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The development of building assessment criteria framework for sustainable non-residential buildings in Saudi Arabia

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ABSTRACT

To quantify the environmental impacts of building construction, many environmental assessment methods for measuring building performance have been proposed worldwide, such as BREEAM (UK), LEED (US) and Green Star (AU). However, much debate exists about the efficacy of these international assessment tools in measuring building performance outside their country of origin, due to global variations in climate, geography, economics and culture. To address this debate, this study proposes a framework for developing domestic sustainable non-residential building assessment criteria for Saudi Arabia. To create this framework, five major building assessment methods were compared with respect to their application methods, major characteristics and categories. Surveys were conducted with a range of Saudi sustainable construction experts to gain their expertise in reflecting the local context of Saudi Arabian construction. The Analytical Hierarchy Process (AHP) method was applied to evaluate survey data. Nine criteria and 36 sub-criteria were defined in this study for inclusion as the most appropriate assessment criteria for sustainable non-residential construction in Saudi Arabia. These criteria include water efficiency and energy efficiency, indoor air quality, materials selection, effective management, land and waste, whole-life cost, quality of service and cultural aspects.

1. Introduction

The Kingdom of Saudi Arabia is a major oil exporting country and produced 15.7% of the global oil supply in 2014 (BP, 2014). Rapid population growth in Saudi Arabia has expanded its construction industry, resulting in increased demand for new buildings, and in turn greater resource consumption (Lahn & Stevens, 2011). As a result, in 2010 the Saudi government launched the Saudi Green Building Council (SGBC) to apply the concept of green buildings into construction projects (SGBC, 2011).

Recent construction projects such as the King Abdullah City for Atomic and Renewable Energy (KACARE), was planned using the Sustainable Built Environment Tool (SuBET) framework to achieve a high sustainable urban design standard (Alwaer & Clements-Croome, 2010). Another example is the King Abdullah Financial District (KAFD) project, which adopted an applied sustainability design approach to deliver a number of key objectives, such as minimising water use and energy consumptions, improving indoor air quality, and reducing greenhouse gas emissions (Kurek, 2007). However, while the industry has used tools specific to sustainable construction, to date no assessment tools has been developed that broadly considers Saudi Arabia's specific climatic, societal and cultural contexts. Hence, there is a need to develop a building sustainability assessment tool to measure the extent to which the sustainability agenda are implemented in buildings in Saudi Arabia.

Previous studies have highlight that assessment methods created for one nation or region might not be applicable to others (Cole, 1999; Darus et al., 2009; Reed, Bilos, Wilkinson, & Schulte, 2009). In addition, a number of environmental factors may prevent the transfer of currently available environmental assessment tools to other nations (Mao, Lu, & Li, 2009; Suzer, 2015). Some of these factors include; climate, geography, resource consumption,

Abbreviations: A_{group}, group comparison matrix; AHP, Analytical Hierarchy Process; BREEAM, Building Research Establishment's Environmental Assessment Method; CASBEE, comprehensive assessment system for building environmental efficiency; CI, the consistency index; CR, the consistency ratio; HVAC, heating, ventilating and air-conditioning system; IEQ, indoor environment quality; KACARE, King Abdullah City for Atomic and Renewable Energy; KAFD, King Abdullah Financial District; LEED, leadership in energy and environmental design; QSAS, Qatar sustainability assessment system; RI, random consistency index; SAT, Saudi assessment criteria of sustainable buildings for non-residential purposes; SBC, Saudi building code; SGBC, Saudi Green Building Council; SuBET, Sustainable Built Environment Tool; UAE, the United Arab Emirates; USGBC, U.S. Green Building Council's; W, vector of weights (eigenvector); λ_{max}, principle eigenvalue.

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understanding of building stocks, the vernacular architecture, government policies and regulation, historical context, cultural values and level of public awareness. Many, if not all, of these factors vary across global regions. Therefore an understanding of the concept of sustainability for a given region may change with respect to these factors. Indeed, even designing environmental assessment tools applicable to a single nation where climate and topography vary could be a challenge. For example, Ali and Al Nsairat (2009) concluded that Jordan should develop a range of domestic environmental assessment methods due to its variations in climate and topography.

Saudi Arabia exhibits a range of different climates, cultures and topographic features and would benefit from implementing a domestic assessment method of measuring building performance.

In the last decade BREEAM and LEED attempted to make their assessment tools compatible with conditions of different regions in the World including the Middle East. However, it is revealed that they were not able to fully incorporate the social and cultural elements in the satiability assessment criteria. For instance, although BREEAM has released a BREEAM Gulf/Middle East assessment system, it was strongly influenced by BREEAM-UK, which assessed buildings based on the UK (Alyami & Rezgui, 2012). In another study, Todd, Crawley, Geissler, and Lindsey (2001) highlighted the importance of considering economic, social and cultural factors for developing domestic rating methods in developing countries. Importance of considering these elements in environmental and sustainable assessment tools has been also addressed in many studies in this field (Forsberg & Von Malmborg, 2004; Haapio & Viitaniemi, 2008a; Mao et al., 2009; Sinou & Kyvelou, 2006).

A number of Arabian countries in the Middle East have introduced domestic building assessment tools. For example, the United Arab Emirates (UAE) has introduced Estidama (AUPC, 2010b) and the Qatar Sustainability Assessment System (QSAS) is used in Qatar (GORD, 2012). Therefore, it would be beneficial for Saudi Arabia to develop its own assessment method, which ideally should consider a number of factors, such as vernacular architecture as well as cultural, social and economic contexts (Alyami & Rezgui, 2012).

Recently, the SGBC adopted the U.S. Green Building Council's (USGBC) LEED criteria as its official assessment tool for measuring building performance in Saudi Arabia (SGBC, 2011). However, there are presently no specific assessment tools that encompass the economic, social and cultural aspects in the assessment criteria.

To date, in terms of applying green building concepts and tools in Saudi Arabia, most attention has been paid to residential buildings (Alyami, Rezgui, & Kwan, 2013; Attia, 2013; Taleb & Sharples, 2011). However, new government policies encouraging international investment to improve private and national industry development have spurred commercial construction in the Saudi construction industry (Ameen, Mourshed, & Li, 2015). As a result, these is an increasing demand for non-residential buildings nationwide. To ensure success in implementation of the concept of sustainability in the building sector, architects, contractors, environmental engineers, clients and allied professionals should have a better Saudi-specific understanding of, and information about, the relationship between the various aspects of sustainability in non-residential construction projects.

2. Criteria of the buildings environmental assessment tools

Most building environmental assessment tools are similar in some of their criteria, which typically focus on site protection, energy and water consumptions, indoor environment quality, building materials, waste, pollution, resources, transportation and innovation (Forsberg & Von Malmborg, 2004; Dirlich, 2011; Kajikawa, Inoue, & Goh, 2011). These criteria are regarded as facets of the interaction between buildings and their environment (Reijnders & van Roekel, 1999). However, Dixon et al. (2007) believe that this common agreement between different assessment schemes indicates negligence of the economic and social aspects of sustainability, which could lead to a loss of balance among sustainability dimensions, thereby missing the real goals of sustainable development (Goh & Rowlinson, 2013). Furthermore, these tools were developed for a certain geographic context largely without considering regional variations in environment, economics and culture (Cole, 1998; Ding, 2008). Hence, adapting an assessment tool requires significant adjustment of its criteria, priorities, weighting coefficients and scoring benchmarks (Attia, 2013; Darus et al., 2009; Kajikawa et al., 2011).

Haapio and Viitaniemi (2008a) reviewed the predominant building environmental assessment tools developed in Europe and North America. To analyse these assessment methods, the authors categorised sixteen existing building environmental assessment tools using two classification methods: ATHENA and IEA Annex 31 (Energy Related Environmental Impact of Buildings). Based on these methods, the studied tools were classified into two principal categories so called, interactive software and passive tools. The study reported that a consideration of the experiences of different tool users—such as architects, engineers, and contractors—is important in developing assessment tools that tend to be defined differently due to varying cultures and regions. Haapio and Viitaniemi (2008a) concluded that in addition to environmental factors, existing building assessment tools should incorporate economic and cultural aspects to effectively transform into sustainability assessment tools.

Moreover, inflexibility, complexity and lack of consideration of weighting systems are identified as major barriers to the acceptance of any particular assessment method (Ding, 2008).

2.1. Weighting methods for assessment criteria

Almost all building assessment schemes, including BREEAM and LEED, share some common criteria such as water and energy consumptions for assessing building performance (Lee, Chau, Yik, Burnett, & Tse, 2002). However, the severity of these factors can vary across regions, depending on local factors such as climate, materials and building stock (Ding, 2008; Kajikawa et al., 2011; Rahardjati, Khamidi, & Idrus, 2010). Ding (2008) has suggested that a weighting system can provide opportunities to enhance environmental assessment scales through accommodating these regional variations.

Abdalla, Maas, Huyghe, and Oostra (2011) examined the approach of LEED with respect to weighting environmental parameters to determine regional priorities. They analysed the regional priority credits assigned for several LEED case studies in four different countries: Canada, Turkey, China and Egypt. The outcomes of research highlighted the weighting system as the core asset for an environmental assessment method. In addition, it is concluded that the lack of such a weighting system that allows for adjustments with respect to local priorities could be considered a fundamental drawback of the LEED system. This has been also implied in other research that developing a weighting system is a necessary phase in prioritising each assessment criterion to accommodate a particular local context (Ali & Al Nsairat, 2009; Alyami & Rezgui, 2012; Shaawat & Jamil, 2014). For example, the highest possible assessment ranking is 'excellent' for BREEAM and "platinum" for LEED. However, after comparing both systems, researchers found that LEED's 'platnium' rank is approximately equal to BREEAM's second-highest rating, 'very good', rather than to its 'excellent' rating. This difference is due to the variation in building codes and regulations between countries (Reed, Wilkinson, Bilos, & Schulte, 2011). This suggests that the weighting system of respective sustainable crite-