (Langston et al., 2008; Goded et al., 2017).

Rather than climate changes, global economy, information society and international exchange have grown rapidly since 1999 and sustainable development gradually has been compromised due to the deterioration of the global environment (Hegazy, 2015).

More efficiently, rather than removing raw materials throughout deconstruction, demolishing process and applying them for new proposes, is to keep the fabric and building structure and change the usage which has been mentioned as adaptive reuse. The new life injected into existing heritage building helps to conserve immovable cultural heritage which is completing together with social and environmental concerns. (Chusid, 1993.; Langston et al., 2008). Figure 1 explains the difference between paradigms of heritage according to Ashworth (2011).

| FOCUS | PARADIGM | | |
|---|---|---|---|
| | PRESERVATION | CONSERVATION | HERITAGE |
| GOAL | *Object* | *Ensemble* | *Message* |
| JUSTIFICATION | *Keep* | *Adaptive reuse* | *Use* |
| TIME | *Value* | *Value/ Reuse* | *Utility* |
| CRITERIA | *Past* | *Past/ Present* | *Present/ Future* |
| PAST | *Intrinsic* | *Preserve* | *Extrinsic* |
| FOCUS | *Real* | *Given* | *Imagined* |
| AUTHENTICITY | *Object* | *Compromise* | *Experience* |
| CHANGE | *Immutable* | *Adaptable* | *Flexible* |
| ACTORS | *Experts* | *Policy markers* | *Users* |

Figure 1: Difference between paradigms (Ashworth, 2011; p: 13).

On the other hand, as far as the planet is getting harm from climatic changes, it raises the awareness of policy-makers and scientists to struggle with this problem for anthropic activities. Regarding to this issue, the concepts of sustainability and sustainable development have spread their discussion into public (Bernardi, et al., 2017).

Shetabi (2015) expressed that, in the development strategies of UNESCO (2013), culture is considered as significant as the concepts of justice, human rights, and sustainability. As a symbol of cultural identity, cultural heritage needs to be sustained for future generations. Heritage has evolved in time to contribute to environmental sustainability, as can be seen in conventional knowledge and pragmatic design solutions.

Recent debates have been concerned with the potential of heritage conservation to help the environmental sustainability by reducing the energy associated with constructing new buildings. In 2015, the World Heritage Committee started to use a policy that integrated a sustainable development viewpoint into the procedures concerning world heritage (UNESCO, 2013). Recently, cultural issues have been integrated into the goals and as the forth pillar of sustainable development has been shown in (Figure 2, and Figure 3).

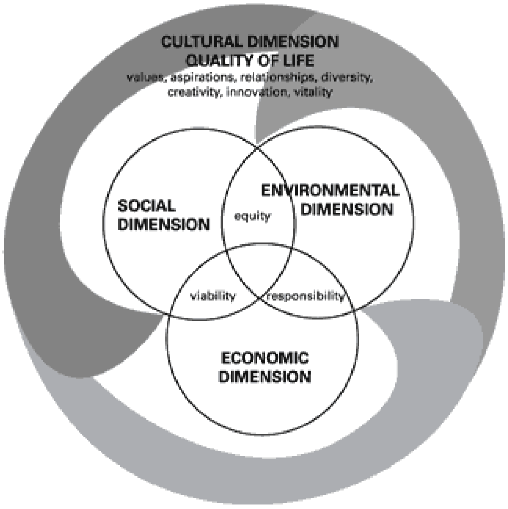


Figure 2: Four Pillar of sustainability (Jon Hawkes integrates four intertwined dimensions (Hawkes. 2001, p:11).

Social sustainability has the ability to provide high life quality by producing liveable and healthy communities based on democracy, connectivity, diversity and equity as it is mentioned in Western Australia Council of Social Services (2005).

A successful capital preservation in long-term is achieved through providing beneficial and responsible balance for existing resources which are approaching this successfulness via considering economic suitability as the optimal factor (Berardi, 2015). Bernardi, et al. (2017) stated that economic sustainability addresses the actual economic effect that exists on its economic environment.

In later studies (Hawkes. 2001; Ayalp and Bozdayi, 2013; Blagojević, and Tufegdžić, 2016, x; y; z; Dunn, 2016) culture is integrated into social pillar and mentioned as social / cultural sustainability as illustrated in (Figure 3).

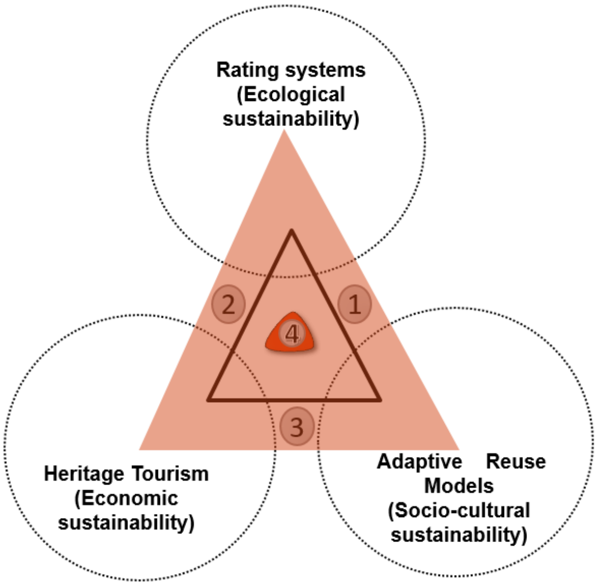

Figure 3: Farjami and Turker 2020, adapted from Triple bottom line of sustainability (TBL) (Dunn, 2016, p:1)

The approach in this study is according to (Figure 2 and Figure 3) which contains three main sustainability pillars such as economic, environmental, socio-cultural and the recent recognized pillar as cultural sustainability. The last description to complete TBL triad is environmental sustainability (Bernardi, et al. 2017) which is defined as the ability of protecting the “natural capital” and the using of natural resources without over using of their renewable capacity (Berardi, 2015).

According to sustainability dimensions of TBL framework, numerous types of rating systems have been improved in current market in line with sustainability pillars for evaluating the building environmental performance as a comprehensive method (Goodland, 2005;Bernardi, et al., 2017; Berardi, 2015).

Environmental rating systems can cover different fields as community projects, infrastructures and urban-scale projects. This system has been designed to support project management in order to make projects in more sustainable way by introducing frameworks with their criteria precisely to achieve different aspects of building's environmental effects. Rating systems are proposed to measure the building performances in harmonized and consistent manner towards pre-stablished criteria, factors, standards and guidelines. Continually, the sustainable development interest is rising up worldwide as several rating systems have been established recently with their own fields of applicability and peculiarities. The greatest important factor in creating rating systems is the scoring method for environmental sustainability assessment which has been done according to four major component as social, economic, cultural and environmental (Goodland, 2005; Podvezko, 2011; Awadh, 2017; UN, 2005).

As Fenner and Ryce, (2007), UN, (2005), Awadh, (2017), mentioned, Sustainability Rating Systems (SRSs) have three different stages:

(1) Classification: Environmental variation prospects determine the impact categorization based on outputs and inputs,

(2) Characterization: classify the effects of each output and input with their category relations,

(3) Valuation: comparing a category's weight with other categories.

Based on Paola Boarin et al (2014, p:1), The identification of historical worth must be a component of a long-term construction process aimed at preserving and improving all prior manifestations, with the ultimate goal of identifying, enhancing, and transmitting cultural heritage to future generations.

This dissertation will investigate various environmental rating systems related to the common criteria of discussion according to the four sustainable development pillars. Rating systems such as BREEAM©, LEED©, GBRS©s, STb© tools, etc. have been evaluated, in parallel with assessing adaptive reuse models such as ARP, Adapt-star, HBIM, etc. Furthermore, a new rating system which has been discussed by Boarin et al., (2014) as ‘GBC Historic Building™’ in Italy, is going to be evaluated regarding their considerations to increasing sustainability level without compromising the cultural value and provide a new topic as “Historic Value”.

Natural friendly decisions in adaptive reuse projects of these heritage buildings is as important as sustainable development strategies for the new buildings. According to Donnell, (2004); Pivo and McNamara, (2005); Conejos, et al. (2016) ,there are limited supports from landlords and commercial marketplaces in updating life quality to sustainability standards (Table 1).

Table 1: This table defines different levels of sustainability and the relation of keywords adapted from Cantell (2005)

| Environmental | Social | Cultural | Economical | |
|---|---|---|---|---|
| Survival Sustainability | | | | |
| Protection of life support systems<br><br>Prevention of species extinction | Capacity to solve serious problems | Supportive public plans and program<br><br>Strong cultural organization<br><br>Cultural spaces and facilities | Subsistence | Global<br>⇩<br>Local |
| Maintaining quality of life | | | | |
| Maintenance of decent environmental quality | Maintenance of decent social quality (community life) | Maintenance of decent cultural quality (community life) | Maintenance of decent standard of living | Global<br>⇩<br>Local |
| Improving quality of life | | | | |
| Improving Environmental quality | Improving social quality | Improving cultural quality | Improving standard of living | Global<br>⇩<br>Local |

As it has been identified in Table 1, sustainability pillars in different manners such as: survival, maintaining and improving the life quality have been summarized in global and local area which expresses the idea of integrating sustainability factors via adaptive reuse of historic buildings. Hence, Adaptive reuse as sustainability factor of conservation, attempt to raise up the life quality through improving social, cultural and the living standards, in addition to maintenance, supportive systems and environmental quality via environmental rating systems.

In contemporary concept of building conservation, imperative practicing in reuse process has been done on various sustainability aspects (Blagojević & Tufegdžić, 2016). Heritage buildings can find new, mixed, or extended uses by logical conversion processes, increasing their values and enhancing their cultural significance (Declaration, 2018). Adaptive reuse of cultural heritage, as a significance of conservation, expresses the rehabilitation, redevelopment, and retrofit of HB that reveals the changing community needs (Foster, 2020). By considering local needs and enhancing and conserving built heritage value, a broad range towards sustainable development has been enlightened (Faro, 2019).

“In more recent times, communities have preserved old buildings and neighbourhoods out of a desire to retain their historical, social and aesthetic cultural contribution” (Kerr, 2004, p: 17 cited in Conejos et al., 2014, p:7; UNESCO, 2009). The conservation concept is aligned with the United Nation’s (UN, 2030); agenda for sustainable development (UNESCO 2015), and defined the means by which world heritage can help the three key aspects of sustainable development contains social development, inclusive economic development, and environmental sustainability (Siebrandt, 2017).

Through redesign and renovations, architects are able to dramatically decrease energy consumption, improve indoor temperature conditioning, and at the same time, maintain the heritage value of such buildings (Martínez-Molina, 2016;Foster, 2020). The Burra Charter states that maintaining these buildings has to be a priority and it must be recognizable from repair because maintenance contains restoration or reconstruction, (Truscott & Young, 2000). Furthermore, cultural heritage and architectural features in existing buildings help sustainable development and therefore require consideration (Roders, 2011).

Adaptive reuse refers to upgrading buildings for new functions. For instance, by taking control of the embedded energy via adaptive reuse and upgrading old buildings in terms of environmental friendliness, passive heating and cooling, harnessing of natural light, improving water infrastructure for efficiency and improving energy efficiency are achieved (Siebrandt, 2017).

Adaptive reuse is sustainable if the energy enhancement can offer comfort for users besides preserving structural integrity throughout adaptation project of historic buildings. This varieties from integrity and authenticity conservation, within lowest reversibility and intervention as ‘cultural sustainability’ aspect, resource efficiency and energy as ‘ecological sustainability’ (Blagojević & Tufegdžić, 2016).

Environmental point of view, building strengthening and retrofitting especially for historic buildings are mostly expensive and significant quantity and variety of materials are required, but several strategies can be applied to reach the ideal balance between initial investment for saving energy cost, and decreasing the environmental effects during building life-cycle (LC). Adaptive reuse can significantly reduce entire waste, life-cycle cost and increase the functionality of historic buildings (Blagojević and Tufegdžić.2016; Rodrigues and Freire, 2017).

Adaptive reuse of heritage buildings is also defined as renovating or rehabilitating for new uses with three levels of changes:

- no significant changes in cultural fabric,
- minimal impact changes and
- changes that are reversible (Latham et al.,1999; ICOMOS, 2000).

Regarding to the importance of adaptive reuse of HB became a spot point attention in US, Europe and worldwide. A expansive number of historic buildings and sites were getting to be the major objective within the renewal and recreation of ancient towns (Mısırlısoy and Günçe, 2021). Additionally, refurbishment or renovation are accompanying to adaptive reuse in order to increase the achieved earning potential when the building life cycle ends (Conejos et al., 2014).

Architectural heritage development contains adaptive reuse or renovation of historic buildings and its successfulness is distinguished in terms of features such as architectural and promoting approach, public policy recommendations and effective citizen involvement, architectural and marketing approach and building type (Lehmann, 2012). Lehmann (2012) recommends to offer a better solution package for upgrading historic buildings efficiently, and he states that there is a need to concentrate on decreasing amount of new materials, transport, reduce pollution, consumption and resources, (Bullen, 2007; Prihatmanti and Susan, 2017).

Adaptation has been considered as significant approach to develop the sustainability of historic buildings and it is upgrading the performance which has been identified as vital effect on built environment. Adapting the historic building to contemporary needs or converting the historic building into new uses rather than demolishing, is one of the stakeholders and conservator interest reasons. The understanding of heritage status should be defined by developers and the sympathetic tracking through giving new functions to the building. Another important feature of adaptive reuse is self-defeating in order to protect heritage building's value which shows the successfulness of adaptive reuse projects and respects to the retain heritage building implications for additional layers to be preserved for future (Robles, 2010).

Although, in adaptive reuse procedure, the needs of applying new materials for conversion or adding new elements are certain, the aforementioned needs can be prepared In addition, all modifications to the heritage building (HB) need to be made by considering the decision taken based on level of interventions and the adaptation stages. By improving the sustainability and efficiency of the historical building in terms of the environment and energy, cultural heritage is expected to sustain its unique nature and arrangement (Castaldo et al, 2017).

## 1.2 Problem definition and research questions

As Robles (2010) describes, the involvement of professionals in finding the suitable conservation criteria for heritage buildings remained quite undefined. Additionally, based on heritage building characteristics which contribute to social and cultural context in different regions, the adaptive reuse and rehabilitation methods require appropriate experts to keep the heritage values of the buildings according to their new function, space quality and environmental sustainability issues (Turan 2017).

Lately, as the human beings' demand for sustainable developments increase, and therefore nature friendly approaches gained importance, environmental friendly issues became one of the most significant concerns throughout the world. There are different kind of challenges such as balance between social cultural sustainability, economic sustainability issues, and change in global climate, limited energy sources and etc. which makes the major problems in 21st century.

There are insufficient activities and achievements due to the concept of nature friendliness in the existing studies on adaptive reuse of HB. Regarding the previous research on adaptive reuse, the complex part of the study is the absence of guidance about applying both environmental rating systems (ERS) and adaptive reuse models (ARM) on heritage buildings in particular. The problem is determined as the absence of the mutual features extracted from both ARM and ERS that are intertwined for a green adaptive reuse approach for the continuity and conservation of HB.

The vital question of this study is:

What are the prerequisite criteria and the weight of each sub-criteria towards environmentally certified adaptive reuse of heritage buildings? Furthermore, several sub-questions have been mentioned to clarify the procedure of data collection that are: What are the comprehensive criteria extracted from worldwide adaptive reuse models for cultural sustainability?

What are the comprehensive criteria extracted from worldwide environmental rating systems for environmental sustainability?

What are the mutual criteria and sub-criteria for both cultural and environmental sustainability of architectural heritage?

## 1.3 Aims and objectives

he Venice Charter (ICOMOS 1964) and the Burra Charter (Australia ICOMOS, 2013) have been established about the required guidance for assessing and managing change and additions in heritage building. Therefore, this dissertation attempt to prepare the sufficient platform in order to overlap cultural and environmental sustainability development to gain a vital guidance for managing heritage buildings and preserve for future generations. As for cultural sustainability, ARM address the innovative evaluation method for heritage buildings. Furthermore, using ERS as ecological sustainability tools under the environmental sustainability umbrella is the innovative part of the combination.

The aim of this study is the alignment of related criteria in both ERS and ARM to create a unique framework for environmentally certified adaptation of heritage buildings, for achieving or improving both cultural and ecological sustainability of HB. The proposed alignment schema is derived from related aspects of ARM and ERS associated with heritage buildings (HB). By considering environmental rating systems as a tool in addition to adaptive reuse models as an input to achieve environmentally certified adaptation of heritage buildings, the framework is developed. Accordingly, by investigating various types of both adaptive reuse models and environmental rating systems worldwide, the alignment of criteria extracted from both of them, emerged a unique framework to be used as a guideline to make an environment-friendly adaptive reuse of HB with the sub-criteria 's weight calculation. The scope of the study covers the mutual design criteria derived from both ARM and ERS worldwide therefore the proposed framework can be applied to any heritage building where a green adaptive reuse is targeted. Hence, it can be concluded that, introducing the ‘Prerequisite Criteria Schema’ proposes a tool for guiding the design or assessmentof environmentally certified adaptation of heritage buildings.

## 1.4 Methodology and research limitations

This study contains both qualitative and quantitative research methods. Qualitative data collection was performed for two different topics within this study. The grounded theory research method was used for the selection of both ARM and ERS , which have special focus on heritage buildings. One of the quantitative research methods known as ‘descriptive statistics method’ has been selected, based on the evaluation requirements with numerical simulations which are associating with the average calculations to achieve presice criteria and sub-criteria.

Progressively, the efficiency of conservation measures available for heritage buildings can be evaluated for how building conservation costs in relation to the conservation process with the new function approprience (Moayed and Türker, 2021) meld with environmental sustainability. Significantly, conservation also extends their life and capacity, including repair, maintenance, and restoration. Heritage buildings’ conservation and sustainability are two interrelated concepts and are frequently encountered when it comes to maintenance and repair (Dal Bello, 2017; Kayan, 2018).

Historical buildings are part of each region’s treasure, since they have inherited heritage value. Thus, these buildings need to be specifically cared for, treated, and conserved. Such building stocks, when incorporating environmental systems in their conversion designs, can alleviate the problems caused by global environmental issues like high-energy consumption and greenhouse gasses (Webb, 2017; Kilitci, 2018).

By concerning existing systems, the environmental rating systems and adaptive reuse models which are allocated to heritage buildings are selected for this study. Based on quantitative research methods, the weights of criteria and sub-criteria are calculated mathematically, which refer to their explanations and points that have been defined in the main sources. Calculations are made by descriptive statistics research method. The Microsoft Excel© software as the numerical analysis program has been used in order to present the alignment of the adaptive reuse models (ARM) and environmental rating systems (ERS) through the features which have been chosen. Therefore, the numerical method has been chosen in order to calculate various criteria, which are clarified according to HB and to achieve a comprehensive framework, (Table 2).

Table 2: Methodology of research

<table>
<tr><th colspan="4">Methodology</th></tr>
<tr><td rowspan="6">Develozping Framework</td><td rowspan="6">Qualitative Research method</td><td rowspan="2">Literature Survey (Ground theory method)</td><td>Data gathering on existing adaptive reuse models<br>-ARP Model<br>-Adapt star Model<br>-PAAM<br>-etc.</td></tr>
<tr><td>Data gathering on existing environmental Rating Systems<br>-LEED-V4<br>-GBC-Historic BuildingTM<br>-BREEAM<br>-etc.</td></tr>
<tr><td rowspan="2">Action Research</td><td>A more holistic approach of problem-solving instead of using a single method for data collection is action research method.</td></tr>
<tr><td>In this study, various features of data collection have been explained separately( cultural and environmental sustainability) in order to combine them based on correlation research method</td></tr>
<tr><td rowspan="2">Correlation Research</td><td>Correlation research is a type of qualitative research which will explore the relationships between the main keywords</td></tr>
<tr><td>Alignment of both adaptive reuse and rating system features</td></tr>
<tr><td>Creation of the Framework</td><td>Quantitative Research method</td><td>Descriptive Statistics</td><td>Valuation/ Weighting the criteria and Computing the<br>Collecting data by using comparison in excel.<br>Numerical analysis by Excel software for computing the data and allocating weight to each ERS and ARM criteria and sub-criteria.</td></tr>
</table>

Therefore, the thesis methodology structure has been shaped through qualitative and quantitative research methods, Figure 4, Figure 5.

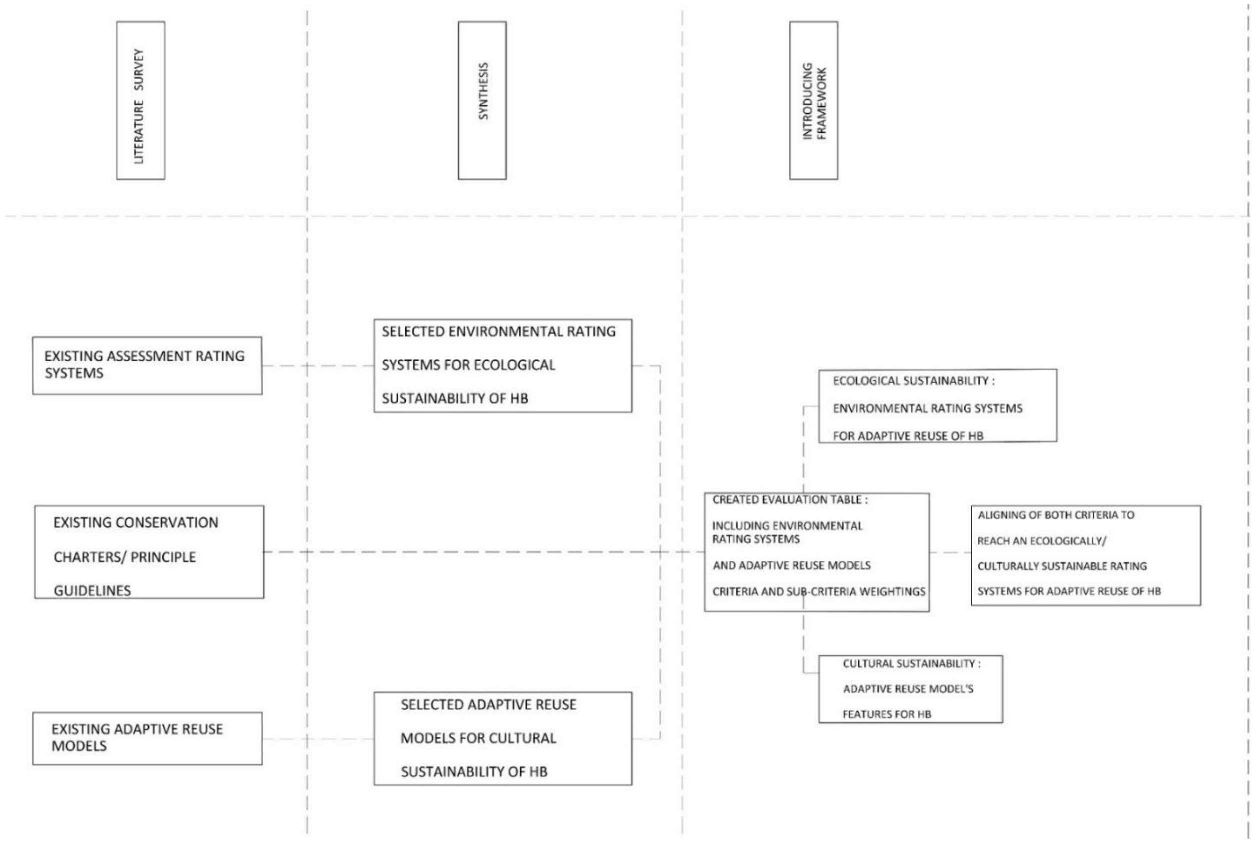

Figure 4: Thesis methodology in general

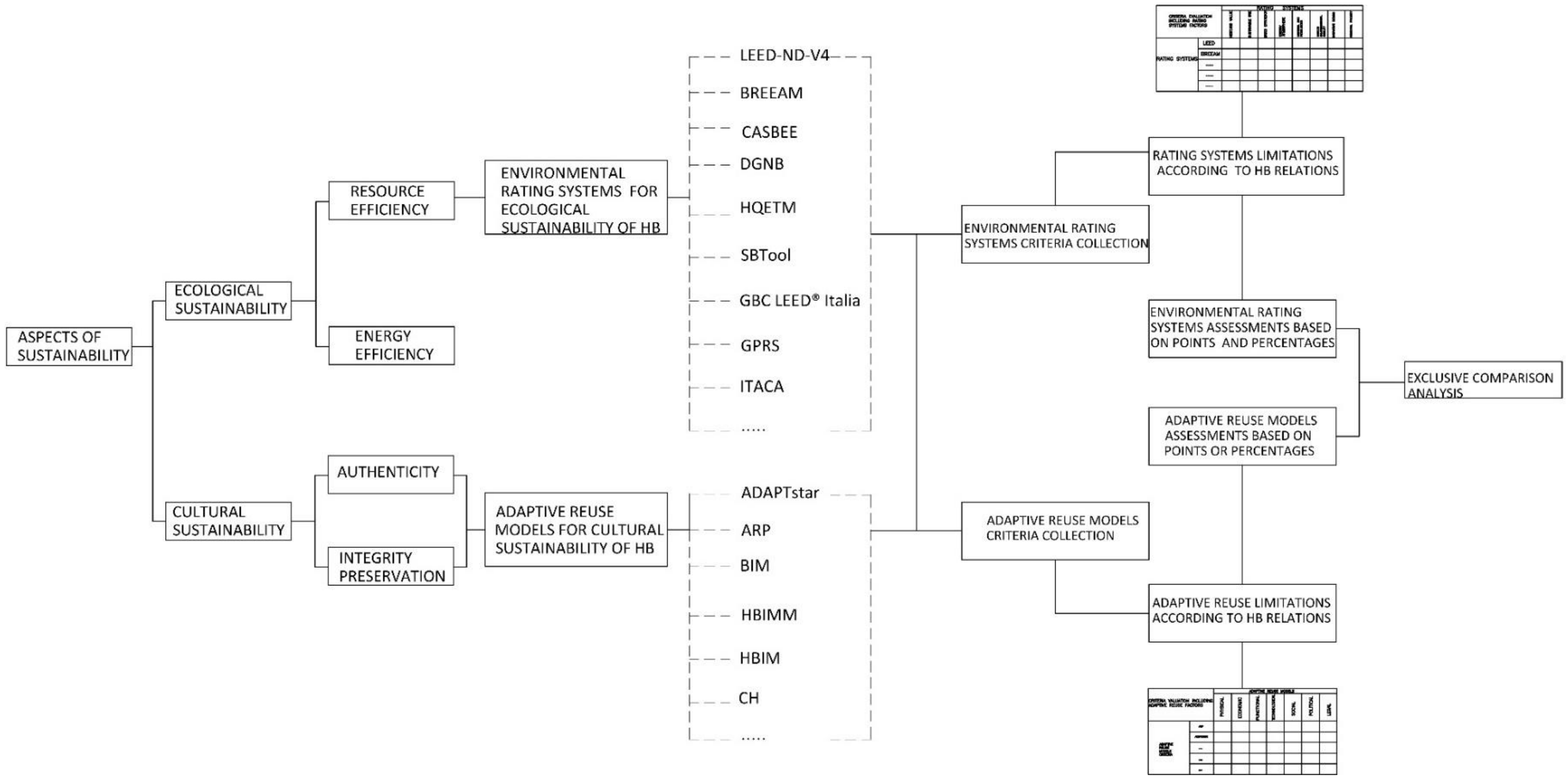


Figure 5: Thesis methodology in detail

## 1.5 Thesis structure

The schematised structure of the thesis has been illustrated in (Figure 6) , that expresses various stages of the study procedure. The information as a background of the study has been collected in the first chapter based on the previous researches and investigations. This chapter includes the problem definition which highlighted the vital gap for the integration of both cultural and environmental sustainability of heritage building (HB). Moreover, focusing on the gap of research, this study attempts to improve a framework and solve the lack of valuation of criteria in order to guide or assess environmentally certified adaptation of heritage buildings. The aim, objectives, scope, methodology and limitations have also been explained in this chapter. Following chapter has discussed about the continuity of architectural heritage and conservation of heritage buildings, besides introducing their features towards socio-cultural, environmental and economical sustainability pillars.

Chapter three and four have described the theories derived from literature survey, presenting the adaptive reuse concepts and adaptive reuse models serving for cultural sustainability issue; in parallel to investigating environmental rating system serving for ecological sustainability issue. The alignment of both cultural and ecological sustainability has been highlighted in Chapter 5 as the unique point of the study with the proposed framework to achieve prerequisite criteria for the certified adaptation of heritage buildings.

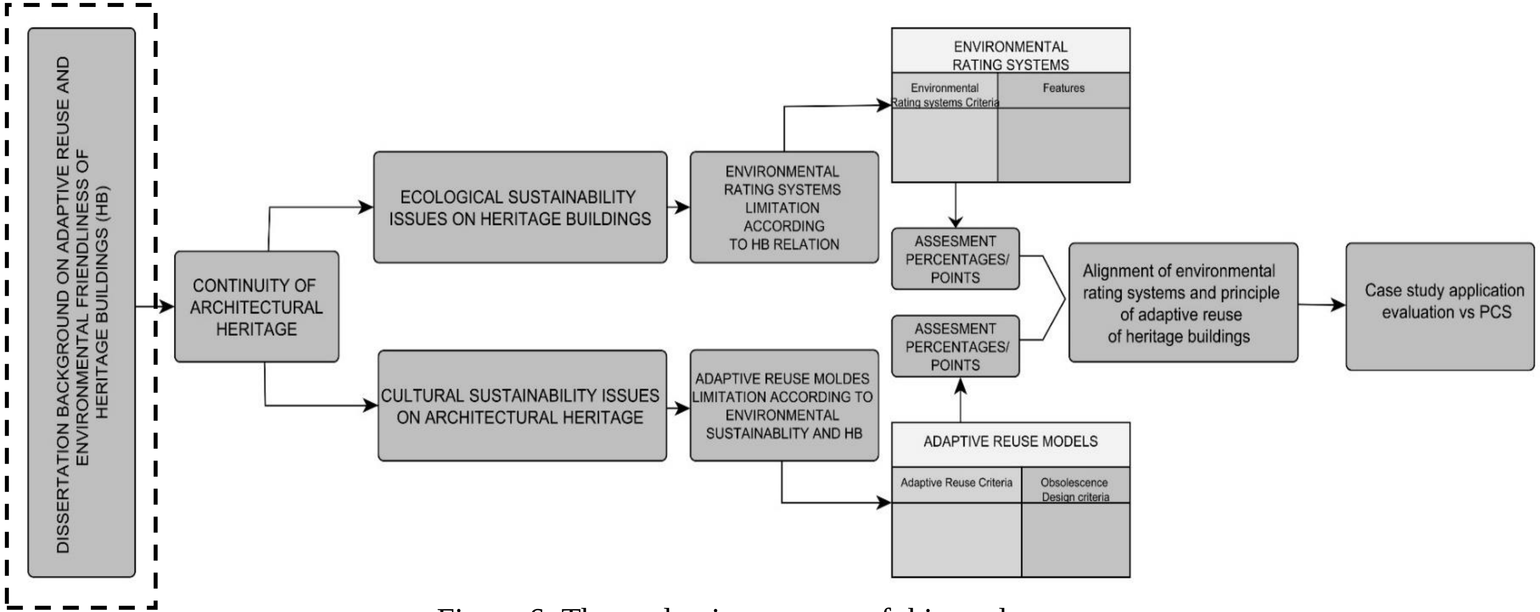

Figure 6: The evaluation process of this study

# Chapter 2

# CONTINUITY OF ARCHITECTURAL HERITAGE

## 2.1 Theoretical background for cultural heritage

ICOMOS was authoritatively established after the adoption of the International Charter for the Conservation and Restoration of Monuments and Sites known as Venice Charter (ICOMOS, 1964; Rahman, 2013), which explained about the adaptation of historic buildings and the duty to towards a sense of place and safeguard them for future generations. As mentioned in the Athens Charter (1931), the Venice Charter (1964) addressed the "world heritage" idea and mentioned "People are becoming more and more conscious of the unity of human values and regard ancient monuments as a common heritage" (Venice Charter, 1964, p:1). Moreover, the Burra Charter (1999) brings forward the appropriateness of adaptation which should have minimal effect on cultural significance of a place, including urban fabric, historic structures, interior spaces, objects while the changes on fabric should be applied after alternatives are considered (Conejos, et al., 2016).

Rahman (2013) states that, "although heritage, by its very nature, has been in existence for a long time, an understanding of the way it is used is relatively recent. Heritage is a valuable legacy inherited from the past" (Rahman, 2013, P:13). The Council of Europe in 1975 and Burra Charter in 1979 have introduced the scope of heritage in three terms:

- “Place referring to site, area, building or other work, group of buildings or other works together with pertinent contents and surroundings.
- Cultural significance, referring to an aesthetic, historic, scientific or social value
- Fabric means all the physical material of a place”( Al-Sakkaaf et al., 2020, p:4).

“Cultural heritage is the product or physical remains of the creative activity of humans, including their creative thinking and processes” (LU Zhou, 2014: p:3). The fundamental values of heritage buildings that might vary according to specific philosophical and cultural backgrounds arise from creative thinking, as well as understanding and intuitive exploration of the world (LU Zhou, 2014).

European Union (2020, p:17), Cultural heritage strategies should not only focus on preservation, protection or conservation of cultural heritage assets but also they need to take into account the spill-over effects and contribution of cultural heritage to sustainable development and the well-being of citizens.

## 2.2 Classification of cultural heritage

Architectural heritage buildings are different from contemporary buildings in that they have a definite timelessness and quality, contributing to culture and community value. Conservation of heritage buildings for long-term usefulness is a major priority and this requires high responsibility from policy-makers, developers and designers, for managing their sustainability (Conejos et al., 2016). As stated by Goded et al. (2017) architectural heritage buildings are witnesses of identity and reminders of history history. This is the motivation behind architectural conservation in many parts of the world. In line with this, Ministry of Culture and Heritage (2008) in New Zealand declared that 95% of public concerns conservation of their historic buildings and places. (Goded et al., 2017).

Historic buildings with particular values became a sustainability generator which acts as one element of the human environment and part of heritage building. Industrial heritage as one of the important issue of cultural heritage also has significant role in sustainable development for the city and society recently. (Blagojević & Tufegdžić, 2016).

As an example, the remained effects of Roman colonization in terms of administrative and legal systems, social entertainment and transportation and of urban form and development. In this regard, the necessity of education about significance of past history, conservation of architectural heritage, heritage site and monuments to presents and future generations is obvious and crucial (Rahman, 2013). The working documents of the Cultural Sector of UNESCO, in 1968 and 1969, presented a definition of heritage inclusive of the cultural and natural heritage. Under cultural heritage, only monuments, group of buildings and sites were addressed. However today's definition of heritage is updated by Malini Wan, 2020 inclusive of much wider number of categories (Figure 7).

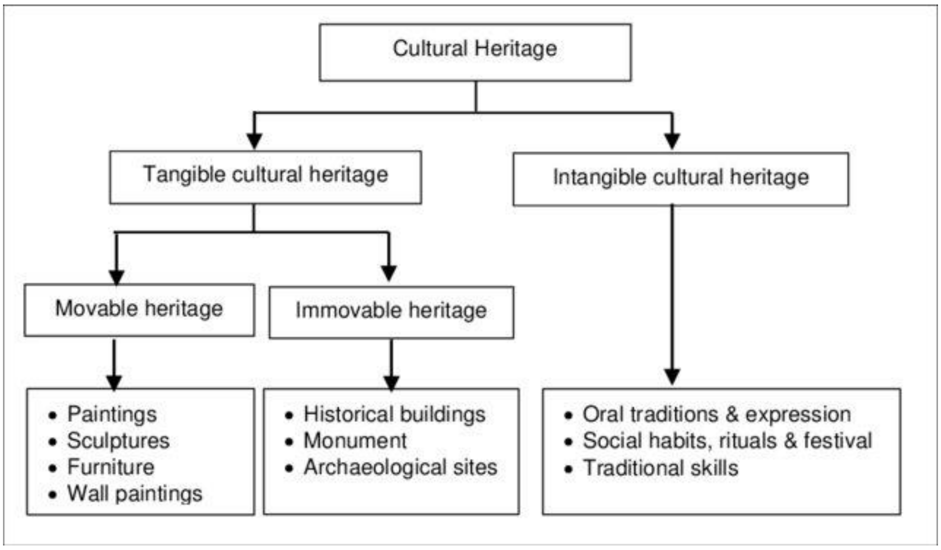

Figure 7: Cultural Heritage classification (Malini Wan, 2020, p:3)

Since the foundation of UNESCO, each significant feature of culture is elaborated such as tangible or intangible, movable or immovable, individual or group or intricately linked with nature, terrestrial or submerged (Roders & Oers, 2011). The following sub-sections explore the classifications of cultural heritage:

### 2.2.1 Tangible cultural heritage

Based on ICOMOS (2002), Tangible Cultural Heritage includes enormous works created by humankind, human habitation places, cities and towns, villages, buildings and structures, art works, handicrafts, documents, furniture, musical instruments, clothing, personal decoration items, funerary / ritual / religious objects, machinery and equipment, tools and industrial systems. Tangible heritage contains movable or immovable cultural heritage such as artefacts, monuments, groups of buildings and historic places, etc. which present conservation value for the future. These involve objects significant to architecture, archaeology, technology or science of a particular culture based on cultural significance and multi-dimensional dialogue across different regions or countries (UNESCO, 2003 & 2005).

UNESCO (2005, p:7) “explained about the practices, representations, expressions, knowledge, skills – as well as the instruments, objects, artefacts, and cultural spaces associated with them – that communities, groups, and, in some cases, individuals recognize as part of their cultural heritage are referred to as tangible cultural heritage”. Therefore, different layers of tangible cultural heritage (movable and immovable) and intangible cultural heritage will be explained in further steps.

#### 2.2.1.1 Movable Cultural Heritage

Antiquity act 1964 expressed that any cultural heritage movable objects made before 1863 which are made of carved, shaped, inscribed, produced or modified by human agency and any human or botanical remains of building should be restored and added at a later date (Ndoro et al., 2008)

Movable tangible heritage refers to articles, objects and tangible practices which essentially do not need to be rooted spatially. As examples are large libraries and depositories of archives, refuges intended to shelter halls of fame and museums or special collections where the artefacts and displays are the source of heritage. They can be transported easily for exhibitions or relocations of museums (Ramshaw, & Gammon, 2005; Jokilehto, 2005).

Furthermore, - 'movable cultural property' has been defined for all movable objects which are the testimony of human  and the expression creation, which are of archaeological and historical development, artistic, scientific or technical value and interest, metal, wood, stone and other materials (UNESCO, 1954; Ndoro et al., 2008)
.

### 2.2.1.2 Immovable cultural heritage

Cultural heritage contains historic sites and events, previously lived people of historical significance, immovable, intangible heritage, objects and sites, heritage cultural landscape and heritage documents. The Venice Charter emphasizes on the actions made for “monuments and sites”. Although this term was then used as an inclusive concept which is today known as ‘immovable cultural heritage’ which generically explains the heritage of the built or humanized environment (Bumbaru, 2014).

Ramshaw & Gammon (2005: p:7), discuss that immovable intangible heritage can comprise traditions and rituals which are generally connected with “particular spatially rooted locations”. Therefore, the existence of chants, traditions, or rituals, etc. depend on the existence and accessibility of their location (Ramshaw & Gammon, 2005).

The physical immovable remains that were built during the humankind history and include significance, can be exemplified as historic villages and towns, traditional architecture, tombs, ruins, stone, brick or mud brick structures and their associated features like mosaics, plasters and wall paintings, cave temples and archaeological sites (Ahmad, 2006).

### 2.2.2 Intangible cultural heritage

Cultural heritage establishes a symbiotic relationship between the tangible and the intangible heritage, involving society, norms and values such as ideas, belief systems and their reflections. In other words, objects, technologies and symbols are tangible evidence of underlying norms and values of a society (Bouchenaki, 2003). Bouchenaki, (2003) states that the tangible cultural heritage which provides numerous challenges and opportunities, survives easier than the intangible heritage since intangible heritage depends on verbal transmission generally.

The intangible cultural heritage that has been transferred from one generation to the following generation, is reformed continuously by groups and communities as a response to their history, environment and nature (UNESCO, 2003). As Sagazio (2009) points out, considerable international importance is given to intangible cultural heritage and all national governments have been expected to contribute to the discussion.

Lisa Rogers (2017), investigates the relation between environmental law and intangible cultural heritage. She determines that the aim of both is to make contribution for sustainable development. Particularly, she mentions about the recognition arises of the involvement of intangible cultural heritage to sustainable development. Within this framework, she claims that there is a mutual contribution of them to each other. In other words, intangible cultural heritage contributes to sustainable development while at the same time, sustainable development values might help the conservation and continuity of intangible cultural heritage.

For the safeguarding purposes of the intangible cultural heritage, the focuses will be only on the intangible cultural heritage which is well-matched with the international human rights instruments, besides, with the needs of common respect of sustainable development between individuals, groups, communities, highlighted the importance of resilient cities, safeguarding natural and cultural heritage for safe and inclusive (Deacon, 2003; Erkan, 2018).

The "intangible cultural heritage" as described in previous paragraph, is revealed in detail in the following statements from (UNESCO, 2003a): Performing arts; Traditional craftsmanship Social practices; rituals and festive events; Knowledge and practices concerning nature and the universe and language as a channel for intangible cultural assets, including oral traditions and expressions (Harrison, 2019).

This study has focused on the tangible and immovable cultural heritage as a part of cultural heritage classification, since the scope of this thesis covers architectural conservation, heritage buildings, structure, multi-dimensional dialogue across different regions or countries, etc.

## 2.3 Continuity of architectural heritage through conservation

According to the International Council of sites and Monuments, the basic principles and international code of practice for both identification and also for the conservation of historic monuments and sites has been set out by the Venice Charter (ICOMOS, 1964; Türker, 2002). Similarly in other countries, such as Canada and Australia's Burra Charter (2013), they framed their own guideline and standards for historic places (Hill, 2016).

The heritage and sustainability are known to share similarities in concept (Auclair & Fairclough 2015). Siebrandt, et al, (2017) defines, the vital mission of conveying the past values to present and to future generations is achieved through sustainability through cultural heritage conservation, as well as following the principle of "do as much as necessary and as little as possible" (Siebrandt, et al, 2017, P:3).

Culture and heritage were not included in sustainability either in its goals or its explanations, up to recent discussions. On the other hand, as Johnston (2015) states, a permanent definition of sustainability is needed which connects to cultural heritage via its concentration on human needs, a sense of past, present and future, a concept of being non-renewable and limited, as well as the earth as socio-culturally, ecologically and economically interconnected system. Blagojević and Tufegdžić, (2016, p:2) stated "Ten years after sustainability was conceived of in terms of the three pillars of economic viability, social responsiveness and respect for the environment culture was recognized as the forth pillar of sustainable development" (United Cities and local Government, 2001).

Heritage development necessitates a value-based heritage management with all difficulties. This brings the comprehensive questions as: 'for whom heritage is commodified? 'Whose heritage is being considered as a product?

Hall and McArthur (1997) stated that in the past, heritage has rarely been accepted as a static commodity. It is important to be conscious that heritage as a resource and its related values continuously change. Within this scope, any kind of serious consideration in order to accomplish sustainability, needs the management that can include change (Rahman, 2013).

As for the aim and objective of this dissertation, with the focus of architectural heritage, understanding and the conservation of architectural heritage, It considers continuity movements such as socio-cultural, ecological / environmental and economical continuity in order to clarify the role of sustainable movements on the adaptation of heritage buildings.

### 2.3.1 Socio-cultural continuity

In developing the traditional concept of conservation, social development goes beyond professionals and educational systems, focusing on the understanding of the monument, as an art form, and as a struggle for the Social History Association (Steiner, 2017). As Leitao (2012) discussed better and more inclusive conservation policies have resulted in further conservation of historic settlements. Langston et al., (2008, p:4) have been explained that “Older buildings are often in advantageous locations in city centres and they add to a sense of community and are often appreciated as comfortable working environments by occupants”.

Reduction in vacant or derelict buildings potentially adds vibrancy to communities, reduces crime and other unsocial behaviour, and raises living standards through added investment and revitalization (Langston et al., 2008; Elsorady, 2014). Langston et al (2008) and Jahromi and Türker (2020) state that old buildings generally provide social benefits such as intrinsic heritage values. Additionally, they can add character, present aesthetical streetscapes, provide image and status, to an organization based on the use of massive and highly crafted materials. One of the features of older building is that they were generally located in advantageous locations such as the city centres and nearby transport facilities. This makes the reuse more practical and feasible.

Auclair and Fairclough (2015, p: 3) discuss the consistency of adaptation and resilience themes with focus on cultural and social sustainability dimensions which should not be reflected as a separate pillar but as a vital part of sustainable development pillar named as socio-cultural pillar (Lebel et al., 2006). Additionally, they present sustainability and heritage by opening the discussion that “heritage is a central thread of sustainability, not only as an issue of preservation but of creation, adaptation and resilience to change" (Auclair and Fairclough, 2015, p: 3).

The international collaboration for the cultural heritage protection has mainly developed after the two World Wars' destruction. UNESCO has published different recommendations and conventions including concerns for various issues ranging from conflict or climate change to development (Leitao, 2012).

Socio-cultural continuity necessitates "to respect, preserve and maintain the knowledge, innovations and practices of indigenous and local communities embodying traditional lifestyles" (Assembly, 2011,p:110) relevant to both cultural diversity through the conservation and sustainable use of heritage places including urban and architectural heritage.

**2.3.2 Ecological / environmental continuity**

Preserving the present needs without compromising the capacity of upcoming generations in order to encounter with their needs, this development became sustainable as discussed in the Brundlant Report (1987). Generally in real state segment, adaptive reuse has the investment potential decision which arises from existing building obsolescence due to different aspects (Conejos et al., 2011; Wilkinson et al, 2014; Tan et al, 2015). Occasionally, the adaptation might not be economically sustainable option if the building structure needs the extensive strengthening (Vasilache 2013; İdemen, et al., 2016).

Vasilache (2013) mentions about the adaptive reuse of existing structure that short-term discussion of building changes and improves physical and economic qualities, prevents degradation and obsolescence, minimizes the possibility of redundancy and expands the building's lifespan.

Considerable adaptive reuse projects principles have been identified by (Loures and Panagopoulos, 2007;Wilson, C. 2010) addressed in (İdemen, et al. 2016): They must:

- achieve better functions for their reusing;
- be adaptable to new uses;
- well reacted to environments and context;
- have a graphic consistency and generate ‘delight’;
- energy efficient, no polluting, no environmental effect, be sustainable, non-polluting and easy to assemble”.

Communities have a lot to achieve from adaptive reuse of historic building in the pursuit of sustainable development (Kerr, 2004). As Kerr (2004) it mentioned, the Commonwealth Scientific and Industrial Research Organization (CSIRO) has clarified exemplified energy as the energy consumption through various associated processes such as building production, natural resources achievement to distribution of product, contains mining, administrative functions and transport and manufacturing of equipment and material. In this regard, after adaptive reusing of historic buildings, the embodied energy is preserved and generated from the original construction and hence, the projects become more environmentally sustainable rather than new construction completely (Kerr, 2004; Hill, 2016).

Based on definitions of Shen and Langston (2010), by giving a new life to heritage buildings, social and environmental, Mısırlısoy  and Gunce (2016)Furthermore, environmental advantages are obtaining from material recycling, reusing structural elements and decreasing the landfill waste generated which also increase the cost benefits to the owner with high environmental implication. Sometimes, older buildings are using ranges of material quality that presents a good useful life in excess of their moderns counterparts (marble floors, solid stone walls and slated roofs), (Langston et al., 2008).

### 2.3.3 Economical continuity

Cramer and Breitling (2012, p:9) have been discussed that Society is getting to be more mindful about environmental issues and the demolish of heritage buildings is now perceive as an ecological waste, additionally as the transfer of local character, of social heritage, and of socio-economic values.

Since 2007, European has a great infatuation about economic sustainability development which had influences on conservation practices and service management (Bumbaru, 2014).

Gimblett, 2004, expresses non-feasibility of old life style for economic and not well consistent with national ideologies and the economic development. Besides, it has the ability to turns into economically viable by valorisation of heritage in integration with economic of cultural tourism which has consistency with theory of economic development and national ideologies of cultural exclusivity and modernity (Gimblett, 2004).

Economic advantages have impacts on investors and owners in the manner of reuse projects contribution weather to regional and local economics by increasing the skilled job positions, which establishes new income streams, craftsmanship and professional expertise. Additionally, developers encountered with some obstacle during undertaking adaptive reuse projects such as: physical, financial and regulatory (Elsorady, 2014; Hill, 2016).

The restorative and reformative feature of adaptive reuse of building has extreme alignment with circular principles of economy buildings (Sanchez and Haas 2018) because:

- an gigantic extent of all the materials ever extricated in human history are in today's built environment (Kibert, 2007),
- generally, the lowest consideration is to the turn-over rate of buildings (Wilkinson et al., 2009; Beccali et al., 2013; Conejos et al., 2014; Sandin et al., 2014;).
- the cost of materials extraction is expanding as is the negative natural impacts due to the characteristic imperatives of the more weaken and far off stocks of metals and other assets (Kibert, 2007),
- understanding the genuine esteem of the built environment in terms of circular economy through combining cutting-edge Building Data Modeling (BIM) innovation with the foremost overhauled, total, and reasonable databases of the existing building stock is moving forward (Langston, 2013; Ortlepp et al 2016; Stephan and Athanassiadis, 2017)
- the precise monetization of environmental impacts through technological advancement and investigate within the field is progressing (Viscusi, 2005; Shindell, 2015; Yeung, 2016).

There are limit existing researches about economic advantages of architectural heritage buildings. The adaptive reuse concept for architectural heritage buildings is highly supported from respondents as a sustainability component, but the viability remained doubly, especially about economic issue (Bullen and Love, 2010).

Langston et al. (2008), state that apart from the time benefits, the cost of building adaptation is lower than new construction since most of building elements are already exists and also, there is no expensive problems to overwhelm such as foundation subsidence or asbestos removal which presents economically saving. However, older buildings might not compatible with new rules and regulations in their area or fire safety issues which are making changes in structure and additional protection measures, there is necessity to consider main refurbishment survey in order to approve the constructional and structural quality (Langston et al., 2008). In order to question the success of an adaptive reuse projects, it is not enough to evaluate the project only in terms of conservation principles. The strategic plan also should be prepared for sustainable heritage adaptations such as selecting the most suitable ERS and ARM with high range of mutual aspects (Mısırlısoy & Günçe, 2016).

## 2.4 Chapter conclusion

This chapter has been discussed about the identification and classification of cultural heritage and its significant footprint on architectural conservation worldwide and determining their vital value and authenticity for history and future generation. Therefore, the continuity explanation of architectural heritage is required to be expanded in different point of view such as socio-cultural, ecological and economical in order to brighten the pathway towards promoting the fourth branch of sustainability pillars as cultural sustainability (Figure 8). Therefore, the relation of cultural and ecological sustainability has become the main focus of this dissertation.

As following step, in the next chapter, the cultural sustainability approach has been clarified through adaptive reuse concept as a tool for sustainable conservation of architectural heritage.

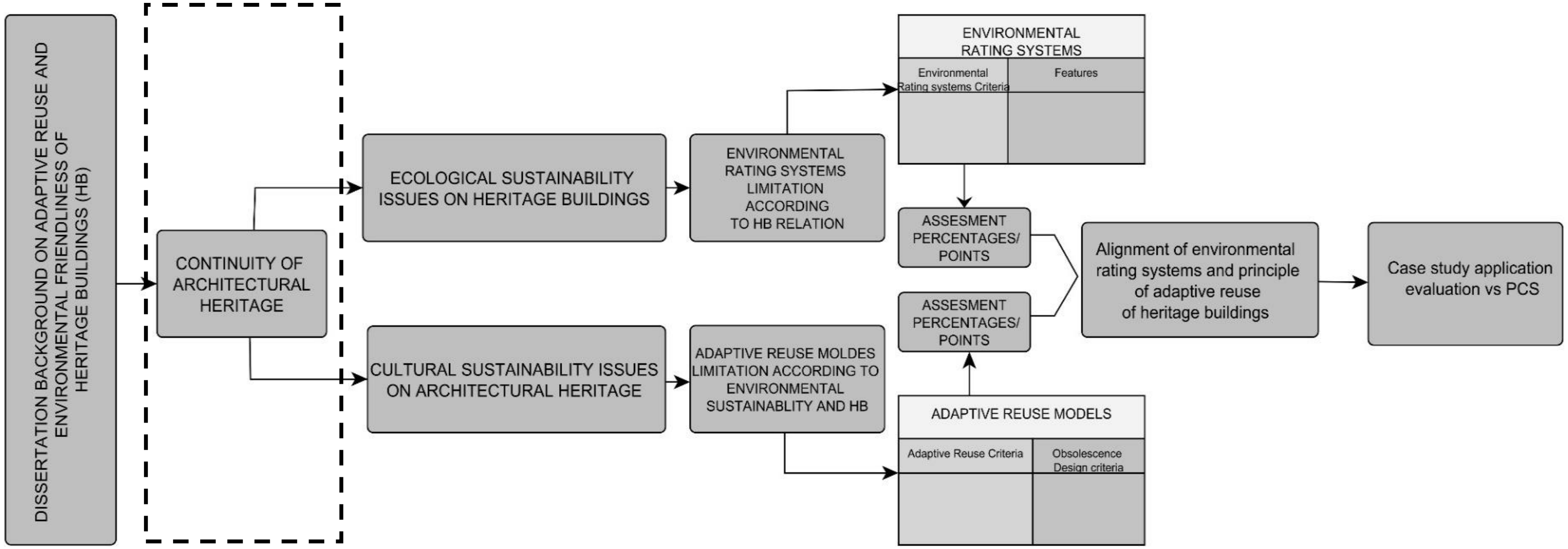


Figure 8: The evaluation process of this study

# Chapter 3

# CULTURAL SUSTAINABILITY ISSUES ON ARCHITECTURAL HERITAGE

Ayala and Forsyth (2007) state that, preservation can be described as interpreting, managing and understanding the architectural heritage in order to deliver it to the future. Furthermore, in developed countries, the conservation of historic buildings, has been identically significant, accumulated a wealth of experience and quite well approved (Hegazy, 2015). Moreover, the real estate sectors are becoming interested with adaptation of architectural heritage. Adaptive reuse is defined as any work to a building over and over support to alter its capacity, work or execution [or] 'any intercession to adjust, reuse, or update a building to suit modern conditions or necessities, (Douglas, 2006, p:1; Idemen, et al, 2007; p:4; Wilkinson et al, 2014, p:11) .

As Douglas (2006) stated, the level of intervention in adaptation is directly related with the level of deterioration. In between minimum to maximum level of interventions, in almost up to down order are preservation, conservation, refurbishment, rehabilitation, renovation, remodelling, restoration and demolishing (Douglas, 2006) (Table 3).

Table 3: The range of interventions in adaptation (adapted from Douglas, 2006, p:3)

| LEVEL OF INTERVENTION (MINIMUM TO MAXIMUM) | TYPE OF INTERVENTION | EXPLANATION |
|---|---|---|
| Preservation: Arrest decay | Maintenance: | Basic adaptation works including fabric repairs |
| Conservation: preserve purposefully | Maintenance:<br>Stabilisation: | Basic adaptation works including fabric repairs<br>Strengthening and main improvement works to the structure. |
| Refurbishment: facelift or makeover | Stabilisation: | Strengthening and major improvement works to the structure. |
| Rehabilitation: modernisation | Stabilisation: | Strengthening and major improvement works to the structure. |
| Renovation: upgrading | Stabilisation:<br>Consolidation: | Strengthening and major improvement works to the structure.<br>Medium adaptation and maintenance works |
| Re modelling improving /extending | Consolidation: | Medium adaptation and maintenance works |
| Restoration: bringing back | Consolidation:<br>Reconstruction: | Medium adaptation and maintenance works<br>Substantial rebuilding of part or parts of the building. |
| Demolition: removing completely | Reconstruction: | Substantial rebuilding of part or parts of the building. |

## 3.1 Adaptive reuse within contemporary conservation concept

The main concept of adaptive reuse plays a vital role when the function of historic buildings became obsolete and the only way to maintain and preserve them is, renewing its purpose and while maintaining the heritage value. The spirit part of adaptive reuse is sustaining the building's heritage values by conversion of it into a useful place for the future community besides preserving its cultural significance ((Latham, 2000; Kerr, 2004; ; Wilkinson et al., 2009; and Conejos, et al., 2016).

As Hill (2016) explains, socially, adaptive reuse socially conserves the area character, increases improves the quality of the public quality empire, and generates a sense of place and develops all our surrounding features which affects people’s health and the other social issues as vandalism, crime and community cohesion. In addition, culturally, it protects a significant part of our identity and heritage which can increase the building’s significance through uncovering forgotten stories, adding new points of interest or value and returning lost elements, (Hill, 2016).

The adaptation concept can be applicable on a part or the whole building (Douglas, 2006). Wilkson 2012 states that the ‘adaptation event’ term contains whole related activities to individual building authorization on existing building. This event might include the renovation of a site, change of use, extension, alteration, upgrade and as a multi-tenanted buildings, multiple events in one building could be applied, in case of building occupation (Wilkinson, 2012). Beside, Building adaptation can provide economic, environmental, and social benefits to society, according to Langston (2010, p:5), which should be at the considerationcenter of existing building stock thinking (Wilkinson, 2011, p: 206; Vasilache 2013).

Adaptive reuse is known as an investment decision in the real estate sector which comes from existing building obsolescence due to various factors (Idemen, et al. 2016). Langston (2014) expresses the definition for the adaptation of existing structure as alters and improves physical and economic characteristics of the building, prevents deterioration and obsolescence, reduces the likelihood of redundancy and increases building's lifespan, short-term disuse of building.

As for the economic point, the advantages of adaptive reuse have been under discussion due to the amount of risk related to reuse projects, which contain unexpected expenses, costly involvements or obstacles such as non-conformance with safety standard and governmental health (Vasilache, 2013; İdemen,et al. 2016).

As for environmental point, adaptive reuse projects are using internal sources and do the green field preservation. From the social aspect, adaptive reuse projects have been emphasized by different decision makers who believe that "presents problems of insecurity and social uncertainty and may bring about criminality ranging from vandalism and graffiti to break-ins, illegal occupancy and fires ” (Vasilache, 2013, p:9).

As for Cantell (2005)’s explanations, the adaptive reuse primarily arises from a method in order to protect the significance of historical buildings as well as saving them from being demolished. Generally, it has been clarified as an act of proposing new function for a structure or site such as educational buildings (schools), industrial buildings, office buildings, public buildings, warehouses, sport centers, shopping centers and numbers of other kinds of buildings that can be reused as training centers, residences, retail outlets, shelter or service units (Tan et al. 2015; Acar &Yalçınkaya, 2016).

Several types of successful adaptive reuse facilities contain industrial buildings, schools, defense structures, airfields, government buildings, offices and religious buildings (Van Driesche and Lane, 2002; Abbotts et al., 2003; Johnson, 2004; Langston et al., 2008;).

Furthermore, a successful adaptive reuse requires preparing the management plan for sustainable heritage adaptation in addition to the conservation principles evaluation (Mısırlısoy & Günçe, 2016). Joudifar and Türker (2020) also state that a successful adaptive reuse requires the historical, architectural and heritage value analysis of a heritage buildings in order to recommend appropriate new functions.

Kurul (2003) mentioned that the obsolete stage of any aforementioned functions is carrying the risk of becoming a vacant or under-utilized to the building. Therefore, there has to be an action for solving the obsolescence problem through giving a new lease of life to the building or by replacing it (Kurul, 2003). By considering the 'place fixity' and 'considerable life-expectancy', buildings can be usable as a source. However, Nutt (1997: 114) argues that "the transience of the demand side characteristics lead to a shift In the means of supplying space and facilities from procuring new buildings to the adaptive re-use of existing buildings", (Kurul, 2003, p:53).

Another feature of adaptive reuse is bringing up a strong, effective interference strategy, based on its potential to obtain rapid design, low-cost solutions, which may require various types of extra efforts and skills, in comparison to the new construction process such as the required material quality in order to gains higher adaptation cost (Bullen, 2007; Acar &Yalçınkaya, 2016).

Kurul (2003) states about the world motivations for indirect agents who are strongly related to the "conventional wisdom" of heritage buildings. Since historical buildings have lost most of their original functions, the adaptive reuse has been used for their survival based on the archeological manifest motivation as integral parts of cultural heritage (Kaplan, et al., 2013). As for aesthetic point of view in adaptive reuse, there have been debates on aesthetically appealing character in older buildings which is higher than new ones and their maintenance contributes to the 'quality of the environment', and the 'character and identity of the locale' (DoE, 1994a & b; Kurul, 2003). Economic point of adaptive reuse and indirect agents which can get benefit retrieved from heritage by using it for leisure and tourism purposes, hence, this is completed by the declaration that adaptive reuse is quicker, energy efficient and cheaper than new construction (Ball 2002; Kurul, 2003; Douglas 2006), (Figure 9).

| Evaluation criteria | Evaluation focus |
|---|---|
| Economic criteria | The economic alignment of the building asset with business requirements in the market in terms of costs (benefits-costs ratio; operating and maintenance cost; life cycle costs); financial resources; subsidies; exemptions; location, type, quantity and quality. |
| Functional criteria | The "fitness for purpose" of building assets including considerations of an appropriate and productive working environment in terms of configuration, layout and amenities. |
| Physical criteria | Physical condition, architectural evaluation; structural analysis; functional changeability, technical difficulties; material and deterioration; refurbishment feasibility; functional performance. |
| Service criteria | The satisfaction of users with building assets in service and their operating facilities. |
| Environmental criteria | The wider role of building assets and their impact on the built environment at the natural ecology and community level as well as their specific operational facilities. Criteria related to site layout; environmental impact; environmental quality of surroundings; energy usage. |
| Social criteria | Compatibility with existing social values; public interest and support; enhanced community; loss of habitat. |
| Legal criteria | Compliance with building codes; zoning laws; monument status; health and safety; land ownership. |

Figure 9: Evaluation criteria for adaptive reuse (İdemen, et al. 2016, p:3)

### 3.1.1 Adaptive reuse of architectural heritage

The architectural heritage gives us the opportunity to preserve the significance of social and cultural values embodied in historical buildings for upcoming generations (Kerr 2004; Bromley et al. 2005; Wilkinson, 2012).As Snyder (2005) explains, the cultural and social view in adaptation of industrial buildings has been concurred in US. Wilkinson (2012), established the criteria which present the potential exist in adaptation of architectural heritage buildings for sustainability: building age, adaptation trends by year, space height and form, aesthetics, building quality, location and number of adaptations (Wilkinson, 2012).

The ideal of conservation movement is avoiding extensiv changes and sustaining material continuation within built environment. The most significant justification is the contribution of continuity to the formation of sense of identity through society since the broad changes create 'a sense of loss' (Fielden, 1982; D0NH, 1996; DETR, 2000b; DCMS, 2001; Lichfield, 2009). Thus, based on Thomas (1996: 3) “'the support for conservation is not based on the need for sustainability or the economic virtue of re-use of resources, but rather on the profound sense of unease about the future and a sense of loss of what is perceived as being destroyed”. This definition expresses the conservation arguments for the ideal approach for retaining buildings as the result of building mummification (Kurul, 2003).

### 3.1.2 Adaptive reuse as a sustainable conservation approach

As Rodrigues and Freire (2017) state, European cities are mostly retrofitting historic buildings to be adapted as office building while preserving their historical value. Reconciling the historic preservation and sustainable design is the vital challenge of adaptive reuse. Historic building embodies numerous type of materials and construction techniques which depend on the geographical zone and the construction period (Rodrigues and Freire, 2017). Furthermore, adaptive reuse has impacts on life-cycle, waste and cost reduction besides building functionality improvements (Bullen and Love, 2011; Rodrigues and Freire2017).

The Country and Town Planning Act 1990 describes the reusing development as: “the carrying out of building, engineering, mining or other operations on, 1%, over or under land, or the making of any material change in the use of any buildings or other land” (Kurul, 2003, p:57; Greenwood, 1992: viii). There is the improvement process that has been explained by Byrne, (1996) investigates on the secure of economic and social objectuves through the refurbishment or construction of the building and land for occupation by different users. Furthermore, the concept has been analysed by Woodcock (1988, p: 49) and Kurul (2003, p:43) by an economical perspective as "Adaptive re-use is a development process by which structurally sound older buildings are developed for economical sustainability new uses".

Rodrigues and Freire (2017) point out that in South European cities, adaptive reuse has not been considered as the integration of cost life-style and environment perspective, however, by investigating substitute habitation patterns and historic buildings, adapted to commercial functions. Additionally, eco-efficiency examination has not been applied on historic building-retrofits, in order to analyse the highest eco-efficient approaches according to the occupancy and use type (Rodrigues and Freire, 2017).

Generally cultural sustainability of heritage buildings is the priority of conservation actions. Eco-efficiency needs to be balanced with the contemporary conservation criteria as well as the financial sustainability. There are many scholars who are concerned about the connection between adaptive reuse and sustainability as a common agreement (Kerr, 2004; UNESCO, 2007; Langston et al., 2008; Bullen and Love, 2010)). The contribution of adaptation of historic buildings to economic sustainability has been defined by Kerr (2004) as creating a new contemporary life in order to meet the functional requirement of the current user potentials. This can reduce the locational obsolescence which might be a cause of fail in social configuration (Kerr, 2004).

Adaptive reuse delivers an opportunity to preserve heritage buildings as a part of sustainable development for the communities to gain from historic building adaptation (Warren, 2004). As for social sustainability, the social demand of communities are appearing during the adaptation of the cultural and historical building significance. Additionally, adaptive reuse can relieve the building's natural decay during time period, increase energy efficiency by reducing the deterioration, and avoid the ineffective reconstruction and demolition procedure which leads to environmental sustainability contribution (Kerr, 2004; Sözer, 2010; Yung, et al, 2013)

"Environmental benefits, combined with energy savings and the social advantage of recycling a valued heritage place make adaptive reuse of historic buildings an essential component of sustainable development" (Kerr, 2004, p:4). Yung, et al (2013) have published a shortlist which contains 18 factors based on adaptive reuse in contribution to cultural sustainability development in order to be used for various types of analysis which are categorized into four ranges of sustainability agenda, (Figure 10).

| Sustainability factors | Description of sustainability factors | Source |
|---|---|---|
| Economic | | |
| Self-sustain | Whether it can be self-sustaining would affect the economic viability of the new use (considering future running and maintenance costs) | Murtagh (2006), UNESCO (2007) |
| Economic efficiency | Costs of rehabilitation versus economic return from either rent income, business return, and/or tourism revenue | Murtagh (2006) |
| Business return | The extent to which it can generate employment, tourism, and business activities leads to economic growth | Tweed and Sutherland (2007), Steinberg (1996) |
| Land value and rent | Increase in land values and rent as a result of growth in traditional and new economic activities indicates economic growth | Tweed and Sutherland (2007), Steinberg (1996) |
| Social | | |
| Quality of life | Social sustainability refers to harmonious development that is compatible with the cohabitation of diverse groups while encouraging social integration, with improvements in the quality of life for all segments of the population | Polse and Stren (2000) |
| | It is a common indicator which can be measured through people's own evaluation | DETR (1997) |
| Social networks | Connectedness with people, place, and time; social relationship, interaction, and support | Bramley and Power (2009), Atkins (2004) |
| Social inclusion and cohesion | Combat social exclusion of the poor and the disadvantaged, access issues, e.g., gentrification. Achieved through community involvement | Tweed and Sutherland (2007), Yung and Chan (2011, 2012b) |
| Sense of place and belonging | A feeling of belonging to a particular community or group and members which are important to one another. It helps us to link our roots | Pendlebury et al. (2004) |
| Conserve original way of life | Enhance continuity of life and strengthen cultural traditions and forms and cultural diversity | Lowenthal and Binney (1981), Steinberg (1996) |
| Community development | Empower community through participating in collective activities and developing networks | UNESCO (2007), Woolever (1992) |
| Satisfaction of new use | A common measure for social well-being | Shipley et al. (2011), Ashworth and Tunbridge (2000) |
| Environmental | | |
| Development density | Overly dense development has negative impact on urban development | Chan and Lee (2009) |
| Noise level | LEED environmental quality: energy efficiency, carbon emission, noise level, air quality, lighting, heat, waste, etc. can affect environmental performance | U.S. Green Building Council (2000), Langston (2010) |
| Urban environment | Urban patterns and form can preserve and enhance the original townscape, street patterns, land use, building form, etc. | Steinberg (1996) |
| Political | | |
| Community participation | Participation in decision making, and execution and use of the buildings | The International Council on Monuments and Sites (ICOMOS) (1987), 2009), Shipley et al. (2011) |
| Government policies and strategies | Supportive government policies and strategies at local level. Strengthening the local authorities' decision-making power | Steinberg (1996, 2004) |
| Effectiveness and transparency | Optimal administrative costs. Citizens are well informed about the formulation and implementation of the policies | World Bank (2008) |
| Financial support | Heritage project funding or incentives | Bullen and Love (2010), Shipley et al. (2011) |

Figure 10: Summary of sustainability factors for the adaptive reuse of historic buildings according to different sources (Yung et al., 2013, p:3).

According to Figure 10, sustainability factors for adaptation of HB and their explanations were the focus of the study in order to find out the potential features for achieving obsolescence design criteria and to be a part of this thesis analysis on both cultural and ecological sustainability. As an example, as the figure describes 'social factor: sense of place and belonging', it has been under investigation for achieving the final adaptation approaches, hence, at the proposed framework is taking place by 'social: Image and identity/ Image and history.

### 3.1.3 Obstacles faced by adaptive reuse

Fournier and Zimnicki (2004) proposed some principles to give direction to the adaptive reuse of buildings, in line with the aims of heritage preservation through transforming heritage building and sustainable planning. This idea brings the concept towards ‘eco-vernacular’ (Dittmark, 2008) or ‘green adaptive reuse’ (Langston, 2010), which attempts to combine technologies and green approaches for adaptation of heritage buildings in order to develop the preservation quality of cultural and heritage value. Although, adaptation has several opportunities and benefits, but, it carries many obstacles in adaptive reuse of heritage buildings specifically (Conejos, et al, 2016). Figure 11 defines a shortlist of obstacles that adaptive reuse is encountered with, during the conservation projects (Conejos et al., 2016).

| Barrier | Brief description | References |
|---|---|---|
| (1) Building codes and regulations/legal constraints | Compliance with current building codes, regulations, conservation guidelines, licensing and planning requirements | Bruce et al. (2015), Bullen and Love (2011), Cooper (2001), Douglas (2006), Shipley et al. (2006) |
| (2) Physical restrictions | Restrictions due to existing floor layouts, number of columns/walls and structural system layouts | Bruce et al. (2015), Bullen and Love (2011), Cox (2004), Reyers and Mansfield (2001) |
| (3) High remediation costs and construction delays | Contamination due to the use of hazardous materials in buildings that causes additional costs and time delays | Bruce et al. (2015), Bullen and Love (2011), Wilkinson et al. (2009) |
| (4) Availability of materials and lack of skilled tradesmen | Compatibility of new materials with existing materials, as well as the availability of local expertise and tradesmen capable of implementing conservation works | Cox (2004), Bullen and Love (2011), Douglas (2006), Remoy and van der Voordt (2007), Reyers and Mansfield (2001) |
| (5) Complexity and technical difficulties | Refurbishment techniques, technical installations and innovative solutions for the adaptive reuse of heritage buildings | Ball and Ball (1999), Bruce et al. (2015), Bullen and Love (2011), El Kerdany (2002), Kronenburg (2007), Shipley et al. (2006) |
| (6) Economic considerations | Direct and indirect cost considerations in terms of the conservation requirements for the adaptation of heritage buildings | Cox (2004), Douglas (2006), O'Donnell (2004), Reyers and Mansfield (2001), Shipley et al. (2006), Yung and Chan (2012), Wang and Zeng (2010) |
| (7) Social considerations | Pertains to the intangible non-economic values considered to maintain the community's daily life (*e.g.* a sense of attachment to the place) | Bond (2011), DEH (2004), Jonas (2006), Yung and Chan (2012) |
| (8) Inaccuracy of information and drawings | Lack of accurate information and drawings for heritage buildings (includes defects or dimensional and material inconsistencies) | Cox (2004), Remoy and van der Voordt (2007), Reyers and Mansfield (2001) |
| (9) Limited response to sustainability agenda | Limited support from building owners and commercial property markets in updating buildings to sustainability standards | Ellison and Sayce (2007), O'Donnell (2004), Pivo and McNamara (2005) |
| (10) Maintenance | High maintenance and repair costs due to physical deterioration and defects | Bullen and Love (2011), O'Donnell (2004), Remoy and van der Voordt (2007) |
| (11) Classification change | Scope and classification changes of buildings that need building code and zoning compliance | Bullen and Love (2011), Cox (2004), Langston et al. (2007), Reyers and Mansfield (2001) |
| (12) Inertia of production and development criteria | Different production and developmental criteria of cities pose challenges to urban regeneration or redevelopment approaches | Bromley et al. (2005), Bullen and Love (2011) |
| (13) Commercial risk and uncertainty | Lengthy and difficult renovation or reuse often leads to reduced profit margins | Bruce et al. (2015), Bullen and Love (2011), Shipley et al. (2006), |
| (14) Financial and technical perceptions | Notion that demolition is the only way to get a reasonable profit since adaptive reuse is seen as | Bruce et al. (2015), Bullen and Love (2011), Shipley et al. (2006), Yung and Chan (2012) |

Figure 11: List and brief descriptions of the barriers in front of adaptive reuse (Conejos, et al., 2016, p:5)

According to the mentioned Figure 11 above, the study also considers barriers and obstacles which occur during the adaptive reuse according to the sustainability pillars. In order to estimate the existing building useful life based on obsolescence categories, a sustainable assessment tool known as SINDEX has been introduced (Langston, et al., 2008).

#### 3.1.3.1 Adaptive Reuse Potential (ARP)

The building ARP also will be rely on various respond to different types of risks (Idenmen, et al. 2007, p: 2-3):

“Health risks can be addressed by an assessment according to factors such as the provision of appropriate areas for the collection, temporary storage and removal of solid waste; and an adequate ventilation and daylight; an adequate number of latrines”

“Security risks can be addressed by an assessment according to factors such as avoiding inadequately illuminated areas, isolated basements, dark areas, hallways, and streets (UNHRC, 2010,p: 73) or marking/isolation of “no-go-zones” (Sphere, 2016 )”.

“Psychological risks can be addressed by an assessment according to factors such as respecting the privacy needs of victims, arranging common spaces for leisure activities, as well as other forms of socialization spaces”.

“Safety risks can be addressed by an assessment according to factors such as arranging collective cooking spaces, rather than individual spaces to reduce fire risk or compliance to access and exit evacuation codes”.

“Risks related to vulnerable groups can be addressed by an assessment according to factors such as the construction of ramps for the disabled and the allocation of easily accessible spaces (e.g., ground floors) to the elderly and disabled victims (IDEMEN, et al., 2007,p2-3) (Figure 12 and Figure 13)”.

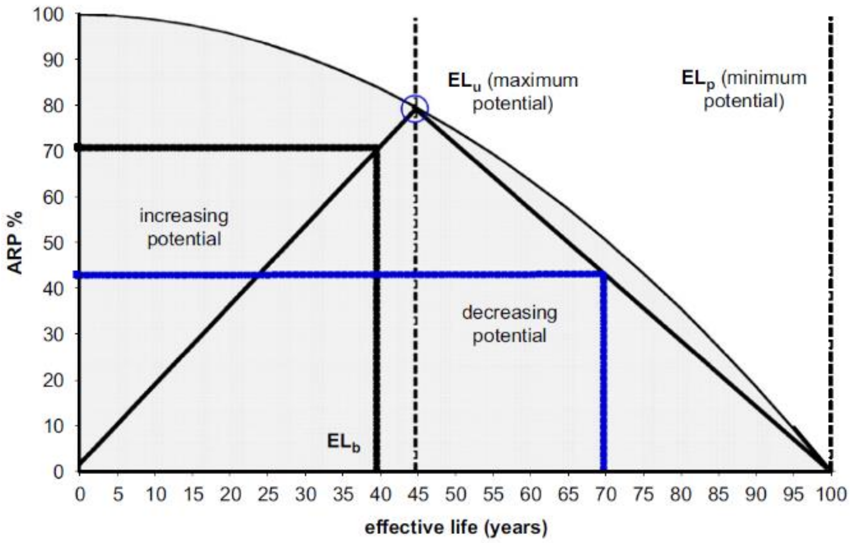

Figure 12: Effective life (years) (Langston et al., 2008, p: 6)

Useful life in the ARP model can be determined from Equation

$$\text{Useful life}(L_u) = \frac{L_p}{\left(1+\sum_{i=1}^{7} o_i\right)^{L_p}}$$

- “Lp ¼ physical life (years),
- O1 ¼ physical obsolescence (% as decimal p:a.),
- O2 ¼ economic obsolescence (% as decimal p:a.),
- O3 ¼ functional obsolescence (% as decimal p:a.),
- O4 ¼ technical obsolescence (% as decimal p:a.),
- O5 ¼ social obsolescence (% as decimal p:a.),
- O6 ¼ legal obsolescence (% as decimal p:a.),
- O7 ¼ political obsolescence (% as decimal p:a.)” (Langston, et al., 2013, p:4).

| Category | Criterion |
|---|---|
| Long Life (Physical) | Structural Integrity |
| | Material Durability |
| | Workmanship |
| | Maintainability |
| | Design Complexity |
| | Prevailing Climate |
| | Foundation |
| Location (Economic) | Population Density |
| | Market Proximity |
| | Transport Infrastructure |
| | Site Access |
| | Exposure |
| | Planning Constraints |
| | Plot Size |
| Loose Fit (Functional) | Flexibility |
| | Disassembly |
| | Spatial flow |
| | Convertibility |
| | Atria |
| | Structural Grid |
| | Service Ducts and Corridors |
| Low Energy (Technological) | Orientation |
| | Glazing |
| | Insulation and Shading |
| | Natural Lighting |
| | Natural Ventilation |
| | Building Management Systems |
| | Solar Access |
| Sense of Place (Social) | Image/ Identity |
| | Aesthetics |
| | Landscape/ Townscape |
| | History/ Authenticity |
| | Amenity |
| | Human Scale |
| | Neighbourhood |
| Quality Standard (Legal) | Standard of Finish |
| | Fire Protection |
| | Indoor Environmental Quality |
| | Occupational Health and Safety |
| | Security |
| | Comfort |
| | Disability Access |
| | Energy Rating |
| | Acoustics |
| Context (Political) | Adjacent Buildings |
| | Ecological Footprint |
| | Conservation |
| | Community Interest/ participation |
| | Urban Masterplan |
| | Zoning |
| | Ownership |

Figure 13: The adaptSTAR model (Conejos et al., 2011, P: 6-7)

### 3.1.3.2 Adapt-Star Model

Based on most of scholars in conservation field, Rodwell (2008) also focuses on the significance of cultural heritage which is a vital element of sustainable development and promote the national identity. The adaptSTAR model which has noticeable consistency with the ARP model can increase the designer’s power for critical decision making that assist the future reuse and longevity improvement, to be ensured about the future adaptive reuse of buildings and the integration with sustainable environment. The design criteria has linkage to the same 7 obsolescence factors as the ARP model as a base of this assessment (Figure 14 and Figure 15) (Conejos, et al., 2014).

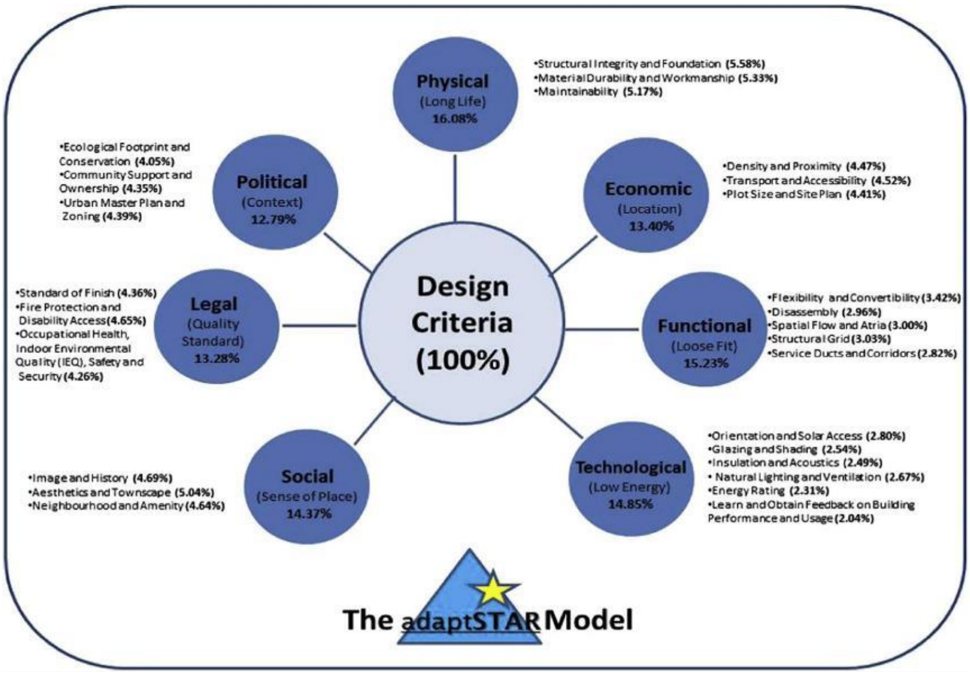


Figure 14: The adaptSTAR model (Conejos et al., 2014, P: 4).

| Category (7) | Sub-category (26) |
|---|---|
| Physical | Structural integrity and foundation |
| | Material durability and workmanship |
| | Maintainability |
| Economic | Density and proximity |
| | Transport and access |
| | Plot size and site plan |
| Functional | Flexibility and convertibility |
| | Disassembly |
| | Spatial flow and atria |
| | Structural grid |
| | Service ducts and corridors |
| Technological | Orientation and solar access |
| | Glazing and shading |
| | Insulation and acoustics |
| | Natural lighting and ventilation |
| | Energy rating |
| | Feedback on building performance and usage |
| Social | Image and history |
| | Aesthetics and townscape |
| | Neighbourhood and amenity |
| Legal | Standard of finish |
| | Fire protection and disability access |
| | Occupational health, IEQ, safety and security |
| Political | Ecological footprint and conservation |
| | Community support and ownership |
| | Urban masterplan and zoning |

Figure 15: Criteria and sub-criteria of adapt-star design criteria (Conejos et al., 2014, p: 43)

### 3.1.3.3 Preliminary assessment of adaptation potential (PAAM)

Building adaptation and property has been investigated between1998 and 2008 in Melbourne central business district (CBD). The property significance was retrieved by using a principal component analysis (PCA) and for optimal decision making as a weighted index, a model was proposed: the Preliminary Assessment Adaptation Model (PAAM), (Wilkinson, 2011).

Minor works (i.e. the slightest work embraced), changes works (i.e. counting corrections to the space plan, redecorations and maintenance of the existing outside fabric with minor alterations remotely), change of utilizing (from one land utilize to another, office to private), changes and extensions (major work counting reconfiguring internal space, changes to the structure and texture, services and decorations), devastation and modern construct were inspected. The focus of this paper is placed on adaptive reuse and accordingly only building adaptation events classified as 'alterations and extensions' (level 4) are examined further, (Figure16) (Wilkinson, 2011, P:6).

| Adaptation level | Title |
|---|---|
| Level 1 | Minor |
| Level 2 | Alterations |
| Level 3 | Change of Use |
| Level 4 | Alterations and extensions |
| Level 5 | Demolition |
| Level 6 | New build |

Figure 16: "The relationship between building adaptation and property attributes" stated by Wilkinson (2011, p:105).

The Preliminary Assessment of Adaptation Model (PAAM) has been developed by Wilkinson (2011) based on selecting 1237 building adaptations in ‘alterations’ stage in (CBD) since 2009-2011. As it shows in figure13, PAAM analysis is based on multiple criteria according to different six stages. Generally, PAAM has been known as one of the reliable representative diagram to express the connection between building adaptation and the significant key of decision making criteria (Langstone et al., 2013).

Wilkinson (2014) expresses the advantages of the PAAM model that is moderately simplifies the understanding of the building adaptation potential in fast and deeper manner and present the essential attributes of the property which are required issues from stakeholders. Additionally, the PAAM can be used by a non-expert to achieve the primary assessment of building’s overall appropriateness for ‘alterations and extensions’. Furthermore, the PAAM model has more integration to recent developments for example environmental sustainability, (Figure 17) (Wilkinson, 2014).

| Category | Attribute |
|---|---|
| Economic | Current value<br>Investment value<br>Yields<br>Increase in value post adaptation<br>Construction and development costs<br>Convertibility (ease of conversion to other use and costs associated with the conversion) |
| Physical | Building height/number of storeys<br>Floor plate size<br>Shape of floor plate<br>Service core location<br>Elasticity (ability to extend laterally or vertically)<br>Degree of attachment to other buildings<br>Access to building<br>Height of floors<br>Structure<br>Floor strength<br>Distance between columns<br>Frame<br>Deconstruction (safe efficient and speedily)<br>Expandability (volume and capacity)<br>Flexibility (space planning)<br>Technological and convertibility<br>Dis-aggregability (reusability / recyclability) |
| Location and land use | Transport<br>Access (proximity to airports, motorways, train stations, public transport nodes, buses and trams)<br>Land uses (commercial, residential, retail and industrial or mixed use such as office and retail)<br>Existing planning zones<br>Rezoning potential<br>Density of occupation |
| Legal | Ownership – tenure<br>Occupation – multiple or single tenants<br>Building codes<br>Fire codes<br>Access acts<br>Health and safety issues<br>Convertibility |
| Social | Community benefits – historic listing<br>Transport noise<br>Retention of cultural past<br>Urban regeneration<br>Aesthetics<br>Provision of additional facilities / amenities<br>Proximity to hostile factors<br>Stigma<br>Age |
| Environmental | Internal air quality<br>Internal environment quality<br>Existence of hazardous materials (asbestos)<br>Sustainability issues |

Figure 17: PAAM design principles criteria (Wilkinson, 2014, p:78).

## 3.2 Investigation of selected adaptive reuse models

By considering PAAM obsolescence design criteria, number of differences appears compare to ARP and adapt-star in terms of design criteria categorization. Although some of the sub-criteria has same definitions as another sub-criteria with different title, but in order to make equal validation system, both criteria have been merged in the matrix. The Table 4 below defines the variety of adaptive reuse models worldwide; makes an analysis of the related models in terms of their scope, direct or indirect relations to adaptive reuse of heritage buildings, the evaluation tools / software and their problems and limitations.

Table 4:Variety of adaptive reuse models design features worldwide

| ADAPTIVE REUSE MODELS CATEGORY | | | |
|---|---|---|---|
| | ARP | ADAPSTAR | PAAM |
| 1 | Physical | Physical | Physical |
| 2 | Economic | Economic | Economic |
| 3 | Social | Social | Social |
| 4 | Functional | Functional | |
| 5 | Technological | Technological | |
| 6 | Political | Political | |
| 7 | legal | legal | Legal |
| 8 | | | Environmental |
| 9* | | | Location and land use |
| * Location and land use contains mutual sub-criteria with the other factors which has been merged with them. | | | |

By addressing the analysed documents from adaptive reuse models related to heritage buildings, the pointed criteria will support evaluation part of the study to achieve the features to shape the proposed framework. In order to achieve the equilibrium in adaptive reuse criteria collection from selected adaptive reuse models, a table has been created in order to define the combination of all adaptive reuse criteria related to heritage buildings, (Table 5).

Table 5: Adaptive re-use models versus adaptive re-use criteria

| No: | Country and Year | Name | Management | Scope | AR Models for HB | AR Software for HB | Documentation System for HB |
|---|---|---|---|---|---|---|---|
| 1 | America (1930s) | HABS | Historic American Building Surveys | "By abiding to such an intense documentation routine that promotes hands-on engagement with a historic structure, a deeper understanding of the historic fabric is achieved and thus is reflected in an accurate set of documentation for the Heritage Documentation Program's archive (HDP)" (Bopp, 2014) | | | x |
| 2 | America (1970) | BIM | Building Information Modelling | "New paradigm of digital design and management, shows great potential for the refurbishment process" (Bruno, 2018) | | X | |
| 3 | Australia (2004) | PAAM | Preliminary Assessment of Adaptation Potential | "PAAM is a reliable diagrammatic representation of the relationship between key significant decision-making criteria and building adaptation" (Wilkson et al, 2014). "The PAAM model facilitates a relatively fast and deeper understanding of the adaptation potential of a building and highlights the important property attributes which are likely to present issues for stakeholders" (Wilkson, 2014) (Idemen, 2016). | x | | |
| 4 | Australia (2007) | ARP | Adaptive Reuse Potential | "The ARP model provides a reasonable straightforward method for accessing effective useful life and adaptive reuse potential (ARP) in existing buildings." "The concept of adaptive reuse potential (ARP) provides a robust assessment of the effective useful life of a historic building, taking consideration of factors affecting obsolescence. The ARP model predicts useful life as a function of (discounted) physical life and obsolescence and allows the calculation of the adaptive reuse potential" (Wilkson, 2009). | x | | |
| 5 | Ireland (2009) | HBIM | Historic Building Information Modelling | "Historic Building Information Modelling (HBIM) is a novel prototype library of parametric objects, based on historic architectural data and a system of cross platform programmes for mapping parametric objects onto point cloud and image survey data" (Murphy, 2013). | | x | |
| 6 | Australia (2010) | AdaptSTAR | Adapt Star Model | "A new design rating tool called adaptSTAR, is a weighted checklist of design strategies that lead to future successful adaptive reuse of buildings." "AdaptSTAR model can empower designers of buildings to make critical decisions that contribute to improving longevity and future reuse" (Rodres, 2011). | x | | |
| 7 | Malta (2011) | CHIMS | Cultural Heritage Information Management System | "The main objective of CHIMS is to create a new knowledge-based context for understanding, managing and disseminating data concerning cultural heritage. CHIMS aims at enabling access to cultural heritage as a requirement for protection as well as a fundamental human right" (Buhagiar, 2006). | | | x |
| 8 | Lithuania (2018) | CHPP | Cultural Heritage Perception Potential | "The CHPP model requires analyzing the indicators which establish the impression for people to evaluate buildings as cultural heritage by contextual analysis" [4]. | | | x |

The presented Table 5, had been express the idea of adaptive reuse criteria taken from adaptive reuse models related to heritage buildings worldwide. Continuously, the common adaptive reuse design criteria have been used in the thesis evaluation criteria which promotes via a excel table. Table 6 describes different models related with adaptive reuse and adaptive reuse of architectural heritage buildings. The following Table 6 describes the summary of adaptive reuse models with direct relations with ecological sustainability and their evaluation tools.

Table 6: Classification of rating systems from the world, according to their relation with adaptive reuse of heritage buildings

| No. | Name of Models related with adaptive reuse | Scope | relation To adaptive reuse of heritage buildings | Evaluation tools/software | Problems and limits in terms of historical buildings | Obsolesce Design criteria |
|---|---|---|---|---|---|---|
| 1 | adaptSTAR (Conejos & Langston 2011). (Conejos et al., 2013, 95-103.) (Conejos, Langston 2010). | "The adaptSTAR is a rating tool that effectively considers or predicts the adaptive reuse potential of new or future buildings". "AdaptSTAR star rating similar in concept to the Green Building Council's Green Star or LEED methodology where performance is assessed using a standard five star rating methodology". | "Use Langston's ARP model to validate a new design rating tool called adaptSTAR, is a weighted checklist of design strategies that lead to future successful adaptive reuse of buildings".<br><br>"The adaptSTAR model is an extension to the existing sustainability tools used to measure a building's energy efficiency". | • Online questionnaire software program survey Monkey. | Lack of clear design criteria for future adaptive reuse. Lack of consensus as to what design criteria would best maximize the adaptive reuse potential of future buildings | Physical<br>Economic Functional<br>Technological<br>Social<br>Legal<br>Political |
| 2 | ARP (Adaptive Reuse Potential). (Seeley, 1983) (Langston, 2008) Conejos & Langston 2011). (Conejos et al., 2013., 95-103.) (Conejos, Langston 2010). | "The ARP model provides a reasonable straightforward method for assessing effective useful life and ARP in existing buildings". "ARP model use of this technique by government authorities to help manage the daunting task of where best to prioritize its resources for heritage protection". | "The concept of adaptive reuse potential (ARP) provides a robust assessment of the effective useful life of a historic building, taking consideration of factors affecting obsolescence".<br><br>"The ARP model predicts useful life as a function of (discounted) physical life and obsolescence. It allows the calculation of the adaptive reuse potentials for historic buildings". | • Online questionnaire software program Survey Monkey.<br>• SYNDEX methodology | Evidence is needed to determine if these findings are replicable for a wider range of contexts. | Physical<br>Economic Functional<br>Technological<br>Social<br>Legal<br>Political |
| 3 | PAAM (Preliminary assessment of adaptation potential )<br><br>İdemen et al. (2016). Wilkinson (2014). | "A predictive model for the preliminary assessment of adaptation potential (PAAM) which was based on building adaptation events between 1998 and 2008 in Australia". | "The PAAM incorporated more recent developments such as environmental sustainability. The PAAM model facilitates a relatively fast and deeper understanding of the adaptation potential of a building and highlights the important property attributes which are likely to present issues for stakeholders". | • Using a principal component analysis (PCA) | PAAM was developed to be "used by a non-expert to make an initial assessment of a building's general suitability for 'alterations and extensions' adaptations It is limited for existing office buildings only.<br><br>A further limitation of the approach is that the model is derived from an analysis of past practices.<br><br>In undertaking an assessment the assessor does not consider current property market and general economic conditions within the PAAM, | Economic obsolescence<br>Physical obsolescence<br>Location and land use<br>Legal<br>Social<br>Environmental |

## 3.3 Adaptive reuse design criteria based on ARM as cultural sustainability tools

Adaptive reuse design criteria for heritage buildings had been extracted from the investigated ARM. Formation of adaptive reuse models has been made by addressing sustainability factors in relation with heritage building. Additionally, criteria derived from existing adaptive reuse models has been added to the particular Table 9 in order to prepare the evaluation criteria document, Table 7.

Table 7: Adaptive re-use models versus adaptive re-use criteria

| **CRITERIA EVALUATION Including Adaptive Reuse Factors** | | **CREDIT** | ADAPTIVE REUSE MODELS DESIGN | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Physical Obsolescence | Economic Obsolescence | Social Obsolescence | Funtional Obsolescence | Technological Obsolescence | Political Obsolescence | Legal Obsolescence | Environmental Obsolescence |
| **ADAPTIV EREUSE MODELS** | ADAPTSTA | | | | | | | | | |
| | ARP | | | | | | | | | |
| | PAA | | | | | | | | | |

Based on the collected data from ARM related to HB, an evaluation has been made to examine and reveal the adaptive reuse design criteria by extracting particular criteria from existing adaptive reuse models. The examination was targeted to find certain criteria within ARM, which have a relationship with HB that are pointed with dashed-lines (Figure 18).

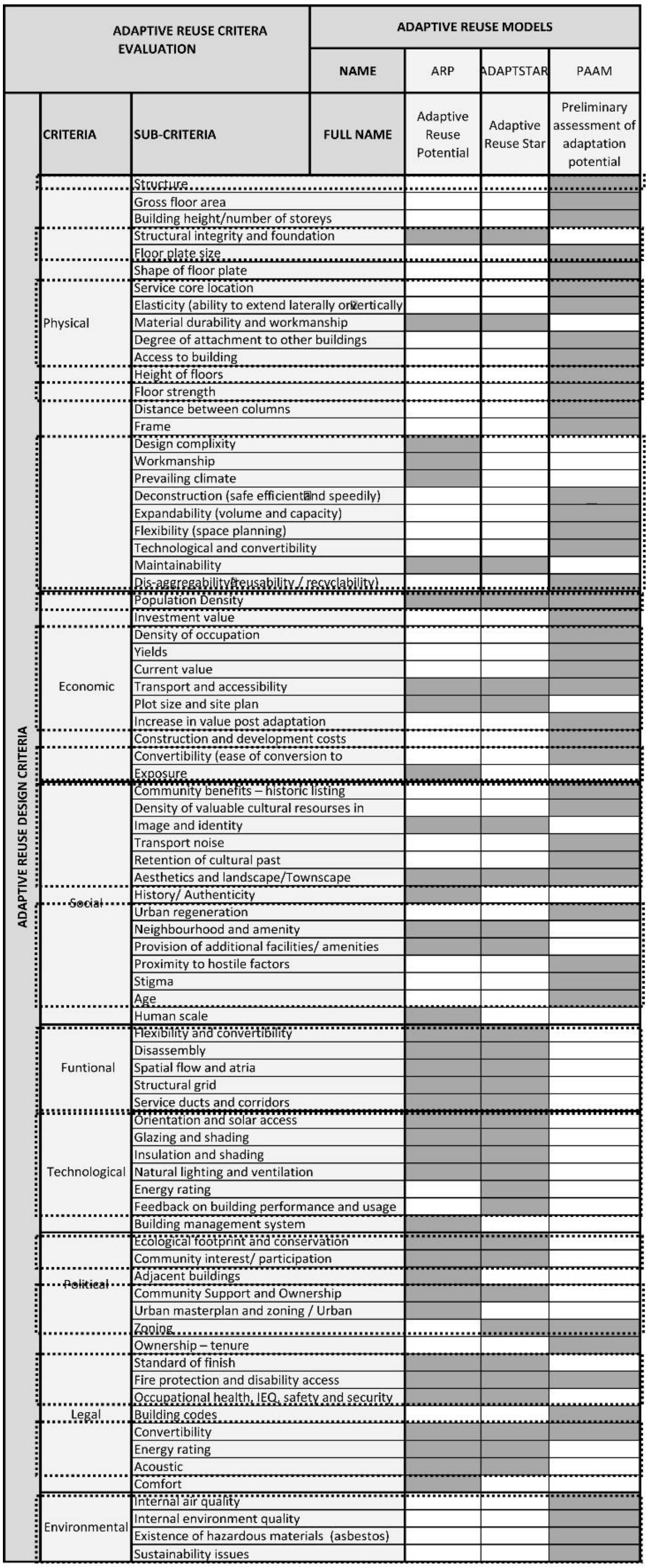


Figure 18: Adaptive reuse design criteria related with HB extracted from adaptive reuse models (ARM)

Aforementioned Figure 18 presents design criteria and sub-criteria derived from ARM. As mentioned earlier, the design criteria and dub-criteria are based on the levels of obsolescence categories related with HB. The related features of each adaptive reuse model will be composed into the proposed framework to achieve related cultural sustainability criteria and sub-criteria as the initial step: This will be followed by the insertion of the ecological sustainability criteria and sub-criteria which will be examined in the coming chapter.

## 3.4 Chapter conclusion

Consideration about the adaptive reuse of architectural heritage instead of demolishing them has always been a worthy topic, and lately, this topic is discussed further by means of both environmental, socio-cultural and economic points of view. Furthermore, increase in the demand for ecological sustainability in different fields is noticeable, especially in architectural conservation. Hence, the main aim of this study has been mentioned as, the integration of applying the mutual cultural and ecological sustainability criteria on adaptive reuse of architectural heritage buildings. Accordingly, the definitions of Adaptive reuse models (ARM) are described in Chapter 2, in addition to introducing the evaluation tools for cultural sustainability.

In order to apply cultural sustainability features on architectural heritage, criteria and sub-criteria which are derived from existing "Adaptive Reuse Models" have been examined in this chapter. Moreover, in the next chapter, ecological sustainability of heritage buildings will be introduced, which needs assessment tools such as "Environmental Rating Systems (ERS)" to evaluate the environmental friendly features of heritage building adaptations. several case studies worldwide have been mentioned in order to expand the discussion through various heritage buildings, which were under adaptation work according to environmental sustainability certification. Hence, these cases have been collected based on the scope of this study which attempt to investigate heritage buildings with the focus of environmental aspects. Figure 19 has been drawn in order to present the structure of the chapter.

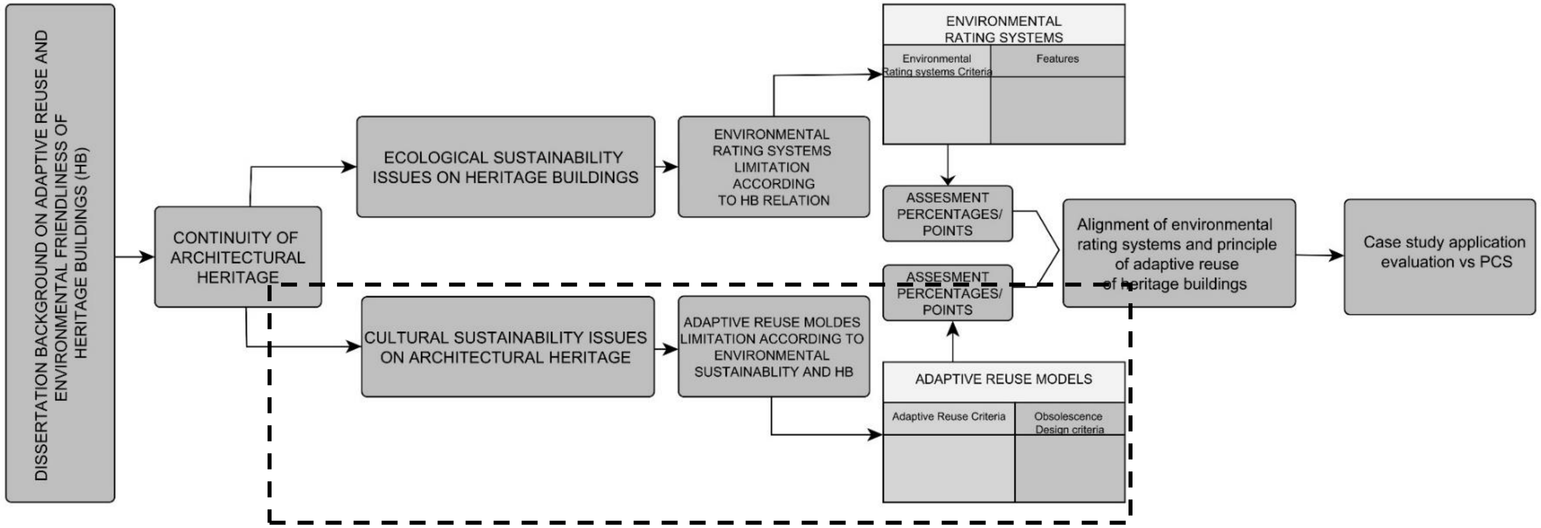

Figure 19: The evaluation process of this study

# Chapter 4

# ECOLOGICAL SUSTAINABILITY ISSUES ON HERITAGE BUILDINGS

Recently there is an increase in the arguments which focus on the potential of adaptive reuse of existing building stock in order to retain ecological sustainability by reduction in the energy required for construction of new buildings. Integration of historic building stock into environmental systems, can help with the global environmental issues by reduction in energy consumption and release of greenhouse gasses (ICOMOS. 1964; Castaldo et al, 2017), The World Heritage Committee started to apply a policy in 2015 which integrated a sustainable development approach into the procedures of World Heritage (UNESCO. 2015). It is in alignment with United Nation’s (UN) (2030) Agenda for Sustainable Development. It also states the methods by which world heritage can support the three critical aspects of sustainable development: inclusive economic viability, environmental conservation and inclusive social justice (Siebrandt, 2017; Doğan, 2019; Atun et al, 2019).

In this chapter ecological sustainability of heritage buildings will be introduced, which are discussed through assessment tools such as “Environmental Rating Systems (ERS)” to evaluate the environmental friendly features of heritage building adaptations.

## 4.1 Environmental rating systems for assessing ecological sustainability

Conservation processes of heritage buildings need to fulfil the preservation and improvement of their past expressions, with the extreme objective of identification and transmission of the cultural heritage to the future generations. Hence, rating systems have been introduced by Boarin et al., (2014, p:1), in order to develop the level of sustainability for historic buildings without compromising the heritage values.

Most of the sustainability rating systems are established according to sustainable development pillars. The rating systems for evaluating the environmental performance of buildings are aimed at establishing an objective and inclusive technique for assessing a wide range of environmental performance. These rating systems, in a number of cases, can also include community projects, infrastructure and urban-scaled projects. These systems are aimed to increase the project's sustainability by assisting project management through frameworks with defined criteria for evaluating different features of a building's environmental impact. This system is intended to assess the performance of a building in a harmonized and corresponding manner in accordance to pre-designed criteria, standards, factors and guidelines.

In recent years, with global interest in sustainable development, several rating systems for evaluation of the buildings' environmental impacts have been developed. Each and every method has its own particularities and applicability. Rating systems are created by scoring methods in order to evaluate the environmental sustainability of buildings and are generally established according to four main criteria including social, cultural, environmental and economic issues (United Nations, 2005; Podvezko, 2011; Bernardi et al., 2017; Awadh, 2017).

Sustainability Rating Systems (SRSs) consist of three stages:

- " Classification: Environmental change expectations determine the impact category based on various inputs and outputs.
- Characterization: Identify the impact of each input and output with relation to their category.
- Valuation: Category weighting in comparison to other categories" (United Nations, 2005; Fenner, 2007).

This study has examined different types of common rating systems such as Green Building Rating System (GBRSs), LEED and BREEAM, Estidama, GSAS, etc. according to their relationship with heritage buildings. Additionally, there is a new rating system called 'GBC Historic Building™' which aims to improve a building's sustainability level without compromising its cultural value, by defining a new criteria titled "Historic Value" (Boarin, 2014). Rating systems can be applied to different projects with a variety of intervention degrees such as preservation to renovation. Altogether, the main goal of the GBC HB rating system is to assess and ensure that a historic building's major renovation and renewal or functional reorganization of interior spaces is consistent and in line with ecological sustainability (Green Building Council Italia, 2016; Castaldo, et al., 2017).

The Table 8 demonstrates different types of global rating systems and their direct or indirect relations with adaptive reuse, specially allocated to architectural heritage buildings:

Table 8: Classification of rating systems from the world, according to their relation with adaptive reuse of heritage buildings

| NO | Country | Name | Management | Related with AR of HB | Indirectly Related with AR of HB | Non-Related with AR of HB |
|---|---|---|---|---|---|---|
| | | | **Africa** | | | |
| 1 | South Africa | Green Star SA | South Africa GBC | | | X |
| 2 | | SBAT | CSIR (Council for Scientific and Industrial Research | | | X |
| 3 | Northeast Africa | GPRS | Green pyramid rating system | X | | |
| | | | **Asia** | | | |
| 4 | China | GHEM | China Real Estate Chamber of Commerce | | X | |
| 5 | | GOBAS | Minister of Science and Technology | | X | |
| 6 | | DGNB | DGNB China | | X | |
| 7 | | ESGB | Ministry of Housing and Urban-Rural Construction | | | X |
| 8 | Hong Kong | BEAM Plus | HK-BEAM Society | | | X |
| 9 | | CEPAS | Comprehensive Environmental Performance Assessment Scheme for Buildings | X | | |
| 10 | | HK-BEAM | Hong Kong Building Environment Assessment Method | | | X |
| 11 | | IBI | The Intelligent Building Index | | | X |
| 12 | | BQI | The Building Quality Index | | | |
| 13 | India | TERI-GRIHA | The Energy and Research Institute (TERI) | | X | |
| 14 | | LEED® India | Indian GBC | | X | |
| 15 | Japan | CASBEE | Japan Sustainable Building Consort | X | | |
| 16 | | NIRE-LCA | National Institute for Resource and Environment | | | X |
| 17 | Korea | GBCC | Korean Korea Institute of Energy Research | | X | |
| 18 | Singapore | Green Mark | Singapore Building and Construction Authority | | | X |
| 19 | Taiwan | EEWH | Architecture and Building Research Institute | | | X |
| 20 | Thailand | DGNB | ARGE—Archimedes Facility-Management GmbH, Bad Oeynhausen and RE/ECC | | | X |
| 21 | Vietnam | LOTUS | Vietnam GBC | | | X |
| 22 | Egypt | GBRSs | (Green Building Rating Systems) | | X | |
| | | | **Europe** | | | |
| 23 | Austria | BREEAM AT | DIFNI | | X | |
| 24 | | DGNB | ÖGNI | | X | |
| 25 | Belgium | LEnSE | Belgian Building Research Institute | | | X |
| 26 | Bulgaria | DGNB | Bulgarian GBC | | X | |
| 27 | Czech | DGNB | DIFNI | | X | |
| 28 | Republic | SBToolCZ | iiSBE International, CIDEAS | | X | |
| 29 | Denmark | BEAT 2002 | SBI | | X | |
| 30 | | DGNB | Denmark GBC | | X | |
| 31 | Finland | PromisE | VTT | | | X |
| 32 | France | HQE™ Method | HQE™ | | X | |
| 33 | | ESCALE | CSTB and the University of Savoie | | | X |
| 34 | Germany | DGNB | German Sustainable Building Council | | X | |

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| NO | Country | Name | Management | Related with AR of HB | Indirectly Related with AR of HB | Non-Related with AR of HB |
|---|---|---|---|---|---|---|
| 35 | | BREEAM DE | DIFNI | | X | |
| 36 | Greece | DGNB | DIFNI | | X | |
| 37 | Hungary | DGNB | DIFNI | | X | |
| 38 | Italy | GBC HB/LEED®Italia | Italy Green Building Council—Historic Buildings | X | | |
| 39 | | Protocollo ITACA | iiSBE Italia | X | | |
| 40 | Luxembourg | BREEAM-LU | DIFNI | | X | |
| 41 | Netherlands | BREEAM-NL | Dutch GBC | | X | |
| 42 | Norway | BREEAM-NOR | Norwegian GBC | | X | |
| 43 | | Økoprofil | SINTEF | | | X |
| 44 | Poland | DGNB | DGNB International | | X | |
| 45 | Portugal | LiderA | Instituto Superior Técnico, Lisbon | X | | |
| 46 | | SBToolPT | iiSBE Portugal, LFTC-UM, ECOCHOICE | X | | |
| 47 | Russia | DGNB | DGNB International | | | X |
| 48 | Spain | DGNB | N/A | | | X |
| 49 | | BREEAM ES | Fundacion Instituto Technològico de Galicia | | X | |
| 50 | Sweden | EcoEffect | Royal Institute of Technology | | | X |
| 51 | | BREEAM SE | Swedish GBC | | X | |
| 52 | Switzerland | BREEAM CH | DIFNI | | X | |
| 53 | | DGNB | SGNI | | X | |
| 54 | Turkey | DGNB | - | | | X |
| 55 | Ukraine | DGNB | DGNB International | | X | |
| 56 | United Kingdom | BREEAM | BRE | X | | |
| **North America** | | | | | | |
| 57 | Canada | LEED® Canada | Canada GBC | | X | |
| 58 | | GreenGlobes | ECD Canada | | X | |
| 59 | Mexico | SICES | Mexico GBC | | | X |
| 60 | United States | LEED® | United States GBC | X | | |
| 61 | | GreenGlobes | Green Building Initiative | | | X |
| 58 | | BEES | Building for Environmental and Economic Sustainability | | | X |
| **Oceania** | | | | | | |
| 59 | Australia | Green Star | Australian GBC | | X | |
| 60 | | NABERS | NSW Office of Environment and Heritage | X | | |
| 61 | New Zealand | Green Star NZ | New Zealand GBC | | | X |
| **South America** | | | | | | |
| 62 | Argentina | LEED® Argentina | Argentina GBC | | X | |
| 63 | Brazil | LEED® Brazil | Brazil GBC | | X | |
| 64 | | HQE™ | Fundação Vanzolini | | | X |

By addressing Table 3 ERS with direct relation to HB have been marked to be under precise information detail. Notably, Figure 3a-3f investigates the selected ERS, which have direct relation to heritage buildings, by evaluating their scope. Furthermore, they were examined in terms of problems/limitations and used software in order to achieve certification for adaptive reuse projects to be ecologically sustainable.

In this study, the rating systems which have direct relation with heritage buildings will be the basis for analysis, on the other hand, the rest with indirect relation with architectural heritage buildings will be in coverage of the basic information.

## 4.2 Analysis of environmental rating systems worldwide, with relations to heritage buildings

The following Table 9, describes the summary of different types of rating systems globally having and their direct or indirect relations with architectural heritage buildings and their evaluation tools.

Table 9: Weights of criteria and sub criteria based on "Economic" category of ARM related to ecological sustainability and HB

| No. | Name of Rating Systems | Scope | Direct relation To adaptive reuse of heritage buildings | Evaluation tools/software | Problems and limits in terms of historical buildings | Source |
|---|---|---|---|---|---|---|
| 1 | LEED (The Leadership in Energy and Environmental Design) American LEED-ND-V4) 1998 | 'In LEED-ND (2009 vV3) neighbourhood development and new construction, this system is the most used one for historic buildings'.<br><br>"LEED vV4 adds specific points for historic preservation and adaptive use in the newly introduced Building Life-Cycle Reduction Impact credit". | "This new system has to consider preservation and adaptive reuse value-added in green building projects". "LEED-ND projects and historic resources attempt to either create or preserve distinct places, where visitors feel connected to their communities and to the built environment through appreciation of the past or a plan for the future". | • Autodesk Ecotect™,<br>• Autodesk Green Building Studio (GBS)™<br>• Integrated Environmental Solutions (IES)®,<br>• Virtual Environment (VE)™<br>• IES-VE™ software<br>• BIM software (Autodesk Revit™ and IES Virtual Environment™) | This is where the problem arises for preservationist conservationist professionals, because they have to force fit their project into one of the nine existing systems while still attempting to maintain the authenticity of the structure. | Council, U. G. B., (2014).<br><br>NAGUIB (2016).<br><br>Azhar et al. (2011)<br>Boarin et al. (2014) |
| 2 | BREAM UK (Building Research Establishment Environmental Assessment Methodology) United Kingdom 1990 | "Launched in 1990 by the Building Research Establishment (BRE) and used across Europe. It is an environmental assessment method and rating system for buildings. It encourages designers, clients and others to think about low carbon and low impact design, minimizing the energy demands created by a building before considering energy efficiency and low carbon technologies". | BREEAM Infrastructure 2016 has a category named as Landscape and Heritage.<br><br>A separate scale is provided for heritage buildings to reflect limitations in the scope to reduce energy demand. | • IES-VE™ software | The general perception is that, because of heritage and conservation considerations, it will be more difficult to achieve higher BREEAM ratings for listed refurbishments. | BREEAM (2018)<br>NAGUIB (2016)<br>Balson et al. (2014) |

| No. | Name of Rating Systems | Scope | Direct relation To adaptive reuse of heritage buildings | Evaluation tools/software | Problems and limits in terms of historical buildings | Source |
|---|---|---|---|---|---|---|
| **3** | CASBEE (Comprehensive Assessment System for Built Environment Efficiency) Japan 2001)<br><br>CASBEE for Renovation - CASBEE-RN | CASBEE system was developed in Japan, beginning in 2001. The family assessment tools are based on the building's life cycle: pre-design, new construction, existing building and renovation. It presents a new concept of assessment that distinguishes environmental load from quality of building performance. | CASBEE-RN: is designed to evaluate the performances of existing buildings based on predicted performance and specifications with renovation. CASBEE-RN may also assess improvement of specific performance in relation to the purpose of the renovation. (CASBEE-RN) to help generate proposals for building upgrades and to assess improvements" | BEE (Building Environmental Efficiency) | CASBEE created just for Home program | NAGUIB (2016)<br>CASBEE (2016)<br>Atanda & Öztürk (2018).<br>Sasatani et al. (2015). |
| **4** | LIDERA (Lead for the Environment) 2005 | This system can be applied to the different stages of the building process (project, construction, operation/use, maintenance and renovation and demolition) | Enhance local dynamics and promote proper integration (Site and integration), with regard to Soil, to Natural Ecosystems, and to Landscape and Heritage | LiderA evaluation system | | Pinheiro (2010)<br>Miranda & J.A.P. (2013).<br>Pinheiro (2011) |
| **5** | SBTool (Sustainable Building Tool) 1996 | It is specifically designed to allow users to reflect on different priorities and to adapt it to the environmental, socio-cultural, economic and technological contexts of different regions. | The greatest constraint to sustainability assessment is that assessment involves subjective rating and depends above all on the planned function of the building, as well as on its socio-economic and cultural heritage context.<br>SBToolPT (the Portuguese chapter of iiSBE), to develop and propose a generic methodology to assess the sustainability of existing, new and renovated buildings in urban areas | SBTool uses the Science Advisory Board (SAB) | To facilitate the quantification of environmental performance, SBToolPT uses the same environmental categories declared in the Environmental Product Declarations (EPDs). However, there are, at present, some limitations to this approach due to the scarcity of available EPDs. | Mateus & Braganca (2011). |

| No. | Name of Rating Systems | Scope | Direct relation<br>To adaptive reuse of heritage buildings | Evaluation tools/software | Problems and limits in terms of historical buildings | Source |
|---|---|---|---|---|---|---|
| **6** | GBC Historic Building™, (Green Building Council) Italy. LEED® Italia. 2017 | GBC Italia decided to develop GBC Historic Building™ , a new LEED®-based rating system for the voluntary certification of the sustainability level in restoration, recovery and integration of historic buildings, with the ultimate purpose of recognition, enhancement and transmission to the future of cultural heritage in its usefulness, historic interest and significance | GBC Historic BuildingTM is a new rating system for the voluntary certification of the sustainability level of conservation, requalification and partial tegration of historic buildings, respecting and protecting their cultural value. | Dynamic simulation engine (EnergyPlus) | the weakness of existing tools when applied to the historical context, by highlighting the need of a new assessment framework in case of restoration and preservation processes | Boarin et al. (2014)<br>Boarin, P. (2016). |
| 7 | GPRS (Green pyramid rating system Levels) Egypt 2009 | Egypt green building council has commissioned to define the framework of a rating system and a national committee has been formed to review and ultimately approve the Green Pyramid Rating System completed and took place 2010.<br>The GPRS sustainable building rating system, where it was developed by the HBRC, is the national rating and certification system for sustainable new buildings and major renovation in Egypt. | Cultural Heritage: Credit points are obtainable for incorporating architectural, construction and technical solutions which excel in reflecting national and regional cultural heritage while contributing to the environmental performance of the building.<br>GPRS-V2-2017-NB: Sustainable site. Innovation and added values aspect, the ‘‘Culture heritage’’ is well covered in vernacular architecture related modules and ‘‘Innovation’’ is well covered too in the innovation, design studio and architecture modules. | statistical computer software called : SPSS 250 | | NAGUIB (2016)<br>Zhang et al. (2019).<br>Moussa (2019) |

| No. | Name of Rating Systems | Scope | Direct relation To adaptive reuse of heritage buildings | Evaluation tools/software | Problems and limits in terms of historical buildings | Source |
|---|---|---|---|---|---|---|
| **8** | ITACA ( Institute for Transparency of Contracts and Environmental Compatibility) 2001 | This rating system is at the aim of describing the building environmental quality, including the maintenance of indoor comfort during the entire life cycle. | It analysed the origin and the historic development of energy certification schemes in buildings together with the definition and scope of a building energy certificate and critical aspects of its implementation. | MC4Suite<br>IES Virtual Environment | The methods outlined limited performance about the indoor environmental quality: | Asdrubali et al. (2015). |
| **9** | CEPAS (Hong Kong) 2001 | As a green building labelling scheme initiated under the 2001 Government Policy Objectives, the CEPAS endeavours to address both physical and human-related issues amongst the core aspects of sustainability. | CEPAS considers traditional environmental performances, such as energy, indoor air quality, and the maintenance of building services installations, the CEPAS also considers other social-economic factors, such as impacts on surroundings, communal interactions, building economics, transportation, heritage conservation, etc. Conserve and protect archaeological and historic buildings, monuments, components and artefacts | Calculation of CEPAS Total Score by numbers of formula | The CEPAS framework is derived to suit the Hong Kong context after careful evaluation of existing schemes and international experience. | Awadh (2017).<br>Ho et al. (2005).<br>Wu, & Yau (2005).<br>Bernardi et al. (2017) |
| **10** | (NABERS) National Australian Built Environment Rating System Australia 1998 | Green Star, announced by the Green Building Council, is a national voluntary rating system that evaluates the environmental performance of buildings. Rating tools are under development for a range of building types and phases.<br>The tool addresses the largest segment of the commercial office market, existing buildings, Building Environmental Assessment methods and helps building owners to assess the environmental merits of their existing or future assets | NABERS is Australia's first comprehensive built environment rating system that has been developed in consultation with industry and other stakeholders by the Australian Government Department of the Environment and Heritage. NABERS is a performance-based rating system that measures an existing building's overall environmental performance during operation against a set of key impact categories | Reverse calculations | This calculation methodology has served well over 12 years but has limitations for high efficiency buildings. The normalization factors derived theoretically which to some extent reflects the limitations of the underlying dataset but also reflects the limited domain and range of such factors. | Bernardi et al. (2017)<br>Gu et al. (2006)<br>NABERS (2019)<br>Bannister (2012). |

By addressing the analysed documents from environmental rating systems related to adaptive reuse of heritage buildings, the pointed criteria will support evaluation part of the study to achieve the features to shape the proposed framework.

## 4.3 Environmental rating systems for assessing ecological sustainability of adaptive reuse of heritage buildings

Investigation on worldwide rating systems for assessing ecological sustainability issue, is eliminated to the ones with direct relation to heritage buildings. Therefore, various types of rating systems, which have direct relation with heritage buildings, have been introduced in this section.

### 4.3.1 LEED ND-V4

As NAGUIB (2016) state, Leadership in Energy and Environmental Design which was founded in 1993, in America, has specific section related to historic building conservation known as LEED-ND (2009 v3). In March 2013, a new assessment system has been designed for such buildings, called as 'LEED for Neighbourhood Development and historic preservation' shortly LEED-ND V4, in order to cover the sustainability needs of the historic buildings. The new method is designed to ensure preservation and adaptive reuse is being considered in green building projects.

LEED-ND projects and historic resources endeavor to either make or protect distinct places, where visitors feel associated to their communities and to the built environment through appreciation of the past or a plan for the future (NAGUIB, 2016, p:2). The evaluation points and percentages have been explained in (Table 10).

### 4.3.2 BREEAM UK

The world's first sustainability assessment and leading certification system for the built environment has been Building Research Establishment Environmental

Assessment Methodology shortly named BREEAM (BREEAM, 2018). It is considered as an international standard that is adapted and applied through a network of local scheme operators, evaluators and also industry experts. BREEAM rating system acknowledges and reflects the value in higher performing assets through its application and its goal is to inspire and empower change by rewarding and inspiring sustainability throughout the lifecycle of buildings, infrastructure and master-planning projects. BREEAM has been launched in 1990 and till now more than 590,000 buildings evaluations has been certified by it. BREEAM is being used in more than 78 countries (BREEAM, 2018). The assessment points and percentages have been explained in (Table 10).

#### 4.3.3 CASBEE

Comprehensive Assessment System for Built Environment Efficiency (CASBEE) has been launched in 2002, and since then, techniques for evaluating the environmental performance of buildings have gained more global interest and the movement towards sustainable construction continues (Endo, 2005). This has a specific section related to renovation, known as CASBEE- (RN: Renovation). CASBEE-BD/RN has been proposed to assess the performances of existing buildings (contain heritage buildings or non-heritage buildings) according to specifications for refurbishment and the foreseen performance (NAGUIB, 2016, p:6). It can be used:

- With a view to Energy Service Company (ESCO) projects, remodelling existing buildings or proposing building-operation monitoring, commissioning, and upgrade designs
- To assess the environmental performance relative to the stage before to renovation.

- To determine the improvement of a particular performance has improved in respect to the renovation's goal. For example, the BEE (Built Environment Efficiency)
- Scores for assessment categories specifically relevant to energy saving remodeling, such as Energy (LR1: Reduction and Built Environment Load) and Indoor environment, can also be used to measure energy savings (Q1: Built Environment Quality) (MLIT, 2016, p:3;NAGUIB, 2016:6).

The evaluation is valid up to three years after conclusion of adaptation work, and evaluation should be repeated according to latest version of CASBEE-BD/RN (CASBEE 2016). The evaluation points and percentages have been explained in (Table 10).

### 4.3.4 LIDERA

As Pinheiro (2011) state, LiderA (Lead for the Environment) has been registered as a Portuguese trademark and sustainable assessment method that is intended to be used for finding out solutions and evaluating projects in order to certify or recognize them by system’s brand in accordance with different categories. In 2005, the initial version was released (V1.02) and aimed to assess, identify or certify projects in accordance with the building scale and respective surroundings. Nevertheless, because of the number of applications studied, a new version (V2.00) was designed in order to extend the reach of assessment to the built environment, including the demand for open-air spaces, neighborhoods, blocks and sustainable communities (Pinheiro, 2011). According to LiderA, the sustainability degree can be quantified and certified in performance levels have been explained in (Table 10).

The related sub-criteria of LiderA rating system is landscape and heritage which defines heritage protection and enhancement with the value of 2% within other criteria. “The adoption of conservation practices, as well as the built environment’s preservation and enhancement is a major issue that sould also be considered in the surrounding areas” (Pinheiro, 2011, p:17).

**4.3.5 SBTool**

As Mateus and Bragança (2011) state, the SBTool (Sustainable Building Tool) has been created by 20 countries whose collaboration work began in 1996 and sponsored by ‘International Initiative for a Sustainable Built Environment (iiSBE)’. The high range on international involvements made the SBTool a more distinguished system than others, since it allows to reflect various priorities and adapt to each region according to technological, socio-cultural and environmental context (Mateus and Bragança, 2011).

There has been an effort to propose a system in order to look into the adaptation assessment in Malaysian context which is known as SBTool (Ng et al. 2007). SBTool has been developed as a standard framework with high capability to reflect the significance of related performance issues, with the region and therefore it involves local standards (Larsson, 2007). By publishing the local benchmarks and weights, the country ensures that the proposed system is related with their own conditions and they are evaluated in 3 different levels based on their vital role from higher to lower which have been explained in (Table 10). Larsson and Bragança (2012) defined the following list which presents the main features of the SBTool system:

- covers a wide extend of maintainable building issues, extending from 100+ criteria to half a dozen;

- takes into consideration region-specific and site-specific context features;
- is able to carry out appraisals at four particular stages of the life-cycle and the frameworks give default benchmarks suited to each stage (Pre-design, Plan, Construction and Operations)
- gives isolated modules for Site and Building evaluations; handles huge projects or single buildings, which can be commercial and residential, new and existing construction or a mixture of the two;
- Architects can indicate execution targets and can score self-assessed execution;
- Assessors can acknowledge or adjust self-assessed execution scores submitted by architects.
- Within a single building or as independent structures in a major project, parameters can be set for up to three occupancy types.

Third parties can use the system to create parameter weights that reflect the varying importance of concerns in the region, as well as applicable benchmarks in local languages for each occupancy type, (Larsson and Bragança, 2012, p : 7).

#### 4.3.6 GBC Historic Building™

As Boarin et al. (2014: 3) state, the new system arises in Italy, is known as GBC Historic Building™ which is applied on historic buildings and the existing structures that are worthy of attention as “material witness having the force of civilization”. Accordingly, in order to use this system, the existing building must be built before 1945, which expresses a significant and deep sense in Europe building sector in terms of technologies, materials and techniques given by the industrialization sector of construction procedure (Boarin et al, 2014).

The GBC Historic Building™ has been designed according to all the LEED® protocols and the structure has the consistency as LEED does, therefore the maximum score is 110 points. “100 points are calculated as sum of the scores assigned to the credit of thematic areas such as: Historic Value, Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources and Indoor Environmental Quality, to which further 10 points allocated to thematic areas as: Innovation in Design and Regional Priority, are added” (Boarin, 2016, p:21). GBC Historic Building® rating system attempts to be applicable more internationally (global) and in European level (regional), but for now it is accessible just in Italian market (Boarin, 2016). The related percentages and point are given in (Table 10).

#### 4.3.7 GPRS

As the Egypt Green Building Council (2010) state, Egyptian official government and related stakeholders have investigated on the historic building’s value to find out an assessment method in order to decrease the Green House Gases emissions (GHG) and the power consumption. The Green Pyramid Rating System (GPRS) has been launched in 2010, by the approval of the Egypt Green Building Council for the confirmation of the proposed rating system framework by a national committee as reviewers (NAGUIB, 2016). In order to identify the specific social, ecological and industrial challenges, the proposed rating system assisted to explain what an “Egyptian Green Building” is (Egypt Green Building Council, 2010).

The related sub-criteria of GPRS related to historical building has been introduced as ‘Innovation and Design Process’ which is the mixture of regional cultural heritage value and national design reflection to buildings’ environmental performance

(NAGUIB, 2016). GPRS involves four different stages of certification assessment which are explained in (Table 10).

#### 4.3.8 ITACA

As Catalino et al. (2005) state, the Federal Association of the Italian Regions has a gathered working group on green building who established ITACA (Institute for Transparency of Contracts and Environmental Compatibility) in 2001. One of the vital proposes of this research assessment method is to promote and distribute high quality performances for environmental sustainability and to improve the region's policies (Catalino et al, 2005).

The ITACA certification system involves 20 technical panels, which are allocated to different energy and environmental features of buildings therefore the building which required to be certified (Asdrubali et al. 2015). The five classification of ITACA has been mentioned in (Table 10).

#### 4.3.9 CEPAS

As Wu and Yau (2005) state, one of the holistic building assessment systems has been introduced as 'The Comprehensive Environmental Performance Assessment Scheme (CEPAS)' which is applicable for different types of buildings with the clear building life-cycle differentiation and contains 'pre-design, design, construction & demolition and operation stages'. The vital aim of CEPAS rating system is to present the current environmental performance movement for Hong Kong buildings, besides to keep them update with global development of building sustainability (Wu and Yau, 2005).

Additionally, HKSAR (2006) published a statement about the target of CEPAS rating system to design an outline to serve green buildings. In this regard, a consultancy group has been assigned by the Buildings Department to propose a comprehensive and user-friendly CEPAS for evaluating Hong Kong's buildings. The complete CEPAS assessment has finalized the design / construction / operation levels based on building's environmental performances for the related procedure. Each building performance has its own label which represents the level of satisfaction according to their related requirements which are explained in (Table 10) (Ho, et al, 2005;Wu and Yau, 2005).

**4.3.10 NABERS**

Bannister (2012) stablished a statement about the introducing of a certification system for Australia context in 1998 named as 'The National Australian Built Environment Rating System' known as NABERS (NABERS, 2019)'. The NABERS rating system aimed to develop the green / greenhouse efficiency and sustainable energy which requires to distinguish different buildings according to their efficiency levels (Bannister 2012). Additionally, the NABERS rating system plays a vital role to evaluate the actual environmental impact based on the defined rules and regulations (NABERS, 2019).

"A Commitment Agreement is a contract between the NABERS National Administrator, the Office of Environment and Heritage NSW (OEH) and the building proponent to design, build, commission and operate the premises to achieve a NABERS Energy star rating of 4 or more without Greenpower" (Handbook for Estimating NABERS Ratings, 2021, P: 8)

Furthermore, the NABERS Energy Commitment Contract allows tenants, developers and building owners in order to market and promote the predictable greenhouse of renovated or new spaces in different design stages. the market in different established stages (NABERS, 2019). The NABERS scoring system has been described in (Table 10) based on the estimation of simulation criteria for energy score.

## 4.4 Score levels in selected ERS

Based on the collected data from selected ERS worldwide Levels of scoring sustainability within the explained ERS) are summarised in (Table 10).

Table 10: Summary of Selected ERS and their evaluation criteria

| **LEED ND-V4 (Leadership in Energy and Environmental Design)** | **BREAM UK (Building Research Establishment Environmental Assessment Methodology)** | **CASBEE (Comprehensive Assessment System for Built Environment Efficiency)** | **LIDERA (Lead for the Environment)** | **SBTool (Sustainable Building Tool)** | **GBC Historic Building™,** | **GPRS (Green pyramid rating system)** | **ITACA (Institute for Transparency of Contracts and Environmental Compatibility)** | **CEPAS (Comprehensive Environmental Performance Assessment Scheme)** | **NABERS (National Australian Built Environment Rating System)** |
|---|---|---|---|---|---|---|---|---|---|
| Four levels for green building certification LEED-ND v4: | "BREEAM rating benchmarks for projects assessed using the 2018 version of BREEAM UK New Construction are": | "The proposed rating method is as follows. Rating value limits still need to be considered". | "LiderA, the sustainability degree is measurable and able to be certified in performance levels (C, B, A, A+ and A + +)": | "SBTool framework is structured hierarchically into 3 levels, with the higher levels logically derived from the weighted aggregation of the lower ones": | "GBC Historic Building®" LEED ®-GBC historic version-Italy Additional criteria : "Historic value" | Four levels for green pyramid certification: | There are five "classes" of certification: A+, A, B, C, D but a building Class-D does not get the Certificate of Environmental Sustainability | "There are 4 classification for this rating system as: Platinum, Gold, Silver and Bronze". | There are 4 score classification between 4-6 stars: |
| (march 2013). (NAGUIB, 2016). | (BREEAM2018 ). | (Endo, et al, 2005) (CASBEE 2016) (CASBEE for Market Promotion, 2011) | (Pinheiro, 2011). | (Larsson, 2007) (Ng, et al, 2007) Mateus and Bragança, 2011). | (march 2013). (NAGUIB, 2016). | (NAGUIB, 2016). | (CATALINO, et al, 2005) (Asdrubali et al. 2015). | (HKSAR Government. 2006) | (Bannister 2012) (NABERS, 2019). |
| Platinum: 80 to 110 points.<br><br>Gold:<br>60 to 79 points.<br><br>Silver:<br>50 to 59 points.<br><br>Certified:<br>40 to 49 points. | Outstanding ≥ 85%<br><br>Excellent ≥ 70 %<br><br>Very good ≥ 55%<br><br>Good ≥ 45%<br><br>Pass ≥ 30%<br><br>Unclassified < 30% | Points scored > approximately 60 ★★★ (equivalent to B+ of the current CASBEE)<br><br>Points scored > approximately 70 ★★★★ (equivalent to A of the current CASBEE)<br><br>Points scored > approximately 80 ★★★★★ (equivalent to S of the current CASBEE) | 25% (Level C), when compared to common practices (Level E),<br><br>An improvement of 50% (Class A),<br><br>a factor 4 improvement (Class A+)<br><br>And<br><br>finally, to factor 10 improvement (Class A + +). | 1) Performance Issues<br><br>2) Performance Categories<br><br>3) Performance criteria<br><br>Or<br><br>Level 1<br>Level 2<br>Level 3 | LEED® (GBC) protocols are structured on the basis of a maximum achievable score of 110 points.<br><br>Platinum:<br>80 to 110 points.<br><br>Gold:<br>60 to 79 points.<br><br>Silver:<br>50 to 59 points.<br><br>Certified:<br>40 to 49 points. | Green Pyramid: 80 credits and above.<br><br>Golden Pyramid:<br>60 to 79 credits.<br><br>Silver Pyramid:<br>50 to 49 credits.<br><br>Certified:<br>40 to 49 credits. | C 40 - 55<br>B 55 - 70<br>A 70 - 85<br>A+ 85 - 100 | "**Platinum:**<br>•Establish a new standard to create a positive paradigm shift to the buildi industry in the forthcomingyears<br>•For building with outstanding performance<br>•Encourage research works on innovation<br>•Buildings adopted many genuineinnovative an additional building environmental performance<br>"**Gold:**<br>•Equivalent to very high building environmental performance standard according to current buildin standards and local conditions"<br>"**Silver:**<br>•Equivalent to good buildin environmental performance standard according to curre building standards and local conditions"<br>"**Bronze:**<br>•Equivalent to above avera building environmental performance buildings" | NABERS Energy score<br>4 star<br>4.5 stars<br>5 stars<br>5.5 stars<br>6 stars |

As for the outcome of the selected ERS evaluation classification worldwide in (Table 10), based on the collected data, this study has been accomplished to the acceptable range of criteria and sub-criteria for the HB which has been described in (Table 11). Therefore, by evaluating the HB adaptive reuse potentials for being environmentally certified, this table works as the guidline for choosing the certification system.

Table 11: The minimum points within the range of acceptable criteria for the HB related ERS

| The range of acceptable criteria for the HB related ERS | | | |
|---|---|---|---|
| NUM | MAX | MIN | Name of certificate |
| | POINT | | |
| 1 | Up to 110 point | > 40 point | LEED ND<br>CASBEE<br>GBC<br>GPRS<br>CEPAS |
| 2 | PERCENTAGE | | |
| | Up to 100% | >30%<br>> 25% | BREEEAM<br>LIDERA |
| 3 | STARS | | |
| | Up to 6 * | > 3 * (half of maximum) | CASBEE<br>NABERS |
| 4 | LEVEL | | |
| | Level 1 | Level 3 | SPTOOL |

Increasing the demand for ecological sustainability in different majors, is noticeable especially in conservation of heritage buildings as it is explained in aforementioned data collection. Therefore, this study targets to align both cultural and ecological sustainability design criteria in the case of heritage buildings' obsolescence in order to accomplish the particular framework for green adaptation approach as a result.

## 4.5 Adaptive reuse examples based on green adaptive reuse design

There are five examples which have been selected from a variety of counties and various evaluation systems. Their adaptation process and their criteria and sub-criteria are investigated related to green adaptive reuse of heritage buildings. The adaptation dates of these examples vary between the years 1889-2007.

### 4.5.1 Example from Canada: Artscape wychwood barns, Canada

Sugden, (2017, p: 55) has been explained that Artscape Wychwood Barns at 601 Christie Street in Toronto was originally dedicated to five (5) streetcar buildings that served as a repair and housing facility for the Toronto Civic Railway between 1913 and 1921 (TCR), (Figure 20).

Figure 20: Wychwood Barns – In Use Pre-Adaptation

As Sugden, (2017, p: 56) explained The Wychwood Barns were set to be demolished by the city between 1996 and 1998. However, Local politicians and locals, , have been recognized the property and barns as having the cultural historical significance potential. The site and structures were determined to be historically significant cultural heritage after the City hired an architect to conduct a heritage study. After the newly named Artscape Wychwood Barns, Sugden, (2017, p:63) mentioned about the completion of reusing project. According to Lobko (2008), the Wychwood Barns adaption is the first heritage restoration project in North America to be awarded a LEED Gold certification through the Leadership in Energy and Environmental Design (LEED) program.

According to Artscape Inc. (n.d.): The Artistic Environment Wychwood Barns is a community cultural center that integrates a diverse range of arts, culture, food security, urban agriculture, environmental, and other community activities and initiatives to give a century-old former streetcar maintenance facility a new lease on life, (Figure 21, Figure 22) (Sugden, 2017, p:63).

- The Wychwood Barns complex now houses :
- artist live/work spaces;
- Programming and administrative facilities for not-for-profit organizations;
- Indoor and outdoor urban-food growing areas;
- A community-run gallery; and,
- A 7,680 ft2 “Covered Street” used for farmers and art markets, conferences and events.

Figure 21: Artscape Wychwood Barns – Post-Adaptation (Sugden, 2017)


Figure 22: Artscape Wychwood Barns – Post-Adaptation(Sugden, 2017)

It is the first designated heritage sites in Canada to be awarded LEED Gold Canada certification. Environmental and energy-efficient features include:

Sugden, (2017, p: 56), "A geo-thermal heating, ventilation and air conditioning system:

- Stormwater harvesting and reuse system
- Energy efficient lighting and appliances
- Water-conserving plumbing fixtures

▪ White roof (reflects solar heat; reduces need for air conditioning in summer months)

▪ 100% recycled environmentally-friendly siding panels (Artscape Wychwood Barns community, 2008).

### 4.5.2 Example from Canada: evergreen brick works, Canada

Figure 23: Don Valley Brick Works – Quarry, Pit and Buildings Pre-Adaptation (Irvine, 2012).

Figure 24: Evergreen Brick Works (Irvine, 2012).

Irvine, (2012, p:21) has mentioned that the property at 550 Bayview Avenue in Toronto's Don Valley was formerly home to one of Canada's most major brick producers for more than a century as the Don Valley Pressed Brick Works. The property's original owners ran into financial difficulties in 1901 and were forced to sell it. The firm name was changed from Don Valley Pressed Brick Works to the more identifiable Don Valley Brick Works at that time, (Figure 23 and Figure 24) (DVBW).

Irvine, (2012 p: 2) explained that Evergreen, a Canadian non-profit group, became interested in the property and the former DVBW facilities in 2002. Evergreen, which is known for transforming public places into vibrant community spaces with environmental, social, and economic benefits, began the difficult but highly collaborative process of adaptively repurposing the site. Irvine, (2012 p: 2) expressed that Evergreen Brick Works was officially launched as Canada's first large-scale community environmental centre and a forum for promoting urban greening innovation. According to Irvine (2012 p: 21), in order to achieve a successful site transformation, Evergreen incorporated the values of collaboration, environmental sustainability, economic viability, and change and adaptation into their design process.

Sugden, 2017 has been explained that designers attempted to establish a paradigm of green design as an environmental organization. As a result, that was always a driving force in our design process, and it was critical that we not only become a green design site, but that they also meet the highest standards. That decision significantly increased our costs and influenced our decisions. The designers debated whether we should pursue LEED Silver or Gold certification, but ultimately determined that if we are to be what we want to be and live in harmony with the valley's ecological environment, they must apply for the Platinum (Sugden, 2017, p:105).

The site was legally declared under Part IV (individual) of the Ontario Heritage Act in November 2002 because of its immense industrial, architectural, environmental, and cultural heritage value to the community (Figure 25).

Figure 25: Evergreen Brick Works – Post-Adaptation, (Sugden, 2017)

### 4.5.3 Example from Europe: Reichstag parliament building (conversion with extension), Germany

As Norman Foster (2007, p:148), describes in his firm's monograph, Foster 40, "Our transformation of the Reichstag is rooted in four related issues": the Bundestag's significance as:

1. a democratic forum, an understanding of history,
2. a commitment to public accessibility and a dynamic environmental plan (Figure 26) (Foster and partners, 2021).

Figure 26: AD Classics: New German Parliament, Reichstag / Foster + Partners, (URL6)

Foster's description in 2007, sounds straightforward enough, but the process of creating the New German Parliament at the Reichstag was only the latest entry in the long, complex, and contentious history of the building (Figure 27, Figure 28 and Figure 29).

Figure 27: AD Classics: New German Parliament, Reichstag / Foster + Partners 1894

Figure 28: AD Classics: New German Parliament, Reichstag / Foster + Partners 1971

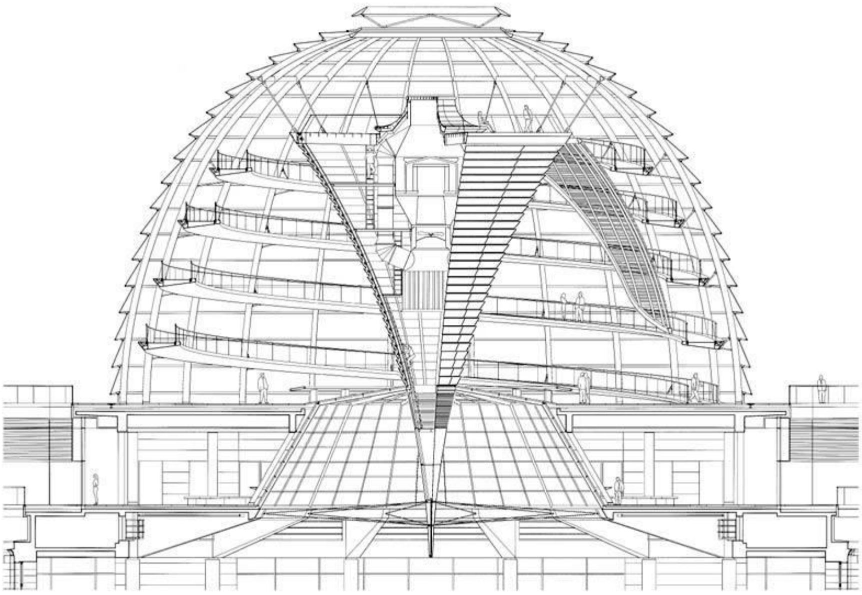


Figure 29: AD Classics: New German Parliament, Reichstag / Foster + Partners extention

Foster and partners (1999, p:4) explained that the cupola is the foremost publicly available part of the building; it gives a visual connection to the project within the parliamentary chamber underneath, it could be a useful component of the building's sustainability methodology and, in spite of Foster's initial hesitation, it serves as a reference to the history of the building. The cupola is additionally the foremost obvious demonstration of Foster's intercession within the historic building. In spite of the fact that it may be a gesture to the building's history, the shape is completely new.

Foster and partners (1999, p:5) The helical ramp along the external edges of the space makes a different character for the dome-shaped volume, and leads to an perception deck that gives a vantage point for guests to look out on the encompassing Berlin cityscape. The helical ramp along the external edges of the space makes a difference characterize the dome-shaped volume and leads to a perception deck that gives a vantage point for guests to look out on the encompassing Berlin cityscape. At the same time, skylights at the base of the cupola open into the debating chamber underneath, giving a visual association to the government at work. In the center of the dome, an inverted cone of mirrored panels reflects daylight down into the debating chamber and also aids ventilation by venting hot air through the top of the cupola. Foster was also committed to conserving the building's numerous layers of history, particularly the Cyrillic graffiti.

Therefore, the German parliament building has been considered as one of the significant case studies to present the role of sustainable strategy and cultural sustainability issues on preserving the history for future generations.

### 4.5.4 Example from Europe: MEIS (national museum of italian judaism and the shoah) In Ferrara: an  example of GBC HB

The National Museum of Italian Judaism and the Shoah - MEIS - in Ferrara, is one of the first restoration sites of historic buildings in Italy to apply for the certification GBC Historic Building: a system of verification that follows every part of the building life cycle, from the design passing through restoration and directly to the daily use, once the works are finished. The process towards certification requires the observation of a rigid and complex protocol, (Figure 30, Figure 31a and 31b) (GBC Historic Building, 2019).

Figure 30: MEIS

Figure 31: (a-b) MEIS

Historic buildings represent in Italy, in terms of number and quality, one of the main values of public and private heritage. The ability to redevelop these buildings, preserving their historical value and at the same time updating their ability to respond to modern needs of use, determines the success of the related investment. The application of the GBC Historic Building protocol drawn up by the Green Building Council Italy, in the context of the LEED® international rating systems, represents a world novelty, certifies the level of environmental sustainability of the restoration and redevelopment of existing historic buildings. The use of the GBC Historic Building protocol allows the implementation of an integrated process of design and construction of the redevelopment works of a historic building, achievement of this objective - Arch. Andrea Valentini LEED AP BD + C GBC HB AP ( Valentini, 2018).

Ferrara, a UNESCO protected city, boasts a cultural and architectural heritage of absolute value and historical and cultural value with an excellent testimony of civilization. Ferrara also expresses a cultural and technical tradition on the restoration and conservation of historical architectural heritage both with the University and with the local institutions of which it has extensive knowledge, culture and technology. The application of the GBC Historic Building protocol drawn up by the Green Building Council Italy, in the context of the LEED® international rating systems, represents a world novelty, certifies the level of environmental sustainability of the restoration and redevelopment of existing historic buildings with specific requirements in able to consider both aspects related to the context of the historical value of the property, with the effectiveness of an intervention strategy aimed at conservation and enhancement in comparison with the environmental impact requirements with the site, internal environmental comfort, materials with high environmental performance, energy efficiency of all installed systems summarized in a virtuous approach that is attentive from design to construction ( Valentini, 2018).

The environmental sustainability is increasingly taking on a key role in the construction, design and renovation of buildings and neighborhoods. The crucial aspect of sustainability lies in the quantities of carbon dioxide emissions associated with the production of energy for the construction and use of buildings and in all the materials used analyzed in their life cycle. Buildings are responsible for nearly 40% of all energy consumed. As a result, the community focuses primarily on reducing the energy consumed in buildings. Metrics and requirements of the LEED ® protocol promoted by US Green Building Council , the most widespread energy-environmental certification protocol in the world and adopted in over 150 countries with consolidated validation by major international investors, these technical specifications measure not only energy performance but also the management of water resources, the quality of indoor air, the choice of biocompatible materials with attention to the use of resources, the amount of energy incorporated in their production, use and disposal, the management of waste with a holistic and integrated approach to all environmental issues. In this context, the Green Building Council Italy has developed a new rating system for the certification of buildings subject to conservation interventions, called GBC Historic Building ® , based on the matrix of the LEED® system and, in particular, on the LEED® Italia 2009 New Construction and Restructuring version (Valentini, 2018).

This rating system, which represents a world innovation, certifies the level of sustainability of the restoration and redevelopment interventions of existing buildingswith specific requirements capable of considering the aspects related to the context of the historical value of the property, as well as the effectiveness of an intervention strategy aimed at conservation and enhancement. The recognition of the testimonial value of a historic building is an integral part of a sustainable design process aimed at safeguarding and enhancing cultural heritage. In fact, sustainable buildings are more attractive to users thanks to the possibility of an increase in worker productivity resulting from the improvement of environments and working conditions ( Valentini, 2018).

**4.5.5 Example from USA: Fay House: Preservation and LEED**

McDonald (2015, p:1) interpreted that historic preservation is a noble goal that has always been pursued. Preservationists were concerned about the implementation of objects and new "green" equipment such as solar panels. However, both sides have recently recognized that they share more in common than they previously assumed. Both are concerned about historic structures and acknowledge that retrofitting existing structures rather than demolishing and rebuilding new ones is more environmentally beneficial, (Figure 32) (URL4).

Figure 32: Fay House: Preservation and LEED (URL4).

McDonald (2015, p:6) explained that Fay House in 1807, the first permanent home of Radcliffe College in Cambridge, MA, is the oldest known historic structure in the United States to obtain LEED certification (Gold), according to the USGBC. The Radcliffe Institute for Advanced Study at Harvard University was restored by Venturi Scott Brown and Associates, Inc (formerly VSBA) of Philadelphia, (Figure 33).

Figure 33: Fay House: Preservation and LEED (URL4).

The project developed out of a Radcliffe master plan that we had completed "VSBA, LLC principal Nancy Rogo Trainer, FAIA, comments "Fay House, which was built in 1807, had been considerably expanded horizontally and vertically throughout the years, which was making difficulties to see the original house. It had structural issues, fire exits on the exterior, and very limited accessibility for those with mobility disabilities. Inside, it had devolved into a rabbit warren. We wanted to preserve what was gracious and elegant while adaptation reuse, systems, and accessibility." Adapting for LEED certification was a simple decision, she says, because it is required for all Harvard projects.The utilization of geothermal energy was one of the most significant contributions to sustainability. Fay House was allowed to use the wells because there was additional geothermal capacity in the wells created for the building next door, (Figure 34 and Figure 35) (McDonald, 2015, p:8,9).

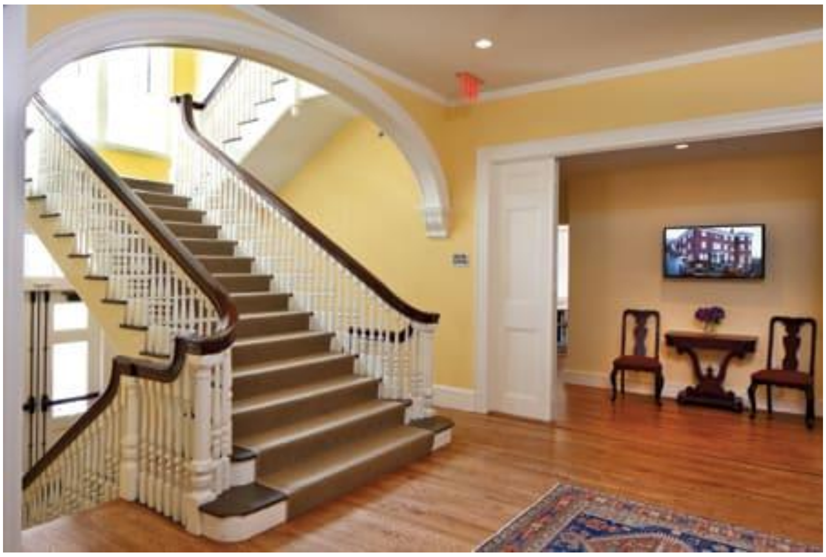


Figure 34: Fay House: Preservation and LEED (URL4).

Figure 35: Fay House: Preservation and LEED (URL4).

Projects with preservation and sustainability purposes require to manage a lot of factors. At Fay House, designers have assessed the energy savings for outdoor wall insulation against the risk for interior finishes and masonry deterioration to be destroyed. Additionally, sing geothermal wells, on the other hand, achieved both goals and eliminated the need for cooling towers. Therefore, there is a consistency between sustainability and preserving the main building characteristics, (Figure 36) (McDonald, 2015).

Figure 36: Fay House: Preservation and LEED (URL4)

**4.5.6 Example from USA: Christman building: A historic building in Michigan**

The Christman Building ability to merge historic preservation with sustainable attributes supports its second-place win in eco-structure's inaugural Evergreen Awards' "commercial" category, (Figure 37). Making the Platinum results of the project's design amaze contemporary visitors, as well. The 6-story, 60,000-square-foot (5574-m²) Christman Building, which was completed in January 2008, not only reclaimed a vacant structure on the National Register of Historic Places to help revitalize the city's core, it managed to garner an unprecedented two LEED Platinum awards from the Washington, D.C.-based U.S. Green Building Council one for LEED for Core and Shell and one for LEED for Commercial Interiors (Figure 38).

Figure 37: Christman Building, a historic building earns two LEED Platinum

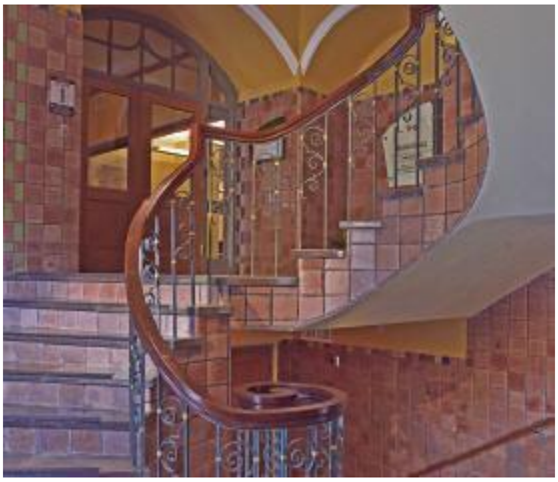


Figure 38: LEED for Commercial Interiors

Historic preservation regulations frequently conflict with long-term sustainability aims, however the Christman Building demonstrates that the two goals aren't mutually contradictory. It's a fantastic example of what may be accomplished. The Christman Co.'s offices demonstrate the company's ability to renovate old spaces while maintaining a fresh, innovative work environment. To encourage cooperation, the offices are divided into "community" with mini-studio spaces. The skylight remains above the parapet to emphasize the original character of light, and a new inner courtyard serves as the office's focal point. When tax incentives are involved, meeting energy efficiency regulations and historical criteria is difficult. The interior design also perfectly blends human comfort and architectural beauty (Fields, 2009).

### 4.5.7 Example from USA: canon design office, USA

Sustainable Design (2021, p:5) states that “The 19,000-square-foot Power House building in downtown St. Louis reopened as CannonDesign's St. Louis headquarters after nearly 30 years of being unoccupied”. The Power House, built in 1928 and listed on the National Historic Register, provided coal-fired steam heat to a dozen downtown buildings until it was decommissioned in 1980. Although the building's outer shell and original structural steel were essentially intact, converting it for office use took a lot of inventiveness and careful architectural research (Figure 39), (URL3).

Figure 39: Canon Design Office

This project has been converted from a former power house also a LEED Gold building certificate without any extension only conversion (Figure 40 and Figure 41) (Sustainable Design, 2021).

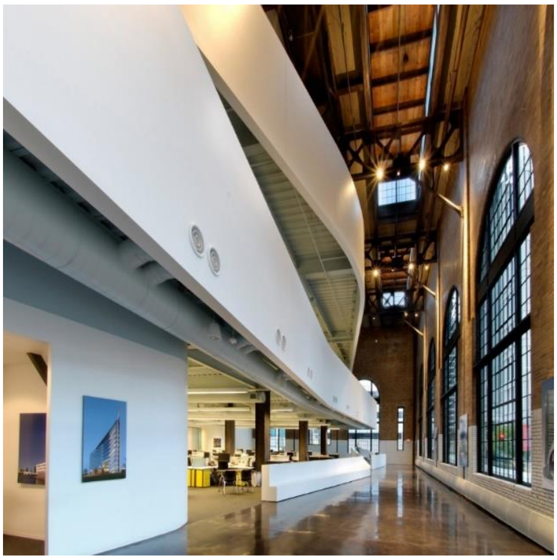


Figure 40: Canon Design Office, industrial adaptation project

The LEED Gold building is presently performing at an extraordinary level, outperforming even predicted energy consumption expectations. The high-efficiency window system, day and night cooling control systems, and CO2 sensors that control ventilation are all major components to this achievement, (URL3)”:

- Sustainable design matters to the greater good of improving our environment for generations to come and it matters to the users, conservators and specialists.
- The specialized sustainability services that create enduring value cannon design is through reducing cost, optimizing energy and water consumption and creating durable, lasting and respected environments.
- The project has evolved into one of unlimited needs and aspirations, yet one with increasingly limited and threatened resources. The project attempts for the continuous improvement of leveraging the integrated culture to bring greater value to users and help to solve some of society’s greatest resource challenges, (Sustainable Design. 2021).

The Canon design office as an adaptation project by converting a power station to an office space has been design dealing with sustainable energy strategy in order to get LEED certification which introduce a professional platform for the future of this study by considering green adaptation achievement.

#### 4.5.8 Examples from Australia: Sydney harbour yha and the big dig archaeology education centre, Australia

The Big Dig archaeological site is located on Cumberland and Gloucester Streets in the area of Sydney called ‘The Rocks’. The Big Dig commenced in 1994 and continued until 2008. During that time archaeologists discovered the remnants of over forty buildings and collected over one million artefacts (Figure 41a, Figure 41b Figure 42 and Figure 43) (UNESCO 2007).

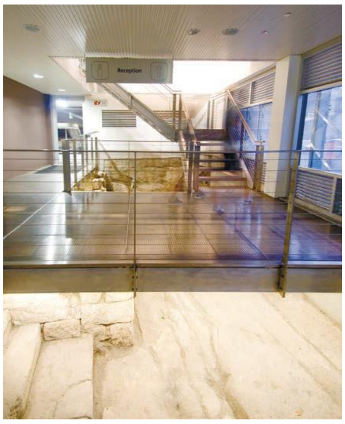
 a.  b.

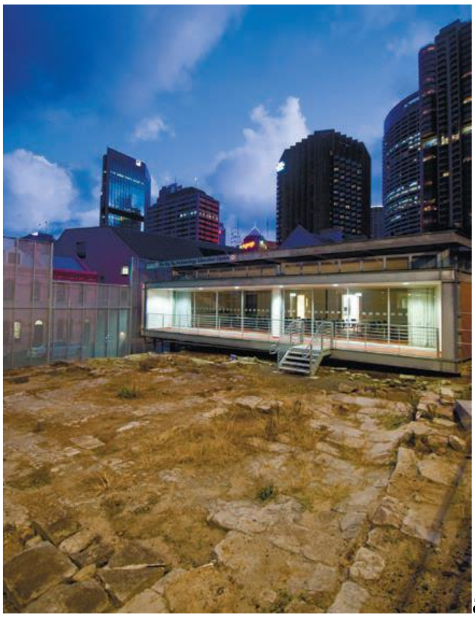
Figure 41a: and Figure 41 b: Sydney Harbour Yha And The Big Dig Archaeology Education Centre, interior before and after the adaptation UNESCO (2007)

Figure 42: Sydney Harbour Yha And The Big Dig Archaeology Education Centre

Figure 43: Sydney Harbour Yha And The Big Dig Archaeology Education Centre section

The core objective of the project – and what made it stand out from other adaptive use proposals  was the YHA's vision of integrating affordable tourist accommodation with an education centre while retaining the archaeological dig in site, (Figure 44a and 44b).

The designers of the education centre combined it with a hostel, providing both a learning centre for visitors and locals alike, and a place for visitors to stay. Completed in 2009, the Sydney Harbour YHA is an elevated two building, three-storey contemporary hostel. Completed the following year, the single-storey Big Dig Archaeology Education Centre, which cantilevers over the exposed archaeological remains, is a key component of the hostel. As a significant archaeological site, The Big Dig is protected under the Heritage Act 1977 (New South Wales) through its listing on the state heritage register, the highest level of protection offered by the state UNESCO (2007).


a.


b.

Figure 44 a: and Figure 44b: Sydney Harbour Yha And The Big Dig Archaeology Education Centre adaptation units

The design limited the impact on the archaeological site by limiting the building's footprint, thereby giving priority to the historic remains over the new structure. Sustainability was incorporated into the building design, which relies on natural ventilation and light, creating voids compatible and appropriate to the site, (Figure 44a and Figure 44b) . Providing shading and insulation reduced requirements for energy for heating, cooling and lighting. Other sustainability-oriented initiatives included the incorporation of rainwater tanks (with an 80,000-litre capacity), solar-powered water heaters, a gas generator, building materials low in volatile organic compounds (VOC) and formaldehyde, environmentally-sound rubber flooring and ‘no-spill’ external lighting. The project also ingeniously incorporated modern sustainable installations and interpretive displays to serve the goals of conservation, tourism and education without sacrificing the integrity of the site. The success of the project was in its respect for history, UNESCO (2007) .

#### 4.5.9 Summary on selected green adaptive reuse examples

According to the case studies worldwide which have been selected based on their relation to both cultural and environmental sustainability of heritage buildings, (Table 12) illustrats the evaluation of extracted features based on green adaptation criteria.

Table 12: Evaluation of the worldwide examples in terms of contribution to ecological and cultural sustainability.

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| CANADA | | | |
| 1 | Artscape Wychwood Barns | - Gold Certification LEED | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | - A geo-thermal heating, ventilation and air conditioning system<br>- Stormwater harvesting and reuse system<br>- Energy efficient lighting and appliances<br>- Water-conserving plumbing fixtures | ▪ **Historic Value (HV):** Advanced analysis: energy audit<br>▪ **Technological:** Natural lighting and ventilation<br>▪ **Legal:** Energy rating |
| | | - 100% recycled environmentally-friendly siding panels (Artscape Wychwood Barns is a community, 2008) | ▪ **Physical:** Material durability and workmanship |
| | | - White roof (reflects solar heat; reduces need for air conditioning in summer months) | ▪ **Environmental:** Internal environmental quality |

| No | Worldwide case studies | - Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| 2 | Evergreen Brick Works | - environmental sustainability | ▪ **Environmental:** Sustainability issues |
| | | - adaptation into their design process" to successfully transform the site | ▪ **Historic Value (HV):** Specialist in preservation of buildings and sites |
| | | - Increase cultural heritage value to the community.<br>- economic viability | ▪ **Economic:** Increase in value post adaptation, Current value |
| | | - Applied for Platinum LEED | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | - Innovation | ▪ **Innovation And Added Value:** Cultural Heritage<br>▪ **Innovation** |
| | | EUROPE | |
| 3 | Reichstag Parliament Building (conversion with extension), Germany | - a democratic forum, an understanding of history | ▪ **Economic:** Current value<br>▪ **Social:** Community benefits – historic listing, Image and identity/ Image and history |
| | | - a commitment to public accessibility and a vigorous environmental agenda<br>- skylights<br>- sustainable strategy and cultural sustainability | ▪ **Historic or cultural interest**<br>▪ **Technological:** Natural lighting and ventilation<br>▪ **Political:** Ecological footprint and conservation<br>▪ **Environmental:** Sustainability issues<br>▪ **Sustainable Site (SS):** Respect for sites of |

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| 4 | Meis (National Museum of Italian Judaism And The Shoah) In Ferrara: An example of GBC HB | certification GBC Historic Building | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | preserving their historical values and respond to modern needs of use | ▪ **Sustainable Site (SS):** Respect for sites of historic or cultural interest |
| | | conservation and enhancement in comparison with the environmental impact | ▪ **Innovation And Added Value:** Innovation (environmental benefit) |
| | | environmental impact requirements with the site, internal environmental comfort<br>the quality of indoor air | ▪ **Environmental:** Internal environmental quality, Internal air quality |
| | | materials with high environmental performance<br>all the materials used analyzed in their life cycle<br>the choice of biocompatible materials with attention to the use of resources | ▪ **Physical:** Material durability and workmanship<br>▪ **Social:** Density of valuable cultural resources in surrounding area |
| | | energy efficiency of all installed systems<br>quantities of carbon dioxide emissions associated with the production of energy for the construction and use of buildings<br>Buildings are responsible for nearly 40% of all energy consumed<br>the management of water resources<br>the amount of energy incorporated in their production<br>use and disposal, the management of waste with a holistic and integrated approach to all environmental issues | ▪ **Historic Value (HV):** Advanced analysis: diagnostic tests on materials, Advanced analysis: energy audit<br>▪ **Technological:** Energy rating, Feedback on building performance and usage |
| | | innovation | ▪ **Innovation And Added Value:** Innovation |

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| USA | | | |
| 5 | Fay House | LEED certification (Gold) | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | use of geothermal energy save countless tons of carbon emissions each year | ▪ **Historic Value (HV):** Advanced analysis: energy audit |
| | | energy benefits of insulating the exterior walls against the destruction of interior finishes and the potential deterioration of the masonry it would eventually cause – and decided against it | ▪ **Technological:** Energy rating |
| | | earth-friendly to retrofit | ▪ **Energy and Atmosphere (EA):** Total Life Cycle Non Renewable Energy |

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| 6 | Reichstag Parliament Building | Skylight<br>inner courtyard | ▪ **Technological:** Natural lighting and ventilation |
| | | LEED Platinum awards<br>LEED for Core and Shell<br>LEED for Commercial Interiors | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | energy efficiency parameters | ▪ **Historic Value (HV):** Advanced analysis: energy audit<br>▪ **Technological:** Energy rating<br>▪ **Legal:** Energy rating |
| | | historic criteria | ▪ **Sustainable Site (SS):** Respect for sites of historic or cultural interest, Historic Resource Preservation and Adaptive Reuse<br>▪ **Social:** Community benefits – historic listing, Image and identity/ Image and history |

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| 7 | Christman Building | LEED Gold building certificate without any extension only conversion | ▪ **Innovation in Design (ID):** LEED/GBC Historic Building Accredited Professional |
| | | respect to history and reuse<br>- respected environments | ▪ **Sustainable Site (SS):** Respect for sites of historic or cultural interest, Historic Resource Preservation and Adaptive Reuse<br>▪ **Social:** Community benefits – historic listing, Image and identity/ Image and history |
| | | - forecasted energy use predictions<br>- high-efficiency window system<br>control systems for day and night cooling<br>- control of $CO_2$ sensors that control ventilation<br>optimizing energy and water consumption<br>- durable | ▪ **Historic Value (HV):** Advanced analysis: energy audit<br>▪ **Environmental:** Sustainability issues, Internal environmental quality<br>▪ **Innovation And Added Value:** Innovation (environmental benefit) |

| No | Worldwide case studies | Contribution to Green adaptation (derived from main sources) | Contribution to ecological and cultural sustainability |
|---|---|---|---|
| AUSTRALIA | | | |
| 8 | Sydney Harbour Yha And The Big Dig Archaeology | natural ventilation<br>- natural light<br>- creating voids compatible and appropriate to the site<br>Providing shading and insulation reduced requirements for energy for heating, cooling and lighting<br>- incorporation of rainwater tanks<br>- solar-powered water heaters<br>- gas generator<br>- building materials low in volatile organic compounds (VOC) and formaldehyde<br>- environmentally-sound rubber flooring<br>- 'no-spill' external lighting | ▪ **Technological:** Natural lighting and ventilation<br>▪ **Social:** Community benefits — historic listing, Image and identity/ Image and history, Transport noise<br>▪ **Environmental:** Sustainability issues, Internal environmental quality<br>▪ **Historic Value (HV):** Advanced analysis: energy audit, Advanced analysis: diagnostic tests on materials |
| | | respect for history | ▪ **Sustainable Site (SS):** Respect for sites of historic or cultural interest, Historic Resource Preservation and Adaptive Reuse |

## 4.6 Formation of evaluation criteria related to HB out of ecological rating systems

Ecological sustainability have been considered as one of the significant pillars of sustainability. Accordingly, ecological sustainability principles are focusing on the environmental values of design strategy. As for the vital idea of this study, rating systems play a core role in standardization of ecological value during adaptive reuse of heritage buildings. Hence, there is an increase in the numbers of rating systems worldwide which have direct or indirect relation with adaptive reuse of heritage buildings. The sub-criteria in different Environmental Rating Systems have similarities, however the major evaluation / design criteria may vary. In order to achieve a comprehensive accumulation of all criteria and sub-criteria for design / evaluation of ecological sustainability, an inventory (Table 13) has been formed in this study to achieve a comprehensive matrix.

Table 13: Weights of criteria and sub criteria based on "Functional" category of ARM related to ecological sustainability and HB

| **EVALUATION CRITERIA including Rating System Factors** | | CREDIT | **ENVIRONMENTAL FRIENDLY (GREEN) DESIGN / EVALUATION CRITERIA** | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Management | Historic Value (HV) | Innovation and added value | Health and wellbeing | Pollution | Sustainable Sites (SS) | Site regeneration and development, Urban design and infrastructure | Water Efficiency (WE) | Social, cultural and percept aspects | Cost and economic aspects | Energy and Atmosphere (EA) | Energy efficiency | Materials and Resources (MR) | Indoor Environmental Quality (IEQ) | innovation in Design (ID) | Regional priority | Location and transportation | Smart location and linkage | Neighbourhood pattern and design | Environmental loadings | **Green infrastructure** and building |
| **ENVIRONMENTAL RATING SYSTEMS** | LEED-v4 | | | | | | | | | | | | | | | | | | | | | | |
| | GBC | | | | | | | | | | | | | | | | | | | | | | |
| | BREEAM | | | | | | | | | | | | | | | | | | | | | | |
| | SBTOOL | | | | | | | | | | | | | | | | | | | | | | |
| | GPRS | | | | | | | | | | | | | | | | | | | | | | |
| | CASBEE | | | | | | | | | | | | | | | | | | | | | | |
| | NABERS | | | | | | | | | | | | | | | | | | | | | | |
| | CEPAS | | | | | | | | | | | | | | | | | | | | | | |
| | LIDERA | | | | | | | | | | | | | | | | | | | | | | |
| | ITACA | | | | | | | | | | | | | | | | | | | | | | |

Ecological sustainability principles are focused on the environmental values of design strategy. As for the central fundamental idea of this study, ERS play a core role in the standardization of the ecological principles to be considered in ecologically sustainable adaptive reuse of heritage buildings. Figures 45a– 45f represent design criteria and sub-criteria gathered from selected ERS, which are explained in (Figure 45a and 45f) and analysed according to different headings. The marked ones express the features with relations to HB extracted among all features.

In this Figure, ecological design criteria and sub-criteria in relation to HB have been marked and extracted based on the definition made in related original ERS (Figures 45a– 45f). The inclusion of keywords such as historic site, historic interest, cultural interest, heritage building, historic building, architectural heritage, cultural heritage, heritage value, heritage significance, etc., in the original definition helped the re-searcher in the determination of related sub-criteria.

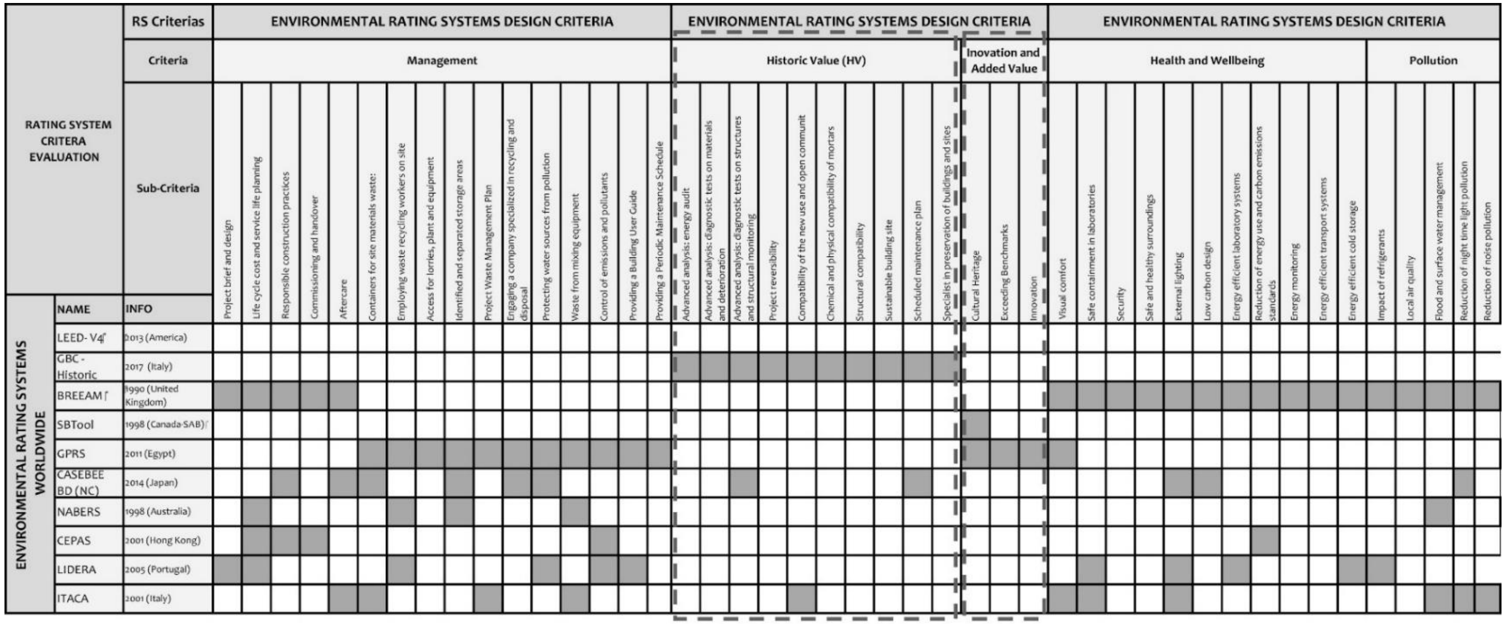
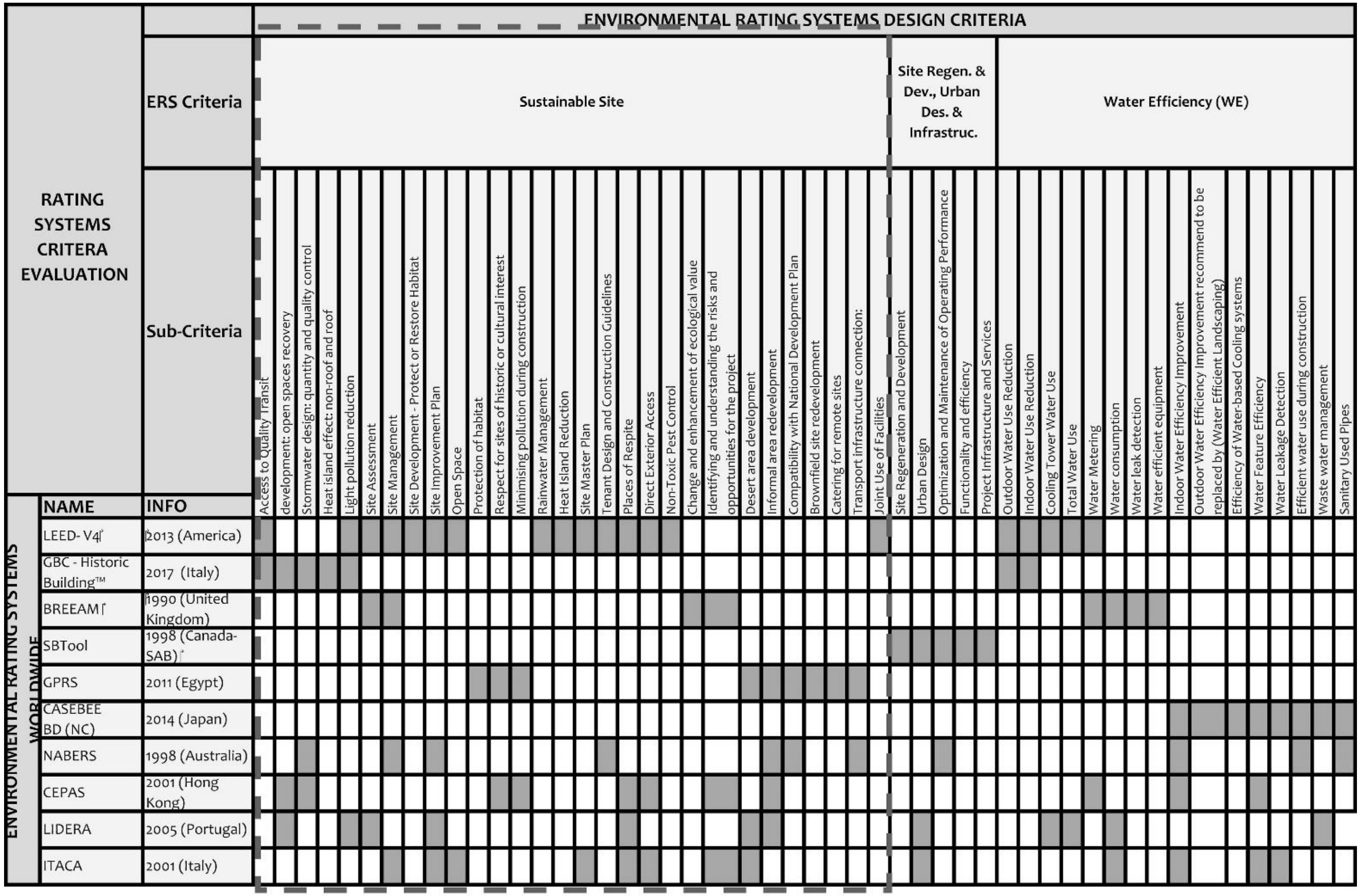
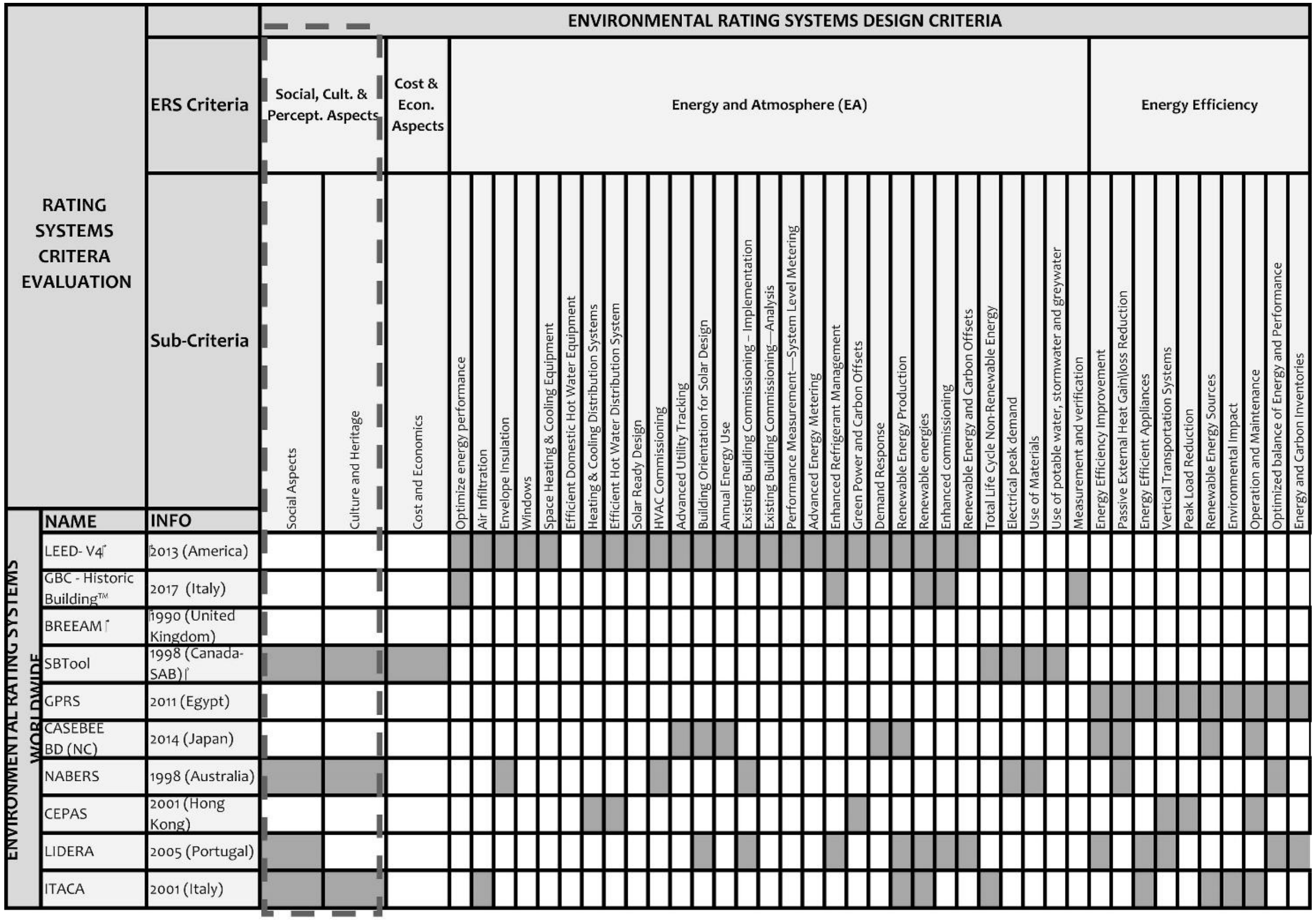



Figure 45:a) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB



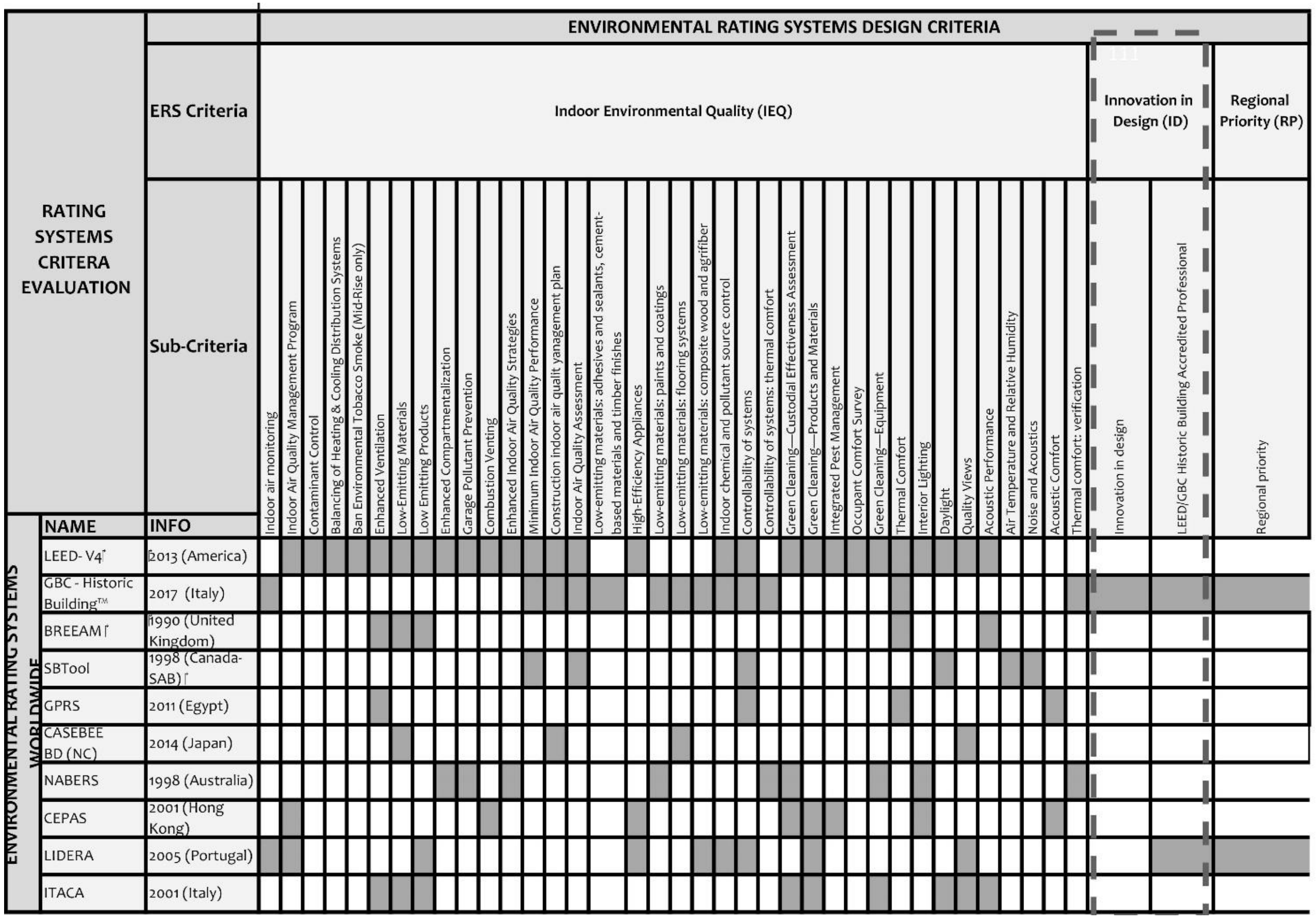
b) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB




c) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB

| RATING SYSTEMS CRITERA EVALUATION | | ENVIRONMENTAL RATING SYSTEMS DESIGN CRITERIA | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | ERS Criteria | Materials and Resources (MR) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Sub-Criteria | Building Life Cycle Impact Reduction | Durability Management Verification | Purchasing—Ongoing | Material Efficient Framing | Construction Waste Management | Environmentally Preferable Products | Purchasing—Lamps | Purchasing—Facility Maintenance and Renovations | Solid Waste Management—Ongoing | Solid Waste Management—Facility Maintenance and | Construction and Demolition Waste Management | Materials reuse | Building Product Disclosure & Optimization - Environmental Product Declarations | Building Product Disclosure and Optimization—Material | PBT Source Reduction- Mercury (Healthcare) | PBT Source Reduction- Lead, Cadmium, Copper (Healthcare) | Design for Flexibility". | Furniture and Medical Furnishings (Healthcare) | Tenant Space – Long Term Commitment | Interiors Life Cycle Impact Reduction | Adaptation to climate change | Design for disassembly and adaptability | Responsible sourcing of construction products | Speculative finishes (Offices only) | Building Product Disclosure and Optimization—Sourcing of Raw Materials | Regionally procured materials (to reduce the env. impact of transportation) | Materials fabricated on site | Use of readily renewable materials | Use of salvaged materials | Use of recycled materials | Use of lightweight materials | Use of higher durability materials | Use of prefabricated elements | Life Cycle Cost (LCC) analysis of materials in the project |
| ENVIRONMENTAL RATING SYSTEMS WORLDWIDE — NAME | INFO | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| LEED- V4 | 2013 (America) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | ■ | | | | | | | | | |
| GBC - Historic Building™ | 2017 (Italy) | ■ | | | | | | | | | | ■ | ■ | ■ | | | | | | | | | | | | ■ | | | | | | | | | |
| BREEAM | 1990 (United Kingdom) | ■ | ■ | | ■ | | | ■ | | | ■ | ■ | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | | | |
| SBTool | 1998 (Canada-SAB) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| GPRS | 2011 (Egypt) | | | | | | | | | | | | | | | | | ■ | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| CASEBEE BD (NC) | 2014 (Japan) | | | ■ | | | ■ | ■ | | | | | | | | | | | ■ | | | | ■ | ■ | | ■ | ■ | | | | | | | | ■ |
| NABERS | 1998 (Australia) | | ■ | | | | ■ | | | | | | | | ■ | | | | | | | ■ | ■ | | | | | ■ | | | | | ■ | | |
| CEPAS | 2001 (Hong Kong) | | | | | | | ■ | | | ■ | | | | | | | | | | | | | | | | | | ■ | ■ | | | ■ | ■ | |
| LIDERA | 2005 (Portugal) | | ■ | ■ | ■ | | | | | | | | | | | ■ | ■ | ■ | | ■ | ■ | ■ | | ■ | ■ | | | ■ | | ■ | | | | ■ | |
| ITACA | 2001 (Italy) | | | | | | | | | | | ■ | | | | | | | | ■ | | | | | ■ | ■ | | ■ | | | | | | ■ | |

d) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB




e) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB

**ENVIRONMENTAL RATING SYSTEMS DESIGN CRITERIA**

**RATING SYSTEMS CRITERA EVALUATION** — **ENVIRONMENTAL RATING SYSTEMS WORLDWIDE**

ERS Criteria: Location and Transportation

| NAME | INFO | LEED for Neighborhood Development Location | Sensitive Land Protection | High Priority Site | Surrounding Density and Diverse Uses | Access to Quality Transit | Bicycle Facilities | Reduced Parking Footprint | Green Vehicles | Compact Development | Community Resources | Sustainable transport measures | Transport assessment and travel plan | Alternative Transportation | Site Location and Context | Off-site services available | Site Characteristics |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LEED- V4 | 2013 (America) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | ■ | | | |
| GBC - Historic Building™ | 2017 (Italy) | | | ■ | | | ■ | ■ | ■ | | | | | ■ | | | |
| BREEAM | 1990 (United Kingdom) | | | | | | | | | | | ■ | ■ | ■ | | | |
| SBTool | 1998 (Canada-SAB) | | | | | | | | | | | | | | ■ | ■ | ■ |
| GPRS | 2011 (Egypt) | | | | | | | | | | | | | ■ | | | |
| CASEBEE BD (NC) | 2014 (Japan) | | | | | ■ | | | | | | | | | | | |
| NABERS | 1998 (Australia) | | | | ■ | | | | | | | | | | | | |
| CEPAS | 2001 (Hong Kong) | | ■ | | | | | | | | | | | | | | |
| LIDERA | 2005 (Portugal) | ■ | ■ | ■ | | ■ | | | | | ■ | | | ■ | ■ | ■ | |
| ITACA | 2001 (Italy) | | ■ | | | | | | ■ | ■ | | | ■ | | | | ■ |

ERS Criteria: Smart Location and Linkage

| NAME | INFO | Preferred Locations | Brownfield Remediation | Access to Quality Transit | Housing and Jobs Proximity | Steep Slope Protection | Site Design for Habitat or Wetland and Water Body | Restoration of Habitat or Wetlands and Water Bodies | Long-Term Conservation Management of Habitat or Wetlands and Water Bodies |
|---|---|---|---|---|---|---|---|---|---|
| LEED- V4 | 2013 (America) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| GBC - Historic Building™ | 2017 (Italy) | | | | | | | | |
| BREEAM | 1990 (United Kingdom) | | | | | | | | |
| SBTool | 1998 (Canada-SAB) | | | | | | | | |
| GPRS | 2011 (Egypt) | | | | | | | | |
| CASEBEE BD (NC) | 2014 (Japan) | | | | | | | ■ | |
| NABERS | 1998 (Australia) | | ■ | | | | | | |
| CEPAS | 2001 (Hong Kong) | | | | | | | | |
| LIDERA | 2005 (Portugal) | | | | | | | | |
| ITACA | 2001 (Italy) | | ■ | | | | ■ | ■ | ■ |

ERS Criteria: Neighborhood Pattern and Design

| NAME | INFO | Walkable Streets | Compact Development | Mixed-Use Neighborhoods | Mixed-Income Diverse Communities | Street Network | Transit Facilities | Transportation Demand Management | Access to Civic and Public Space | Access to Recreation Facilities | Visitability and Universal Design | Community Outreach and Involvement | Local Food Production | Tree-Lined and Shaded Streets | Neighborhood Schools |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LEED- V4 | 2013 (America) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| GBC - Historic Building™ | 2017 (Italy) | | | | | | | | | | | | | | |
| BREEAM | 1990 (United Kingdom) | | | | | | | | | | | | | | |
| SBTool | 1998 (Canada-SAB) | | | | | | | | | | | | | | |
| GPRS | 2011 (Egypt) | | | | | | | | | | | | | | |
| CASEBEE BD (NC) | 2014 (Japan) | | | ■ | | | | ■ | ■ | | | ■ | | | |
| NABERS | 1998 (Australia) | | | | | | | | | | ■ | | | | |
| CEPAS | 2001 (Hong Kong) | | | | | | | | | | ■ | | | | ■ |
| LIDERA | 2005 (Portugal) | ■ | | ■ | | | ■ | | | | | ■ | | | |
| ITACA | 2001 (Italy) | | | | ■ | | ■ | | | | | | | | ■ |

ERS Criteria: Environmental Loadings

| NAME | INFO | Greenhouse Gas Emissions | Other Atmospheric Emissions | Solid and Liquid Wastes | Impacts on Project Site | Other Local and Regional Impacts |
|---|---|---|---|---|---|---|
| LEED- V4 | 2013 (America) | | | | | |
| GBC - Historic Building™ | 2017 (Italy) | | | | | |
| BREEAM | 1990 (United Kingdom) | | | | | |
| SBTool | 1998 (Canada-SAB) | ■ | ■ | ■ | ■ | ■ |
| GPRS | 2011 (Egypt) | | | | | |
| CASEBEE BD (NC) | 2014 (Japan) | | | | | |
| NABERS | 1998 (Australia) | | | | | ■ |
| CEPAS | 2001 (Hong Kong) | | | | | |
| LIDERA | 2005 (Portugal) | | | | | |
| ITACA | 2001 (Italy) | | | | | |

ERS Criteria: Green Infrastructure and Buildings

| NAME | INFO | Walkable StreetsCertified Green Buildings | Existing Building Reuse | Minimized Site Disturbance in Design and Construction | Solar Orientation | District Heating | Infrastructure Energy Efficiency | Wastewater management | Recycled Content in Infrastructure | Solid Waste Management |
|---|---|---|---|---|---|---|---|---|---|---|
| LEED- V4 | 2013 (America) | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| GBC - Historic Building™ | 2017 (Italy) | | | | | | | | | |
| BREEAM | 1990 (United Kingdom) | | | | | | | | | |
| SBTool | 1998 (Canada-SAB) | | | | | | | | | |
| GPRS | 2011 (Egypt) | | | | | | | | | |
| CASEBEE BD (NC) | 2014 (Japan) | | | | | | | | | |
| NABERS | 1998 (Australia) | | ■ | | | | | | | |
| CEPAS | 2001 (Hong Kong) | | | | | ■ | | | | |
| LIDERA | 2005 (Portugal) | | | | | ■ | ■ | | | — |
| ITACA | 2001 (Italy) | | | | ■ | ■ | | | | |

f) Heritage building related criteria marked on design criteria extracted from environmental rating systems worldwide, which concentrate on HB

As aforementioned explanations, (Figure 45a– 45f) have introduced the HB related criteria and sub-criteria derived from the inclusive categorization of design criteria extracted from ERS worldwide. In this study, these criteria and sub-criteria are transferred to the proposed particular framework for evaluating adaptive reuse of heritage buildings in order to create mutual aspects between ARM and ERS.

## 4.7 Chapter conclusion

As for the numerous numbers of rating systems and adaptive reuse models worldwide, the limitation of this study addresses to the ones, which focus on heritage buildings particularly. Therefore, several case studies worldwide have been selected according to their relation to both cultural and environmental sustainability of heritage buildings. Hence, they express the idea of emerging cultural and environmental sustainability features.

In further steps, the data collection has been completed with the explanation of each selected rating system and adaptive reuse model accordingly. Furthermore, in terms of applying both cultural and ecological sustainability issues on heritage buildings, an assessment has been done according to ARM and ERS criteria and their evaluation principles.

In the next chapter of this study, the marked mutual aspects of ARM and ERS collected from Chapter 3 and 4 will be evaluated by calculations and will be transferred to the proposed particular alignment schema called the prerequisite criteria schema (PCS). PCS includes the criteria and sub-criteria checked among the inclusive features to be fulfilled in the ecological adaptive reuse process of HB.

The (Figure 46)  expresses the evaluating processes of this study which refers to every single method that has been used in order to get reasonable outcomes for the next step in chapter 5 (Figure  65).

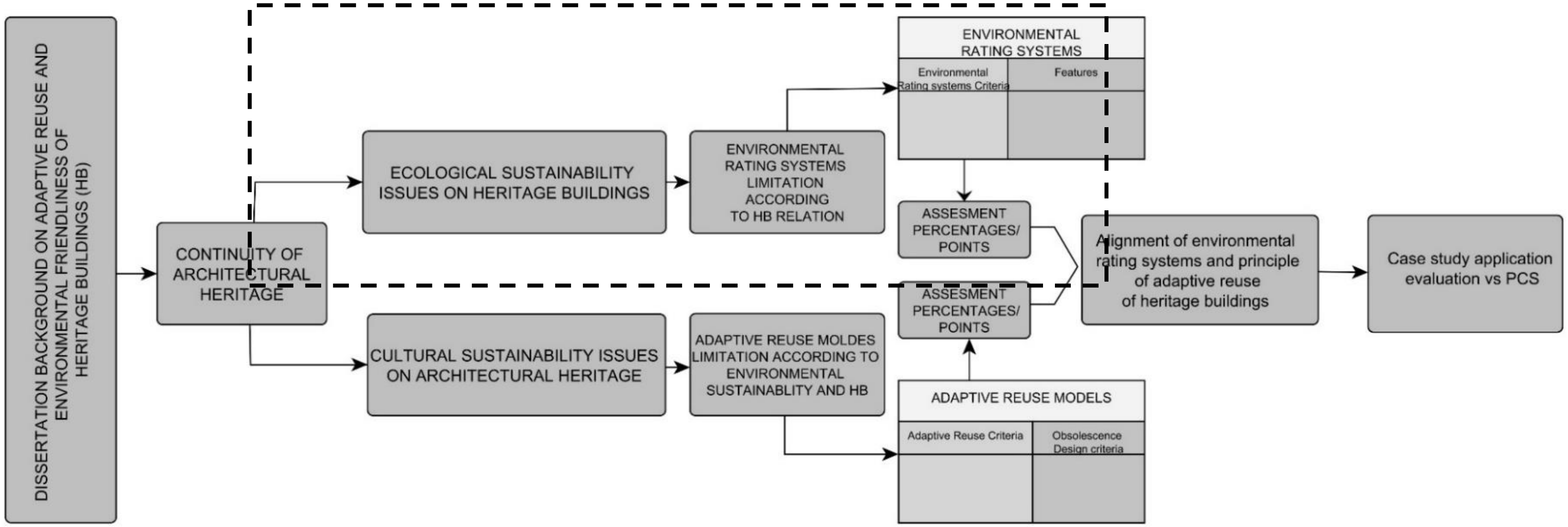



Figure 46: The evaluation process of this study

# Chapter 5

# ACHIEVING PREREQUISITE CRITERIA THROUGH ALIGNING CULTURAL SUSTAINABILITY AND ECOLOGICAL SUSTAINABILITY FOR GREEN ADAPTIVE REUSE OF HB

The association between cultural and ecological pillars of sustainability is considered in this study. The aim is to propose the integration of adaptive reuse models and environmental rating systems for achieving a framework to be applied to heritage buildings. An appropriate methodology is required since there are different approaches to be combined. As Bryman (2016) states, the comparative analysis method essentially contains two or more cross-sectional studies carried out at more or less the same point in time. The comparative analysis can also be applied in relation to a qualitative research strategy.

Hence, this study is providing comparison analysis methodology to achieve accrue evaluation and precise data collection from all cultural and ecological sustainability features for evaluation and design criteria. In a further step, all criteria are collected in Excel© software have gone through a calculation procedure in order to point out the weight scores of each criteria and sub-criteria. Lastly, based on different range of criteria weights, several charts have been drawn as outcome of the results, which express the significance of each criteria for achieving green adaptive reuse. The final result is described as a complete framework, including all weighted criteria which precisely define both cultural sustainability and ecological sustainability features.

## 5.1 Methodology derivation for the ARM and ERS (descriptive analysis) calculation assessment method

The evaluation section follows a quantitative method. It firstly presents the assessment of ARM through a score table which comprises criteria and sub-criteria with relation to environmental sustainability. The core significant aim of this study is the alignment of both adaptive reuse models as tools for cultural pillar of sustainability, and environmental rating systems as tools for ecological pillar of sustainability. In order to accomplish this aim, several methodology requires to be applied into the thesis study.

The comparison analysis attempts to evaluate the weights of given criteria and sub-criteria and get their percentages as a result by means of mathematical calculations via EXCEL© software. A system has been designed in Excel in order to calculate the average of each sub-criteria's weight in percentages to find out the real criteria value which are collected from ARM and ERS sources as it is mentioned in previous chapters. The final results contain two different evaluation:

1. Criteria percentage: It expresses the percentage of each sub-criteria out of 100% from the averages
2. Criteria weight: It presents the scores that have been calculated within final sub-criteria

Therefore, as far as this study addresses two different strategies, after the evaluation of features from each and every single ARM-adaptive reuse model and ERS-environmental rating system, each sub-criteria value is compared with each other to determine their significant role among existing ERS or ARM. This quantitative comparison of the data, led the researcher to conclude comparing the value of each data and achieve the significance results. Hence, both qualitative and quantitative research methods have been applied to this study as the (Figure 47) describes the methodology structure.

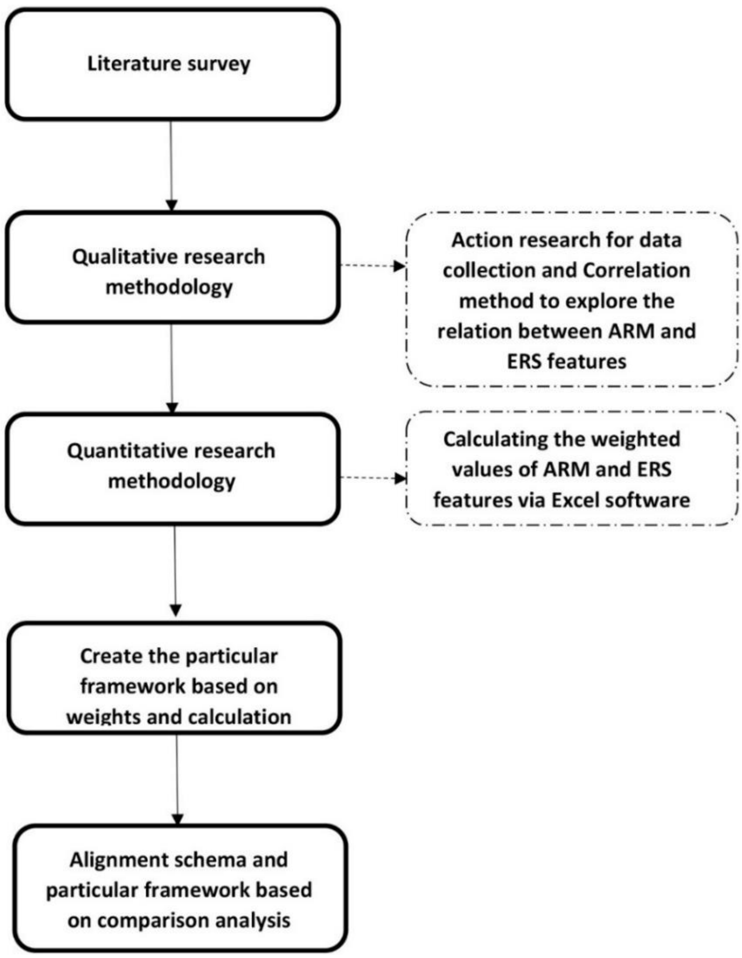



Figure 47: Alignment Methodology Structure

As for the main target of the study, in the first step, all criteria and sub-criteria of ERS which include HB related criteria serving for cultural sustainability, and ARM related with HB which contain environmental sustainability features, have been investigated through qualitative research method. Furthermore, the classification has been prepared based on the extraction of sub-criteria phrases and definitions from ERS, about cultural sustainability and the extraction of sub-criteria phrases and definitions from ARM about environmental sustainability. The framework has been created by calculating the average of points given to sub-criteria in selected ERS and ARM. Weights of each related sub-criteria of various selected ARM besides, the weights of each cultural sustainability related sub-criteria of various selected ERS are included in the calculations of average values.

The outcome of the value averages express the identification of significance of criteria among all sub-criteria derived from rating systems. The study is limited with the ERS-environmental rating systems which consider adaptive reuse of heritage buildings and ARM-adaptive reuse models which seek the importance of environmental sustainability for heritage buildings. For the validation of the quantitative method, extraction process from each system's and model's values have been described in the next section through calculation tables.

## 5.2 Weight extraction from adaptive reuse models (ARM)

Based on the explorations from their main resources and explanations, the points assigned for each criteria and sub-criteria are explored. An evaluation table has been drawn in Excel software in order to collect these points and get their averages to achieve the results for each criteria and sub-criteria. Additionally, graphs have been prepared for the visual demonstration of the outcome.

In this manner, the upcoming tables indicate the ARM criteria listed below and also the sub-criteria according to their relation to environmental sustainability and with heritage buildings as a tool for cultural sustainability. The extracted seven obsolescence design criteria are:

- Physical (long life)
- Economic (location)
- Social (sense of place)
- Functional (loose fit)
- Technological (low energy)
- Political (concepts)
- Legal (regulations)
- Environmental (sustainability).

Therefore, each aforementioned criteria and sub-criteria are described individually in further steps. In the explanation row, the original definition of each sub-criteria as stated in the examined ARM, has been revealed. Additionally, the following row dedicated to 'Thesis contribution' describes the interaction exists between definition and explanation of each sub-criteria within ARM by pointing out its relation to the cultural heritage. In the 'Standard value' row in (Tables 14-21) and (Figures 48-55), each and every weight or score that are given to the criteria or sub-criteria by different ARM have been collected from the main sources.

In the last row, the 'Average' of each criterion's score has been calculated by a comparative approach in percentages for equalizing the weights among all criteria and sub-criteria. Additionally, there are a few sub-criteria which do not use any numerical value for assessment, but they are just explanations. In this case, the percentages have been estimated by the researcher on a ratio basis, based on the collected definitions. Besides, the sub-criteria without relation to HB have been eliminated in a further step in order to achieve only the HB related ones as prerequisite criteria and sub-criteria for the green adaptive reuse of HB. The drawn graph in (Figure 28) has been prepared for the visualization of weights and percentages in a clear way. The pointed sub-criteria and their percentages can be effective in following prerequisite criteria of both environmental and cultural sustainability while reusing heritage buildings. Weight extraction process for each of the seven criteria are explained in a separate table in the following sub-sections.

### 5.2.1 Physical criterion and Sub-Criteria

As it is shown in this (Table 14) and in (Figure 4), there are sub-criteria with highest average among all contained criteria, such as ‘Service core location’ (6.97%), and ‘Degree of attachment to other buildings’ (6.96%). In second highest level, the ones are: ‘Floor plate size / Typical floor area’ (6.67%), and ‘Access to building / Site access’ (6.62%). At the same time, ‘Material durability and workmanship’ (5.33%) appears in third level, followed by ‘Structural integrity and foundation’ (2.58%). There are 10 sub-criteria in similar lower weight as: ‘Structure’, ‘Elasticity’, ‘Floor strength’, ‘Design complexity’, ‘Prevailing climate’, ‘Deconstruction’, ‘Expandability’, ‘Flexibility’, ‘Technological and convertibility’, and ‘Dis-agreeability’ with (2.14%) and the rest of two criteria remained with lowest weight (1.43%) as ‘Workmanship’ and ‘Maintainability’. Furthermore, non-credit features are ‘Access to building’, ‘Flexibility (space planning)’ and ‘Dis-agreeability’. Therefore, as physical criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 14: Weights of criteria and sub criteria based on "Physical" category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Physical | | | | | |
| Sub-Criteria | Structure | Structural integrity and foundation | Floor plate size/ Typical floor area | Service core location | Elasticity | Material durability and workmanship |
| Explanation | Considerations about adaptation process in order to keep the fabric structure | Floor structural design of the building with strength to cater for different future building uses and loading scenarios. Foundation for potential vertical expansion of the building and the stability of the structure. | It is useful to have this information for adaptive reuse time to offer new functions. | In adaptadion of heritage building, it may affect not to do any changes on the main service location | ease of extending the building laterally or vertically. Other attributes within elasticity are building form, organisational space and ease of compartmentalisation. (ability to extend laterally or vertically) | the more durable materials are used, the longer is the building's lifespan. |
| Standard value | | ARP- 5.58% | | | | ARP- 5.33% |
| | | ADAPTSTAR-5.58% | | | | ADAPTSTAR-5.33% |
| | PAAM-2.14% | | PAAM-6.67% | PAAM-6.97% | PAAM- 2.14% | |
| Average | 2.14% | 2.58% | 6.67% | 6.97% | 2.14% | 5.33% |

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Physical | | | | | |
| Sub-Criteria | Degree of attachment to other buildings | Access to building / Site access | Floor strength | Design complexity | Workmanship | Prevailing climate |
| Explanation | degree of attachment to other neighbouring buildings and site access | Access to buildings in building design and legislation. | In adaptation, floor strength has to be assessed to determine the land uses that are possible and suited physically to the existing floor structure. | this element consists of various geometries associated with the design and innovation of the building. | pertains to the quality of craftsmanship applied to the building's structure and finishes. | It addresses designing for changing climatic conditions that determine appropriate solutions for warm or cold temperature areas |
| Standard value | | | | ARP-2.14% | ARP- 1.43% | ARP-2.14% |
| | | | | ADAPTSTAR-2.14% | ADAPTSTAR-1.43% | ADAPTSTAR-2.14% |
| | PAAM-6.96% | PAAM-6.62% | PAAM-2.14% | | | |
| Average | 6.96% | 6.62% | 2.14% | 2.14% | 1.43% | 2.14% |

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Physical | | | | | |
| Sub-Criteria | Deconstruction (safe efficient and speedily) | Expandability | Flexibility (space planning) | Technological and convertibility | Maintainability | Dis-aggregability |
| Explanation | Related to keep the basic existing material and main fabric structure during the addaptation process of heritage buildings | volume and capacity of the building to be extended. | It is focusing of the potential of existing bulising in flexibility in planing for new uses during adaptation process. | This item attempts to introduce adaptive reuse technology according to the convertability pontials of existing builsings | This element addresses the issues enhancing building performance over its lifespan, where maintainability attributes are defined as the capability of a building to conserve operational resources. | Reusability/ recyclability |
| Standard value | | | | | ARP- 1.43% | |
| | | | | | ADAPTSTAR-1.43% | |
| | PAAM-2.14% | PAAM-2.14% | PAAM- 2.14% | PAAM-2.14% | | PAAM-2.14% |
| Average | 2.14% | 2.14% | 2.14% | 2.14% | 1.43% | 2.14% |

Based on the (Table 14), the graph in (Figure 48)expresses the comparative analysis data to visualize the weights of each adaptive reuse obsolescence criterion and sub-criterion based on “Physical” category of ecological sustainability features.

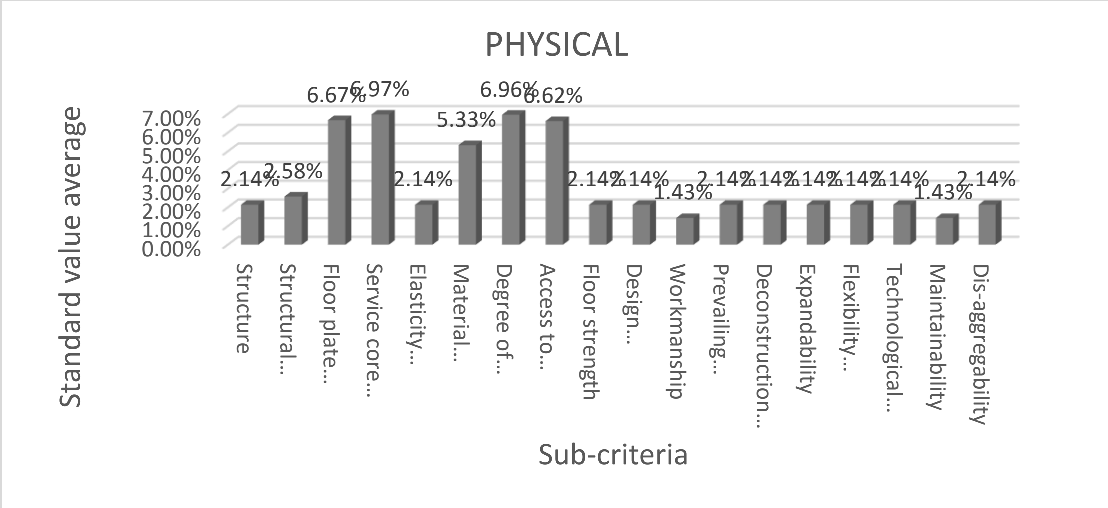



Figure 48: Bar-chart on weights of criteria and sub criteria based on “Physical” category of ARM related to ecological sustainability and HB

### 5.2.2 Economic criterion and sub-criteria

Table 15 presents evaluation process for ‘Economic value’ criteria and sub-criteria. As it shown in this figure, the highest score is allocated to 'Population Density’ (4.47%) and ‘Plot size’ and ‘site plan’ (4.41%). There are five criteria with equal average: ‘Density of occupation’, ‘Yields’, ‘Current value’, Increase in value post adaptation, ‘Convertibility’ with (4.33%). ‘Transport and accessibility’ (4.27%) and ‘Exposure’ (2.8%) are placed in next level. Therefore, as economic criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 15: Weights of criteria and sub criteria based on “Economic” category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Criteria | Economic | | | | | | | | |
| Sub-Criteria | Population Density | Density of occupation | Yields | Current value | Transport and accessibility | Plot size and site plan | Increase in value post adaptation | Convertibility | Exposure |
| Explanation | Population Density-location within major city, CBD, etc. Operational land use issues include the density of occupation of the land. | increasing density of the built environment to prevent erosion of green belt land within and around the existing site beside increasing economic sustainability | It focuses on distinguishing characteristic as a specifically cultural value through its historical or aesthetic significance and the cultural experiences it provides for the community | It may have relation to the current value of heritage building and contributes to the adaptive reuse process | Its related with the degree of attachment to other neighbouring buildings and site access of historic buildings from the main street based on economic issue during | Plot size – built area, spatial proportions, enclosure, etc. | The considerations of preserving the historic value during the adaptation process | Ease of conversion to other use and costs associated with the conversion | Risk exposure is a form of sensitivity testing. Each obsolescence rate is expressed as a probable range |
| Standard value | ARP-4.47% | | | | ARP-4.52% | ARP- 4.41% | | | ARP-2.8% |
| | ADAPT-STAR-4.47% | | | | ADAPT-STAR-4.52% | ADAPTSTAR-4.41% | | | |
| | | *PAAM-4.33%* | *PAAM-4.33%* | *PAAM-4.33%* | *PAAM-4.33%* | | *PAAM-4.33%* | *PAAM-4.33%* | |
| Average | 4.47% | 4.33% | 4.33% | 4.33% | 4.27% | 4.41% | 4.33% | 4.33% | 2.8% |

The graph in (Figure 49) expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Economic” category of ecological sustainability features.

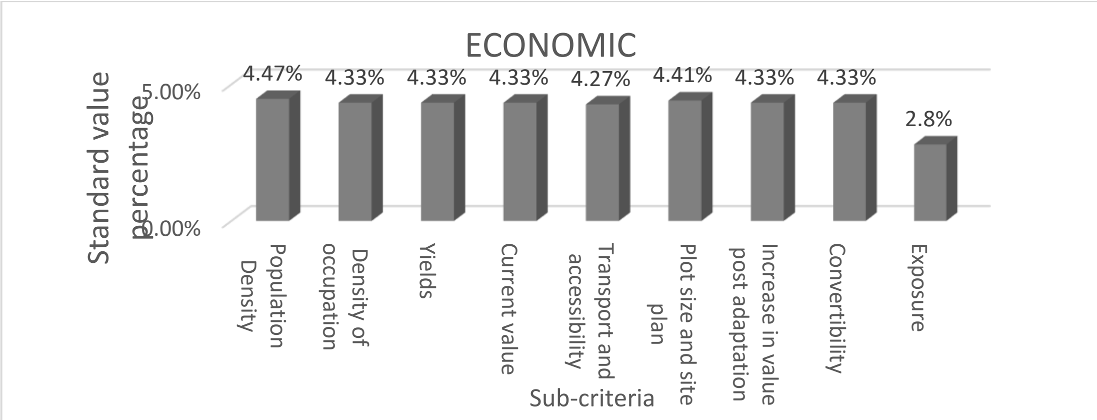


Figure 49: Bar-chart on weights of criteria and sub criteria based on “Economic” category of ARM related to ecological sustainability and HB

### 5.2.3 Social criterion and sub-criteria

Table 16, presents evaluation process for “Social” criteria and sub-criteria. As it shown in this figure, the maximum percentage is for ‘Image and identity/ Image and history’ (4.69%), ‘Neighbourhood and amenity’ (4.64%) and ‘Aesthetics and landscape/Townscape’ (4.14%), in order to help neighbourhoods to adjust with urban growth. ‘Density of valuable cultural resources in surrounding area/ Historic listing’ has got slightly lower weight (3.95%) for staying include the Heritage Register, and/or on the World Heritage List.

The ‘Age’ with (3.03%) placed in next and there are seven sub-criteria with equal percentage: ‘Community benefits – historic listing’ , ‘Transport noise’, ‘Retention of cultural past’, ‘Urban regeneration’, ‘Provision of additional Provision of additional facilities’ / ‘amenities’, ‘Proximity to hostile factor’s , ‘Proximity to hostile factors and Stigma’ with (1.20%). Therefore, as Social criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 16: Weights of criteria and sub criteria based on “Social” category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Criteria** | **Social** | | | | | | | | | | | |
| **Sub-Criteria** | Community benefits – historic listing | Density of valuable cultural resourses in surrounding area/ Historic listing | Image and identity/ Image and history | Transport noise | Retention of cultural past | Aesthetics and landscape/Townscape | Urban regeneration | Neighbourhood and amenity | Provision of additional Provision of additional facilities / amenities | Proximity to hostile factors | Stigma | Age |
| **Thesis contribution** | Buildings have to meet the needs of users and the wider community | Typically the buildings or places have to be of cultural or historic significance, and/or be included in the Heritage Register, and/or on the World Heritage List | social and cultural attributes, values, etc. | Generally, several types of noises might have disadvantages for historic buildings life cycle | It is one of the core factors during adaptation to consider the past cultural history of heritage buidings. | Aesthetics was important in adaptation and assessed on the basis of massing, form, composition, use of materials and so on | Buildings occupying prime sites considered ripe for urban regeneration and redevelopment. The adaptation of heritage stock can promote urban regeneration in run down areas. | it is likely that the convertibility and expandability of individual buildings will help older neighbourhoods modernize and adjust to new urban growth patterns, with less social and economic disruption. | The building provides relevant amenities and facilities within its neighbourhood that can add value to the local community | proximity to hostile factors or aesthetics includes noise, smells, contamination, proximity to power station | The effects of social environment considering the previous function and the new adaptive reuse project on historic buildings. | Building age |
| **Standard value** | | | ARP-4.69% | | | ARP- 5.04% | | ARP- 4.64% | | | | |
| | | | ADAPT STAR-4.69% | | | ADAPTSTAR-5.04% | | ADAPT-STAR-4.64% | | | | |
| | PAAM-1.20% | PAAM-3.95% | | PAAM-1.20% | PAAM-1.20% | PAAM-12.33% | PAAM-1.20% | | PAAM-1.20% | PAAM-1.20% | PAAM-1.20% | PAAM-3.03% |
| **Average** | 1.20% | 3.95% | 4.69% | 1.20% | 1.20% | 4.14% | 1.20% | 4.64% | 1.20% | 1.20% | 1.20% | 3.03% |

The graph in (Figure 50) expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on "Social" category of ecological sustainability features.

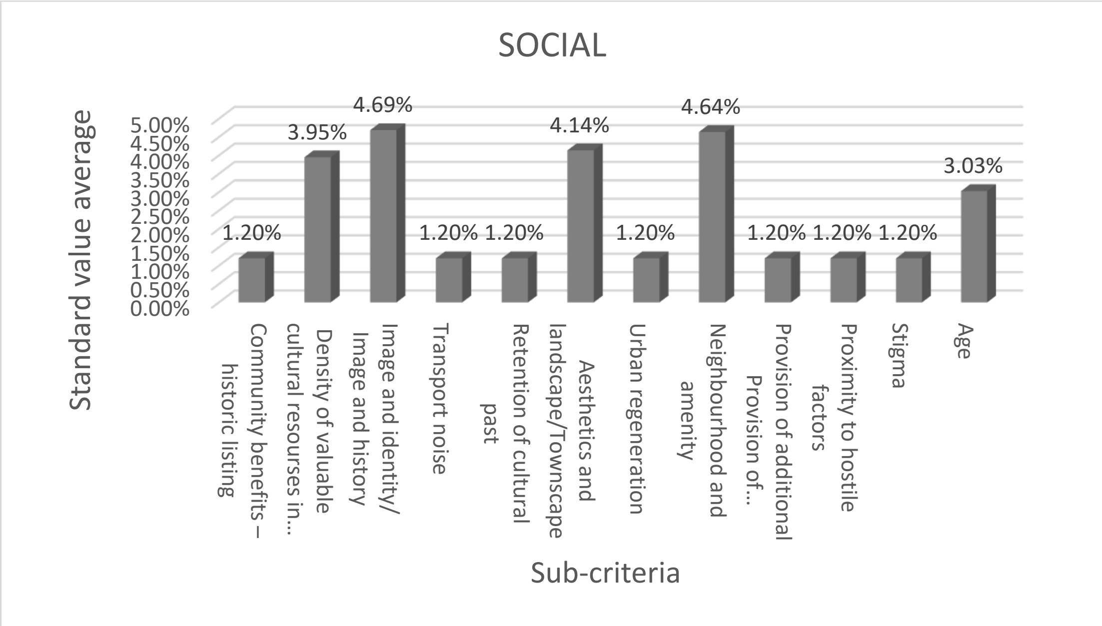



Figure 50: Bar-chart on weights of criteria and sub criteria based on "Social" category of ARM related to ecological sustainability and HB

### 5.2.4 Functional criterion and sub-criteria

Table 17, presents evaluation process for "Functional" criteria and sub-criteria. As it shown in this figure, all three sub-criteria have almost similar importance percentages listed in order such as: 'Flexibility and convertibility' (3.42%) for concerning the potential for indoor flexibility for future conversion, 'Structural grid' (3.03%), 'Spatial flow and atria'' (3.00%) 'Disassembly' (2.96%) and 'Service ducts and corridors' (2.82%). Therefore, as functional criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 17: Weights of criteria and sub criteria based on "Functional" category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | |
|---|---|---|---|---|---|
| Criteria | Functional | | | | |
| Sub-Criteria | Flexibility and convertibility | Disassembly | Spatial flow and atria | Structural grid | Service ducts and corridors |
| Thesis contribution | Functionally and technologically, the building has the potential for interior flexibility and reversibility for future conversion. | It has options for reuse, recycle, demountable systems deconstruction, modularity, etc. | Spatial flow – mobility, open plan, fluid and continuous 5 Convertibility – divisibility, elasticity, multi-functionality. Atria – open areas, interior gardens, etc. | ideal and economical limit of span and fully interchangeable | vertical circulation, service elements, raised floors, etc. |
| Standard value | ARP-3.42% | ARP-2.96% | ARP- 3% | ARP- 3.03% | ARP- 2.82% |
| | ADAPT-STAR-3.42% | ADAPT-STAR 2.96% | ADAPTSTAR- 3% | ADAPTSTAR-3.03% | ADAPT-STAR-2.82% |
| | | | | | |
| Average | 3.42% | 2.96% | 3.00% | 3.03% | 2.82% |

The graph 51 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Functional” category of ecological sustainability features.

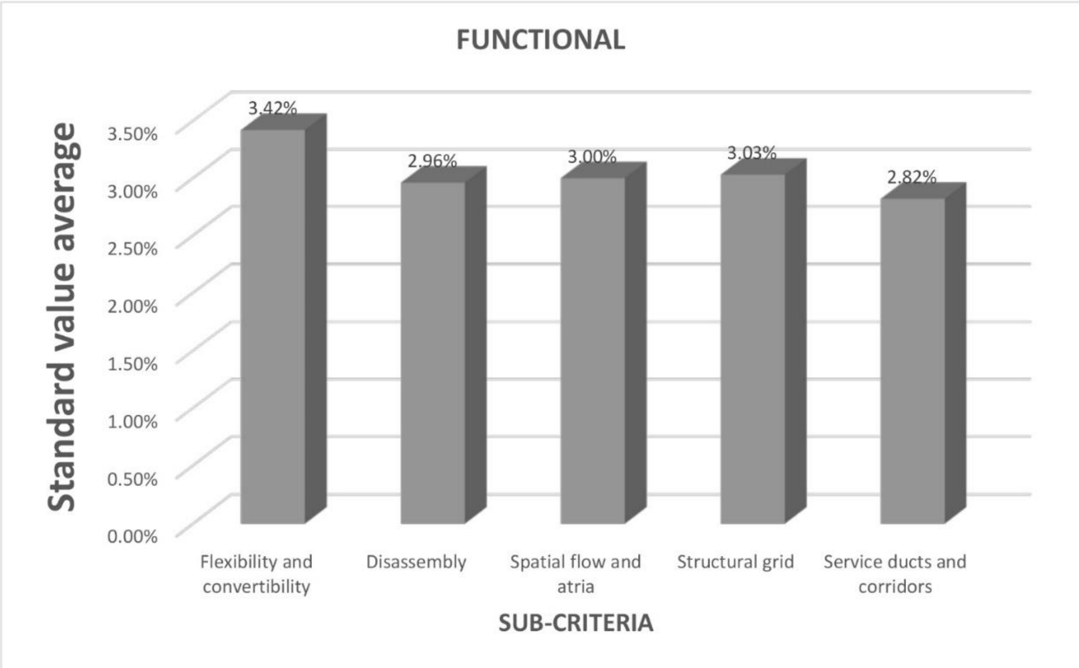



Figure 51: Bar-chart on weights of criteria and sub criteria based on "Functional" category of ARM related to ecological sustainability and HB

### 5.2.5 Technological criterion and sub-criteria

Table 18 presents evaluation process for "Technological" criteria and sub-criteria. As it shown in this table, the similarity between sub-criteria weights is obvious where they are listed in order: 'Orientation and solar access' (2.8%), 'Natural lighting and ventilation' (2.67%), 'Glazing and shading' (2.54%), 'Insulation and Acoustics' (2.49%), 'Energy rating' (2.31%), Feedback on building performance and usage about the adaptation reuse projects by stakeholders (2.04%). As opposed to 'Building management system' without numerical evaluation. Therefore, as Technological criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 18: Weights of criteria and sub criteria based on "Technological" category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Technological | | | | | |
| Sub-Criteria | Orientation and solar access | Glazing and shading | Insulation and Acoustics | Natural lighting and ventilation | Energy rating | Feedback on building performance and usage |
| Thesis contribution | Micro-climate siting, prevailing winds, sunlight and Solar access- measures for summer and winter sun | Glazing: sunlight glare control, regulation of internal temperatures, etc. shading – thermal mass, sunshades, automated blinds, etc. | noise control, sound insulation, etc. | Natural lighting – inclusion for natural daylight, efficient lighting systems, etc. Natural ventilation – optimise airflow, quality fresh air, increase ambient air intake, etc. | Energy rating – environmental performance measures | Taking feedback about the adaptation reuse from the projection users stakholders, etc. |
| Standard value | ARP-2.80% | ARP- 2.54% | ARP- 2.49% | ARP- 2.67% | | |
| | ADAPT-STAR-2.80% | ADAPTSTAR-2.54% | ADAPTSTAR-2.49% | ADAPT-STAR-2.67% | ADAPT-STAR-2.31% | ADAPT-STAR-2.04% |
| | | | | | | |
| Average | 2.8% | 2.54% | 2.49% | 2.67% | 2.31% | 2.04% |

The graph 52 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on "Technological" category of ecological sustainability features.

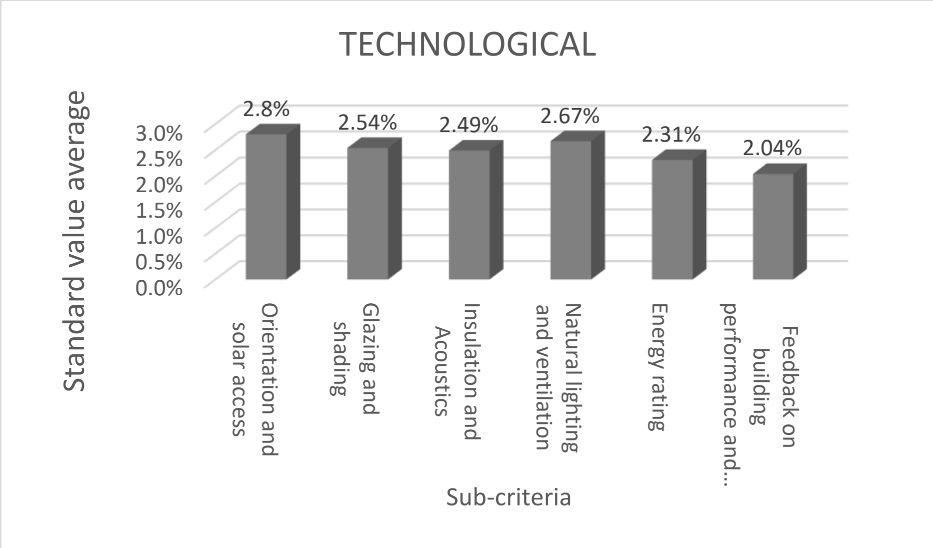



Figure 52: Bar-chart on weights of criteria and sub criteria based on "Technological" category of ARM related to ecological sustainability and HB

### 5.2.6 Political criterion and sub-criteria

Table 19, presents evaluation process for "Political" criteria and sub-criteria. As it shown in this table, the highest score belongs to 'Urban masterplan and zoning' / 'Urban regeneration' (4.39%), 'Community interest'/ 'participation', 'Community Support and Ownership' (4.35%), 'Ecological footprint and conservation' related to stockholders and Ecological footprint and conservation (4.05%) to be used for conservation and heritage protections. At the last level 'Zoning' placed with (2.32%). Therefore, as Political criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 19: Weights of criteria and sub criteria based on "Political" category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | |
|---|---|---|---|---|---|
| Criteria | Political | | | | |
| Sub-Criteria | Ecological footprint and conservation | Community interest/ participation | Community Support and Ownership | Urban masterplan and zoning / Urban regeneration | Zoning |
| Explanation | Ecological footprint – appropriate measure of human carrying capacity and Conservation includes principles, guidelines, charters governing tangible and intangible heritage protection. | Community interest/participation: stakeholder relationship and support | Ownership – collaborative commitment, sense of community or ownership, etc. Community support: stakeholder relationship and support | Adaptation of buildings within urban regeneration projects delivers social goals such as affordable (or social) housing or employment opportunities in areas of high unemployment | The municipal policy and the zoning plan for the area where the building is situated are taken into consideration |
| Standard value | ARP- 4.05% | ARP- 4.35% | ARP- 4.35% | ARP- 4.39% | |
| | ADAPT-STAR- 4.05% | ADAPT-STAR- 4.35% | ADAPT-STAR- 4.35% | | ADAPT-STAR- 4.39% |
| | | | | | *PAAM-0.26%* |
| Average | 4.05% | 4.35% | 4.35% | 4.39% | 2.32% |

The graph 53 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Political” category of ecological sustainability features.

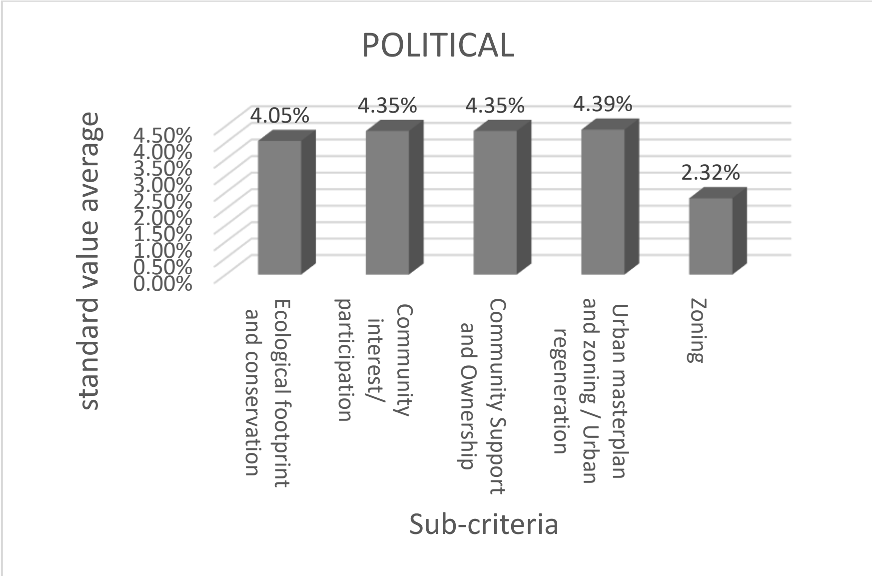



Figure 53: Bar-chart on weights of criteria and sub criteria based on “Political” category of ARM related to ecological sustainability and HB

### 5.2.7 Legal criterion and sub-criteria

Table 20, presents evaluation process for “Legal” criteria and sub-criteria. As it shown in this (Figure 54), The highest point allocated to ‘Standard of finish’ (4.36%), next level belongs to ‘Fire protection and disability access’/ ‘Fire codes’ (3.85%), then ‘Occupational health’, ‘IEQ’, ‘safety and Security’ with (3.59%) ‘Convertibility’ with (3.03%) ‘Acoustic’ (2.40%) ‘Energy rating (2.31%) have been remained afterwards. Therefore, as Legal criteria, the value of each sub-criteria serving to environmental sustainability and heritage buildings has been clarified.

Table 20: Weights of criteria and sub criteria based on “Legal” category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | | | |
|---|---|---|---|---|---|---|
| Criteria | Legal | | | | | |
| Sub-Criteria | Standard of finish | Fire protection and disability access/ Fire codes | Occupational health, IEQ, safety and Security | Convertibility | Energy rating | Acoustic |
| Explanation | Standard of finish – provision for high-standard workmanship | Fire protection – provisions for fire safety | Occupational health and safety – special needs of occupants, health and safety risks, building hazard and risk management plan. IEQ provisions for non-hazardous materials, natural fabrics, etc. Security – provision of direct and passive surveillance designs | Convertibility – divisibility, elasticity, multi functionality | Energy rating – environmental performance measures | Acoustics – noise control, sound insulation, etc. |
| Standard value | ARP- 4.36% | ARP- 4.65% | ARP-4.26% | ARP- 3.42% | ARP-2.31% | 2.49% |
| | ADAPTSTAR-4.36% | ADAPTSTAR-4.65% | ADAPT-STAR-4.26% | ADAPT-STAR-3.42% | ADAPT-STAR-2.31% | 2.31% |
| | | PAAM-2.26% | PAAM-2.26% | PAAM-2.26% | | |
| Average | 4.36% | 3.85% | 3.59% | 3.03% | 2.31% | 2.40% |

The graph 54 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Legal” category of ecological sustainability features.

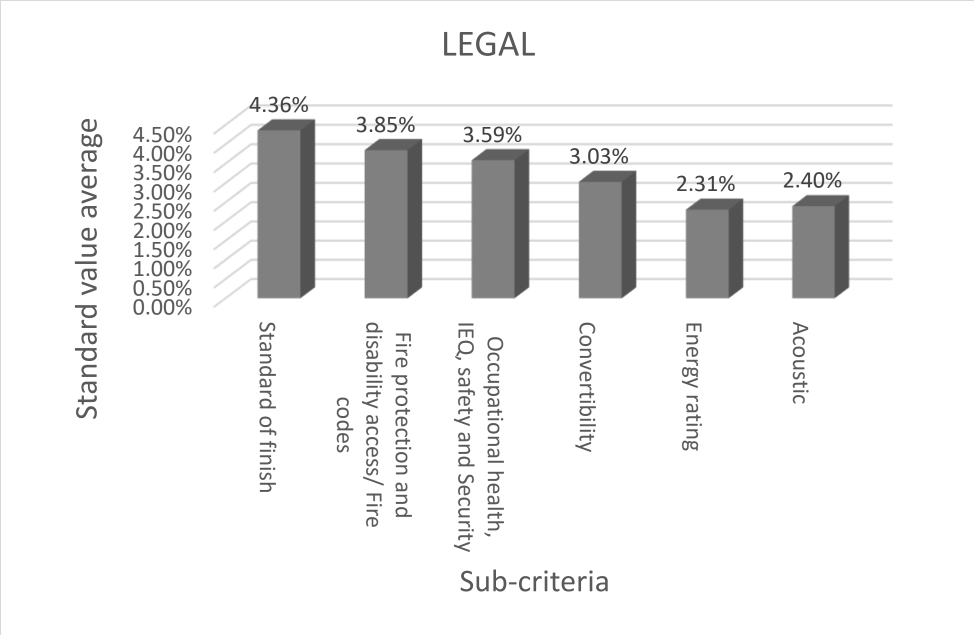



Figure 54: Bar-chart on weights of criteria and sub criteria based on "Legal" category of ARM related to ecological sustainability and HB

### 5.2.8 Environmental criterion and sub-criteria

Table 21 presents evaluation process for "Environmental" criteria and sub-criteria. As it describes in the main sources, there are no credit defined with lack of explanations. As it shown in following table and figure, four of sub-criteria with same percentages as (1.69%) which are 'Internal air quality', 'Internal environment quality', 'Existence of hazardous materials', 'Sustainability issues'.

Table 21: Weights of criteria and sub criteria based on “Environmental” category of ARM related to ecological sustainability and HB

| ARM | ADAPTIVE REUSE MODEL DESIGN CRITERIA | | | |
|---|---|---|---|---|
| Criteria | Environmental | | | |
| Sub-Criteria | Internal air quality | Internal environment quality | Existence of hazardous materials (asbestos) | Sustainability issues |
| Explanation | Internal air quality has to be considered as ecological sustainability factor for adaptiation of heritage builidgs since some of ventilation devices might have negative impact. | Internal environment quality requires special considerations for adaptation of heritage buikdings in order to choose suiatable tools not to destroy the value of HB | This item addresses special cares about types of exiting hazardous materials in HB and it attempts to find a solution to remove the asbestos | Buildings are inextricably linked to sustainability issues, and the construction environment as buildings contribute around half of all greenhouse gas emissions as buildings contribute around half of all greenhouse gas emissions |
| Standard value | | | | |
| | | | | |
| | PAAM-1.69% | PAAM-1.69% | PAAM-1.69% | PAAM-1.69% |
| Average | 1.69% | 1.69% | 1.69% | 1.69% |

The graph in (Figure 55) expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Environmental” category of ecological sustainability features.

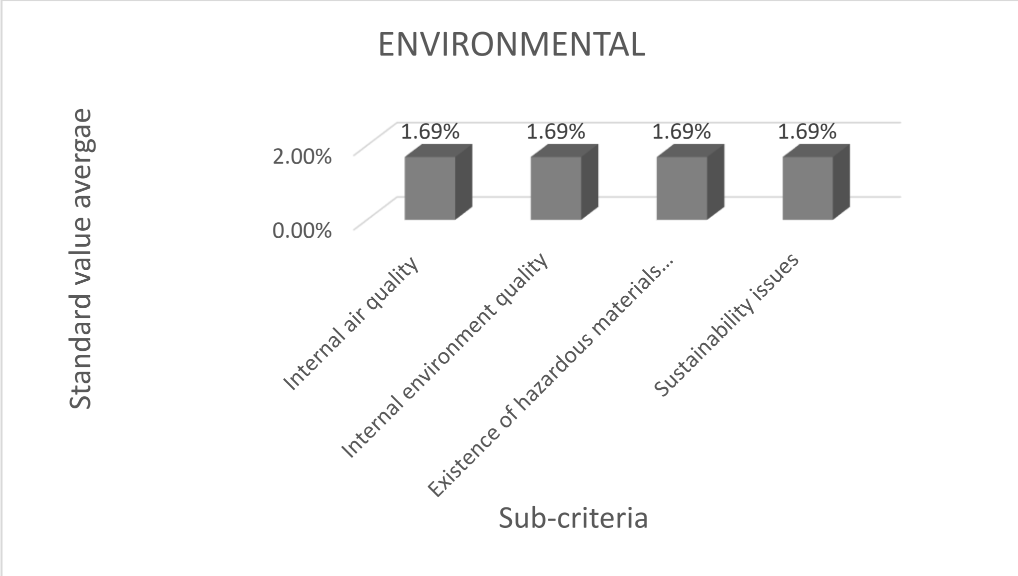



Figure 55: Bar-chart on weights of criteria and sub criteria based on "Environmental" category of ARM related to ecological sustainability and HB

This study attempt to consider two significant features of sustainable approaches such as cultural and environmental sustainability in order to investigate solutions for information absence about certified adaptive reuse worldwide. The Figure 56 demonstrates the range of values calculated for each ARM criteria and sub-criteria serving for environmental sustainability and for continuity of HB. The weighting system has been extracted from calculating the average of each ARM feature through investigation of existing models. Therefore, the particular framework attempts to clarify the weighted value of specific feature in order to be used by experts or non-experts in adaptive reuse processes worldwide in order to achieve both cultural and ecological sustainability of HB.

According to Figure 56, the weight of every single sub-criteria has been implied in percentage and computed in the bottom of the table via two different rows. The first row with dark grey colour presents the total range of sub-criteria examined within the related criteria group itself. The second row with light grey colour expresses the total average of sub-criteria out of 100% for the general outcome of the study.

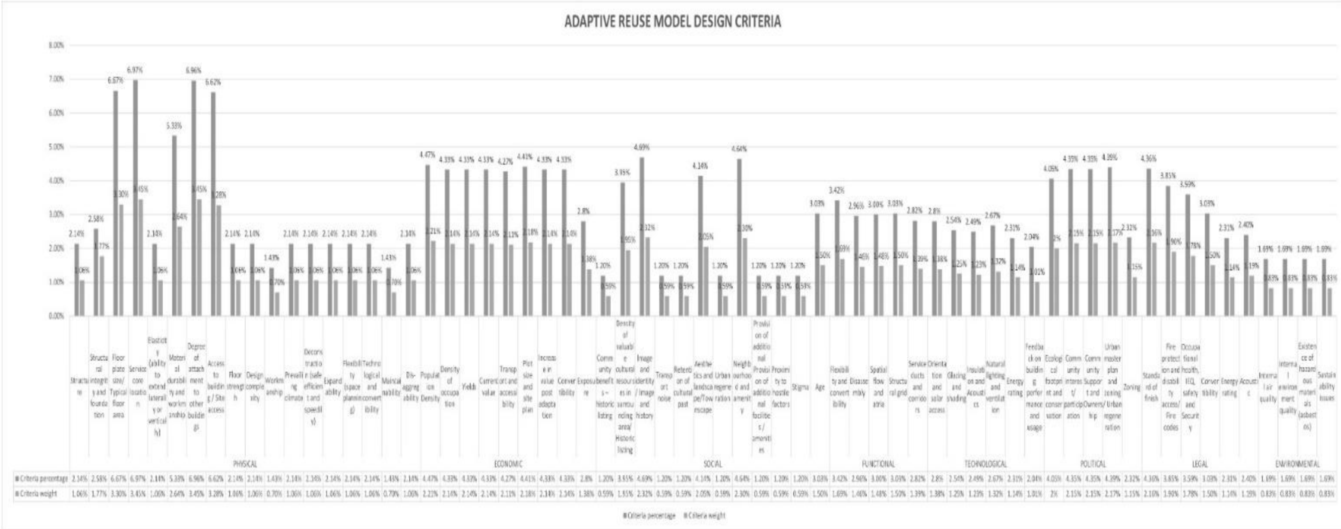



Figure 56: Percentage score criteria extracted from ARM sheet for criteria and sub- criteria

## 5.3 Weight extraction from environmental rating systems (ERS)

The evaluation section of ERS presents the assessment score table which includes criteria and sub-criteria with their relation to cultural sustainability and heritage buildings. Therefore, based on the significance of each criteria and weights that have assigned to them by the investigations on their core resources and descriptions, the evaluation table has been drawn in excel software in order to collect the points and get the averages to achieve the results for each criteria and sub-criteria. The graph has been prepared for the improvement of the visual demonstrations.

The purposed Figures are specifying ERS criteria and sub-criteria according to their relation to cultural sustainability and heritage buildings that has been selected through the study investigations:

- Historic Value
- Innovation and added value
- Sustainable site
- Social, Cultural and Perceptual Aspects
- Innovation in Design.

Therefore, each aforementioned criteria and sub-criteria is described individually in further steps in (Tables 22-26) and (Figures 29-33). The 'Thesis contribution' row is describing the mutual definitions and explanation of each sub-criteria among ERS with similarity in phrases and serving to the cultural sustainability based on chief sources. In the 'Standard value' row, each and every weight or scores that are given by ERS main sources to the criteria or sub-criteria have been collected. As the last row the 'Average' of each feature's score has been calculated as percentage in order to equalizing the weight among all criteria and sub-criteria. Additionally, There are a few sub-criteria which does not evaluated by any weight or numerical value, but just explanations, in this case, the specific key has been added to the figure ' *NC: No Credit'. The drawn graph 34 has been prepared for the visualization of weights and percentages in a clear way. The pointed sub-criteria and their percentages can be effective in cultural sustainability decisions making while reusing Heritage buildings.

### 5.3.1 Historic value criterion and sub-criteria

Table 23, is demonstrating the evaluation process for "Historic value" criteria and sub-criteria. As it shown in this table, the maximum weight belongs to 'Advanced analysis: energy audit' with (6%) to identify energy efficiency study, 'Advanced analysis: diagnostic tests on structures and structural monitoring' with (2.7%) stands as second significant score. Strikingly, 6 different sub-criteria have got same percentage a (1.81%) named as: 'Advanced analysis: diagnostic tests on materials', 'Project reversibility', 'Compatibility of the new use and open community', 'Chemical' and 'physical compatibility of mortars', 'Structural compatibility' and 'Scheduled maintenance plan'. Furthermore, the other two features remained with same value (0.90%) which are 'Sustainable building site' and 'Specialist in preservation' of buildings and sites. Therefore, as Historic value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 22: Weights of criteria and sub criteria based on “Historic value” category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Criteria** | **Historic Value (HV)** | | | | | | | | | |
| **Sub-Criteria** | Advanced analysis: energy audit | Advanced analysis: diagnostic tests on materials and deterioration | Advanced analysis: diagnostic tests on structures and structural monitoring | Project reversibility | Compatibility of the new use and open community | Chemical and physical compatibility of mortars | Structural compatibility | Sustainable building site | Scheduled maintenance plan | Specialist in preservation of buildings and sites |
| **Thesis contribution** | Identifying energy efficient study | standard materials are now available for a number of clinical tests | determining the causes and solutions to problems of materials | The capability of retrieving waste emplaced in geological repositories | Relationship to Onsite Uses Under Alternative | Repair mortars used for restoration | the structure remains fitted together in its original configuration | Example of if soil available on the building site | maintenance planners to schedule a maintenance plan | the professional body for building conservation practitioners and historic |
| **Standard value** | 2/110 (GBC) - 1.81% | 2/110p(GBC) - 1.81% | 3/110p(GBC) - 2.72% | 2/110p(GBC) - 1.81% | 2/110p(GBC) - 1.81% | 2/110p(GBC) - 1.81% | 2/110p(GBC) - 1.81% | 1/110p (GBC) - 0.90% | 2/110p(GBC) - 1.81% | 1/110p(GBC) - 0.90% |
| | NABERS -0 | NABERS -0 | NABERS -0 | NABERS -0 | NABERS -0 | NABERS -0 | NABERS -0 | NABERS -0 | Exist in NABERS- No score | NABERS -0 |
| | CEPAS - 0 | CEPAS -0 | CEPAS -0 | CEPAS -0 | CEPAS -0 | CEPAS -0 | CEPAS -0 | CEPAS - 1.2% | CEPAS -0 | CEPAS -0 |
| | 6.20% | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 | ITACA-0 |
| **percentage** | 6% | 1.81% | 2.7% | 1.81% | 1.81% | 1.81% | 1.81% | 0.90% | 1.81% | 0.90% |

The graph in Figure 57 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Historic value” category of ecological sustainability features.

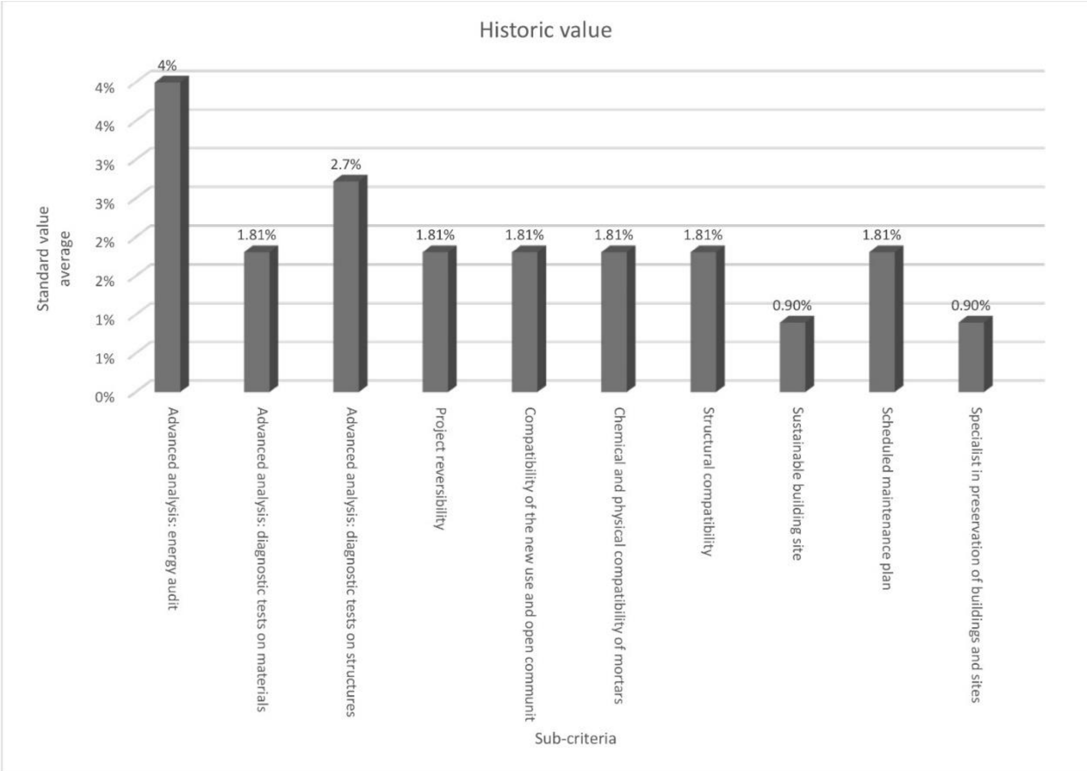



Figure 57: Bar-chart on weights of criteria and sub criteria based on “Historic value” category of ERS

### 5.3.2 Innovation and added value criterion and sub-criteria

Table 24, demonstrates the evaluation process for “Innovation and added value” criteria and sub-criteria. As it shown in this table, ‘Exceeding Benchmarks and deterioration’ (2.53%) took the highest score, ‘Cultural Heritage and Innovation’ (environmental benefit) similarly have got (2.04%) of importance based on their identifications. Therefore, as ‘Innovation’ and added value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 23: Weights of criteria and sub criteria based on “Historic value” category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | | |
|---|---|---|---|
| **Criteria** | **INNOVATION AND ADDED VALUE** | | |
| **Sub-Criteria** | Cultural Heritage | Exceeding Benchmarks and deterioration | Innovation (environmental benefit) |
| **Thesis contribution** | Reflecting national and regional cultural heritage while contributing to the environmental performance of the building. | Initiatives which demonstrate additional environmental benefit by exceeding the current benchmarks of GPRS | Design initiatives and construction practice which have a significant measurable environmental benefit |
| **Standard value** | 3/103p (GBC) - 2.91% | 4/103p (GBC)- 3.88% | 3/103p (GBC) 2.91% |
| | 1.17% (SBTool) | 1.17% (SBTool) | 1.17% (SBTool) |
| **Average** | 2.04% | 2.53% | 2.04% |

The graph in Figure 58 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Innovation value” category of ecological sustainability features.

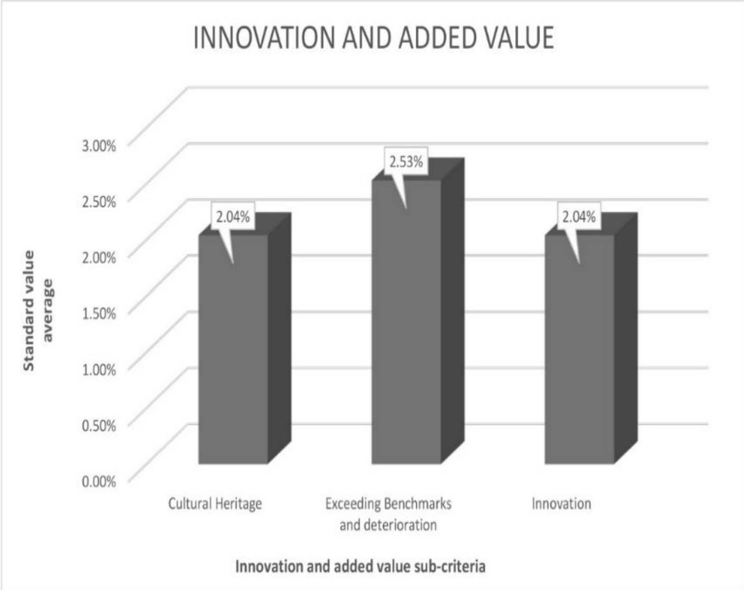



Figure 58: Bar-chart on weights of criteria and sub criteria based on “Innovation value” category of ERS

### 5.3.3 Sustainable site value criterion and sub-criteria

Table 24, demonstrates the evaluation process for “Sustainable site value” criteria and sub-criteria. This table contains just two sub-criteria with high relation to cultural sustainability and heritage buildings according to their descriptions. Respect for sites of ‘historic or cultural interest’ has the highest score with (4%) and ‘Historic Resource Preservation’ and Adaptive Reuse with (3%) remained. The aforementioned features could play a vital role for the reuse project with certification. Therefore, as Sustainable site value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 24: Weights of criteria and sub criteria based on "Sustainable site" category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | |
|---|---|---|
| **Criteria** | **Sustainable Site** | |
| **Sub-Criteria** | Respect for sites of historic or cultural interest | Historic Resource Preservation and Adaptive Reuse |
| **Thesis contribution** | A credit point is obtainable for demonstrating a suitable strategy for conserving and protecting remains of historic or cultural interest that are part of or nearby the site. | Guidelines for rehabilitation extended to restoration and preservation |
| **Standard value** | 1/110p (LEED V4) - 1% | 1/110p (LEED V4) - 1.81% |
| | (GPRS) - 10% | |
| | | 5/100 (CASBEE) -5% |
| | 3.1/100 (CEPAS) - 3.1% | 3.1/100 (CEPAS) - 3.1% |
| | (LIDERA) - 1% | (LIDERA) - 1% |
| **percentage** | 4% | 3% |

The graph in Figure 59 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on "Sustainable site" category of ecological sustainability features.

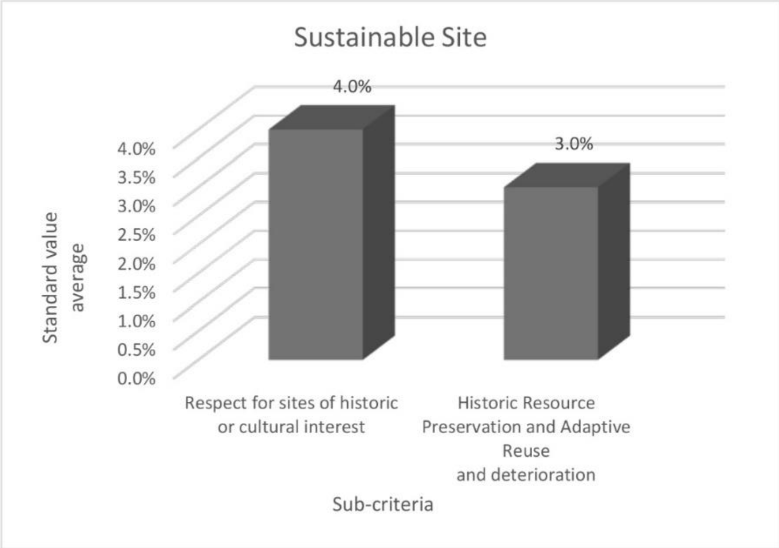



Figure 59: Bar-chart on weights of criteria and sub criteria based on “Sustainable site” category of ERS

### 5.3.4 Social, cultural and perceptual aspects value criterion and sub-criteria

Table 26, demonstrates the evaluation process for “Social, Cultural and Perceptual aspects value” criteria and sub-criteria. The table below presents two sub-criteria which are high effective in order to achieve a certified adaptive reuse project.

The ‘Social Aspects’ has taken (2.09%) and ‘Culture and Heritage and deterioration’ with (1.09%) which is focusing on the public, open space and local cultural values. Therefore, as ‘Social’, ‘Cultural and Perceptual aspects’ value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 25: Weights of criteria and sub criteria based on "Social, Cultural and Perceptual aspects value" category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | |
|---|---|---|
| **Criteria** | **Social, Cultural and Perceptual Aspects** | |
| **Sub-Criteria** | Social Aspects | Culture and Heritage and deterioration |
| **Thesis contribution** | To provide optimum spatial arrangements and facilities to enhance the sense of social interaction for all building occupants and users | Provision of public open space compatible with local cultural values |
| **Standard value** | (SBTool) 1.17% | (SBTool) 1.17% |
| | 1.1/100 (CEPAS) -1.1% | |
| | (LIDERA) - 4% | (LIDERA) - 1% |
| **Average** | 2.09% | 1.09% |

The graph in Figure 60 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on "Social, Cultural and Perceptual aspects value" category of ecological sustainability features.

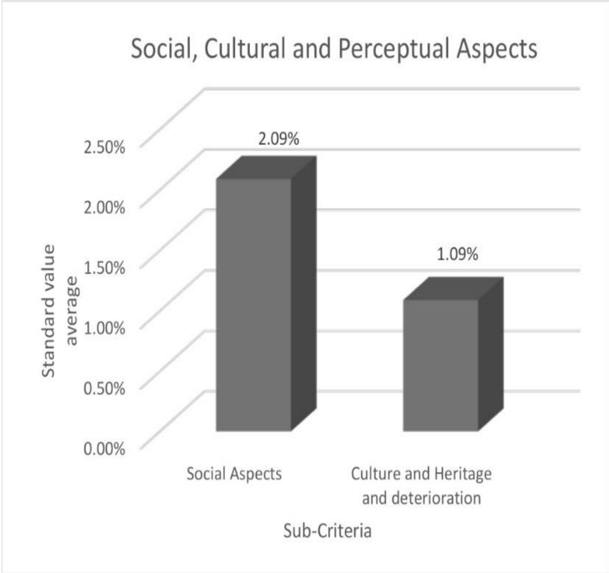



Figure 60: Bar-chart on weights of criteria and sub criteria based on “Social, Cultural and Perceptual aspects value” category of ERS

### 5.3.5 Energy and atmosphere value (EA) criterion and sub-criteria

Table 27, is demonstrating the evaluation process for “Energy and atmosphere value (EA)” criteria and sub-criteria. The table below presents one sub-criteria among all sub-criteria which is high effective in order to achieve a certified adaptive reuse project. The ‘Total life cycle Non-renewable Energy’ with (6%) which is focusing on Use of renewable energy in onsite generation further reduces environmental harms.

Table 26: Weights of criteria and sub criteria based on “Energy and atmosphere value (EA)” category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | |
|---|---|
| **Criteria** | **Energy and atmosphere value (EA)** |
| **Sub-Criteria** | Total life cycle Non-renewable Energy |
| **Thesis contribution** | Use of renewable energy in onsite generation further reduces environmental harms. |
| **Standard value** | (LEED V4) - 3% |
| | (GPRS) - 6% |
| | SB-Tool- 8.31% |
| | GPRS-5% |
| | CASBEE- 0 |
| | NABERS- 0 |
| | CEPAS- 0 |
| | (LIDERA) - 1% |
| | ITACA- 6.2% |
| **percentage** | 4.91% |

The graph in Figure 61 express the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Energy and atmosphere value (EA)” category of ecological sustainability features.

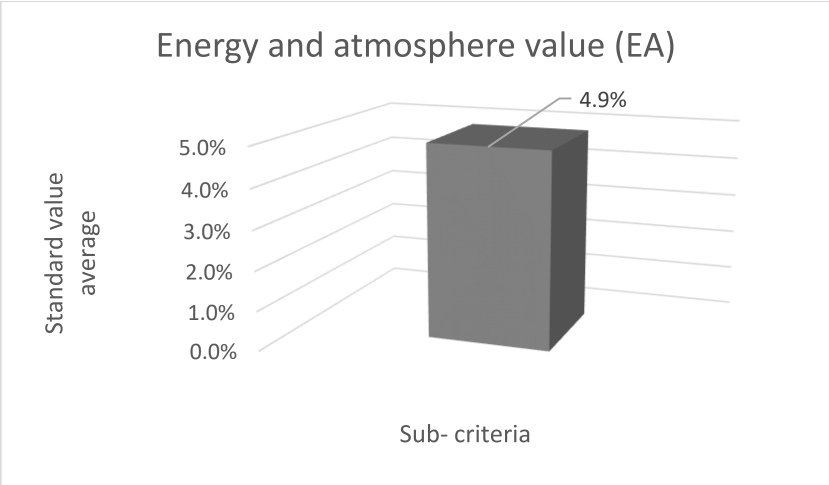


Figure 61: Bar-chart on weights of criteria and sub criteria based on "Energy and atmosphere value (EA)" category of ERS

### 5.3.6 Innovation in design (ID) value criterion and sub-criteria

Table 28 demonstrates the evaluation process for "Innovation in Design (ID) value" criteria and sub-criteria. As the table expresses two sub-criteria, the highest weight belongs to GBC 'Historic Building Accredited Professional' with (2.7%) which has collaboration with LEED ND rating system. 'Innovation in design' feature with (1.33%) is working on practices and strategies during the conservation process. Therefore, as Innovation in Design (ID) value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 27: Weights of criteria and sub criteria based on “Innovation in Design (ID) value” category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | |
|---|---|---|
| **Criteria** | **Innovation in Design (ID)** | |
| **Sub-Criteria** | Innovation in design | GBC Historic Building Accredited Professional and deterioration |
| **Thesis contribution** | Innovative building features, sustainable building practices and strategies during the conservation process | At least one member of the project team should be a LEED ND Accredited Professional experienced in certifying the kind of project being proposed |
| **Standard value** | 1/110 (LEED v4) -1% | 5/110 (LEED v4) - 4.5% |
| | 1/110 (LEED v4) -1% | 5/110 (LEED v4) - 0.9% |
| | (LIDERA) 2% | |
| **Average** | 1.33% | 2.70% |

The graph in Figure 62 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Innovation in Design (ID) value” category of ecological sustainability features.

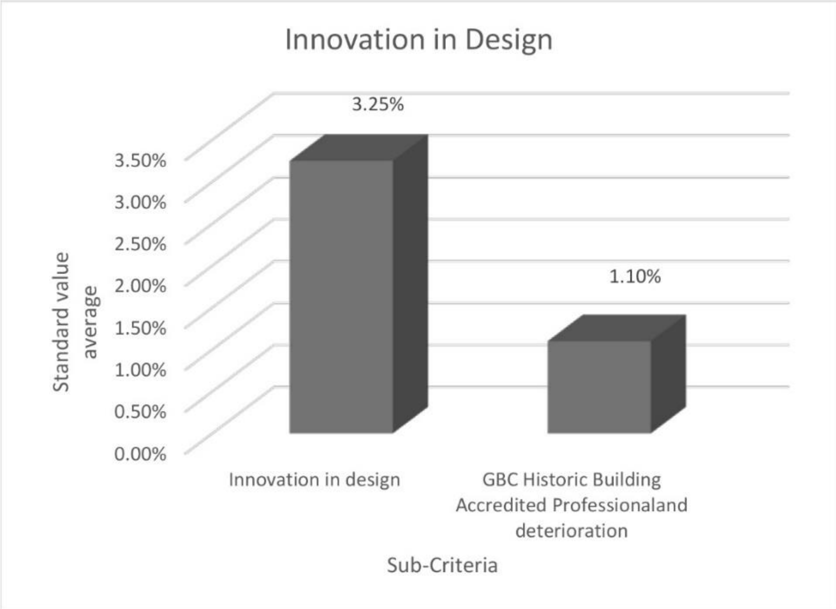



Figure 62: Bar-chart on weights of criteria and sub criteria based on “Innovation in Design (ID) value” category of ERS

### 5.3.7 Green infrastructure and buildings value Criterion and Sub-Criteria

Table 29, demonstrates the evaluation process for “Green infrastructure and buildings value” criteria and sub-criteria. As the table expresses two sub-criteria, the highest weight belongs to ‘Existing building reuse/ Historic Resource Preservation and Adaptive Reuse’ with (3.4%) which has collaboration with LEED ND, CEPAS, LIDERA rating system. ‘Minimized site disturbance in design and construction’ with (3.3%) is working on preserve existing noninvasive trees, native plants, and pervious surfaces and Conserve existing natural areas and protect trees to provide habitat and promote biodiversity. Therefore, as Green infrastructure and buildings value criteria, the rate of each sub-criteria serving to cultural sustainability and heritage buildings has been clarified.

Table 28: Weights of criteria and sub criteria based on “Innovation in Design (ID) value” category of ERS related to cultural sustainability and HB

| Environmental Rating System Design Criteria | | |
|---|---|---|
| **Criteria** | **Green infrastructure and buildings** | |
| **Sub-Criteria** | Existing building reuse/ Historic Resource Preservation and Adaptive Reuse | Minimized site disturbance in design and construction |
| **Thesis contribution** | To respect local and national landmarks and conserve material and cultural resources by encouraging the preservation and adaptive reuse of historic buildings and cultural landscapes.. To conserve and protect archaeological and historic buildings, monuments, components and artefacts. | To preserve existing noninvasive trees, native plants, and pervious surfaces. Conserve existing natural areas and protect trees to provide habitat and promote biodiversity. |
| **Standard value** | (LEED V4) - 2% | (LEED V4) - 1% |
| | (CEPAS) - 3.1% | (CEPAS) - 3.1% |
| | (LIDERA) - 5% | (LIDERA) - 7% |
| | ITACA- 0 | ITACA-2% |
| **percentage** | 3% | 3% |

The graph in Figure 63 expresses the comparison analysis data to clarify weight of each adaptive reuse obsolescence criterion and sub-criterion based on “Green infrastructure and buildings value” category of ecological sustainability features.

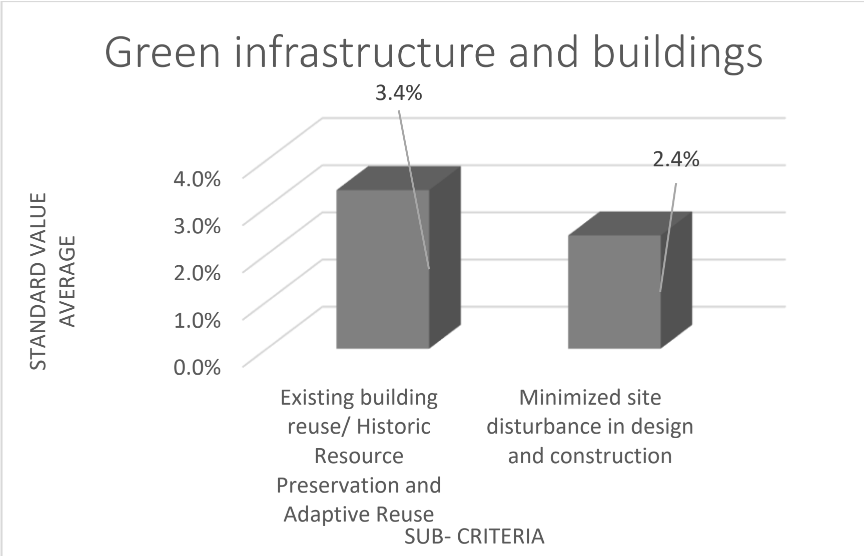



Figure 63: Bar-chart on weights of criteria and sub criteria based on “Green infrastructure and buildings value” category of ERS

This study attempt to consider two significant features of sustainable approaches such as cultural and environmental sustainability in order to investigate solutions for information absence about green adaptive reuse in worldwide. The table below demonstrates the range of value to each ERS criteria and sub-criteria serving to cultural sustainability and HB. The weighting system has been extracted from calculating the average of each ERS features through major resources investigation. Therefore, the particular framework attempts to clarify the weighted value of specific features in order to be used by experts or non-expert in adaptive reuse projects worldwide to achieve both cultural and ecological sustainability of HB.

According to the presented table, the weight of each features has been imply as percentages and computed in the bottom of table via two different row. The first row with light grey colour, total range of sub-criteria examined within the related criteria group itself. The second row with dark grey colour expresses the total average of sub-criteria out of 100% for the general outcome of the study, (Figure 64- 57).

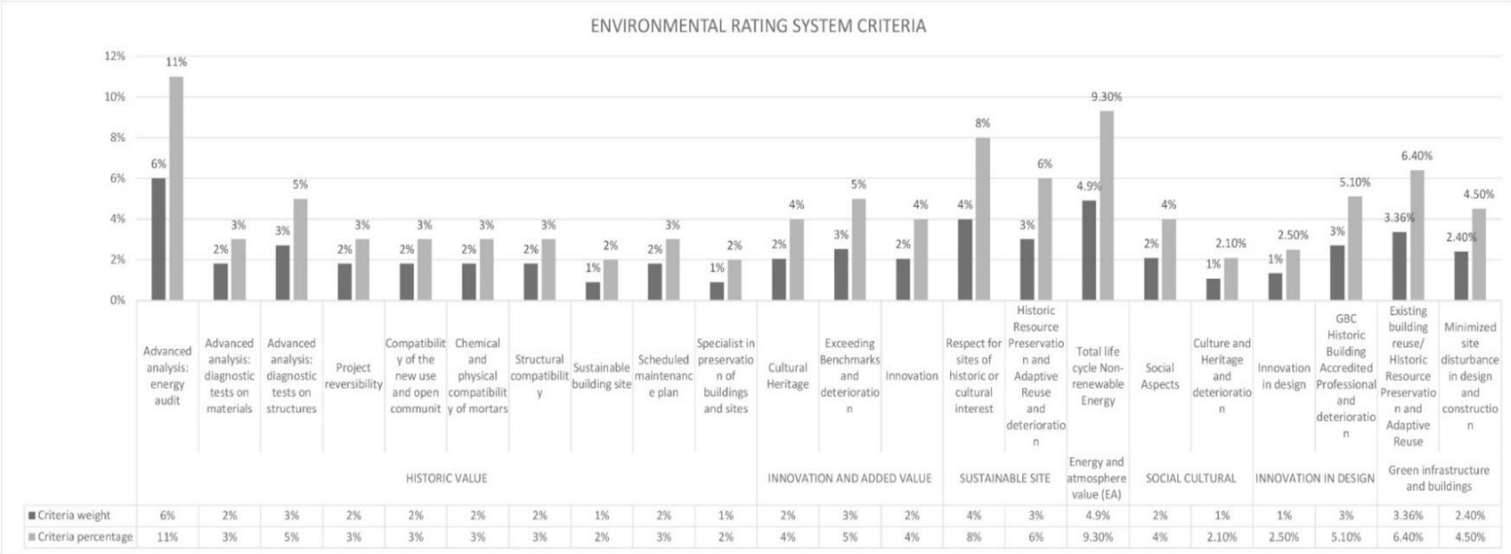



Figure 64: Percentage score sheet for criteria and sub-criteria extracted from ERS

## 5.4 The proposed prerequisite criteria schema (PCS)

Following the alignment of ARM and ERS, the study procedure has been continued by tracking the analysis and evaluations (Figure 65, Figure 66). The combination of achieved data from ARM and ERS has importance in case of adding a creative framework to the contemporary architectural conservation field to be used in green adaptive reuse processes worldwide. Promoting the importance of integrating both ARM and ERS can be framed as a schema that contains the collected data in relation to HBs. The connection to both ARM and ERS criteria and sub-criteria has been explored from their feature descriptions analysis in previous sessions, which attempt to innovate a beneficial PCS for certified adaptive reuse of heritage buildings.

In this manner, PCS was drawn by targeting both “ARM’” as cultural sustainability obsolesce design criteria and “ERS” as ecological sustainability design criteria in relation to HB. PCS serves as the initial step within the procedure of achieving green adaptive reuse of HB. This schema will help the user to check whether they fulfill HB-related features among the inclusive ARM and ERS criteria and sub-criteria. Two columns placed in the middle of the framework serve as mutual features to be concerned as the prerequisite criteria of green certified adaptive reuse projects. The evaluation process uses the appropriate criteria and sub-criteria of both ARM and ERS for HB, based on their percentages and weights presented in the score sheet, (Figure 65, Figure 66) and mark on the option boxes in order to do the assessment procedure accordingly. The other criteria of ARM and ERS might be enough for a project to be evaluated as environmentally sustainable, however, in order to apply for a certification in green adaptive use of HB, the prerequisite criteria in the proposed framework (PCS) need to be fulfilled.

As it is shown in PCS, there are boxes which needs to be filled by the experts on adaptation of HB site before starting the projects. Additionally, all weights and percentages have been written in front of each sub-criteria in order to assist the expert to create the project score sheet. As for the certification process, based on the presented figures and data in Chapter 3 and 4, each conservator can apply for the suitable rating system according to their region and location. Furthermore, since the proposed framework is derived through worldwide data collection, and the chosen systems are flexible to be adapted to different case studies from different contexts, and the mutual criteria assessment, it can be applied for different regions. Therefore, evaluators using this tool need to take local context into account during assessment.

If the majority of the mutual features exist above a certain level in an adaptive reuse project, then the process for applying the green certification can be envisioned for an adaptation prject for HB. If there are insufficient number of criteria fulfilled in an adaptive reuse project, then PCS can be used in order to develop and revise the project according to the related mutual features, ensuring continuity of heritage significance while targeting a green adaptation. The integration of sustainable design with the conservation of HB will be achieved by sustaining their historic values and authenticity while making a green adaptive reuse. The framework (Figure 65 and Figure 66) to achieve a green adaptive reuse of heritage buildings has been proposed based on the assessment of sub-categories of both ERS and ARM which have been explained in (Figure 18 and Figure 45a- 45f).

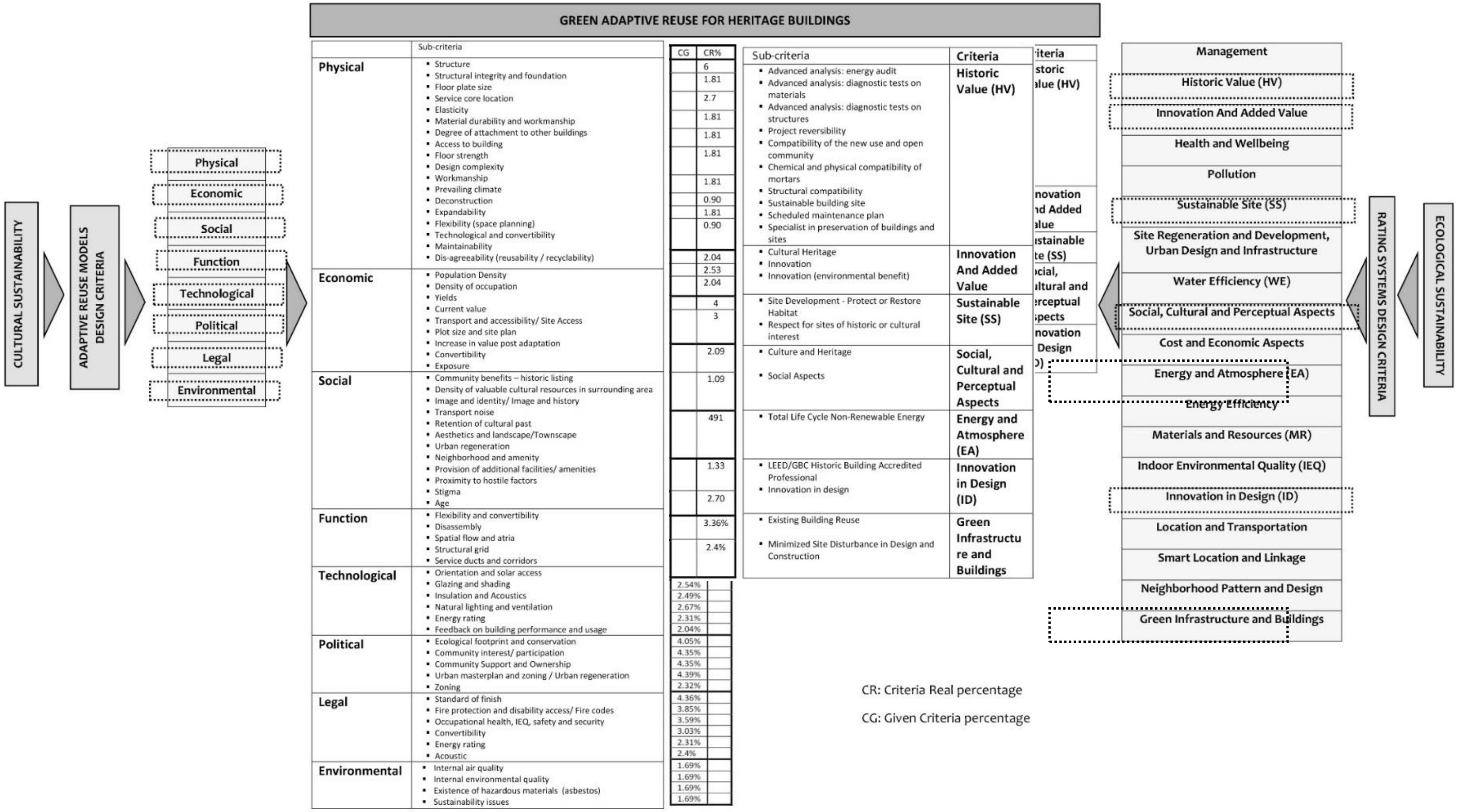



Figure 65: The framework to achieve a green adaptive reuse of heritage buildings has been proposed based on the assessment of each sub-categories which have been explained in Tables 9-22.

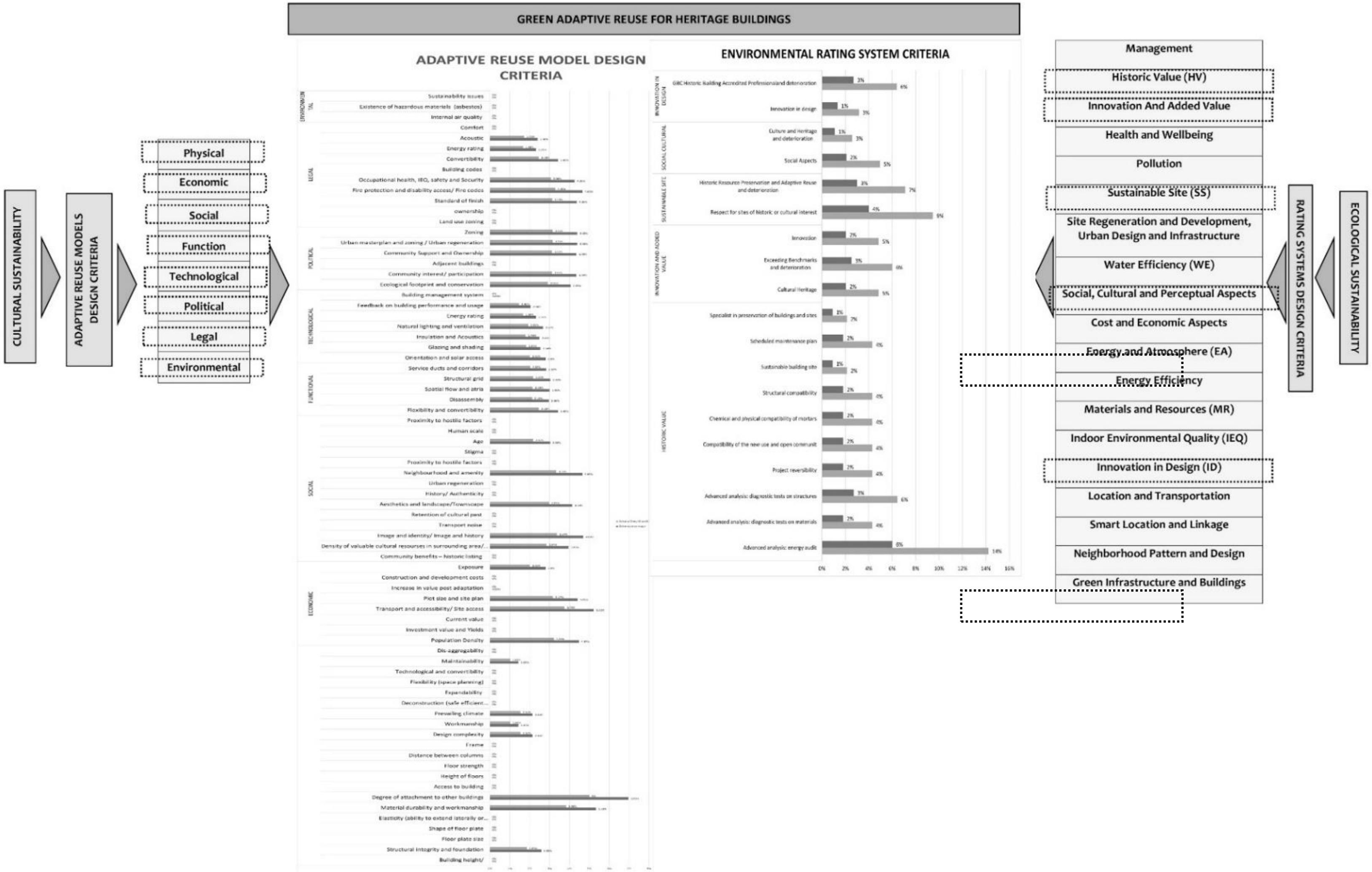



Figure 66: The framework to achieve a green adaptive reuse of heritage buildings

## 5.5 Introducing a case study for application of PCS

As a case study for testing the application of PCS, ‘Boğaziçi Üniversitesi Tarsus-Gözlükule Kazıları Araştırma Merkezi (Boğaziçi University Tarsus-Gözlükule Excavations Research Center), in Turkey, which has received LEED Gold certificate, has been selected. In 2019, the Gözüle Excavations Research Center conservation and reuse project from Boğaziçi University- Tarsus- Mersin has been awarded the 'Conservation Branch' to get GOLD LEED certificate among all ‘European Cultural Heritage Awards / Europa Nostra Award’s winners. Also it has been stated as the first industrial heritage cultural property to receive a Gold LEED certificate (URL 5).

In February 2017, an abandoned 100 year old gin factory (Çırçır Fabrikası) has been restored by Boğaziçi University and turned into a contemporary center for researches on archaeological studies and public participation. In local language ‘çırçır’ means the separation process of cotton from its seeds), The historic Tarsus Gin Factory, which is stated to have been constructed by the British in the second half of the 19th century, was given to Boğaziçi University to be reused as a research center for the excavations directed by Prof. Dr. Aslı Özyar, a member of the History Department of Boğaziçi University, (Figure 67) (URL 5).

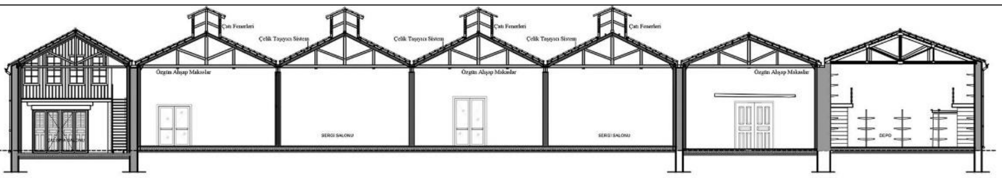

Figure 67: Renovation Process Poster prepared by Boğaziçi University Tarsus-Gözlükule Excavations Research Center to illustrate the renovation processes.

The existing stone walls, roof, and floors were renewed using the restitution data, where the original window and door openings have been preserved. The restoration project was designed according to the new use; where it includes two levels of excavation house, a cafeteria, four hangar warehouses, a library, a water tank, a security room, work offices, a gin process demonstration hall, a laboratory, and a center courtyard, (Figure 68) (URL 5).

Courtyard view

Extension view

Interior views




Poject Section

Courtyard view

Figure 68: Photos from the center (URL 5, URL 6 and URL 7)

### 5.5.1 The comparison of the case study and the thesis study achievement (PCS):

Based on the LEED assessment on the case study which has been awarded with GOLD LEED certificate in the 'Conservation Branch', the Prerequisite Criteria Schema (PCS) is assessed.

#### 5.5.1.1 Historic value (ERS-HV)

As far as the adaptation of the case study project within the existing buildings, the PCS has identified the "Green infrastructure and buildings" value Criterion and Sub-Criteria: Existing building reuse/ Historic Resource Preservation and Adaptive Reuse' with (3.4%) in (Table 23, figure 57).

#### 5.5.1.2 Innovation in design (ERS- ID)

The case study has been awarded the 'Conservation Branch' to get GOLD LEED certificate 1.33% has been allocated to the criteria of "Innovation in design (ID)" with the sub-criteria of LEED accreditated proffessionals (Table 28, figure 62).

It is aimed to support different studies that are outside the scope of LEED credits but may be green building applications. This issue has been mentioned in PCS features as Innovation in Design: innovation in design with 2.7% and innovation (environmental benefit) with 2.04% (Table 28, Figure 62), URL5.

#### 5.5.1.3 Sustainable sites (ERS-SS)

From the main building's entrance to the bus stops, the project is designed to be no more than 400 meters long(URL 6). As for the PCS , the criteria and sub-criteria "Physical": Access to building / Site access with (6.62%), (Table 14, Figure 48). and "Economic" Transport and accessability" with (4.27%) (Table 13, figure 42) have been evaluated (Table 15, Figure 49).

The project, which includes institutional, commercial, and residential areas, does not contain any new parking areas since they have done adaptation for old car park space.

According to the PCS which has been created by this study, there has been no criteria and sub-criteria for this announced system with direct relation to the adaptive reuse of HB (URL 6).

#### 5.5.1.4 Site Selection & transportation

To prevent environmental pollution resulting from the selection of the project site and to reduce the amount of carbon released for transportation to the project location. In the PCS, Green infrastructure: minimized site disturbance in design and construction with 3.4% (Table 29, figure 63) and Historic value: sustainable building site with 0.9% (Table 23, figure 57) have been calculated.

Sustainable Lands: Preventing pollution from construction, evaluating the existing site area before design, protecting or renewing the habitat, creating open spaces, preventing rainwater from accumulating on the surface and regaining it to the ecosystem, reducing the heat island effect and reducing light pollution (URL 5). As for PCS, Sustainable site: site developement: protect or restore habit with 4% (Table 24, Figure 59), Historic value: schadule the maintanance plan with 1.81% (Table 23, Figure 57) and Physical: maintability with 1.43% (Table 14, Figure 49).

#### 5.5.1.5 Materials and resources (ARM-physical)

Construction waste was collected separately and transferred to recycling facilities for re-evaluation. The local material selection is 22% and 32% of the materials are from recycled material, URL 6.

According to the PCS criteria evaluations (figure 65), there are criteria and sub-criteria with the focus on adaptive reuse of HB in both ARM and ERS. As for cultural sustainability (ARM), "physical criteria: Material durability and Workmanship with (5.33%) and Dis-agreeability with (2.14%)" have been considered in (Table 14 and

Figure 48). Furthermore, based on ecological sustainability (ERS), (Table 23 and Figure 57) have been expressed the criteria and sub-criteria as “Historic value: Advanced analysis: diagnostic tests on materials” with (1.81%).

#### 5.5.1.6 Energy & atmosphere (ERS-EA)

It covers topics such as basic testing and commissioning-verification, advanced testing and commissioning, minimum energy performance, optimizing energy performance, renewable energy, building energy measurement, advanced energy measurement, carbon reduction (URL 5). The PCS describes this issue in Historic value, advanced analysis: energy audit-enegy with 6% (Table 23 and Figure 57) , Energy and atmosphere: total life cycle non-renewal energy with 4.91% (Table 27, Figure 61) and Legal:Energy rating with 2.31% (Table 20, Figure 54).

#### 5.5.1.7 Natural lighting and ventilation (ARM-Technological)

Lighting in communal work areas is intended to be regulated by building occupants. Smoking zones have been built at least 8 meters away from building openings (URL 5), In PCS, “Technological” criteria with sub-criteria of Natural lighting and ventilation (2.67%) has been explained in (Table 18 and figure 52).

#### 5.5.1.8 Indoor environmental quality (ARM-environmental)

To reduce the carcinogens that can be found indoors, to provide indoor air quality, to provide daylight and scenery to the building users, to provide indoor air quality, thermal, lighting, visual and acoustic comfort (URL 5), which has been evaluated in PCS A Environmental: internal environmental quality with 1.69% (Table 21, Figure 55).

Indoor air quality criteria has been discussed in this study within two different part in cultural sustainability (ARM) as it shows in (Figure 56). “. Moreover, “Environmental” Criteria and Sub-Criteria: Internal air quality with (1.69%) has been presented in table (21 and figure 55).

#### 5.5.1.9 Regional priority

At the time of project registration, credits that can be scored according to the location of the project are determined from approximately 20 credit titles determined by the USGBC (URL 5). The PCS has been explained this feature in Economic “Transport and accessibility” with 4.33% (Table 15, Figure 49).

### 5.5.2 Case study application evaluation vs PCS

| Mutual criteria | Case study evaluation | PCS evaluation |
|---|---|---|
| **Building access** | Access to the main building's entrance | ARM: "Physical": Access to building / Site access with (6.62%) has been evaluated.<br><br>ARM: "Economic" Transport and accessability" with (4.27%) |
| **Site Selection and Transportation:** | To prevent environmental pollution resulting from the selection of the project site and to reduce the amount of carbon released for transportation to the project location | In the PCS, Green infrastructure: minimized site disturbance in design and construction with 3.4%<br><br>Historic value: sustainable building site with 0.9% |
| **Materials and Resources** | The local material selection is 22% and 32% of the materials are from recycled material | ARM: "Physical criteria: Material durability and Workmanship with (5.33%) and Dis-agreeability with (2.14%)"<br><br>ERS: "Historic value: Advanced analysis: diagnostic tests on materials" with (1.81%). |
| **Regional Priority** | At the time of project registration, credits that can be scored according to the location of the project are determined from approximately 20 credit titles determined by the USGBC | ARM: Economic: Transport and accessibility with 4.33% |
| **Lighting** | Lighting in communal work areas is intended to be regulated by building occupants. Smoking zones have been built at least 8 meters away from building openings | ARM: "Technological" criteria with sub-criteria of Natural lighting and ventilation (2.67%) |

| Mutual criteria | Case study evaluation | PCS evaluation |
|---|---|---|
| **Energy & Atmosphere** | It covers topics such as basic testing and commissioning-verification, advanced testing and commissioning, minimum energy performance, optimizing energy performance, renewable energy, building energy measurement, advanced energy measurement, carbon reduction. | ERS: Historic value, advanced analyisi: energy audit-enegy with 6%<br>ERS: Energy and atmosphere: total life cycle non-renewal energy with 4.91%<br>ARM: Legal:Energy rating with 2.31% |
| **Sustainable Lands** | Preventing pollution from construction, evaluating the existing site area before design, protecting or renewing the habitat, creating open spaces, preventing rainwater from accumulating on the surface and regaining it to the ecosystem, reducing the heat island effect and reducing light pollution. | ERS: Sustainable site: site developement: protect or restore habit with 4%<br>ERS: Historic value: schadule the maintanance plan with 1.81%<br>ARM: Physical: maintability with 1.43% |
| **Indoor Air Quality** | Lighting in communal work areas is intended to be regulated by building occupants. Smoking zones have been built at least 8 meters away from building openings | "Technological": Natural lighting and ventilation (2.67%) has been explained in Environmental" Criteria and Sub-Criteria: Internal air quality with (1.69%) |
| **Innovation in Design (ID)** | The case study has been awarded the 'Conservation Branch' to get GOLD LEED certificate | 1.33% has been allocated to the criteria of "Innovation in design (ID)" with the sub-criteria of LEED accreditated proffessionals<br>Innovation in Design: innovation in design with 2.7% and innovation (environmental benefit) with 2.04% |

| Mutual criteria | Case study evaluation | PCS evaluation |
|---|---|---|
| **Site Selection & Transportation** | To prevent environmental pollution resulting from the selection of the project site and to reduce the amount of carbon released for transportation to the project location. | minimized site disturbance in design and construction with 3.4% - Historic value: sustainable building site with 0.9%.<br><br>site developement: protect or restore habit with 4% -Historic value: schadule the maintanance plan with 1.81% and Physical: maintability with 1.43% |
| **Green infrastructure and buildings** | The case study adaptation has been done on the existing site building. | Existing building reuse/ Historic Resource Preservation and Adaptive Reuse' with (3.4%) in |
| **Total** | | 72.1% = 79.31 LEED point |

By collecting the required data from the case study and using the PCS as the particular achievement of this study, the evaluation has been done through filling the formed sheet in order to express the validation of the proposed guidline. Therefore, the total calculated percentage from PCS for the selected case study is 72.1% which has been equalized to LEED evaluation system with 79.31 point that has been already awarded to the Tarsus Archeology center for the GOLD LEED certification system, (Figure 69).

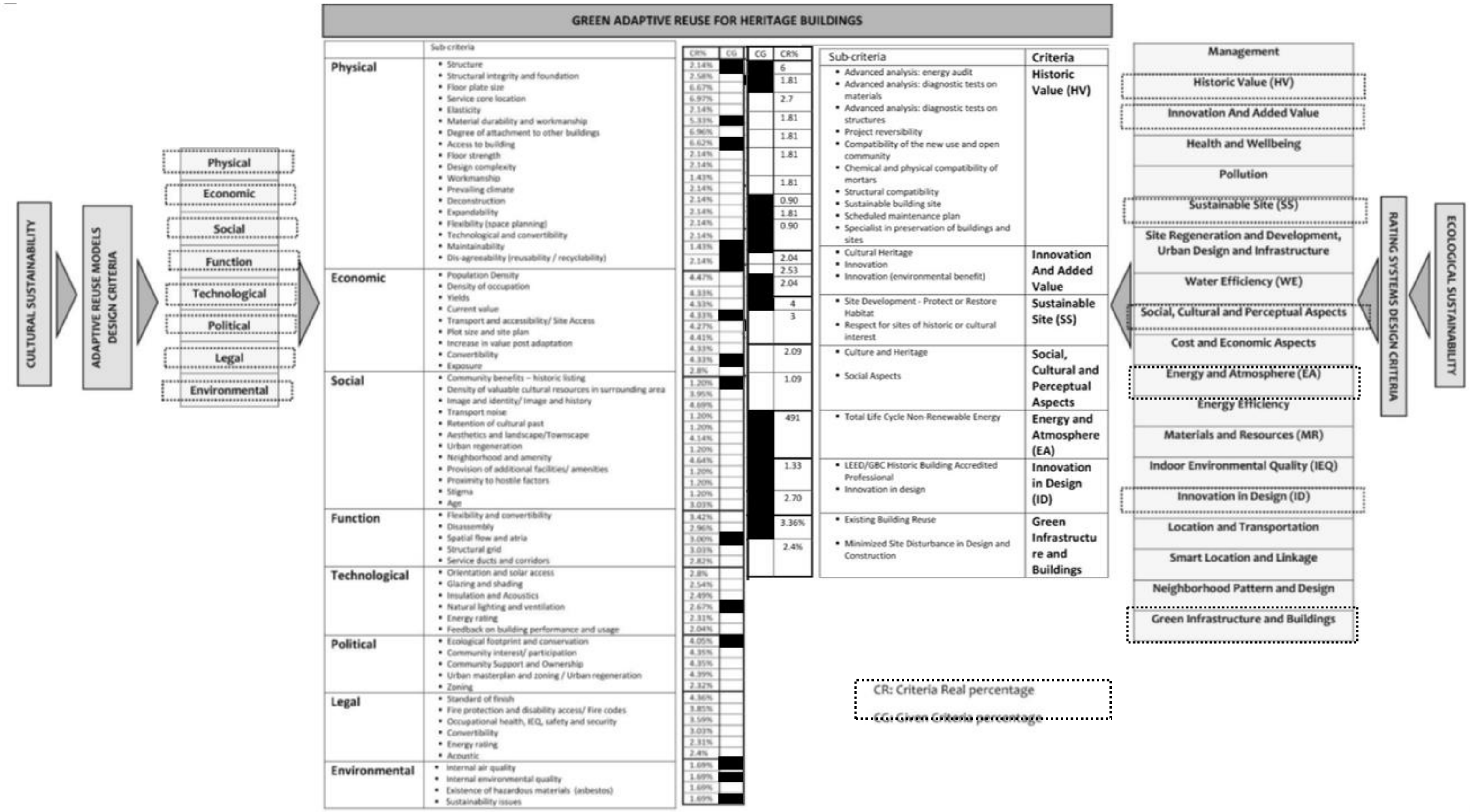



Figure 69: The evaluation sheet which has been done according to the proposed PCS application on the existing case study

## 5.6 Chapter conclusion

In the fifth chapter, the quantitative part of the research methodology known as ‘descriptive analysis’ has been gradually explained in detail. In this manner, the weight extraction of each ARM and ERS criteria and sub-criteria in order to explore the related features with HB based on cultural and ecological have been clarified. The weighting systems have been presented by the drawn tables and figures contains the average percentages of each features that are given by the main data collection sources from previous chapters.

To sum up, as the main target of the study, a particular framework has been proposed based on the weight extraction of both ARM and ERS related to HB to. Hence, the prepared framework named “Proposed Prerequisite Criteria Schema (PCS)” serves the initial step within the procedure of achieving green adaptive reuse of HB. PCS will be applicable for users, experts and conservators in adaptation site worldwide by filling this score sheet whether there are sufficient number of criteria fulfilled in an adaptive reuse project to get the certification, or the development and revision will be required. In this manner, a case study from Mersin-Turkey which was an awarded renovation project has been selected and it has been evaluated by using the proposed PCS sheet in order to achieve the validation of the guideline proposed in this study. The chapter 5 summary has been illustrated in (Figure 70) in order to follow the procedure of the the main target and thesis achievement .

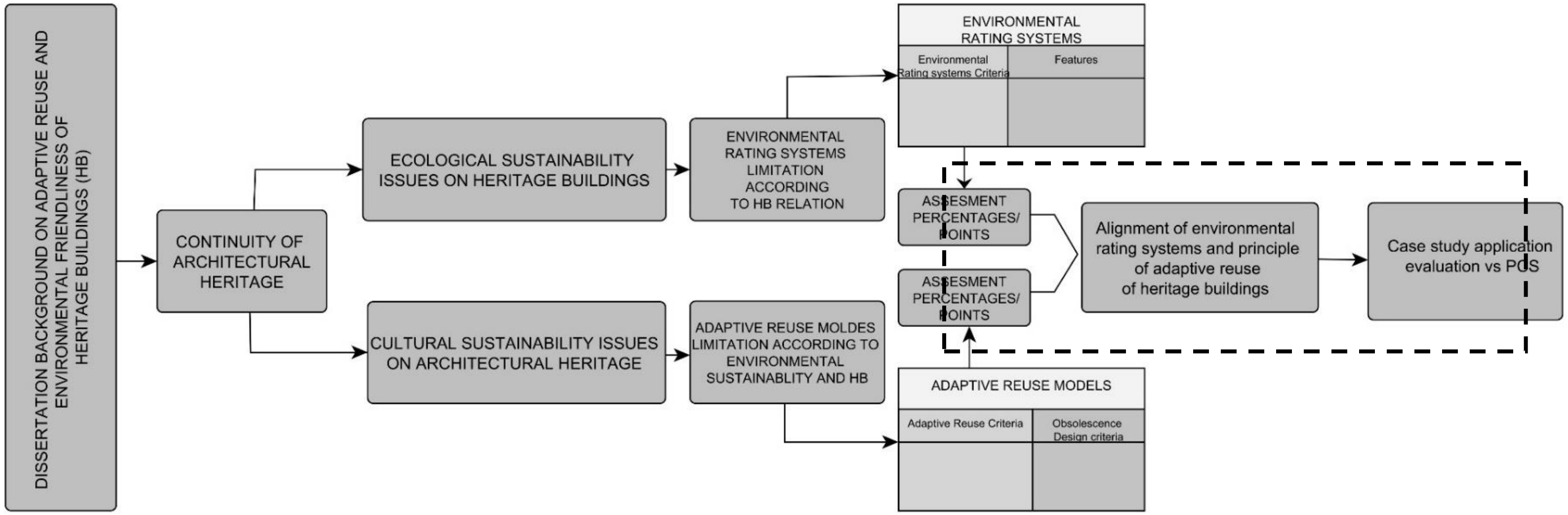



Figure 70: The evaluation process of this study

# Chapter 6

# CONCLUSION AND RECOMMENDATIONS

Heritage buildings as the sign of historical identity are required to be protected and be well managed from hazardous conditions based on the cultural, social, economic and environmental sustainability pillars. Therefore, this process has been investigated since 1964 (ICOMOS) through conservation of heritage buildings. Conservation of heritage buildings helps transmission of the cultural heritage values and sustainable planning to the future generations. The first chapter of the thesis has been clarified the aim and objective of the research which is the integration of both cultural and environmental sustainability on heritage buildings in order to provide a platform to create a unique alignment schema for certified adaptation of heritage buildings for improving cultural and ecological sustainability of HB.

This study has been discussed on the history and background of the conservation and adaptive reuse of heritage buildings in the second chapter which explained the classifications and types of heritage conservation. Furthermore, the proposed framework can be applied for various regions since it contains worldwide data collection in background studies and several case studies have been explained with mutual criteria assessment of both cultural and environmental sustainability approaches, Regarding the third chapter of this study, Adaptive reuse of heritage buildings as a cultural sustainability tool for contemporary conservation, is also favoured for having the capability to replace demolition, since it produces less waste and requires less energy. Concentration on the improvement of new information with respect to future building adaptive reuse, sustainability issues, and future plan headings, will proceed, most likely at an expanding rate for the following years, pushed by an expanding environmental consciousness. As for cultural sustainability tool which is adaptive reuse model (ARM) addresses the innovative evaluation method for heritage buildings. Accordingly, in this chapter, the performances and the role of ARM on the heritage building (HB) has been discussed in order to express the environmentally side of adaptive reuse strategy and the improvement of the adaptation quality.

Parallel to this, in chapter 4, the ecological sustainability issues on heritage building has been defined. In this regard, environmental rating systems (ERS) are proposed for improving a historical building's environmental sustainability level, without compromising its cultural heritage values. Based on numerous ARM and ERS worldwide, the limitation of this study addressed the ones that focus particularly on HB. Moreover, in terms of applying both cultural (ARM) and ecological sustainability (ERS) issues to heritage buildings, an examination of criteria and sub-criteria for adaptive reuse of heritage buildings takes place according to both obsolescence design criteria and environmental design criteria in chapter 5. Hence, an adaptation project which has achieved LEED certification in Turkey has been selected as the case study in order to test the consistency of proposed PCS with the existing evaluation by The Boğaziçi University Tarsus-Gözlükule Excavations Research Center.

As the focus, ARM and ERS consider the features of cultural and ecological sustainability roles on heritage buildings, the evaluation models for adaptations (ARM) and rating systems for environmentally sensitive approaches (ERS) are capable ways to lead conservators toward green adaptations and standardized assessment processes based on Farjami and Türker (2021) study. Therefore, in this dissertation, the Proposed Prerequisite Criteria Schema (PCS) has been prepared the particular platform for the experts and conservators in order to achieve certified adaptation of HB. Based on PCS, the various level of certification will allocated to the number of features that experts and conservator will be selected.

Recommendations:

- In the assessment procedure, there are few sub-criteria which were not evaluated by any score, weight or numerical value, but just explanations and interpretations, in this case, the specific footnote has been added to the analysis sheet named as ‘ *NC: No Credit’. Hence, a gap has appeared which can be improved by the researchers and solve this lack of weight to achieve more precise and helpful framework for adaptive reuse projects on heritage buildings. Besides, it can be solved due to filling this score sheet by experts and after the evaluation system designed by this dissertation, the sub-criteria weight can be calculated.
- This dissertation attempts to create a holistic framework which contains ARM and ERS criteria and sub-criteria serving to both cultural and ecological sustainability which can be applied on local or worldwide heritage buildings.
- Another study can be done to focus on different stages of interventions such as applying an annex and extensions which are new additions to the historic building

- Regarding the alignment of mutual features between ARM and ERS, the proposed prerequisite criteria schema (PCS) has the ability to be updated based on future studies following new models and systems.

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# APPENDICE

# Appendix A: Adaptive reuse potential (ARP) model

The determination of ARP and Adaptstar scores is based on assembled documentation for each project, (Idenmen, et al. 2007); (Langston, et al., 2008); (UNHRC, 2010); (Conejos, et al. 2011); (Langston, et al., 2013); (Conejos. 2013).

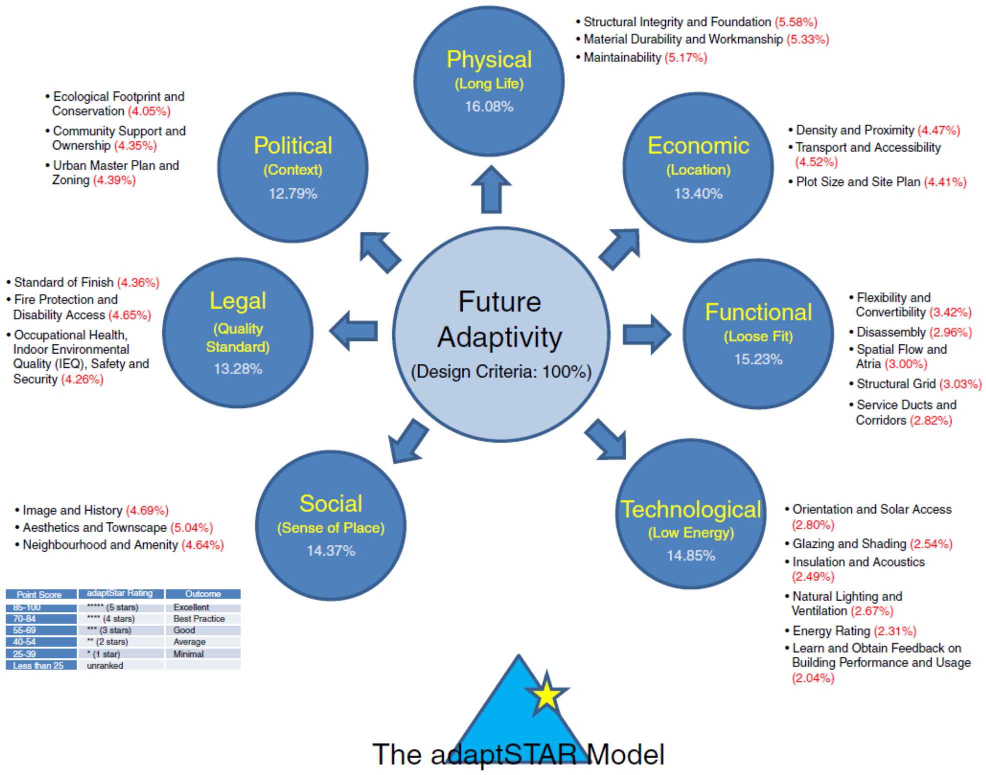
| Category | Criterion | Experts ($n$ = 15) |
|---|---|---|
| Long life (Physical) | Structural integrity – structural design and ability of the building to cater for future uses and loads | 8 |
| | Material durability – durability of the building asset | 8 |
| | Workmanship – quality of the craftsmanship of structure and finishes | 7 |
| | Maintainability – building's capability to conserve operational resources | 7 |
| | Design complexity – various geometries associated with the building's design and innovation | 5 |
| | Prevailing climate – changing climatic conditions | 4 |
| | Foundation – differential settlement and substrata movement | 2 |
| Location (Economic) | Transport infrastructure – availability and access | 4 |
| | Market proximity – distance from major city, the CBD, etc. | 3 |
| | Transport infrastructure – availability and access | 3 |
| | Site access – proximity or link to access roads, parking and communal facilities, etc. | 2 |
| | Exposure – views, privacy | 2 |
| | Planning constraints – site selection, planning, neighbourhood and building design, etc. | 2 |
| | Plot size – built area, spatial proportions, enclosure, etc. | 2 |
| Loose fit (Functional) | Flexibility – space capability to change according to newly required needs, plug and play elements, etc. | 12 |
| | Disassembly – options for reuse, recycle, demountable systems, deconstruction, modularity, etc. | 11 |
| | Spatial flow – mobility, open plan, fluid and continuous | 5 |
| | Convertibility – divisibility, elasticity, multi-functionality | 5 |
| | Atria – open areas, interior gardens, etc. | 5 |
| | Structural grid – ideal and economical limit of span and fully interchangeable | 5 |
| | Service ducts and corridors – vertical circulation, service elements, raised floors, etc. | 4 |
| Low energy (Technological) | Orientation – micro-climate siting, prevailing winds, sunlight | 15 |
| | Glazing – sunlight glare control, regulation of internal temperatures, etc. | 15 |
| | Insulation and shading – thermal mass, sunshades, automated blinds, etc. | 15 |
| | Natural lighting – inclusion for natural daylight, efficient lighting systems, etc. | 15 |
| | Natural ventilation – optimise airflow, quality fresh air, increase ambient air intake, etc. | 15 |
| | Building management systems – monitor and control building operations and performance systems | 15 |
| | Solar access – measures for summer and winter sun | 3 |
| Sense of place (Social) | Image/identity – social and cultural attributes, values, etc. | 4 |
| | Aesthetics – architectural beauty, good appearance, proportion, etc. | 4 |
| | Landscape/townscape – visual coherence and organisation of the built environment | 4 |

| | | |
|---|---|---|
| | History/authenticity – original fabric, timelessness, socio-cultural traditions, practices, historic character or fabric, etc. | 3 |
| | Amenity – provides comfort and convenience, facilities | 2 |
| | Human scale – anthropometrics and fit to average human scale | 2 |
| | Neighbourhood – local and social communities | 2 |
| Quality standard (Legal) | Standard of finish – provision for high-standard workmanship | 11 |
| | Fire protection – provisions for fire safety | 9 |
| | Indoor environmental quality – provisions for non-hazardous materials, natural fabrics, etc. | 8 |
| | Occupational health and safety – special needs of occupants, health and safety risks, building hazard and risk management plan | 6 |
| | Security – provision of direct and passive surveillance designs | 6 |
| | Comfort – hygiene and clean environment, et cetera | 3 |
| | Disability access – provision for disability easement, facilities, etc. | 3 |
| | Energy rating – environmental performance measures | 2 |
| | Acoustics – noise control, sound insulation, etc. | 2 |
| Context (Political) | Adjacent buildings – adjacent enclosures, vertical and visual obstacles | 15 |
| | Ecological footprint – appropriate measure of human carrying capacity | 12 |
| | Conservation – principles, guidelines, charters governing tangible and intangible heritage protection | 8 |
| | Community interest/participation – stakeholder relationship and support | 8 |
| | Urban master plan – integrated skyline, urban landscape, built environment design and management/practice | 7 |
| | Zoning – land uses and land patterns | 4 |
| | Ownership – collaborative commitment, sense of community or ownership, etc. | 1 |

| adaptSTAR criteria | Raw weight (%) | Total weight (%) |
|---|---|---|
| *Physical= 16.08* | | |
| Structural integrity and foundation | 34.70 | 5.58 |
| Material durability and workmanship | 33.12 | 5.33 |
| Maintainability | 32.18 | 5.17 |
| *Economic= 13.40* | | |
| Density and proximity | 33.33 | 4.47 |
| Transport and accessibility | 33.76 | 4.52 |
| Plot size and site plan | 32.91 | 4.41 |
| *Functional = 15.23* | | |
| Flexibility and convertibility | 22.45 | 3.42 |
| Disassembly | 19.44 | 2.96 |
| Spatial flow and atria | 19.68 | 3.00 |
| Structural grid | 19.91 | 3.03 |
| Service ducts and corridors | 18.52 | 2.82 |
| *Technological = 14.85* | | |
| Orientation and solar access | 18.87 | 2.80 |
| Glazing and shading | 17.11 | 2.54 |
| Insulation and acoustics | 16.75 | 2.49 |
| Natural lighting and ventilation | 17.99 | 2.67 |
| Energy rating | 15.52 | 2.31 |
| Feedback on building performance and usage | 13.76 | 2.04 |
| *Social = 14.37* | | |
| Image and history | 32.65 | 4.69 |
| Aesthetics and townscape | 35.03 | 5.04 |
| Neighbourhood and amenity | 32.31 | 4.64 |
| *Legal = 13.28* | | |
| Standard of finish | 32.85 | 4.36 |
| Fire protection and disability access | 35.04 | 4.65 |
| Occupational health, IEQ, safety and security | 32.12 | 4.27 |
| *Political = 12.79* | | |
| Ecological footprint and conservation | 31.66 | 4.05 |
| Community support and ownership | 33.98 | 4.35 |
| Urban masterplan and zoning | 34.36 | 4.39 |

## Appendix B: Adapt-star ,model

The adaptSTAR model is a rating tool that specifies a scoresheet with design criteria that contribute to the advancement of existing and newly constructed buildings that have the potential to be adaptively reused and recycled in the future, (Langston, et al., 2008; Conejos, et al. 2011; Langston, et al., 2013; Conejos. 2013; Conejos, et al., 2014).




AdaptSTAR model star ratings

| adaptSTAR score | Star rating |
|---|---|
| 85-100 | ***** (5 stars) |
| 70-84 | **** (4 stars) |
| 55-69 | *** (3 stars) |
| 40-54 | ** (2 stars) |
| 25-39 | * (1 star) |
| Less than 25 | unranked |

Sample computation of adaptation reuse project using the adaptSTAR scoresheet

NOTE: 1=STRONGLY DISAGREE, 2=DISAGREE, 3=NEUTRAL, 4=AGREE, 5=STRONGLY AGREE

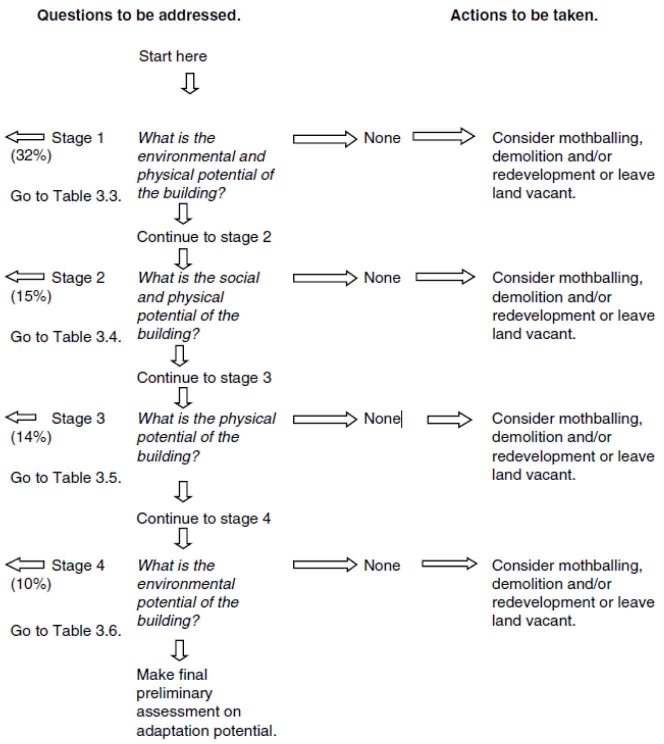
| How do you judge the following statements for the above building/facility? | 1 | 2 | 3 | 4 | 5 | What is the key reason that influenced your opinion? | valid respo |
|---|---|---|---|---|---|---|---|
| The building's foundations and frame have capacity for additional structural loads and potential vertical expansion. | | | | x | | commencing in 1860 the building was designed as a major civic building without a view for expansion, but since it is built in reinforced concrete and steel then it has potential for expansion | ✓ |
| The building fabric is well constructed using durable materials, providing potential retention of existing exterior and interior finishes. | | | | | x | as above, it was designed to last the distance | ✓ |
| The building currently has a low maintenance profile with modest expected levels of component repair and replacement over its remaining lifespan. | | | | x | | at 140+ years old, even quality materials require attention. Some of the stone has poor lasting qualities and ageing exacerbated by 20th century but still only minor repairs and replacements | ✓ |
| The building is situated in a bustling metropolis comprising mixed use development and proximity to potential markets. | | | | | x | located in prime commercial retail centre of Melbourn | ✓ |
| The building is located near transport facilities and provides convenience for vehicular and pedestrian mobility. | | | | | x | served by Melbourne tram network on both of its street frontages | ✓ |
| The building enjoys a site with favourable plot size, access, topography, area, aspect and surrounding views. | | | | x | | minor additional free area only, a tightly controlled high profile heritage site with urbanscape views | ✓ |
| The building's interior layout exhibits strong versatility for future alternative arrangements without significant disruption or conversion cost. | | | | | x | rigid layout for an original purpose not easily adapted to new contemporary use, however the appropriate conversion to retail shops made it versatile and flexible. | ✓ |
| The building has significant components or systems that support disassembly and subsequent relocation or reuse. | | | | x | | as above first point, never intended to change and built accordingly, but the potential to turn it back into offices is high giving support to the concept of reversibility. | ✓ |
| The building has sufficient internal open space and/or atria that provide opportunity for spatial and structural transformations to be introduced. | | | | x | | highly controlled heritage environment with open spaces and clerestories | ✓ |
| The building has large floor plates and floor-to-floor heights with minimal interruptions from the supporting structure. | | | | x | | high ceilings yes, floor plates small in comparison to contemporary spaces but can accommodate open concept in some area | ✓ |
| The building provides easy access to concealed ducts, service corridors and plant room space to ensure effective horizontal and vertical circulation of services. | | | | x | | building originally had minimum services | ✓ |
| The building is designed in such a way that it maximizes its orientation with good potential for passive solar strategies. | | | x | | | orientation not considered when this building designed, its formal civic presence was the prevailing driver of its design | ✓ |
| The building has appropriate fenestration and sun shading devices consistent with good thermal performance. | | | x | | | see above item | ✓ |
| The building has an insulated external envelope capable of ensuring good thermal and acoustic performance for interior spaces. | | | | x | | no wall insulation, 19th century solid brick and stone construction provides good thermal mass. | ✓ |
| The building is designed in ways that maximize daylight use and natural ventilation without significant mechanical intervention. | | | | x | | the original internal work space was a top lit atrium,that changed a few years after its establishment. Large windows onto main streets work | ✓ |
| The building has low energy demand and is operating at or readily capable of achieving a 5-star Green Star® energy rating or equivalent. | | | | x | | very high energy demand to control internal environment for comfort although in those times comfort level of users were sufficiently provided | ✓ |
| The building supports efficient operational and maintenance practices including effective building management and control systems. | | | x | | | high volumes, interconnected spaces hard to get at areas work against efficiency of control and make maintenance difficult both internally and externally | ✓ |
| The building has developed strong intrinsic heritage values, cultural connections or positive public image over its life. | | | | | x | One of Melbourne's most famous architectural heritage buildings with an important social history attached to it | ✓ |
| The building has high architectural merit including pleasing aesthetics and compatability with its surrounding streetscape. | | | | | x | see above item | ✓ |
| The building provides relevant amenities and facilities within its neighbourhood that can add value to the local community. | | | | | x | it provided a postal service to the city and a civic reference point. | ✓ |
| The building displays a high standard of construction and finish consistent with current market expectations. | | | | x | | It displays high quality construction and finish consistent with fine heritage structures, not general current expectations | ✓ |
| The building complies with current standards for fire prevention and safety, emergency egress and disability provisions. | | x | | | | building requires high level of services to achieve compliance | ✓ |
| The building offers an enhanced workplace environment that provides appropriate user comfort, indoor air quality and environmental health and safety. | | | x | | | most workers and occupiers regard it as tired old fashioned and in need of modernisation and upgrade. | ✓ |
| The building's design is compatible with ecological sustainability objectives and helps minimize ongoing habitat disturbance. | | | x | | | building was designed in boom times, post gold rush when the advancement of the great golden city, Marvellous Melbourne was top of mind. | ✓ |
| The building displays a high level of community interest and political support for its future care and preservation. | | | | | x | emotional support for retention of building, heritage controls state and local government reinforce its importance and ensure its retention. | ✓ |
| The building's current or proposed future use conforms to existing masterplan, zoning and related urban planning specifications. | | | | | x | meets all metropolitan and city of Melbourne requirements | ✓ |

# Appendix C: Preliminary assessment of adaptation potential (PAAM)

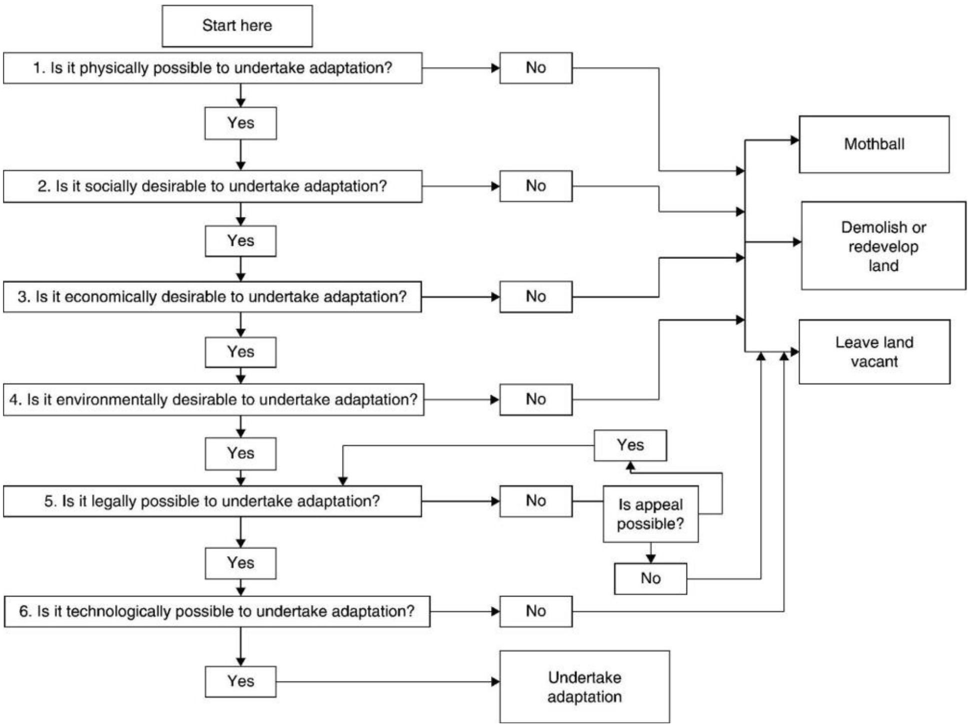
Summary of PCA factors 'alterations and extensions' adaptations which formed the Starting point for the PAAM, (Wilkinson, 2011); (Langstone et al., 2013); (Wilkinson, 2014).

| Factor number | Factor name (% of variance explained) | Factor attributes (% of variance explained within factor) |
|---|---|---|
| 1 | Physical and size (44.86%) | *Number of storeys* (19.19%)<br>*Gross floor area* (19.19%)<br>*Property Council of Australia building quality grade* (16.46%)<br>*Degree of attachment to other buildings* (15.52%)<br>*Typical floor area* (14.88%)<br>*Site access* (14.76%) |
| 2 | Land (19.78%) | *Street frontage* (36.28%)<br>*Vertical services location* (35.26%)<br>*Property location* (28.46%) |
| 3 | Social (9.32%) | *Historic listing* (42.42%)<br>*Age in 2010* (32.58%)<br>*Aesthetics* (25.00%) |

Alterations and extensions' adaptations PAAM



Decision-making PAAM for existing buildings.




Alterations and extensions' adaptations predictive model formed the starting point for the PAAM

| Factor No | Factor name (% of variance explained) | Factor attributes | (% of variance explained within factor) | |
|---|---|---|---|---|
| 1 | Physical and size (44.86%) | Number of storeys | (19.19%) | 7–20 storeys (43.71%)<br>21–45 storeys (30.92%)<br>>46 storeys (15.98%)<br><6 storeys (9.39%) |
| | | Gross floor area | (19.19%) | <50,000m2 (57.73%)<br>50,001–100,000m2 (27.93%)<br>> 100,001m2 (14.35%) |
| | | Local building quality grade | (16.46%) | Grade B (27.42%).<br>Ungraded (22.05%).<br>Grade A (21.49%).<br>Premium (14.09%).<br>Grade C (11.05%)<br>Grade D (3.90%). |
| | | Degree of attachment to other buildings | (15.52%) | Detached (52.39%)<br>Attached on two sides (23.90%)<br>Attached on one side(15.05%)<br>Attached on three sides (8.26%) |
| | | Typical floor area | (14.88%) | 701–1178m2 (27.11%)<br>1179–1346m2 (26.26%)<br><700m2 (23.74%)<br>>1347m2 (22.89%) |
| | | Site access | (14.76%) | Street, side and rear (40.96%).<br>Street and side (27.00%)<br>Street only (15.65%)<br>Street and rear access (12.62%)<br>Access all sides (3.76%) |

| | | | | |
|---|---|---|---|---|
| 2 | Land (19.78%) | Street frontage | (36.28%) | Medium (37.79%)<br>Extra wide (28.07%)<br>Wide (22.83%)<br>Narrow (11.32%). |
| | | Vertical services location | (35.26%) | Central (54.06%)<br>Multiple (35.02%)<br>Elsewhere (10.92%) |
| | | Property location | (28.46%) | Low prime (27.03%)<br>High secondary (25.75%)<br>Prime (25.27%)<br>Low secondary (13.41%)<br>Fringe (8.53%) |
| 3 | Social (9.32%) | Historic listing | (42.42%) | Buildings without historic listing or overlay (75.89%)<br>Buildings with heritage listing or overlay (24.11%) |
| | | Age in 2020 | (32.58%) | 19–42 years (72.89%).<br>>42 years (21.47%).<br><18 years (5.64%). |
| | | Aesthetics | (25.00%) | Quite attractive (35.78%)<br>Very attractive buildings (29.47%)<br>Neither attractive nor ugly (19.85%)<br>Not very attractive (12.71%)<br>Very unattractive (2.20%) |

## Appendix D: LEED ND-V4 (lEED for neighbourhood development and historic preservation)

As NAGUIB (2016) state, Leadership in Energy and Environmental Design which was founded in 1993, in America, has specific section related to historic building conservation known as LEED-ND (2009 v3). (Awadh, et al 2017); (Constr, 2011); (Asdrubali, et al 2015).

**LEED v4 for BD+C: Core and Shell**
Project Checklist

Project Name:
Date:

| Y | ? | N | | | |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |
| 0 | 0 | 0 | | **Location and Transportation** | **20** |
| | | | Credit | LEED for Neighborhood Development Location | 20 |
| | | | Credit | Sensitive Land Protection | 2 |
| | | | Credit | High Priority Site | 3 |
| | | | Credit | Surrounding Density and Diverse Uses | 6 |
| | | | Credit | Access to Quality Transit | 6 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| 0 | 0 | 0 | | **Sustainable Sites** | **11** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| | | | Credit | Tenant Design and Construction Guidelines | 1 |
| 0 | 0 | 0 | | **Water Efficiency** | **11** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 6 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| 0 | 0 | 0 | | **Energy and Atmosphere** | **33** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 18 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| 0 | 0 | 0 | | **Materials and Resources** | **14** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 6 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| 0 | 0 | 0 | | **Indoor Environmental Quality** | **10** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| 0 | 0 | 0 | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| 0 | 0 | 0 | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| 0 | 0 | 0 | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Retail

Project Checklist

Project Name:
Date:

| Y | ? | N | | | Points |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |

| Y | ? | N | | Location and Transportation | 16 |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | **Location and Transportation** | **16** |
| | | | Credit | LEED for Neighborhood Development Location | 16 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 5 |
| | | | Credit | Access to Quality Transit | 5 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| 0 | 0 | 0 | | **Sustainable Sites** | **10** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| 0 | 0 | 0 | | **Water Efficiency** | **12** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 7 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| 0 | 0 | 0 | | **Energy and Atmosphere** | **33** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 18 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| 0 | 0 | 0 | | **Materials and Resources** | **13** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| 0 | 0 | 0 | | **Indoor Environmental Quality** | **15** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 2 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| 0 | 0 | 0 | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| 0 | 0 | 0 | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| 0 | 0 | 0 | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Schools

Project Checklist

Project Name:
Date:

| Y | ? | N | | | Points |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |

| Y | ? | N | | Location and Transportation | 15 |
|---|---|---|---|---|---|
| 0 | 0 | 0 | | **Location and Transportation** | **15** |
| | | | Credit | LEED for Neighborhood Development Location | 15 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 5 |
| | | | Credit | Access to Quality Transit | 4 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| 0 | 0 | 0 | | **Sustainable Sites** | **12** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| Y | | | Prereq | Environmental Site Assessment | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| | | | Credit | Site Master Plan | 1 |
| | | | Credit | Joint Use of Facilities | 1 |
| 0 | 0 | 0 | | **Water Efficiency** | **12** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 7 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| 0 | 0 | 0 | | **Energy and Atmosphere** | **31** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 16 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| 0 | 0 | 0 | | **Materials and Resources** | **13** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| 0 | 0 | 0 | | **Indoor Environmental Quality** | **16** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| Y | | | Prereq | Minimum Acoustic Performance | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 2 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| | | | Credit | Acoustic Performance | 1 |
| 0 | 0 | 0 | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| 0 | 0 | 0 | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| 0 | 0 | 0 | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Healthcare

Project Checklist

Project Name:
Date:

| Y | ? | N | | | |
|---|---|---|---|---|---|
| Y | | | Prereq | Integrative Project Planning and Design | Required |
| | | | Credit | Integrative Process | 1 |
| **0** | **0** | **0** | | **Location and Transportation** | **9** |
| | | | Credit | LEED for Neighborhood Development Location | 9 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 1 |
| | | | Credit | Access to Quality Transit | 2 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| **0** | **0** | **0** | | **Sustainable Sites** | **9** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| Y | | | Prereq | Environmental Site Assessment | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 1 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 2 |
| | | | Credit | Heat Island Reduction | 1 |
| | | | Credit | Light Pollution Reduction | 1 |
| | | | Credit | Places of Respite | 1 |
| | | | Credit | Direct Exterior Access | 1 |
| **0** | **0** | **0** | | **Water Efficiency** | **11** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 1 |
| | | | Credit | Indoor Water Use Reduction | 7 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| **0** | **0** | **0** | | **Energy and Atmosphere** | **35** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 20 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| **0** | **0** | **0** | | **Materials and Resources** | **19** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| Y | | | Prereq | PBT Source Reduction - Mercury | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | PBT Source Reduction - Mercury | 1 |
| | | | Credit | PBT Source Reduction - Lead, Cadmium, and Copper | 2 |
| | | | Credit | Furniture and Medical Furnishings | 2 |
| | | | Credit | Design for Flexibility | 1 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| **0** | **0** | **0** | | **Indoor Environmental Quality** | **16** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 1 |
| | | | Credit | Daylight | 2 |
| | | | Credit | Quality Views | 2 |
| | | | Credit | Acoustic Performance | 2 |
| **0** | **0** | **0** | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| **0** | **0** | **0** | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| **0** | **0** | **0** | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Data Centers

Project Checklist

Project Name:
Date:

| Y | ? | N | | | |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |
| **0** | **0** | **0** | | **Location and Transportation** | **16** |
| | | | Credit | LEED for Neighborhood Development Location | 16 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 5 |
| | | | Credit | Access to Quality Transit | 5 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| **0** | **0** | **0** | | **Sustainable Sites** | **10** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| **0** | **0** | **0** | | **Water Efficiency** | **11** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 6 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| **0** | **0** | **0** | | **Energy and Atmosphere** | **33** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 18 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| **0** | **0** | **0** | | **Materials and Resources** | **13** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declaratio | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| **0** | **0** | **0** | | **Indoor Environmental Quality** | **16** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 2 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| | | | Credit | Acoustic Performance | 1 |
| **0** | **0** | **0** | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| **0** | **0** | **0** | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| **0** | **0** | **0** | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Hospitality

Project Checklist

Project Name:
Date:

| Y | ? | N | | | |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |
| 0 | 0 | 0 | | **Location and Transportation** | **16** |
| | | | Credit | LEED for Neighborhood Development Location | 16 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 5 |
| | | | Credit | Access to Quality Transit | 5 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| 0 | 0 | 0 | | **Sustainable Sites** | **10** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| 0 | 0 | 0 | | **Water Efficiency** | **11** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 6 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| 0 | 0 | 0 | | **Energy and Atmosphere** | **33** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 18 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| 0 | 0 | 0 | | **Materials and Resources** | **13** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| 0 | 0 | 0 | | **Indoor Environmental Quality** | **16** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 2 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| | | | Credit | Acoustic Performance | 1 |
| 0 | 0 | 0 | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| 0 | 0 | 0 | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| 0 | 0 | 0 | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## LEED v4 for BD+C: Warehouses and Distribution Centers

Project Checklist

Project Name:
Date:

| Y | ? | N | | | |
|---|---|---|---|---|---|
| | | | Credit | Integrative Process | 1 |
| 0 | 0 | 0 | | **Location and Transportation** | **16** |
| | | | Credit | LEED for Neighborhood Development Location | 16 |
| | | | Credit | Sensitive Land Protection | 1 |
| | | | Credit | High Priority Site | 2 |
| | | | Credit | Surrounding Density and Diverse Uses | 5 |
| | | | Credit | Access to Quality Transit | 5 |
| | | | Credit | Bicycle Facilities | 1 |
| | | | Credit | Reduced Parking Footprint | 1 |
| | | | Credit | Green Vehicles | 1 |
| 0 | 0 | 0 | | **Sustainable Sites** | **10** |
| Y | | | Prereq | Construction Activity Pollution Prevention | Required |
| | | | Credit | Site Assessment | 1 |
| | | | Credit | Site Development - Protect or Restore Habitat | 2 |
| | | | Credit | Open Space | 1 |
| | | | Credit | Rainwater Management | 3 |
| | | | Credit | Heat Island Reduction | 2 |
| | | | Credit | Light Pollution Reduction | 1 |
| 0 | 0 | 0 | | **Water Efficiency** | **11** |
| Y | | | Prereq | Outdoor Water Use Reduction | Required |
| Y | | | Prereq | Indoor Water Use Reduction | Required |
| Y | | | Prereq | Building-Level Water Metering | Required |
| | | | Credit | Outdoor Water Use Reduction | 2 |
| | | | Credit | Indoor Water Use Reduction | 6 |
| | | | Credit | Cooling Tower Water Use | 2 |
| | | | Credit | Water Metering | 1 |
| 0 | 0 | 0 | | **Energy and Atmosphere** | **33** |
| Y | | | Prereq | Fundamental Commissioning and Verification | Required |
| Y | | | Prereq | Minimum Energy Performance | Required |
| Y | | | Prereq | Building-Level Energy Metering | Required |
| Y | | | Prereq | Fundamental Refrigerant Management | Required |
| | | | Credit | Enhanced Commissioning | 6 |
| | | | Credit | Optimize Energy Performance | 18 |
| | | | Credit | Advanced Energy Metering | 1 |
| | | | Credit | Demand Response | 2 |
| | | | Credit | Renewable Energy Production | 3 |
| | | | Credit | Enhanced Refrigerant Management | 1 |
| | | | Credit | Green Power and Carbon Offsets | 2 |
| 0 | 0 | 0 | | **Materials and Resources** | **13** |
| Y | | | Prereq | Storage and Collection of Recyclables | Required |
| Y | | | Prereq | Construction and Demolition Waste Management Planning | Required |
| | | | Credit | Building Life-Cycle Impact Reduction | 5 |
| | | | Credit | Building Product Disclosure and Optimization - Environmental Product Declarations | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Sourcing of Raw Materials | 2 |
| | | | Credit | Building Product Disclosure and Optimization - Material Ingredients | 2 |
| | | | Credit | Construction and Demolition Waste Management | 2 |
| 0 | 0 | 0 | | **Indoor Environmental Quality** | **16** |
| Y | | | Prereq | Minimum Indoor Air Quality Performance | Required |
| Y | | | Prereq | Environmental Tobacco Smoke Control | Required |
| | | | Credit | Enhanced Indoor Air Quality Strategies | 2 |
| | | | Credit | Low-Emitting Materials | 3 |
| | | | Credit | Construction Indoor Air Quality Management Plan | 1 |
| | | | Credit | Indoor Air Quality Assessment | 2 |
| | | | Credit | Thermal Comfort | 1 |
| | | | Credit | Interior Lighting | 2 |
| | | | Credit | Daylight | 3 |
| | | | Credit | Quality Views | 1 |
| | | | Credit | Acoustic Performance | 1 |
| 0 | 0 | 0 | | **Innovation** | **6** |
| | | | Credit | Innovation | 5 |
| | | | Credit | LEED Accredited Professional | 1 |
| 0 | 0 | 0 | | **Regional Priority** | **4** |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| | | | Credit | Regional Priority: Specific Credit | 1 |
| 0 | 0 | 0 | | **TOTALS** Possible Points: | **110** |

**Certified:** 40 to 49 points, **Silver:** 50 to 59 points, **Gold:** 60 to 79 points, **Platinum:** 80 to 110

## Appendix E: BREAM UK (building research establishment environmental assessment methodology)

Scoring and rating BREEAM-assessed buildings (BREEAM, 2018).

There are a number of elements that determine the overall performance of a new construction project assessed using BREEAM. They are:

1. The BREEAM rating level benchmarks
2. The minimum BREEAM standards
3. The environmental section weightings
4. The BREEAM assessment issues and credits

The next sections summarise how these elements combine to produce a BREEAM rating for a new building and are followed by a description and example calculation of a rating. BREEAM rating benchmarks for projects assessed using the 2018 version of BREEAM UK New Construction are:

BREEAM rating benchmarks:

| BREEAM Rating | % score |
| --- | --- |
| Outstanding | ≥ 85 |
| Excellent | ≥ 70 |
| Very good | ≥ 55 |
| Good | ≥ 45 |
| Pass | ≥ 30 |
| Unclassified | <30 |

BREEAM rating benchmarks enable a client and all other stakeholders to compare the performance of a newly constructed building with other BREEAM rated buildings, and the typical sustainability performance of a stock of new non-domestic buildings in the UK.

In this respect each BREEAM rating broadly represents performance equivalent to:

1. Outstanding: Less than the top 1% of UK new non-domestic buildings (innovator)
2. Excellent: Top 10% of UK new non-domestic buildings (best practice)
3. Very Good: Top 25% of UK new non-domestic buildings (advanced good practice)
4. Good: Top 50% of UK new non-domestic buildings (intermediate good practice)
5. Pass: Top 75% of UK new non-domestic buildings (standard good practice)

An unclassified BREEAM rating represents performance that is non-compliant with BREEAM, in terms of failing to meet either the BREEAM minimum standards of performance for key environmental issues or the overall threshold score required to achieve at least a Pass rating.

BREEAM category weightings:

Category weightings are fundamental to any building environmental assessment method providing a means of defining and ranking the relative impact of environmental issues. BREEAM uses an explicit weighting system to determine the overall BREEAM score buildings (BREEAM, 2018).

This weighting system is defined in greater detail within the BRE Global Core Process Standard (BES 5301) and its supporting procedural documents. The process for defining the weightings is set out in a briefing available on the BREEAM website. These form part of the over-arching BREEAM Standard and the Code for a Sustainable Built Environment buildings (BREEAM, 2018).

BREEAM Environmental section weightings

| Environmental section | Weighting | | | |
|---|---|---|---|---|
| | Fully fitted out | Simple building | Shell and core only | Shell only |
| Management | 11% | 7.5% | 11% | 12% |
| Health and Wellbeing | 14% | 16.5% | 8% | 7% |
| Energy | 16% | 11.5% | 14% | 9.5% |
| Transport | 10% | 11.5% | 11.5% | 14.5% |
| Water | 7% | 7.5% | 7% | 2% |
| Materials | 15% | 17.5% | 17.5% | 22% |
| Waste | 6% | 7% | 7% | 8% |
| Land Use and Ecology | 13% | 15% | 15% | 19% |
| Pollution | 8% | 6% | 9% | 6% |
| Total | 100% | 100% | 100% | 100% |
| Innovation (additional) | 10% | 10% | 10% | 10% |

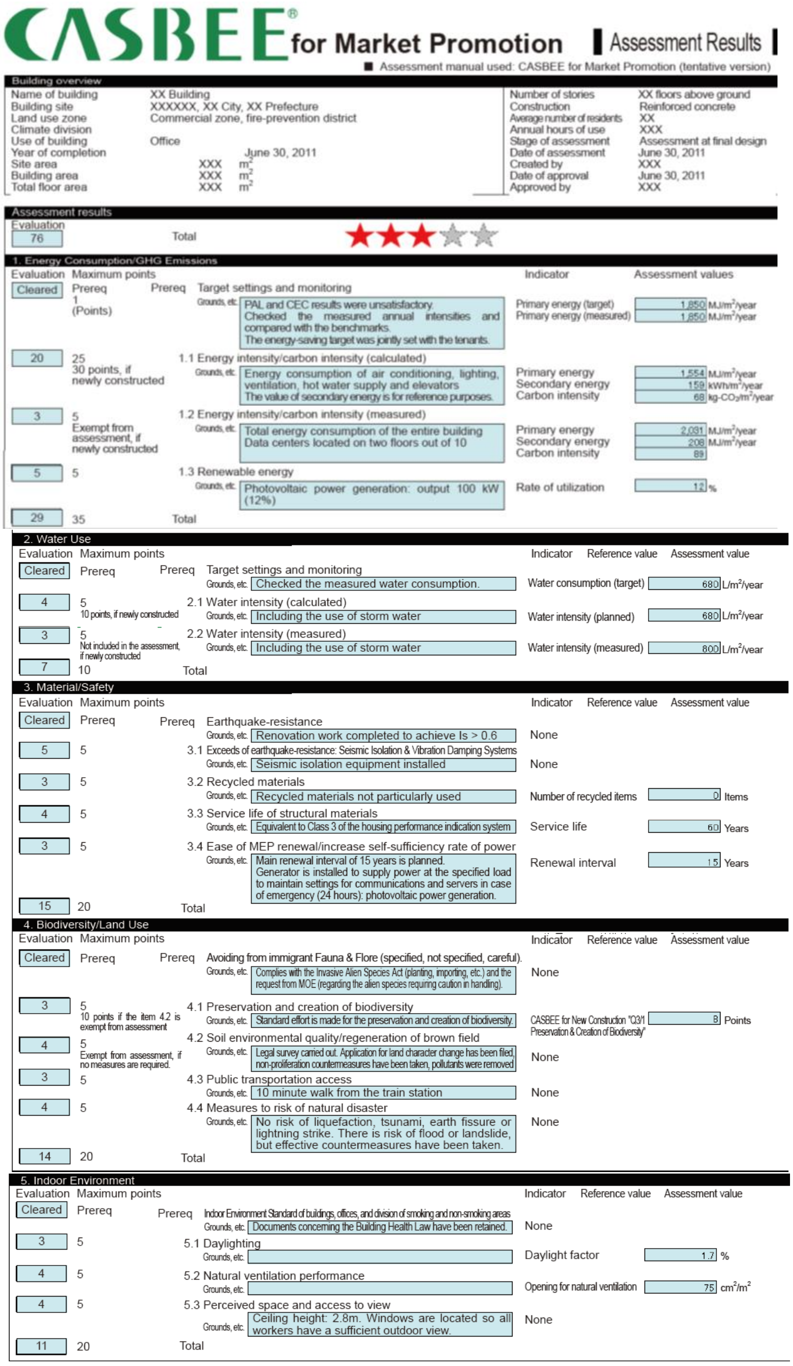
Calculating a building's BREEAM rating

The process of determining a BREEAM rating and an example calculation, see Table below

| BREEAM section | Credits achieved | Credits available | % of credits achieved | Category weighting (fully-fitted) | Section score (%) |
|---|---|---|---|---|---|
| Management | 14 | 21 | 66.67 | 0.11 | 7.33 |
| Health and Wellbeing | 12 | 22 | 54.55 | 0.14 | 7.64 |
| Energy | 15 | 31 | 48.39 | 0.16 | 7.74 |
| Transport | 8 | 12 | 66.67 | 0.10 | 6.67 |
| Water | 4 | 10 | 40.00 | 0.07 | 2.80 |
| Materials | 8 | 14 | 57.14 | 0.15 | 8.57 |
| Waste | 3 | 6 | 50.00 | 0.06 | 3.00 |
| Land Use and Ecology | 5 | 10 | 50.00 | 0.13 | 6.50 |
| Pollution | 8 | 12 | 66.67 | 0.08 | 5.33 |
| Innovation | 2 | 10 | 20.00 | 0.10 | 2.00 |
| Final BREEAM score | | | | 57.58% | |
| BREEAM Rating | | | | VERY GOOD | |

# Appendix F: CASBEE (comprehensive assessment system for built environment efficiency)

Image of assessment result sheet, (Endo, 2005); (NAGUIB, 2016); (CASBEE 2016).



CASBEE® for Market Promotion — Assessment Results

■ Assessment manual used: CASBEE for Market Promotion (tentative version)

**Building overview**

| | | | |
|---|---|---|---|
| Name of building | XX Building | Number of stories | XX floors above ground |
| Building site | XXXXXX, XX City, XX Prefecture | Construction | Reinforced concrete |
| Land use zone | Commercial zone, fire-prevention district | Average number of residents | XX |
| Climate division | | Annual hours of use | XXX |
| Use of building | Office | Stage of assessment | Assessment at final design |
| Year of completion | June 30, 2011 | Date of assessment | June 30, 2011 |
| Site area | XXX $m^2$ | Created by | XXX |
| Building area | XXX $m^2$ | Date of approval | June 30, 2011 |
| Total floor area | XXX $m^2$ | Approved by | XXX |

**Assessment results**

| Evaluation | | |
|---|---|---|
| 76 | Total | ★★★☆☆ |

**1. Energy Consumption/GHG Emissions**

| Evaluation | Maximum points | Item | Grounds, etc. | Indicator | Assessment values |
|---|---|---|---|---|---|
| Cleared | Prereq 1 (Points) | Prereq Target settings and monitoring | PAL and CEC results were unsatisfactory. Checked the measured annual intensities and compared with the benchmarks. The energy-saving target was jointly set with the tenants. | Primary energy (target)<br>Primary energy (measured) | 1,850 $MJ/m^2/year$<br>1,850 $MJ/m^2/year$ |
| 20 | 25<br>30 points, if newly constructed | 1.1 Energy intensity/carbon intensity (calculated) | Energy consumption of air conditioning, lighting, ventilation, hot water supply and elevators. The value of secondary energy is for reference purposes. | Primary energy<br>Secondary energy<br>Carbon intensity | 1,554 $MJ/m^2/year$<br>159 $kWh/m^2/year$<br>68 $kg\text{-}CO_2/m^2/year$ |
| 3 | 5<br>Exempt from assessment, if newly constructed | 1.2 Energy intensity/carbon intensity (measured) | Total energy consumption of the entire building. Data centers located on two floors out of 10 | Primary energy<br>Secondary energy<br>Carbon intensity | 2,031 $MJ/m^2/year$<br>208 $MJ/m^2/year$<br>89 |
| 5 | 5 | 1.3 Renewable energy | Photovoltaic power generation: output 100 kW (12%) | Rate of utilization | 12 % |
| 29 | 35 | Total | | | |

**2. Water Use**

| Evaluation | Maximum points | Item | Grounds, etc. | Indicator | Reference value | Assessment value |
|---|---|---|---|---|---|---|
| Cleared | Prereq | Prereq Target settings and monitoring | Checked the measured water consumption. | Water consumption (target) | | 680 $L/m^2/year$ |
| 4 | 5<br>10 points, if newly constructed | 2.1 Water intensity (calculated) | Including the use of storm water | Water intensity (planned) | | 680 $L/m^2/year$ |
| 3 | 5<br>Not included in the assessment, if newly constructed | 2.2 Water intensity (measured) | Including the use of storm water | Water intensity (measured) | | 800 $L/m^2/year$ |
| 7 | 10 | Total | | | | |

**3. Material/Safety**

| Evaluation | Maximum points | Item | Grounds, etc. | Indicator | Reference value | Assessment value |
|---|---|---|---|---|---|---|
| Cleared | Prereq | Prereq Earthquake-resistance | Renovation work completed to achieve Is > 0.6 | None | | |
| 5 | 5 | 3.1 Exceeds of earthquake-resistance: Seismic Isolation & Vibration Damping Systems | Seismic isolation equipment installed | None | | |
| 3 | 5 | 3.2 Recycled materials | Recycled materials not particularly used | Number of recycled items | | 0 Items |
| 4 | 5 | 3.3 Service life of structural materials | Equivalent to Class 3 of the housing performance indication system | Service life | | 60 Years |
| 3 | 5 | 3.4 Ease of MEP renewal/increase self-sufficiency rate of power | Main renewal interval of 15 years is planned. Generator is installed to supply power at the specified load to maintain settings for communications and servers in case of emergency (24 hours): photovoltaic power generation. | Renewal interval | | 15 Years |
| 15 | 20 | Total | | | | |

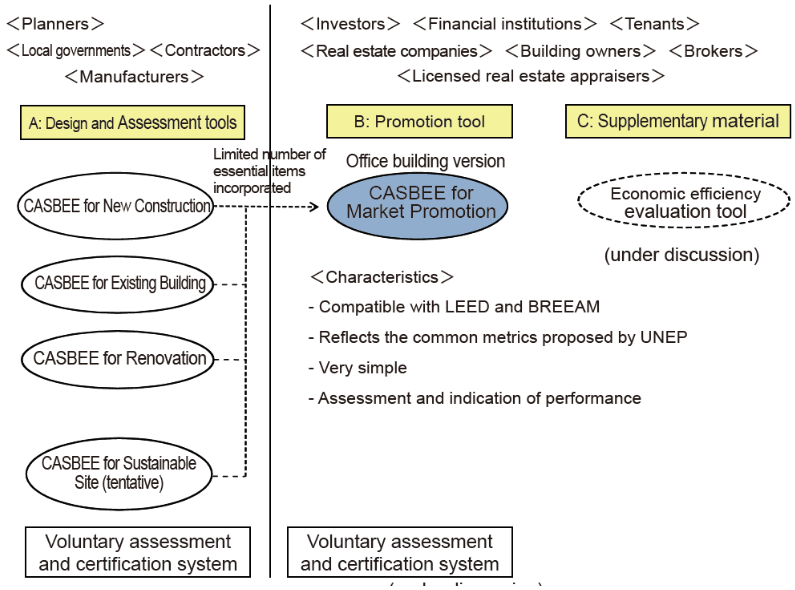
**4. Biodiversity/Land Use**

| Evaluation | Maximum points | Item | Grounds, etc. | Indicator | Reference value | Assessment value |
|---|---|---|---|---|---|---|
| Cleared | Prereq | Prereq Avoiding from immigrant Fauna & Flore (specified, not specified, careful). | Complies with the Invasive Alien Species Act (planting, importing, etc.) and the request from MOE (regarding the alien species requiring caution in handling). | None | | |
| 3 | 5<br>10 points if the item 4.2 is exempt from assessment | 4.1 Preservation and creation of biodiversity | Standard effort is made for the preservation and creation of biodiversity. | CASBEE for New Construction "Q3/1 Preservation & Creation of Biodiversity" | | 8 Points |
| 4 | 5<br>Exempt from assessment, if no measures are required. | 4.2 Soil environmental quality/regeneration of brown field | Legal survey carried out. Application for land character change has been filed, non-proliferation countermeasures have been taken, pollutants were removed | None | | |
| 3 | 5 | 4.3 Public transportation access | 10 minute walk from the train station | None | | |
| 4 | 5 | 4.4 Measures to risk of natural disaster | No risk of liquefaction, tsunami, earth fissure or lightning strike. There is risk of flood or landslide, but effective countermeasures have been taken. | None | | |
| 14 | 20 | Total | | | | |

**5. Indoor Environment**

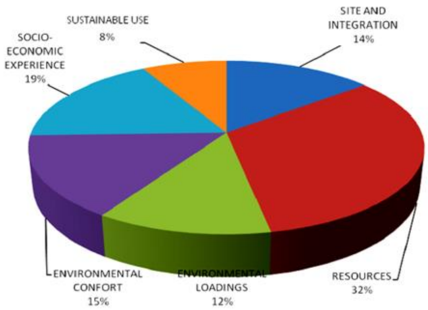
| Evaluation | Maximum points | Item | Grounds, etc. | Indicator | Reference value | Assessment value |
|---|---|---|---|---|---|---|
| Cleared | Prereq | Prereq Indoor Environment Standard of buildings, offices, and division of smoking and non-smoking areas | Documents concerning the Building Health Law have been retained. | None | | |
| 3 | 5 | 5.1 Daylighting | | Daylight factor | | 1.7 % |
| 4 | 5 | 5.2 Natural ventilation performance | | Opening for natural ventilation | | 75 $cm^2/m^2$ |
| 4 | 5 | 5.3 Perceived space and access to view | Ceiling height: 2.8m. Windows are located so all workers have a sufficient outdoor view. | None | | |
| 11 | 20 | Total | | | | |

Position of CASBEE for market promotion among CASBEE tools

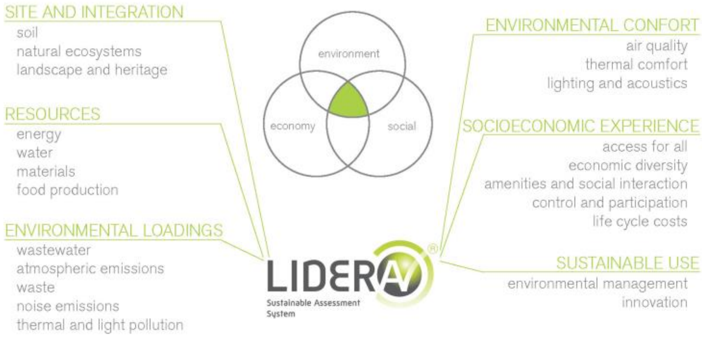


## Appendix G: LIDERA (lead for the environment)

Illustration – Weighting by Categories LiderA (V 2.00), (Pinheiro, 2011); (Carapinha, 2016).




The performance clustered in the areas of Local Integration, Resources and Environmental Loadings profile a strict environmental performance, which combined with the areas Environmental Comfort, Socioeconomic Experience and Sustainable Use perspective the general performance in the search for sustainability (Pinheiro, 2011). Illustration - LiderA's Categories and Areas scheme




Project location is one of the key elements in the building's initial development. Conditionings like soil occupancy, ecological land changes and landscape, the area needs for development, the ecological network and landscape and heritage enhancement are associated with the choice of location and the delimitation of any building or developing area environmental performance.

Table 1 - Site and Integration: considered areas and criteria

| CATEGORY | AREA | Wi | Pre-Req. | CRITERIA | C No. |
|---|---|---|---|---|---|
| SITE AND INTEGRATION | SOIL | 7% | S | Territorial valorisation | C1 |
| | | | | Environmental deployment optimization | C2 |
| | NATURAL ECOSYSTEMS | 5% | S | Ecological valorisation | C3 |
| | | | | Habitats connection | C4 |
| 6 Criteria | LANDSCAPE AND HERITAGE | 2% | S | Landscape integration | C5 |
| 14% | | | | Heritage protection and enhancement | C6 |

Table 1 - LiderA System, guidelines and application in each stage of built environments lifecycle (1/2)

| LEVEL 1 | LIDERA 2.00 | LIDERA SUSTAINABILITY BUILDING EVALUATION SYSTEM - CRITERIA FOR SUSTAINABLE CONSTRUCTION | | | | |
|---|---|---|---|---|---|---|
| CATEGORY | AREA | Wi | Pre-Req. | CRITERION | C No. | GOOD PRACTICE GUIDELINES |
| SITE AND INTEGRATION | SOIL | 7% | S | Territorial Valorisation | C1 | Building in degraded or abandoned areas (already used), with contaminated soil, which must be decontaminated. Building in infrastructured areas: with sewerage and water networks. Respecting and safeguarding territorial planning conditions as well as sensitive areas (according to territorial planning and management instruments). Using impermeable zones or already constructed areas to the yard's placement, minimizing the impact of construction operations on the ground. |
| | | | | Environmental Deployment Optimization | C2 | Reducing the building's deployment area. For example, buildings could be built on piles as a way to minimize the occupied land area by each one, thus minimizing the sealed area. |
| | NATURAL ECOSYSTEMS | 5% | S | Ecological Valorisation | C3 | Development should enhance local ecological value: all local fauna and flora species (particularly endemic) should be preserved, therefore allowing an increase of the area's ecological biodiversity. |
| | | | | Habitats connection | C4 | Promoting a continuous green structure in surrounding areas: green roofs, green facades, trees and green spaces, in order to ease the interconnection of habitats. Avoiding barriers/obstacles between physical habitats or within the same habitat, introducing new structures (burrows, nests, etc.) that encourage species development. |
| 6 Criteria | LANDSCAPE AND HERITAGE | 2% | S | Landscape Integration | C5 | Fostering integration and landscape recovery through some possible measures of integration in the area's visual surroundings: using a colour palette and materials similar to those typically used on surrounding buildings, promoting the insertion within the visual surroundings (in a mountainous area the building should have a kind of construction according to the region; historic buildings should keep the facade, the type of deployment, etc). Buildings' height should be similar to the local average. (2 floors above or below the average of the block). |
| 14% | | | | Heritage Protection and Enhancement | C6 | If there is local heritage, the intervention should preserve it. When intervention is necessary, make it in an appropriate way, in terms of rehabilitation and / or in terms of restoration. The building should have a formal relationship with the surrounding heritage (built or natural) and be suitable for the use and type of environment. |
| ESOURCES | ENERGY | 17% | S | Efficiency in consumption – Energy certification | C7 | Compliance with the energy certification law, preferably by obtaining higher level classes, such as level A and A+. Reduce energy consumption – Monitoring energy consumption and verifying energy certification levels. These solutions should be adapted to the local situation and existing buildings. |
| | | | | Passive Design Performance | C8 | Nominal energy decrease by more than 50%, as a result of adopting bioclimatic and passive solar performance practices, during summer and winter. Applicable parameters: building orientation, insulation, form factor, shading, fenestration, etc. |
| | | | | Carbon Intensity (equipment efficiency) | C9 | Reduce $CO_2$ emission levels through the total amount of energy produced from renewable energy sources. Electricity production from renewable energy sources such as: photovoltaic, wind energy (or urban wind), cogeneration, amongst others. Increase the number of devices (appliances, lamps ...) with good energy efficiency rating and increase the share of renewable energy that is produced in the building. Measures that should be implemented: energy needs for domestic hot water would be supplied by solar collectors and electricity needs would be met by renewable energy sources: solar, wind and others. |
| | WATER | 8% | S | Potable water consumption | C10 | Reduce water consumption from the primary distribution network (should be around 80 litres / inhabitants day and secondary water should be around 95 litres / habitants. day, which would mean a reduction of more than 50% when compared to current practices). Type of efficient equipment that should be used: 1. use of taps with reducer, for example mixer taps; use of taps with sensors; double flushing toilet or waterless toilet, 2. use of rainwater for secondary purposes, 3. other monitoring systems, in addition to water meters; 4. limit drinking water distribution according to the building / type of users; reduce water needs in outdoor spaces. |
| | | | | Local water management | C11 | Some possible measures: local groundwater containment and protection plans; low consumption irrigation system; local water management plan; retention, treatment and on site runoff discharge - types of on-site retention and treatment: wetlands, sedimentation lakes, retention ponds, infiltration basins, waterways, drainage, biological filters; taking measures in order to reduce the percentage of annual rainwater runoff in: parking lots, roofs, impermeable surfaces and coverings; minimizing the sewage discharge; usage of vegetation, in landscaped areas, that reduces the need for water and chemicals ( avoiding contamination of local waters); and to increase infiltration levels. |
| | MATERIALS | 5% | S | Durability | C12 | Designing using durable materials, with longer lifetimes, and fostering materials preservation and maintenance. Measures that should be considered: 1. Building networks - 25 years; 2. Finishes - 5 years; 3. Equipments (elevators, electrical wiring, interior and exterior sensors, solar panel, photovoltaic, effluent treatment, boiler, etc) - 5 to 10 years. It is considered that the weight of the structure and finishes durability is much more important than others, when considering the intervention needs and frequencies. |
| | | | | Local materials | C13 | Use of materials produced within 100 km (more than 50 %). |
| 9 Criteria | | | | Low impact materials | C14 | Use of environmentally certified, recycled and / or renewable materials. Dangerous materials such as lead, asbestos, arsenic, cadmium, mercury, sulphate, benzene, chlorinated solvents, PCB, PCT, formaldehyde, chromium, creosote, phenol resins, amongst others, should be avoided. |
| 32% | FOOD PRODUCTION | 2% | S | Local food production | C15 | Food production of plants and animals in areas belonging to the building's envelope or in the building itself (roof, balconies, etc.). Determine a percentage of land to be assigned for agricultural purposes (terraces, places or areas of the framework). Building's use for agricultural purposes: roofing, balconies, floors, (ex vertical farms). |
| ENVIRONMENTAL LOADINGS | WASTEWATER | 3% | S | Wastewater treatment | C16 | Wastewater treatment carried out on site. Building / area not connected to the urban wastewater treatment system. Check whether it is connected to the urban wastewater treatment system, as all wastewater is treated on site (or partially treated, depending the situation), since the obtained level of treatment will always be the minimum required according to its reuse. |
| | | | | Wastewater use | C17 | Use of reused water for green areas maintenance, through automated irrigation systems and the reuse of gray water (50%). |
| | ATMOSPHERIC EMISSIONS | 2% | S | Atmospheric emissions control | C18 | Possible measures to reduce SO and Knox emissions: elimination or reduction of fuel operated devices (kerosene heaters, fireplaces, etc), cookers, water heaters, boilers, tobacco smoke, transports, particles brought in the feet and carpets, vehicles parked inside, amongst others. |
| | WASTE | 3% | S | Waste control | C19 | Reduction of solid waste production (50%, when compared to the common practices), and the possibility of composting organic waste. |
| | | | | Waste management | C20 | Reduce and manage any generated / used hazardous waste. Possible measures: adequate and safe disposal, management and final disposal; elimination of pesticides and swimming pools' chlorine; facilities for safe storage and proper packaging of cleaning and maintenance products; locations for the disposal of batteries, lamps, cooking oil, or hazardous office (cartridges); disposal of hazardous materials in products used for maintenance and operation; a management and monitoring plan for hazardous waste. |
| | | | | Waste Valorisation | C21 | Increase the amount, of recycled waste in the building, in kilograms or equivalent. |
| 8 Criteria | NOISE EMISSIONS | 3% | S | Noise emissions control | C22 | Implement solutions in order to reduce abroad noise emissions: silent equipments inside (sound power less than 50dB); silent equipments abroad (sound power less than 50dB), noise reduction equipments; appropriate location for equipments that produce noise; baffles that reduce the sound spread; appropriate placement of insulation in inner and outer walls, surrounding noise emitting equipments. |
| 12% | THERMAL AND LIGHT POLLUTION | 1% | S | Thermal and light pollution | C23 | Reducing heat island and light pollution effect. Possible measures that should be considered: placement of shadows on the impervious and / or dark areas; the use of light colours on the building's exterior: walls, roofs, sidewalks and pathways; use of vegetation on the roof; minimization of impervious surfaces: pathways, sidewalks and outside parking lots; underground parking lots; use of vegetation in outdoor areas, with water surfaces; quantifying the light intensity on advertising areas or in buildings. |

Table 2 - LiderA System, guidelines and application in each stage of built environments lifecycle (2/2)

| LEVEL 1 | LIDERA 2.00 | LIDERA SUSTAINABILITY BUILDING EVALUATION SYSTEM - CRITERIA FOR SUSTAINABLE CONSTRUCTION | | | | |
|---|---|---|---|---|---|---|
| **CATEGORY** | **AREA** | **Wi** | **Pre-Req.** | **CRITERION** | **C No.** | **GOOD PRACTICE GUIDELINES** |
| ENVIRONMENTAL COMFORT | AIR QUALITY | 5% | S | Air Quality Levels | C24 | Fostering natural ventilation (its type and incidence in each division). Promoting measures to reduce VOCs (in any materials such as carpets, insulation and others that can be sources of VOCs) and to reduce contaminants in indoor air (micro – contamination). |
| | THERMAL COMFORT | 5% | S | Thermal Comfort | C25 | In order to attain the established thermal comfort, the following measures should be promoted: humidity (35% to 60%), temperature (18° to 26°; minimum 18° in the Winter and maximum 26° in the Summer; the seasonal variation should correspond to seasonal air temperature variation outside); air velocity (≤ 0.2 m/s in the Winter; ≤ 0.5 m/s in the Summer). Ensuring good comfort conditions in outdoor areas, with shadows and wind protections, for example. |
| 4 Criteria | LIGHTING AND ACOUSTIC | 5% | S | Lighting levels | C26 | Lighting levels in accordance to those defined by CIBSE for the different areas studied and adapted to local activities (interior lighting between 350 to 400 lux). |
| 15% | | | | Acoustic insulation/noise levels | C27 | Setting the noise levels inside the building (dB): through the characterization of equipment's sound characteristics, insulation and windows specifications, taking into account the activities within it. |
| SOCIOECONOMIC EXPERIENCE | ACCESS FOR ALL | 5% | S | Public transportation access | C28 | Access to the public transport or the promotion of interface access. In specific cases providing mechanisms for public transport and checking distances between them. |
| | | | | Low impact mobility | C29 | Promoting low impact mobility solutions. |
| | | | | Accessibility to disabled people | C30 | Reducing potential accessibility problems in sites and identifying inclusive solutions that can be adopted for their resolution, either inside or outside local buildings. |
| | ECONOMIC DIVERSITY | 4% | S | Flexibility / Adaptability | C31 | Encourage spaces flexibility, including the existence of modular and adaptable buildings, when considering various uses. |
| | | | | Local Economic dynamics | C32 | Enhance and encourage local economic activity. Reduce social inequalities locally, identifying and adapting specific solutions when considering their resolutions. Encourage the establishment of relevant economic activities to the developing area. |
| | | | | Local Work | C33 | Generating new jobs in the built environment and / or fomenting existence of nearby job opportunities (up to 1000 m), which could contribute to the building's occupants social integration. There should be no decrease in local job offer. It should encourage the provision of employment activities within the public space: commercial, cultural, or other local activities. Creating high-skilled jobs that contribute to the region's development. |
| | AMENITIES AND SOCIAL INTERACTION | 4% | S | Local Amenities | C34 | The existence of Natural (river, forest) and human (food shops, post offices...) amenities in a 500 m radius. Proximity to five of the following amenities, in a 1000 m radius: post office, bank, pharmacy, school, health centre, leisure centre, community centre and children's garden. |
| | | | | Community Interaction | C35 | Interventions that facilitate the community's integration and accessibility to the enterprise: allow non-residents, of any age group, to enjoy natural outdoor spaces for recreational and / or sportive purposes. The utilization of the building's interior areas, which can be accessed by the community (ex inland areas of restoration associated with public open spaces), should be considered. |
| | CONTROL AND PARTICIPATION | 4% | S | Controllability | C36 | It is fundamental to control comfort levels in 5 major areas: Temperature, Humidity, Ventilation, Shading and Lighting. Some solutions must be adopted in order to cover all of these areas and to promote interaction between them, resulting in buildings' upgraded performance and in a greater efficiency to obtain the appropriate comfort levels for users. |
| | | | | Participation and governance conditions | C37 | Promote in the initial phase of the strategic plan an extensive exchange of information between project leaders and potential users. Promote regular meetings in each project phase, where potential users are represented by a diverse population (age, education level, economic status).Define a project team, organized hierarchically, with well defined and set functions for each of its members. Decisions taken by the project's team should always be disclosed to the local population before initiating any intervention in public spaces. Create conditions and implement measures that enable community interaction, allowing it's inhabitants to have an influence in decision-making, when considering the built environment's management and evolution. |
| | | | | Natural risks - Safety | C38 | Matching the intervention with the existing natural risks and avoiding risks inherent to the adopted architectural solutions. Measures that should be implemented: structures protection/resistance to earthquakes, high winds, floods and other natural risks in places with high or medium danger degree to the user. For example, implementation of protection elements outside the building, with a good resistance to extreme weather conditions; incorporation of tempered glass in buildings or furniture that is partially or completely weather exposed, in popular areas or highly frequented; use of trees with medium to deep roots near areas subjected to inclement weather and adequate protection elements in areas with some degree of danger (stairs, sloping areas, etc) or with big flow of people; implementation of measures to reduce cars' speed of along the building's access roads to access, near areas with big flow of people. External solutions adapted to protect these risks. |
| 13 Criteria | | | | Human Threats - Security | C39 | Implementation of measures to control and inhibit crime and vandalism on two different but complementary category's: building and adjacent public space, therefore, the measures at public space level are the most prevalent. These measures can be organized in areas related to lighting, surveillance, space permeability and vision fields. Implement measures to: control risks associated with activities that use dangerous substances. Existence of well illuminated, monitored and open-fronted spaces; buildings with main access situated at street level; establishment of opening / closing hours in areas where security/crime is difficult to control, like interior courtyards. |
| 19% | LIFE CYCLE COSTS | 2% | S | Life cycle costs | C40 | Promote the use of cost-effective and quality materials, equipments, systems and other elements that compose buildings. Possible measures: 1. Equipments choice / efficient and low cost energetically efficient solutions; 2. Costs and maintenance intervals. |
| SUSTAINABLE USE | ENVIRONMENTAL MANAGEMENT | 6% | | Environmental Information | C41 | Provide environmental information and outer space and buildings' usage methods, in order to facilitate proper use and the enterprise's good performance. Information: user's manual, electric installations, plumbing installations, architectural plans, equipments' use and maintenance information, structure, materials, amongst others. Monitoring and performance information, amongst others. |
| 3 Criteria | | | | Environmental Management System | C42 | Implement documented environmental management methods. Boost the demand for management objectives that seek environmental sustainability. If possible, environmental management systems should be implemented and should be certificated by ISO 14001 or EMAS. |
| 8% | INNOVATION | 2% | | Innovative solutions | C43 | Systematize and analyze structural innovations that have a specific and effective contribution to one or more evaluation criteria and contribute effectively to the environmental performance improvement of the building, with the possibility to affect also the incidence area. Verify the existence of innovative elements in at least two of the following measures (Site and Integration, Resources, Environmental Loadings and Socio-economic Experience). |

# Appendix H: SBTool (sustainable building tool)

SBTool: Site Assessment: Maximum: Total of 35 weights is 100% (Ng et al. 2007); (Mateus and Bragança 2011);

Category S1: Site location and characteristics: 12 active criteria

Category S2: Off-site services available: 9 active criteria

Category S3: Site Characteristics :14 active criteria

| | | |
|---|---|---|
| | S3 | Site Characteristics |
| ■ | S3.1 | Pre-development ecological sensitivity or value. |
| ■ | S3.2 | Pre-development agricultural value. |
| ■ | S3.3 | Pre-development contamination status of land. |
| ◆ | S3.4 | Ambient air quality conditions - particulates PM2.5 |
| ■ | S3.5 | Ambient air quality conditions - sulphur dioxide. |
| ■ | S3.6 | Ambient air quality conditions - other. |
| ■ | S3.7 | Ambient noise conditions. |
| ◆ | S3.8 | Availability of existing structure(s) on the site suited to new functional requirements. |
| ■ | S3.9 | Impact of orientation and topography of the site on the passive solar potential of buildings. |
| ■ | S3.10 | Feasibility for the use of renewable energy systems on the site. |
| ■ | S3.11 | Impact of size and shape of the land parcel on the economic viability of the development. |
| ■ | S3.12 | Regulations applicable to the site pertinent to heritage conservation. |
| ■ | S3.13 | Regulations applicable to the site pertinent to mixed use and medium-rise development. |
| ■ | S3.14 | Regulations applicable to the site pertinent to the use of private vehicles. |

SBTool Project Assessment: Maximum scope version; Categories A and B

Category A: Site regeneration and development: 14 active criteria

Category B: Energy and Resource Consumption: 13 active criteria

| | | | |
|---|---|---|---|
| | **A** | **Site Regeneration and Development, Urban Design and Infrastructure** | |
| | A1 | Site Regeneration and Development | |
| ■ | | A1.5 | Remediation of contaminated soil, groundwater or surface water. |
| ■ | | A1.6 | Shading of building(s) by deciduous trees. |
| ■ | | A1.7 | Use of vegetation to provide ambient outdoor cooling. |
| ■ | | A1.8 | Reducing irrigation requirements through the use of native plantings. |
| ■ | | A1.12 | Provision and quality of bicycle pathways and parking. |
| ■ | | A1.13 | Provision and quality of walkways for pedestrian use. |
| | A2 | Urban Design | |
| ■ | | A2.3 | Impact of orientation on the passive solar potential of building(s). |
| ■ | | A2.5 | Impact of site and building orientation on natural ventilation of building(s) during warm season(s). |
| ■ | | A2.6 | Impact of site and building orientation on natural ventilation of building(s) during cold season(s). |
| | A3 | Project Infrastructure and Services | |
| ■ | | A3.6 | Provision of solid waste collection and sorting services. |
| ■ | | A3.9 | Provision of surface water management system. |
| ■ | | A3.13 | Provision of on-site parking facilities for private vehicles. |
| ■ | | A3.15 | Provision of access roads and facilities for freight or delivery. |
| ■ | | A3.16 | Provision and quality of exterior lighting. |
| | **B** | **Energy and Resource Consumption** | |
| | B1 | Total Life Cycle Non-Renewable Energy | |
| ■ | | B1.1 | Embodied non-renewable energy in original construction materials. |
| ■ | | B1.2 | Embodied non-renewable energy in construction materials for maintenance or replacement(s). |
| ◆ | | B1.3 | Consumption of non-renewable energy for all building operations. |
| ■ | | B1.4 | Consumption of non-renewable energy for project-related transport. |
| ■ | | B1.5 | Consumption of non-renewable energy for demolition or dismantling process. |
| | B2 | Electrical peak demand | |
| ■ | | B2.1 | Electrical peak demand for building operations. |
| | B3 | Use of Materials | |
| ■ | | B3.3 | Material efficiency of structural and building envelope components. |
| ■ | | B3.4 | Use of virgin non-renewable materials. |
| ■ | | B3.5 | Efficient use of finishing materials. |
| ■ | | B3.6 | Ease of disassembly, re-use or recycling. |
| | B4 | Use of potable water, stormwater and greywater | |
| ◆ | | B4.2 | Use of water for occupant needs during operations. |
| ■ | | B4.3 | Use of water for irrigation purposes. |
| ■ | | B4.4 | Use of water for building systems. |

SBTool Project Assessment: Maximum scope version; Categories C and D

Category C: Environmental Loadings: 15 active criteria

Category D: Indoor Environmental Quality: 14 active criteria

| | | |
|---|---|---|
| | **C** | **Environmental Loadings** |
| | C1 | Greenhouse Gas Emissions |
| ■ | C1.1 | GHG emissions from energy embodied in original construction materials. |
| ■ | C1.2 | GHG emissions from energy embodied in construction materials used for maintenance or replacement(s). |
| ◆ | C1.3 | GHG emissions from primary energy used for all purposes in facility operations. |
| | C2 | Other Atmospheric Emissions |
| ■ | C2.1 | Emissions of ozone-depleting substances during facility operations. |
| ■ | C2.2 | Emissions of acidifying emissions during facility operations. |
| ■ | C2.3 | Emissions leading to photo-oxidants during facility operations. |
| | C3 | Solid and Liquid Wastes |
| ■ | C3.2 | Solid non-hazardous waste from facility operations sent off the site. |
| ■ | C3.5 | Liquid effluents from building operations that are sent off the site. |
| | C4 | Impacts on Project Site |
| ■ | C4.3 | Recharge of groundwater through permeable paving or landscaping. |
| ■ | C4.4 | Changes in biodiversity on the site. |
| | C5 | Other Local and Regional Impacts |
| ■ | C5.1 | Impact on access to daylight or solar energy potential of adjacent property |
| ■ | C5.5 | Potential for project operations to contaminate nearby bodies of water. |
| ■ | C5.6 | Cumulative (annual) thermal changes to lake water or sub-surface aquifers. |
| ■ | C5.7 | Contribution to Heat Island Effect from roofing, landscaping and paved areas. |
| ■ | C5.8 | Degree of atmospheric light pollution caused by project exterior lighting systems. |
| | **D** | **Indoor Environmental Quality** |
| | D1 | Indoor Air Quality and Ventilation |
| ■ | D1.1 | Pollutant migration between occupancies. |
| ◆ | D1.5 | CO2 concentrations in indoor air. |
| ■ | D1.6 | Effectiveness of ventilation in naturally ventilated occupancies during cooling seasons. |
| ■ | D1.7 | Effectiveness of ventilation in naturally ventilated occupancies during intermediate seasons. |
| ■ | D1.8 | Effectiveness of ventilation in naturally ventilated occupancies during heating seasons. |
| ■ | D1.9 | Air movement in mechanically ventilated occupancies. |
| ■ | D1.10 | Effectiveness of ventilation in mechanically ventilated occupancies. |
| | D2 | Air Temperature and Relative Humidity |
| ■ | D2.1 | Appropriate air temperature and relative humidity in mechanically cooled occupancies. |
| ■ | D2.2 | Appropriate air temperature in naturally ventilated occupancies. |
| | D3 | Daylighting and Illumination |
| ◆ | D3.1 | Appropriate daylighting in primary occupancy areas. |
| ■ | D3.2 | Control of glare from daylighting. |
| | D4 | Noise and Acoustics |
| ■ | D4.1 | Noise attenuation through the exterior envelope. |
| ■ | D4.2 | Transmission of facility equipment noise to primary occupancies. |
| ■ | D4.3 | Noise attenuation between primary occupancy areas. |

SBTool Project Assessment: Maximum scope version; Categories E, F and G.

Note that average weight for all parameters is only 1.17%

Category E: Service Quality: 16 active criteria

Category F: Social, Cultural and Perceptual: 8 active criteria

Category G: Cost and Economic Aspects: 5 active criteria

| | | | |
|---|---|---|---|
| | **E** | **Service Quality** | |
| | E1 | Safety and Security | |
| | | E1.9 | Maintenance of core building functions during power outages. |
| | | E1.10 | Personal security for building users during normal operations. |
| | E2 | Functionality and efficiency | |
| | | E2.7 | Spatial efficiency. |
| | | E2.8 | Volumetric efficiency. |
| | E3 | Controllability | |
| | | E3.1 | Effectiveness of facility management control system. |
| | | E3.2 | Capability for partial operation of facility technical systems. |
| | | E3.3 | Degree of local control of lighting systems. |
| | | E3.4 | Degree of personal control of technical systems by occupants. |
| | E4 | Flexibility and Adaptability | |
| | | E4.1 | Ability for building operator or tenant to modify facility technical systems. |
| | | E4.2 | Potential for horizontal or vertical extension of structure. |
| | | E4.3 | Adaptability constraints imposed by structure or floor-to-floor heights. |
| | | E4.4 | Adaptability constraints imposed by building envelope and technical systems. |
| | | E4.5 | Adaptability to future changes in type of energy supply. |
| | E5 | Optimization and Maintenance of Operating Performance | |
| | | E5.1 | Operating functionality and efficiency of key facility systems. |
| | | E5.2 | Adequacy of the building envelope for maintenance of long-term performance. |
| | | E5.6 | Retention of as-built documentation. |
| | **F** | **Social, Cultural and Perceptual Aspects** | |
| | F1 | Social Aspects | |
| | | F1.1 | Universal access on site and within the building. |
| | | F1.2 | Access to direct sunlight from living areas of dwelling units. |
| | | F1.3 | Visual privacy in principal areas of dwelling units. |
| | | F1.4 | Access to private open space from dwelling units. |
| | F2 | Culture and Heritage | |
| | | F2.2 | Provision of public open space compatible with local cultural values. |
| | | F2.3 | Impact of the design on existing streetscapes. |
| | | F2.4 | Use of traditional local materials and techniques |
| | F3 | Perceptual | |
| | | F3.7 | Access to exterior views from interior. |
| | **G** | **Cost and Economic Aspects** | |
| | G1 | Cost and Economics | |
| | | G1.1 | Construction cost. |
| | | G1.2 | Operating and maintenance cost. |
| | | G1.3 | Life-cycle cost. |
| | | G1.4 | Investment risk |
| | | G1.5 | Affordability of residential rental or cost levels. |

# Appendix I: GBC historic building™

Structure and main content of GBC historic building (Boarin et al, 2014); (Boarin, 2016).

Table 1. Credits overview of topic "Historic Value".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Fundamental history structure report | Mandatory | | - | D |
| Credit 1.1 | Fundamental history structure report: energy analysis | 1 | 3 | - | D |
| Credit 1.2 | Fundamental history structure report: analysis on materials and decay | - | 2 | - | D |
| Credit 1.3 | Fundamental history structure report: analysis on structures and structural monitoring | 2 | 3 | - | D |
| Credit 2 | Restoration process reversibility | 1 | 2 | Yes | D |
| Credit 3.1 | Compatibility of final-use function and benefits | 1 | 2 | Yes | D |
| Credit 3.2 | Chemical and physical compatibility of mortars for restoration | - | 2 | - | C |
| Credit 3.3 | Structural compatibility | - | 2 | - | C |
| Credit 4 | Sustainable restoration site | - | 1 | Yes | C |
| Credit 5 | Scheduled maintenance plan | - | 2 | - | C |
| Credit 6 | Specialist in restoration of buildings and sites | - | 1 | - | D |

Table 2. Credits overview of topic "Sustainable Sites".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Construction activity pollution prevention | Mandatory | | - | C |
| Credit 1 | Brownfield redevelopment | - | 2 | - | D |
| Credit 2.1 | Alternative transportation: public transportation access | - | 1 | Yes | D |
| Credit 2.2 | Alternative transportation: bicycle storage and changing rooms | - | 1 | Yes | D |
| Credit 2.3 | Alternative transportation: low-emitting and fuel-efficient vehicles | - | 1 | Yes | D |
| Credit 2.4 | Alternative transportation: parking capacity | - | 1 | Yes | D |
| Credit 3 | Site development: open spaces recovery | - | 2 | Yes | D |
| Credit 4 | Stormwater design: quantity and quality control | - | 2 | - | D |
| Credit 5 | Heat island effect: non-roof and roof | - | 2 | Yes | C |
| Credit 6 | Light Pollution Reduction | - | 1 | - | D |

Table 3. Credits overview of topic "Water Efficiency".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Water use reduction | Mandatory | | - | D |
| Credit 1 | Water-efficient landscaping | 1 | 3 | - | D |
| Credit 2 | Water use reduction | 1 | 3 | Yes | D |
| Credit 3 | Water metering | - | 2 | Yes | D |

Table 4. Credits overview of topic "Energy & Atmosphere".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Fundamental commissioning of building energy systems | Mandatory | | - | C |
| Prerequisite 2 | Minimum energy performance | Mandatory | | - | D |
| Prerequisite 3 | Fundamental refrigerant management | Mandatory | | - | D |
| Credit 1 | Optimize energy performance | 1 | 17 | Yes | D |
| Credit 2 | Renewable energies | 1 | 6 | Yes | C |
| Credit 3 | Enhanced commissioning | - | 2 | Yes | C |
| Credit 4 | Enhanced refrigerant management | - | 1 | - | D |
| Credit 5 | Measurement and verification | - | 3 | - | C |

Table 5. Credits overview of topic "Materials & Resources".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Storage and collection of recyclables | Mandatory | | - | D |
| Prerequisite 2 | Fundamental demolition and construction waste management | Mandatory | | - | C |
| Prerequisite 3 | Building reuse | Mandatory | | - | C |
| Credit 1 | Building reuse: maintain existing technical elements and finishing | - | 4 | - | C |
| Credit 2 | Demolition and construction waste management | 1 | 2 | - | C |
| Credit 3 | Materials reuse | 1 | 2 | Yes | C |
| Credit 4 | Products environmental optimization | 2 | 4 | Yes | C |
| Credit 5 | Regional materials | 1 | 2 | Yes | C |

Table 6. Credits overview of topic "Indoor Environmental Quality".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Prerequisite 1 | Minimum Indoor Air Quality Performance | Mandatory | | - | D |
| Prerequisite 2 | Environmental Tobacco Smoke (ETS) Control | Mandatory | | - | D |
| Credit 1 | Environmental air monitoring | - | 2 | - | D |
| Credit 2 | External air minimum ratio evaluation | - | 2 | - | D |
| Credit 3.1 | Construction Indoor Air Quality Management Plan - During Construction | - | 1 | - | C |
| Credit 3.2 | Construction Indoor Air Quality Management Plan - Before Occupancy | - | 1 | - | C |
| Credit 4.1 | Low-Emitting Materials: Adhesives and Sealants, concrete materials and wood finishing | - | 1 | - | C |
| Credit 4.2 | Low-Emitting Materials - Paints and Coatings | - | 1 | - | C |
| Credit 4.3 | Low-Emitting Materials - Flooring Systems | - | 1 | - | C |
| Credit 4.4 | Low-Emitting Materials - Composite Wood and Agrifiber Product | - | 1 | - | C |
| Credit 5 | Indoor Chemical and Pollutant Source Control | - | 1 | - | D |
| Credit 6.1 | Controllability of Systems - Lighting | - | 1 | - | D |
| Credit 6.2 | Controllability of Systems - Thermal Comfort | - | 1 | - | D |
| Credit 7.1 | Thermal Comfort - Design | - | 1 | - | D |
| Credit 7.2 | Thermal Comfort - Verification | - | 2 | - | D |

Table 7. Credits overview of topic "Innovation in Design".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Credit 1 | Innovation in Design | 1 | 5 | - | P/D |
| Credit 2 | GBC Accredited Professional | - | 1 | - | C |

Table 8. Credits overview of topic "Regional Priority".

| Prerequisite/ Credit | Title | Points | | Exemplary Performance | Design/ Construction |
|---|---|---|---|---|---|
| Credit 1 | Regional Priority | 1 | 4 | - | - |

## Weighting and certification

| | LEED ITALIA NC | % | GBC HB | % |
|---|---|---|---|---|
| Historic Value | 0 | - | 20 | 18,2% |
| Sustainable Sites | 26 | 23,6 | 13 | 11,8% |
| Water Efficiency | 10 | 9,1 | 8 | 7,3% |
| Energy and Atmosphere | 35 | 31,8 | 29 | 26,4% |
| Materials and Resources | 14 | 12,7 | 14 | 12,7% |
| Indoor Environmental Quality | 15 | 13,6 | 16 | 14,5% |
| Innovation in Design | 6 | 5,5 | 6 | 5,5% |
| Regional Priority | 4 | 3,6 | 4 | 3,6% |
| TOTAL SCORE | 110 | 100% | 110 | 100% |

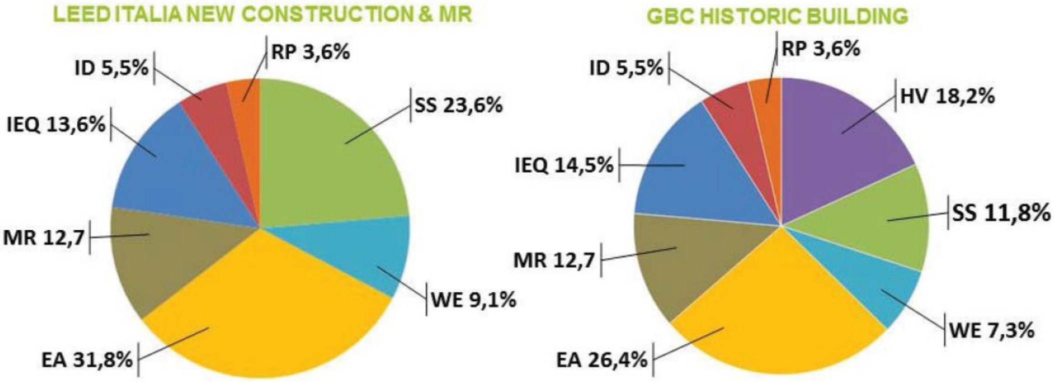



Figure 5. Distribution of points and weights for each topic in *LEED® Italia 2009 New Construction and Major Renovation* e in *GBC Historic Building*™.

## Appendix J: GPRS (green pyramid rating system)

The objectives of this Category are, (Egypt Green Building Council, 2010); (NAGUIB, 2016).

- Cultural heritage: designs which excel in reflecting national and regional cultural heritage while contributing to the environmental performance of the building.
- Exceeding Benchmarks: initiatives which demonstrate additional environmental benefit by exceeding the current benchmarks of GPRS.
- Innovation: design initiatives and construction practice which have a significant measurable environmental benefit and which are not otherwise awarded points by GPRS.
- SUMMARY OF CREDIT POINTS IN THIS CATEGORY

There are no Mandatory Minimum Requirements for this Category

- Cultural Heritage 3 points
- Exceeding Benchmarks 4 points
- Innovation 3 points

TOTAL 10 credit points

**DETAILS OF CREDIT POINTS**

| **CATEGORY 7: INNOVATION AND ADDED VALUE** | | |
|---|---|---|
| 7.1 | **Cultural Heritage:** Credit points are obtainable for incorporating architectural, construction and technical solutions which excel in reflecting national and regional cultural heritage while contributing to the environmental performance of the building. | 1 |
| 7.2 | **Exceeding Benchmarks:** Credit points are obtainable for demonstrating that the current benchmarks of GPRS have been exceeded by a significant margin and providing evidence that the improvement has an additional environmental benefit. One Credit Point is available for each Category (up to a maximum of four Credit Points). | 1 |
| 7.3 | **Innovation:** Credit points are obtainable for innovative design or construction practices which have a significant measurable environmental benefit and which are not otherwise awarded points by GPRS. | 1 |
| **TOTAL AVAILABLE CREDIT POINTS IN CATEGORY 7: INNOVATION AND ADDED VALUE WHICH WILL BE OFFERED AS BONUS CREDITS.** | | 3 |

## Appendix K: ITACA (institute for transparency of contracts and environmental compatibility)

Certification criteria percentage distribution, (Catalino et al. 2005); (Asdrubali et al. 2015):

**Tab. 4: areas and Score of ITACA certification**

| ITACA Areas | Maximum Score |
|---|---|
| Site Quality | 4.0% |
| Resource Consumption | 53.6% |
| Environmental Loads | 17.5% |
| Indoor Environmental Quality | 18.2% |
| Service Quality | 6.7% |
| **Total** | **100.0%** |

**Tab. 5: levels of certification for ITACA**

| Level of Certification | Score |
|---|---|
| D (not certified) | < 40 |
| C | 40 - <55 |
| B | 55 - < 70 |
| A | 70 - < 85 |
| A+ | 85 - 100 |

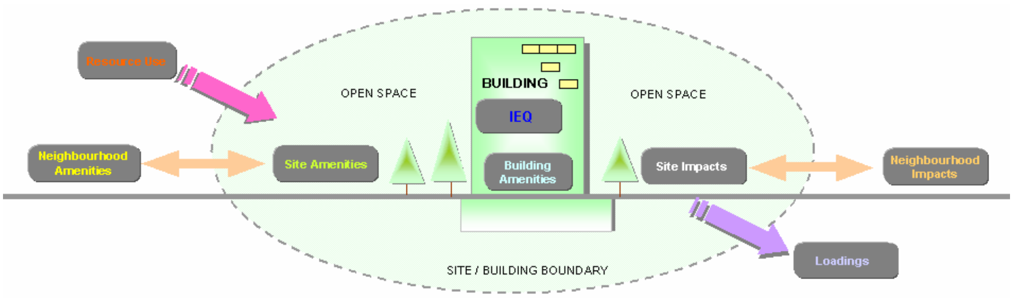

**Fig. 2: areas and "classes" of certifications for ITACA**

**Tab. 7: combination and association of credits to the new areas for ITACA**

| | | |
|---|---|---|
| **1. Site Quality** | | **4.00%** |
| 1.2.1 | Accessibility to public transport | 2.00% |
| 1.2.2 | Distance from commercial, cultural, service activities | 2.00% |
| **2. Resource Consumption** | | **53.60%** |
| 2.1.1 | Thermal transmittance of the building envelope | 7.30% |
| 2.1.2 | Primary energy for heating | 6.20% |
| 2.1.3 | Control of solar radiation | 6.20% |
| 2.1.4 | Net energy for cooling | 6.20% |
| 2.1.5 | Primary energy for the production of DHW | 6.20% |
| 2.2.2 | Electricity generated from renewable sources | 6.20% |
| 2.3.1 | sustainable Materials | 7.20% |
| 2.3.3 | Local Materials | 2.50% |
| 2.4.1 | Drinking water for indoor use | 5.60% |
| **3. Environmental Loads** | | **17.50%** |
| 3.1.1 | Expected emissions in operating phase | 6.10% |
| 3.2.1 | Catched and stockpiled rainwater | 5.80% |
| 3.2.2 | Soil permeability | 5.60% |
| **4. Indoor Environmental Quality** | | **18.20%** |
| 4.1.1 | Ventilation | 4.55% |
| 4.2.1 | Air temperature | 4.55% |
| 4.3.1 | Natural Lighting | 4.55% |
| 4.4.1 | Acoustic insulation of building envelope | 4.55% |
| **5. Service Quality** | | **6.70%** |
| 5.1.1 | Availability of technical documentation of buildings | 3.50% |
| 5.2.1 | System Integration | 3.20% |

# Appendix L: CEPAS (comprehensive environmental performance assessment scheme)

Relationships & Scopes of 8 CEPAS Categories for Buildings, (Wu and Yau, 2005); (HKSAR 2006); (Ho, et al, 2005).




| | Neighbourhood Amenities | Resources Use | Site Amenities | IEQ | Building Amenities | Site Impacts | Loadings | Neighbourhood Impacts |
|---|---|---|---|---|---|---|---|---|
| Health & Hygiene | Environmental interaction; district-wise health & hygiene planning and provisions | No/low emitting and environmental friendly materials | Site-wise health & hygiene provisions of amenities | Low/no emitting material, visual quality & comfort, daylight, IAQ, acoustic & noise, cleansing, drainage | Health and hygiene provisions on building components and systems | Site planning for healthy environment with enhanced ventilation, daylight etc | Waste and pollution management and minimisation / mitigation | Enhanced natural ventilation, microclimate, sunlight access of neighbourhood |
| Resources | Conservation of heritage building; optimisation of facilities provision | Recycled/Environment friendly material use, building reuse, water recycling, water conservation, timber use | Optimised site-wide provision of amenities | Optimise resource use for good ventilation, lighting and noise provisions. | Green feature and building innovations; flexibility of building components and systems | Buildability; enhanced natural ventilation and daylight reduce system provisions | Waste management and minimisation | Enhanced natural ventilation and lighting neighbourhood for passive design |
| Energy | Green transport; renewable energy | Energy efficiency, renewable energy, passive building design; $CO_2$ and emissions reduction | Green transport; renewable energy | Thermal and visual comfort; controllability, serviceability and energy efficiency of systems. | Controllability and energy efficient of systems | Enhancement of site environment on natural ventilation & daylighting | Waste sorting & storage; $CO_2$ and emissions reduction | Natural ventilation and natural lighting |
| Materials | Conservation of heritage building; optimisation of facilities provision | Minimised material use, building reuse, material sorting & recycling | Optimisation of provision, minimisation of material use | Low/no emitting material; minimisation of material use | Low/no emitting material; minimisation of material use | Low/ no emitting material | Low/no emitting material | Reduced material use due to improved environment |
| Environment | Landscape; district-wide open space; minimised environmental Impacts | Waste recycling, water treatment, optimised built form & building designs | Landscape, tree preservation | Controllability, serviceability, maintainability. | Green features and building innovations; flexibility of building components and systems | Site environment, nature conservation, habitat & biodiversity | Air & Noise pollution, Waste management, Waste sorting & storage, C&D waste | Optimised solution for microclimate and heat island effect |
| Living Quality | Environmental nuisance; transport environmental interaction | Enhanced liveability with optimised material use | Landscape, security | Thermal comfort, visual quality and comfort, daylight & acoustic environment | Liveability; adaptability of spaces and systems | Site investigation, & planning, microclimate | Air pollution, noise pollution | Enhanced neighbourhood environmental conditions |
| Social | Environmental nuisance and Impacts to communities, provisions and supports to community; public participation | Optimise and reduced material use enhance competitive advantage | Inclusion, cultural character, social interaction, connectivity | Enhanced user satisfaction of good IEQ | Safety, improved quality of building and construction technology | Heritage conservation, site investigation & planning | Waste and pollution minimisation | Transport, provision for communities, minimised Impacts to communities |
| Management | Security of neighbourhood; public participation | Energy monitoring and audit; implementation of recycling during construction | Implementation of safety and security plan for site and building, | Implementation of IAQ management and energy efficiency plan | Safety, quality & environmental management; Controllability and serviceability of systems | Minimised site and neighbourhood impact | Waste and pollution minimisation plan | Plan for improved social assets and environmental benefits to neighbourhood |
| Economics | Sustainability economics | Building reuse; optimised and reduced material use; enhanced competitive advantage | Building economics; LCC | Enhanced productivity and user satisfactory of good IEQ | Optimise design and operation reduce capital and operating cost; | Reduced environmental costs | Reduced environmental costs | Environmental economics |

Summary of CEPAS Indicators

| Criteria | | Intent |
|---|---|---|
| **Indoor Environmental Quality (IE)** | | |
| IE 1 | Health & Hygiene | Enhance of health and hygiene |
| IE 2 | Indoor Air Quality | Maintain the environment of occupied space with good indoor air quality |
| IE 3 | Noise and Acoustic Environment | Minimise the noise nuisance affecting building occupants |
| IE 4 | Lighting Environment | Create a comfort visual environment by means of energy saving operations |
| **Building Amenities (BA)** | | |
| BA 1 | Safety | Provide a safe habitation and working environment for building occupants and users |
| BA 2 | Management | Design the building and its facilities ease of effective management |
| BA 3 | Controllability | Design the building and its facilities ease of effective control and operation |
| BA 4 | Serviceability | Design the building and its facilities ease of effective maintenance |
| BA 5 | Adaptability | Design the building and its facilities with high adaptability in usage changes |
| BA 6 | Living Quality | Design and provide better spatial and facility provisions in building to enhance the living quality |
| **Resources Use (RE)** | | |
| RE 1 | Energy Consumption | Reduce the overall building energy consumption of the planned Building |
| RE 2 | Energy Efficiency | Enhance the energy efficiency of the planned Building and its systems |
| RE 3 | Use of Renewable Energy | Encourage the use of renewable energy technology to reduce environmental impacts associated with fossil fuel use |
| RE 4 | Water Conservation | Minimise water consumption and wastage, and to reuse water in an appropriate way |
| RE 5 | Timber Use | Reduce the use of timber and encourage the use of timber from sustainable source |
| RE 6 | Material Use | Reduce material consumption and to encourage the use of recycled materials |
| RE 7 | Building Reuse | Encourage refurbishment of building to reduce the amount of resources use and waste generation |
| **Loadings (LD)** | | |
| LD 1 | Pollution | Minimise and mitigate outdoor air, noise and water pollution and the subsequent health and environmental impact |
| LD 2 | Waste Management | Encourage best practices in waste management, including sorting, recycling and disposal of municipal, construction and demolition waste |
| **Site Amenities (SA)** | | |
| SA 1 | Inclusion | Provide optimum spatial arrangements and facilities to enhance the sense of inclusion for all building occupants and users |

| Criteria | | Intent |
|---|---|---|
| **SA 2** | Landscape | Design and provide greenery sensitive boundary treatment and landscape features within a site |
| **SA 3** | Cultural Character | Provide a cultural character to the Building and its occupants and users |
| **SA 4** | Building Economics | Encourage comprehensive and life-cycle building economic considerations in building development |
| **SA 5** | Security | Provide effective security to the Building and its occupants and users |
| **Neighbourhood Amenities (NA)** | | |
| **NA 1** | Provisions for Community | Provide spatial and facility provisions in the Building that benefits to the community |
| **NA 2** | Transportation | Provide convenient and sustainable transportation services within or around the Building |
| **NA 3** | Sustainability Economics | Recognise the effort of the additional expenditure on improving environmental and social performance |
| **Site Impacts (SI)** | | |
| **SI 1** | Site Environment | Consider existing environmental conditions of the land and its surroundings |
| **SI 2** | Nature Conservation | Conserve and enhance the natural environment by preserving landscape resources and protecting the ecological value of the site |
| **SI 3** | Heritage Conservation | Conserve and protect archaeological and historic buildings, monuments, components and artefacts |
| **SI 4** | Buildability | Design and construct the building and its facilities ease of construction and less materials used, and encourage the use of innovative construction technology to enhance buildability |
| **Neighbourhood Impacts (NI)** | | |
| **NI 1** | Environmental Impact Assessment | Avoid environmental impacts and to mitigate adverse effects due to environmental impacts of the Building |
| **NI 2** | Environmental Interactions | Minimise adverse environmental impacts the surrounding buildings and streets due to the Building form and arrangements |
| **NI 3** | Impacts to Communities | Encourage public participatory approached planning, and to minimize social problems generated from the building that cause adverse impacts to the community and surroundings |

# Appendix M: NABERS (national australian built environment rating system)

NABERS category definitions (Bannister 2012); (NABERS, 2019).

| Term | Definition |
|---|---|
| **Assessor** | An Accredited Assessor of the NABERS scheme, authorised by the **National Administrator** to conduct accredited ratings. |
| **Base case model** | A reference model that represents the space type as it is expected to operate. |
| **Date of Agreement** | Agreement Date means the date the Commitment Agreement fee payment has been received *and* NABERS / OEH have counter-signed the Commitment Agreement contract. The Agreement Date will be designated by NABERS/OEH. |
| **Estimate** | A realistic Estimate of the NABERS rating of a new or refurbished space type, developed in accordance with the requirements of this Handbook. The Estimate does not constitute a NABERS Accredited Assessment. |
| **Estimator** | The person who develops the NABERS Estimate. While there are no compulsory requirements for the Estimator's qualifications or experience, it is recommended that the Estimator's skills include:<br>• Ability to conduct a NABERS performance assessment for the relevant project type. This could be demonstrated, for example, if the Estimator is an Accredited **Assessor**<br>• Ability to construct a thermal simulation in an appropriate **simulation package**<br>• Ability to identify performance risks that are likely to emerge for the types of building, services and technology covered by the Estimate. This could be demonstrated, for example, by the Estimator's experience working in existing buildings of this type. |
| **Independent Design Reviewer** | A person appointed by the project proponent to review the NABERS **Estimate** for compliance with this Handbook. The Reviewer will also assess all aspects of the design documentation and project team assumptions for NABERS risks and opportunities and report back to the project design team.<br>The Independent Design Reviewer must be:<br>• A member the NABERS Independent Design Review panel (appointed and maintained by the NABERS **National Administrator**)<br>• Independent of the project design team<br>• Independent of the NABERS **Estimator**. |

| | |
|---|---|
| **Metering system** | Device(s) providing an individual measurement which include all of the following:<br>• The meter<br>• The processes that convert the initial meter signal into an energy reading (for example, current transformers and K factors for electricity meters and pressure correction factors for gas meters)<br>• The interface through which the meter reading is taken (for example, manual readings, utility software or a Building Management System). |
| **Minimum energy coverage** | Minimum scope of energy consumption to be included in a NABERS Rating. The Minimum energy coverage is defined in the relevant version of **The Rules**. |
| **NABERS Energy Commitment Agreement or Commitment Agreement** | A contract between the NABERS **National Administrator**, the Office of Environment and Heritage NSW (OEH) and the building proponent to design, build and commission the premises to achieve a NABERS Energy star rating of 4 or more. |
| **National Administrator** | The body responsible for administering the NABERS scheme, in particular for:<br>• Establishing and maintaining the standards and procedures<br>• Determining issues that arise during the operation of the scheme and the making of ratings<br>• Accrediting assessors and awarding accredited ratings in accordance with NABERS standards and procedures. |
| **Off-axis model** | A model that represents the space type after factoring in a minimum of four off-axis scenarios. |
| **Off-axis scenario** | A scenario representing operational change/s, such as how a building is occupied, controlled or maintained. off-axis scenarios are designed to test a building's ability to reach the targeted star rating with modelled changes to assumptions and inputs. |
| **Online calculator** | The online calculator is available on the NABERS website. It allows the calculation of the star rating that would be achieved given specific rating calculation inputs. |

| | |
|---|---|
| **Rating types** | The NABERS Rating types covered by the **Commitment Agreement** process are:<br>• Office Energy – Base building, tenancy and whole building<br>• Shopping Centre Energy<br>• Hotel Energy<br>• Data Centre Energy – IT equipment, infrastructure, and whole facility<br>• Apartment Building (please contact the National Administrator for more information). |
| **Rating scope** | The rating scope identifies what energy coverage is required for a rating, and what inputs and methodologies are required to calculate the rating result.<br><br>For Offices, rating scope can mean:<br>• Base building<br>• Tenancy<br>• Whole building.<br><br>For Data Centres, rating scope can mean:<br>• IT equipment<br>• Infrastructure or<br>• Whole facility. |
| **Reverse calculator** | The reverse calculator is available on the NABERS website. Reverse calculators allow the calculation of the maximum amounts of energy and water a building can use to achieve a star rating that is specified. |
| **Ruling** | An authoritative decision by the NABERS **National Administrator** which acts as an addition or amendment to the NABERS **Rules**. |
| **Simulation model** | An entire building energy model used to calculate the thermal performance of a building in response to its external environment (e.g. weather) and internal loads (e.g. occupants and equipment).<br>The calculation process must account for hourly changes in loading, internal conditions, and the impact of the thermal inertia of the building. Minimum outputs from the simulation model include energy consumption, internal temperatures achieved and plant and equipment loading.<br>The thermal simulation model may be supplemented by a variety of other estimates such as simple spreadsheet calculations (e.g. for lift energy) or other simulation tools (such as for light levels). |

| | |
|---|---|
| **Simulation package** | A software package used to input, run and report on the thermal simulation model. The simulation package must meet the requirements of ANSI/ASHRAE Standard 140. The simulation must contain a thermodynamic representation of the building, its content and its environment. The thermal simulation model may be supplemented by other simulation tools (such as a simulation of light levels or data centre IT equipment) for small / low energy consuming systems. All large systems, such as the HVAC central plant, must be modelled in an appropriate simulation package. A variety of other estimation techniques may be used for small / low energy consuming systems, but all methodologies and assumptions must be described and disclosed for the Independent Design Review. |
| **Space type** | A building, or part of a building able to have its future operational performance estimated through a NABERS **Commitment Agreement**. The space types covered by the **Commitment Agreement** process are:<br>• Office<br>• Office tenancy<br>• Shopping centre<br>• Hotel<br>• Data centre<br>• Apartment building.<br>Some **space types** have multiple rating scopes available. See the **Rating scope** definition for more details. |
| **The Rules** | The version of the NABERS Rules that is current at the **Date of Agreement**. Separate Rules documents are published for each of the following space types:<br>• Office<br>• Shopping centre<br>• Hotel<br>• Data centre<br>• Apartment building<br>The latest versions can be found on the NABERS website.<br>The Rules must be considered together with any current **Rulings** issued by the **National Administrator**. |

Australian Government

COMMERCIAL BUILDING DISCLOSURE
A National Energy Efficiency Program

# BUILDING ENERGY EFFICIENCY CERTIFICATE

## BUILDING DETAILS

| | | | |
|---|---|---|---|
| Building name | Example Building | Certificate no. | B0085-2018/3 |
| Owner's name | LEADING OWNER PTY LTD | Current from | 29 Jan 2018 |
| Building address | 1 Example St, Sydney, NSW, 2000 | Current to | 22 Jan 2019 |
| Net Lettable Area of the building 16,678.7 m² | | CBD assessor name | Sample Assessor |
| | | CBD assessor no. | CBDA0XXX |

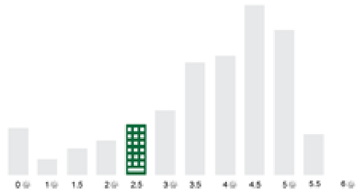
## PART 1 - NABERS ENERGY RATING

NABERS

This building has

2.5 STAR NABERS ENERGY RATING

(excluding GreenPower)




HOW DOES YOUR BUILDING COMPARE?

The highlighted building on the adjacent graph compares the NABERS Star rating of your building to other buildings that were issued a BEEC nationally in 2015.

## PART 2 – TENANCY LIGHTING ENERGY EFFICIENCY ASSESSMENT

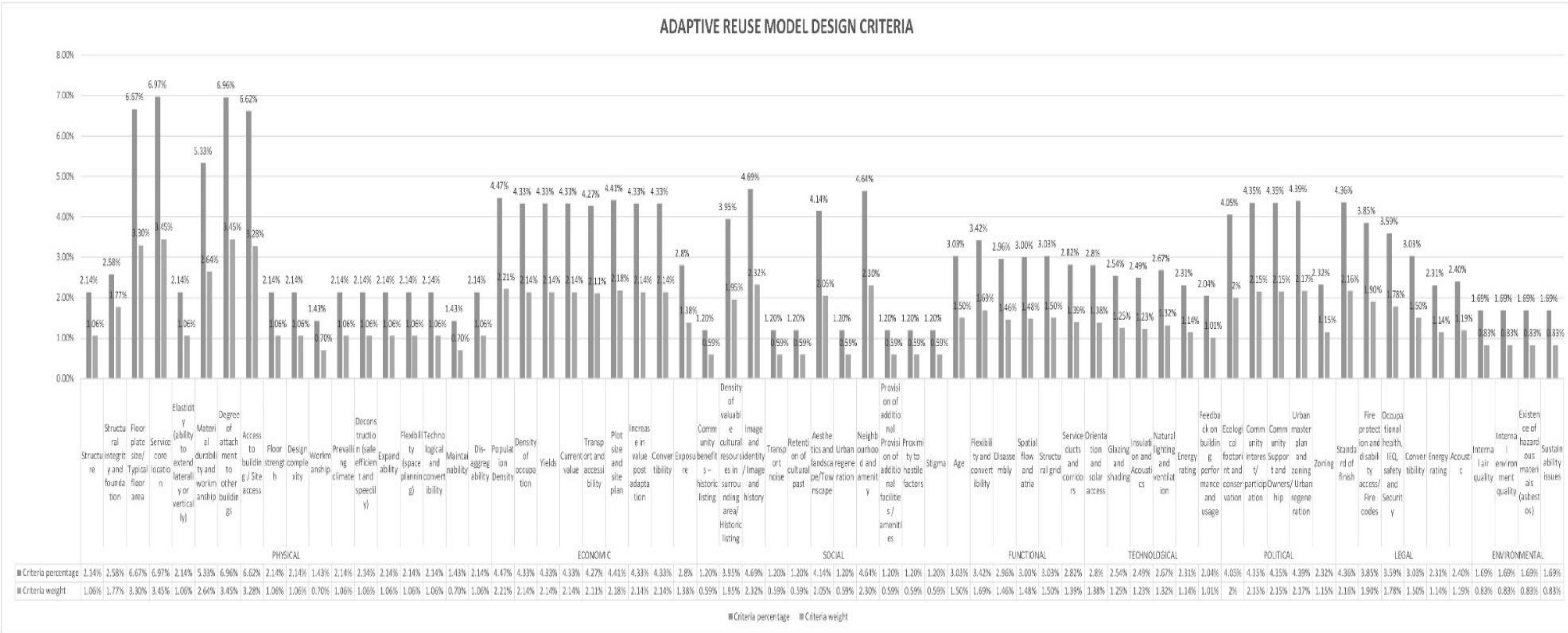
The average tenancy lighting efficiency in the assessed spaces of your building is 'Very Poor'.

| YOUR LIGHTING | NATIONAL AVERAGE |
|---|---|
| Excellent | Excellent |
| Good | Good |
| Median | Median |
| Poor | Poor |
| Very Poor | Very Poor |

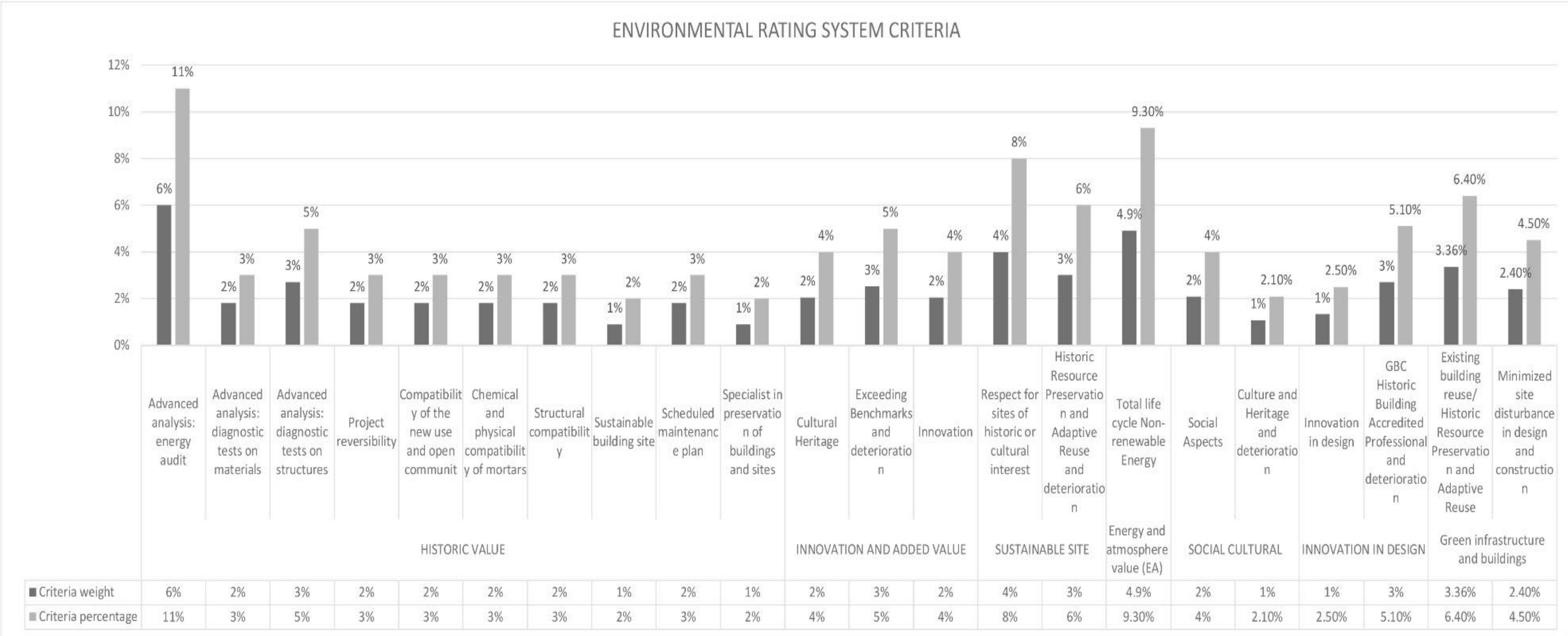
This table shows how your building compares with other buildings that were issued a BEEC nationally in 2017.

These averages are area-weighted. Individual spaces may perform better or worse than the average.

The worst performing space in this building is Level 12 – Whole Floor (27.0 W/m²). The full Tenancy Lighting Assessment is on page 3, and shows details of all assessed spaces.



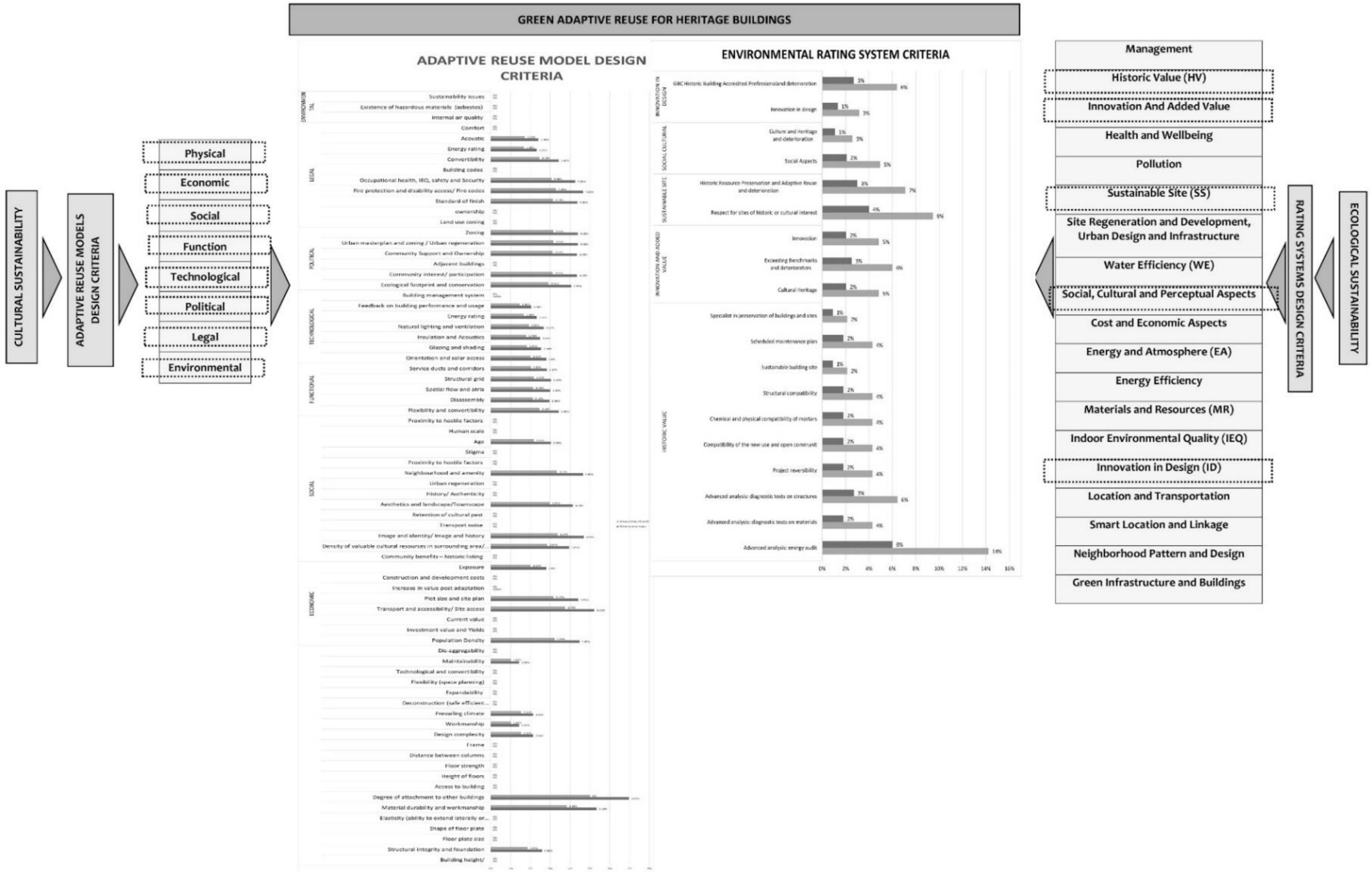

Percentage score criteria extracted from ARM sheet for criteria and sub- criteria




| | HISTORIC VALUE | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Advanced analysis: energy audit | Advanced analysis: diagnostic tests on materials | Advanced analysis: diagnostic tests on structures | Project reversibility | Compatibility of the new use and open communit | Chemical and physical compatibility of mortars | Structural compatibility | Sustainable building site | Scheduled maintenance plan | Specialist in preservation of buildings and sites |
| Criteria weight | 6% | 2% | 3% | 2% | 2% | 2% | 2% | 1% | 2% | 1% |
| Criteria percentage | 11% | 3% | 5% | 3% | 3% | 3% | 3% | 2% | 3% | 2% |

| | INNOVATION AND ADDED VALUE | | | SUSTAINABLE SITE | | Energy and atmosphere value (EA) | SOCIAL CULTURAL | | INNOVATION IN DESIGN | | Green infrastructure and buildings | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Cultural Heritage | Exceeding Benchmarks and deterioration | Innovation | Respect for sites of historic or cultural interest | Historic Resource Preservation and Adaptive Reuse and deterioration | Total life cycle Non-renewable Energy | Social Aspects | Culture and Heritage and deterioration | Innovation in design | GBC Historic Building Accredited Professional and deterioration | Existing building reuse/ Historic Resource Preservation and Adaptive Reuse | Minimized site disturbance in design and construction |
| Criteria weight | 2% | 3% | 2% | 4% | 3% | 4.9% | 2% | 1% | 1% | 3% | 3.36% | 2.40% |
| Criteria percentage | 4% | 5% | 4% | 8% | 6% | 9.30% | 4% | 2.10% | 2.50% | 5.10% | 6.40% | 4.50% |

Percentage score sheet for criteria and sub-criteria extracted from ERS




The framework to achieve a green adaptive reuse of heritage building