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SUSTAINABILITY RATING TOOL AND REHABILITATION MODEL FOR HERITAGE BUILDINGS

Al-Sakkaf, Abobakr[1,2*], Zayed, Tarek[3] and Bagchi, Ashutosh[1]
[1] Department of Building, Civil, and Environmental Engineering, Concordia University, Montreal, QC, Canada.
[2] Department of Architecture & Environmental Planning, College of Engineering & Petroleum, Ḥadhramout University, Mukalla, Yemen.
[3] Department of Building and Real Estate, The Hong Kong Polytechnic University, Hong Kong, Hong Kong.
[*] Corresponding author: abobakr.al-sakkaf@mail.concordia.ca

Abstract: Heritage buildings are historically unique by nature and require specific attention to their architectural element. Due to the lack of the rating systems that have designed specifically for heritage buildings, it is essential to develop and validate a heritage building assessment tool that considers its specific characteristics. The utilized rating systems worldwide are identified, studied and compared to test their advantages and limitations. Results revealed twelve main rating systems. There was great variability among the systems which is mainly attributable to the fact that each of them is assessing a group of criteria including covering attributes that fit its local context. Therefore, it was not consistent across each system. Moreover, part of this variability can be explained by that the calculation methods used, and the numeric scales and threshold values used to cut the scale and rank the quality of sustainability into different categories are totally different among the 12 systems. Most importantly, these systems are lacking some important criteria e.g. energy which is considered essential when it comes to heritage building assessment. There was no single way that can be marked as the 'right one' to use especially in the heritage buildings. Therefore, it is recommended to develop and validate a heritage building-specific system by tailoring other rating systems to fit the context of heritage buildings.

1 INTRODUCTION

1.1 Heritage buildings

Heritage buildings inherited from the past are a crucial component of our modern society. Heritage included those buildings, structures, artifacts, and areas that are historically, aesthetically and architecturally significant. Three key factors determine whether a property worth to be listed as heritage are: historic significance, historic integrity, and historical context. Historic significance is related to how valuable the property to the history, archaeology, engineering or culture of a community. This includes any heritage building that is associated with a past event or an important person in addition to those building that has a distinctive physical characteristic. Historic integrity is relevant to the authenticity of the building identity with existing evidence of its unique physical characteristics during the building's historic period (Central Public Works Department 2013).

1.2 Building Sector and Related Environmental Impacts

The rapid increase in energy consumption has brought worldwide attention to its significant environmental effect as this was obvious in the case of greenhouse gas (GHG) emission, global warming, and climate change. This increase was associated with the growth of urbanization and industrialization in both developing and developed countries which in turns led to a rising in energy consumption. Figure 1,2 shows the top-ranked countries that contributed to global warming. The building sector is a significant contributor to energy consumption in the world. Buildings e.g. living, commercial. public places require around 2 billion Tons Oil Equivalent (TOE) fuel, which is about 31% of fuels for global energy use. Buildings also consume 0.84 billion TOE in electricity and heating, which is about 46% and 51% for energy use. The consumption of building sector on developing countries is about 20% - 25%, while on the developed countries is about 30% - 40% (Zhang et al. 2010, IEA 2010 and Akande 2015).

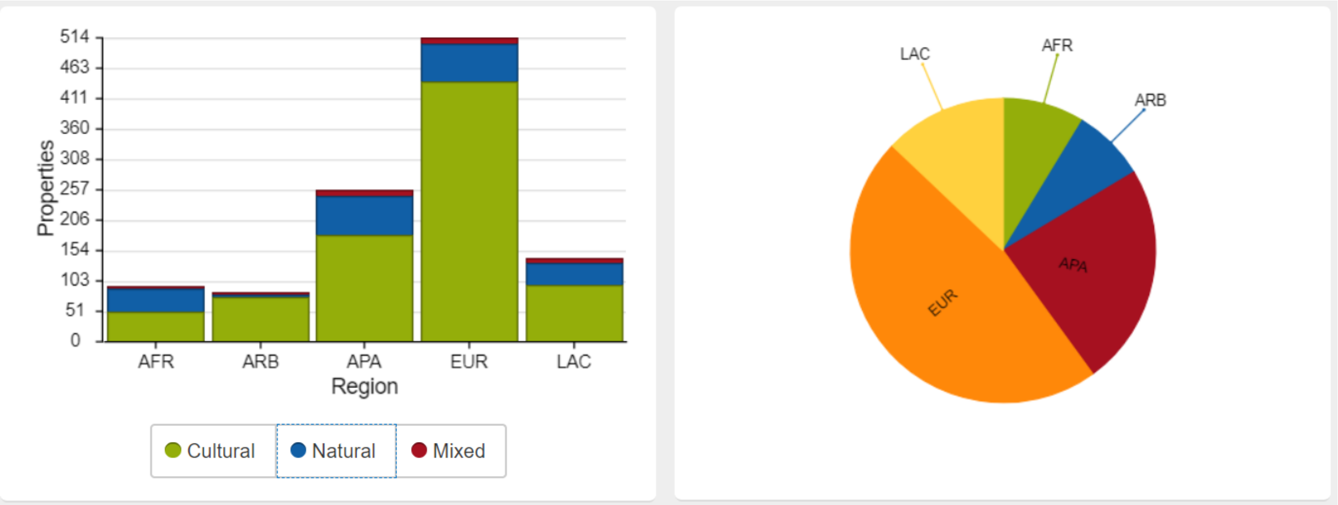

Figure 1: Summary of the number of World Heritage buildings by region (McLennan 2004)

Figure 2: Global warming culprits judged by size (Environmental Research Letter adapted from New Scientist Magazine 2014)

2 RESEARCH OBJECTIVES

Literature for this review was mainly obtained from 12 rating systems. The main objectives of this review were as follows:

a. compare different existing rating systems for sustainable buildings
b. identify different categories that affect the rating systems
c. review different ways of calculating the rating systems;
d. investigate different scales that evaluate buildings in each rating system

3 LITERATURE REVIEW

The literature review addresses the several sustainability-rating systems have been developed in the last few decades. These rating systems focused on the buildings sustainability performance e.g. BREEAM, LEED, ITACA, and others. Each system has its own assessment attributes which are based on its local context in terms of geographical and climate settings. Due to the variability of the settings and surroundings, none of them propose a unique guide on the best cost-effective rating measure that can be used by the decision makers to upgrade their buildings.

3.1 Energy Performance of Heritage Buildings:

Energy performance of a building was defined by Poel et al. (2007, p.395) as '…the amount of energy actually consumed or estimated to meet the different needs associated with a standardized use of a building'. According to the authors, this amount is reflected on one or more numeric indicators calculated while considering other parameters: insulation, technical and installation characteristics, design and position, climatic aspects, solar exposure, an influence of neighboring structures, building's own energy production; and indoor climate that affects the energy demand. Due to increased demand for improving energy performance to meet carbon reduction targets, new buildings are constructed to be more energy efficient than older ones (DCLG, 2006).

The authors (Rye 2010; 2011 & Baker, 2011) pointed out different software accompanied by other methodologies which characterized by built-in inflexibility and can predispose older buildings to inaccurate energy efficiency ratings. Meanwhile, Moran et al. (2012) stated that despite government statistics showing higher CO2 emission levels of modern buildings than their heritage peers, yet there were differences in how the energy efficiency of those buildings was evaluated. These differences emanate from many types of research that have been geared towards investigating and modeling the thermal and energy performance in heritage buildings. The differences in assessing methods of energy performance of the heritage buildings have rather led to more conflicting claims to consider heritage buildings as either good (Wallsgrove, 2008; English Heritage, 2009; Wood, 2009) or poor (DCLG, 2006; EHCS, 2007; Boardman, 2007; DCLG, 2006) in terms of energy performance.

4 RESEARCH METHODOLOGY

The main aim of this review is to provide a comprehensive comparison among the different rating systems used around the world and how they can be tailored and applied to fit the unique nature and characteristics of the heritage buildings. Furthermore, this review can be considered as the first step toward developing and validating a unique rating system that can address the main attributes related to heritage buildings. This can be achieved by using one of the most important decision support techniques Fuzzy Logic with emphasis on the artificial immune systems optimization technique, which is one of the evolutionary multi-objective optimization techniques.

The primary sources involved in this review were the published journal articles in addition to technical reports, manuals and guides of rating systems used by different organizations. Moreover, the first author (A.A.) has contributed to several workshops to broaden his horizons and understanding of the different rating systems and the way they have been used. Published literature was accessed through google search using relevant search phrases such as comparison of the building rating systems around the world; building rating systems used in Canada, USA, UK, Europe, Japan, Indonesia, Singapore; comparison of the different rating systems of heritage buildings. In addition, other sources have been accessed through the Concordia University library as shown in Figure 3.

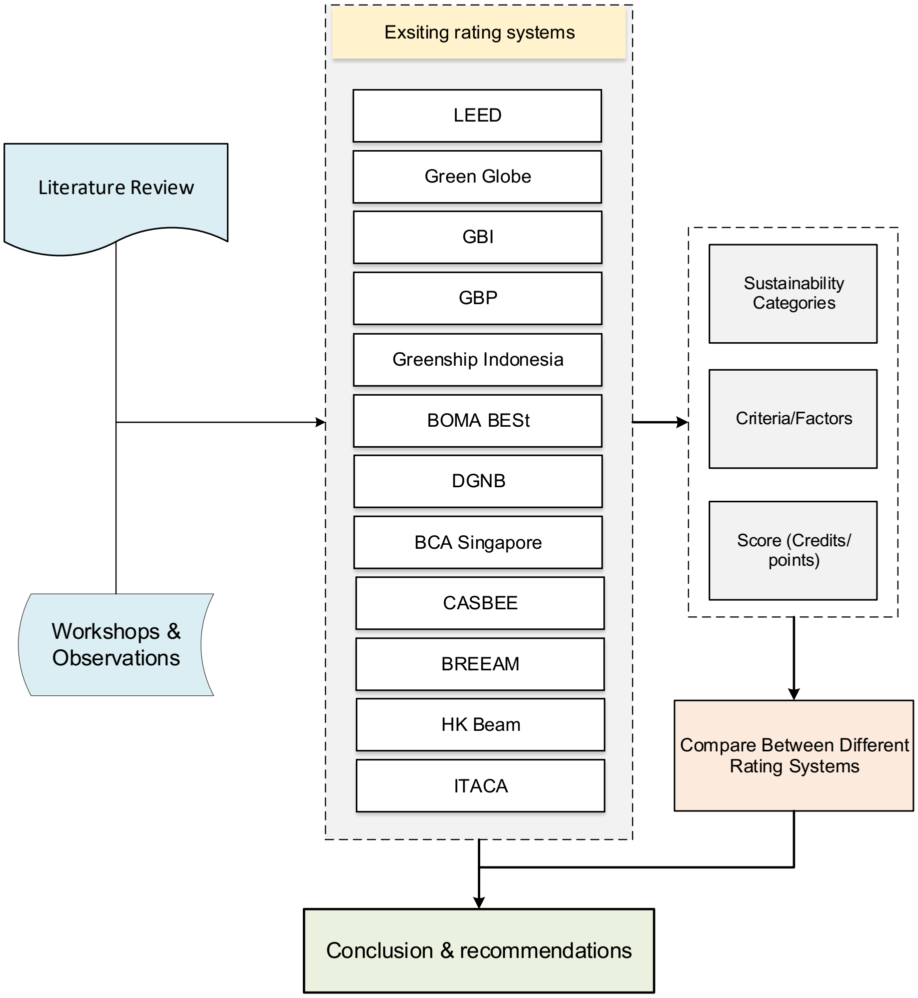

Figure 3: Research flowchart

5 EXPLORATION AND COMPARISON

The exploration is conducted by comparing different worldwide rating systems that are used to evaluate heritage buildings. The comparison is based on sustainability categories that are based on three principles (environmental, social and economic), criteria or factors such as energy and indoor environmental quality (IEQ) and type of score used such as (Fail, Pass, Outstanding) and (Certified, Silver, and Platinum). For instance, the LEED rating system has 8 factors and 4 levels of the score while CASBEE Japan has 2 factors and 4 levels of a score. Table 1 illustrates the rating systems used along with the criteria of comparison.

In this part of the exploration, the goal is to obtain a more accurate rating system to evaluate heritage buildings in terms of energy, management, and heritage rehabilitation methods. For analysis, the most important rating system mainly has a high number of factors to maintain and improve the sustainability in the heritage building. This part focused on the existing rating systems for sustainable buildings of this review were as follows:

5.1 Leadership in Energy and Environmental Design (LEED)

LEED is a rating framework that assesses eight main elements concerning the sustainability of building through its life cycle. It was established in the US in 1998. To accomplish LEED accreditation, a building will be assessed for eight items: location and transportation (LT), supportable site (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), indoor environment quality (IEQ), innovation in outline (ID), and regional priority (RP). There are a few variants of LEED depend on two main factors: 1. building types e.g. new construction, existing buildings, commercial interiors, core and shell, homes and the neighborhood advancement 2. scale used. Table 1 represented that summary of rating and certification framework with the four main levels: Certified (40 - 49), Silver (50 - 59), Gold (60 - 79), or Platinum (+80).

5.2 Green Globe

The Green Globe framework gives an online evaluation convention, rating framework, and guide for green building design, operation, and maintenance. This protocol came as a tool that has a market acknowledgment of a building's natural traits through outsider confirmation. In 2005, GBI has replaced the green globe and has been used by primary green building association as a standard developer for the American National Standards Institute (ANSI). Later, in 2010 an official Green Globes ANSI standard has come to play. However, recently many engineers and administrative organizations tend to use the Green Globe rating framework e.g. the Canadian federal government, which has implemented the program on their real estate stock.

5.3 Green Building Index (GBI)

Malaysian Institute of Architects originally presented the GBI in 2009, which was privately used to survey the execution of the green structures. The GBI contains six appraisal criteria: energy efficiency, indoor environmental quality, supportable locales arranging and administration, material and assets, indoor environmental quality, and sustainable sites planning and management. Table 1. presented the four fundamental orders used by GBI to express sustainability: Certified (50 - 65), Silver (66 - 75), Gold (76 - 85), and Platinum (86 - 100) (GBI, 2011; GREENBUILDINGINDEX SDN BHD, 2016).

5.4 Green Building Program (GBP)

The Green Building Program (GBP) was developed to enhance energy efficiency performance through raising awareness of the public sector and improving their recognition. To participate, in an energy review, an action and execution plans, and commitment to reporting energy consumption on regular basis need to be provided. GBP provides modules that characterize the technical nature of an appropriate committee for each energy service provided by the GBP. Such modules are supplemented by guidelines on relevant issues, such as financing, energy audits, and energy management.

5.5 Greenship Indonesia

The Green Building Council in Indonesia presented the Greenship rating framework for assessing the new development in 2010 and 2011. However, for the existing structures, they have been using another rating framework that evaluates six areas: site development, energy efficiency and conservation, water conservation, material resources, and lifecycle, indoor health and comfort, and building environment management. Greenship incorporates four fundamental evaluations, which are: Bronze (min. of 35%), Silver (min. of 46%), Gold (min. of 57%), and Platinum (min. of 73%) (GBC Indonesia, 2011; GBC Indonesia, 2012).

5.6 Green Globes (BOMA BESt)

The Building Owners and Management Association (BOMA) developed the Building Environmental Standard (BESt). It is a voluntary program, developed in 2005 in Canada that provided building owners and builders with a framework for assessing the environmental performance and management of existing buildings. It tackles six assessment aspects, which are: energy, water, waste and site, emissions and effluents, indoor environment, and environmental management system. It comprises five main levels of certification, which are: Certified (min. of 59%), Bronze (60-69%), Silver (70-79%), Gold (80-89%) and Platinum (90-100%) (BOMA Canada, 2013; Smiciklas, 2016; the Building Owners and Managers Association of Canada Inc., 2013) as showed in table 1.

5.7 German Sustainable Building Council (DGNB)

The DGNB relies on the regular improvements of its baseline certification framework, that is why it has been one of the crucial frameworks around the world. The DGNB accreditation framework tends to touch on financial matters, ecological, and socio-cultural perspectives. The framework covers all buildings perspectives through their whole lifecycles, which provide decision makers with information to characterize their sustainability targets at the planning stage. Furthermore, the DGNB gives a scoring framework covering six criteria covering sixty-four subtopics. The accreditation framework given by DGNB involved 4 levels: Certified (underneath 35), Bronze (35 - 50), Silver (50 - 65), Gold (65 - 80) as shown in table 1.

5.8 BCA Green Mark Singapore

The BCA Green Mark was presented in 2005 to encourage constructing more environment-friendly buildings, to improve sustainability in the built environment, and increase the familiarity of engineers, architects, and developers with the scale, when they begin their plan for aimed development. It assessed the five aspects: energy efficiency, water efficiency, environmental protection, indoor environmental quality, and other green features and innovations. It uses the following four rating benchmark scheme: Green Mark Certified (50 - 74), Green Mark Gold (75 - 84), Green Mark Gold Plus from (85 - 89), and Green Mark Platinum from (+90) (BCA, 2012; Singapore Government, 2016) as summarized in table 1.

5.9 CASBEE Japan

The Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) was introduced in Japan by 2001. CASBEE's core principle is composed of two fundamental groups: 1) building environmental quality (Q), which covers indoor environmental quality, quality of services and outdoor environment on-site, and 2) building environmental load reduction (LR), which focuses on energy, resources and material, and the off-site environment. The final grade is estimated by calculating building and environment efficiency ratio (BEE). A set of three equations are used as follows steps: 1) obtaining the score of each group; 2) estimating the final ranking, and 3) benchmark based on the obtained final ranking. The final CASBEE benchmarks are presented in Table 1 (JaGBC, 2008).

5.10 BREEAM

The Building Research Establishment Environmental Assessment Method (BREEAM) is a voluntary rating framework for green structures that was set up in the UK in 1990. BREEAM used a direct scoring framework which is straightforward and easy to calculate. These scores consider ten topics with underlying fifty criteria to evaluate the sustainability of the building. The quality of building sustainability can be categorized into six different categories depending BREEAM score percentage (0-100%): Outstanding (above 85), Excellent (70-84), Very Good (55-69), Good (45-54), Pass (30-44) and Unclassified (below 30). In general, BREEAM has positively affected the design, development, and administration of structures. Also, it has been viewed as a powerful tool to characterize and keep a thorough quality assurance and accreditation standards. Moreover, BREEAM is appropriate for an extensive variety of building types. It contains nine assessment criteria, which are: management, health, and wellbeing, energy, transport, water, material, land use, ecology, and pollution. The final score is calculated using three steps: 1) calculating the ratio between the achieved points and the number of available points in each criterion; 2) multiplying the weight of each criterion by the percentage of the achieved points; and 3) summation of the resulting product from each criterion. Table1. presented the benchmark scores based on final score: Outstanding (+85%), Excellent (70% - 84%), Very Good (55% - 69%), Good (45% - 54%), Pass (30% - 44%), and Unclassified (below 30%) (BRE, 2015).

5.11 HK Beam

The Building Environmental Assessment Method (BEAM) is a mandatory evaluation tool that has been used by the private sector for evaluation of the green structures in Hong Kong. It was developed in 1996 by modifying the UK Building Research Establishment tool BREEAM. This rating was made for improving the nature of structures, diminishing their ecological effect along their lifecycles, and assessing the office administration researchers. The evaluation estimates the buildings lifetime from administration to activity and support. This tool incorporates the seven following aspects: the site, management, water use, energy, material and waste, IEQ, and innovations. It has four ratings as follows: Bronze (above average) for an overall percentage of 40%, Silver (Good) for overall percentage of 55%, Gold (very good) for overall percentage of 65%, and Platinum (Excellent) for an overall all percentage of 70% (HK GBC, 2012; Kelcroft, 2016).

5.12 ITACA

In 2001, an Italian interregional group at the Institute for Transparency of Contracts and Environmental Compatibility built up ITACA protocol which is a national system of certification of environmental sustainability. It originated from the idea of sharing a global normal standard (the SB-technique), an approach created in the examination procedure of the International Green Building Challenge and has been considered by the International Initiative for Sustainable Built Environment (IISBE) since 2002. Italy took part in this exploration by adjusting the technique to the national settings. Recently, the Italian Standardization Institute UNI issued a standard draft entitled “Environmental sustainability in construction tools for the sustainability assessment” which has been under discussion till now. The assessment procedure described by the UNI draft was based on the ITACA protocol and the European models for sustainability assessment in development (Asdrubali, 2015).

Table 1: Comparison between 12 rating systems of Building Sustainability

Rating systems	Fail	1st rating	2nd rating	3rd rating	4th rating	5th rating	6th rating
LEED	< 40 credits	Certified	Silver	Gold	Platinum	Certified	
		40-49	50-59	60-79	80-116	40-49	
Green Globes	< 15 %	1 Globe	2 Globes	3 Globes	4 Globes	5 Globes	
		15% - 34%	35% - 54%	55% - 69%	70%-84%	85%-100%	
Green Building Index	< 50 points	Certified	Silver	Gold	Platinum		
		50-65	66-75	76-85	86-100		
Green Building Program (GBP)	< 35 %	Bronze	Silver	Gold	Platinum		
		≥60% - <70%	≥70% - <80%	≥80% - <90%	≥90% - <100%		
Green ship Indonesia	< 35 %	Bronze	Silver	Gold	Platinum		
		≥35% - <46%	≥46% - <57%	≥57% - <73%	≥73% - <100%		
Green Globes (BOMA BESt)	< 30%	1 Globe	2 Globes	3 Globes	4 Globes	5 Globes	
		30% - 39%	39% - 59%	60% - 79%	80%-89%	90-100%	
German Sustainable Building Council (DGNB)	< 50 points	Certified	Silver	Gold	Platinum		
		50-65	66-75	76-85	86-100		
BCA Green Mark	< 50 points	Certified	Gold	Gold Plus	Platinum		
		50-74	75-84	85-89	90-180		
CASBEE (Japan)	< 50 points	1 star (Fairy Poor)	2 stars (Poor)	3 stars (Good)	4 stars (Very Good)		
		BEE<0. 5	BEE=0.5-1.0	BEE=1.0-1.5	BEE=1.5-3.0		
BREEAM	< 10 %	1 star* (Acceptable)	2 star** (Pass)	3 star*** (Good)	4 star**** (Very Good)	5 star***** (Excellent)	6 star****** (Outstanding)
		≥10% - <29%	≥29% - <40%	≥40% - <55%	≥55% - <70%	≥70% - <85%	≥85% <100%
HK BEAM	< 40 credits points	Bronze (Above average)	Silver (Good)	Gold (Very Good)	Platinum (Excellent)		
		≥40% - <50%	≥50% - <65%	≥65% - <75%	≥75% - <100%		
		50-65	66-75	76-85	86-100		
ITACA	< 40 credits points	D	C	B	A	A++	
		44	55	70	85	100	

6 CONCLUSION

This article is considered as a comparative study identified 12 rating systems that have been used worldwide. The paper illustrated that these systems differ in many ways. Each system covers a set of criteria which may or may not differ from the others. In my view, systems that take more aspects in their consideration are more likely to broadly cover the different aspects of sustainability than those with fewer criteria or items. In addition, some of these criteria may not directly apply to the heritage building. However, the unique nature of heritage building requires the addition of extra criteria that have not been covered in any of the previously mentioned rating systems. Moreover, the weight of each criterion and the calculation methods used in each system significantly contributes to system variability. Furthermore, the units by which score presented (credits/points); scale (row or percentage); and the threshold values that used to cut score and sort out the different building's sustainability quality categories. To conclude, there was no single way that stood out as the 'best one' to use especially in heritage buildings. Therefore, one should consider tailoring each scale to fit the context of heritage buildings. Therefore, there is a need to develop and validate the rating system that is heritage specific which can be a combination of all these rating systems. This will be explored in a future study.

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