Examining indicators coverage in a sample of sustainable building assessment systems

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Examining indicators coverage in a sample of sustainable building assessment systems

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ABSTRACT

This research examines the usage of indicators and the attributes of sustainability they measure in 11 renowned sustainable building (SB) assessment systems from various regions of the world. The work develops and uses a "Comprehensive List of Sustainable Building Indicators (CLoSBI)" as a base-case to examine the indicators' usage in different SB assessment systems and to what extent these systems are consistent in their coverage of sustainability attributes. The results reveal a deep variation between examined practices, and a lack of consensus not only on the type and the optimal number of indicators used in a system, but also on the depth and breadth of coverage of various SB attributes. The results shows that, in general, most of the examined systems reflect a low to adequate comprehensive coverage, the highest of which is found in the environmental followed by social categories. On the other hand, the most of the examined systems reveal a very low representative coverage, which suggests that a large portion of important SB attributes across the three core dimensions of sustainability are not covered by any indicator. The economic dimension of building's sustainability reflects severe lack of comprehensive and representative coverage in all examined systems. The results also suggest that deep coverage of some SB attributes comes, in many cases, at the cost of underrepresenting some other important sustainability attributes. Furthermore, the research results demonstrate the usefulness of using the coverage analysis framework as a structured and efficient approach to evaluate the appropriateness of a set of indicators to assess the various aspects of SB attributes.

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Introduction

In recent years, there has been a greater interest in assessing and evaluating sustainable buildings and their performance. This has resulted in a wave of developing tools, metrics and methods for assessing sustainability in buildings by a wide range of researchers and organizations. Over the past three decades or so, a number of SB assessment systems (also called SB rating systems and Green building rating systems) have been developed worldwide (Berardi, 2012, 2011; Cole, 2006; Forsberg & von Malmborg, 2004; Haapio & Viitaniemi, 2008; Li, Chen, Wang, Xu, & Chen, 2017; Seo, Tucker, Ambrose, Mitchell, & Wang, 2006; Sev, 2011; Todd, Crawley, Geissler, & Lindsey, 2001). Leadership in Energy and Environmental Design (LEED), Building Research Establishment Environmental Assessment Method (BREEAM), The Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), Green Star are examples of such systems. These SB assessment systems are designed for assessing and evaluating the performance of buildings against a set of sustainability

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criteria during the life cycle of the building. These systems are gaining popularity worldwide, and as such, they are playing an important role in promoting and increasing the adoption of sustainable buildings and sustainability practices (Berardi, 2011; Haapio & Viitaniemi, 2008; Ding 2008; Retzlaff, 2008; Todd et al. 2001).

The most common way to assess the sustainability of buildings is to use indicators in a form of an assessment system; usually called an indicator-based or multi-criteria assessment system. Indicator-based or multi-criteria assessment systems, in which sets of indicators are used to assess the different dimensions of building's sustainability, are the most popular SB assessment systems (Berardi, 2012, 2011; Häkkinen, 2012; Illankoon, Tam, Le, & Shen, 2017). However, despite their importance and popularity, the usefulness and efficiency of these systems are still questionable (Berardi, 2011; Berardi, 2012; Conte & Monno, 2012; Devuyst, 2000; Ding 2008; Haapio & Viitaniemi, 2008). Literature refers to several limitations of these systems such as validity and reliability problems, lack of indicators that assess the social and economic aspects of sustainability, among others (Berardi, 2011; Conte & Monno, 2012; Haapio & Viitaniemi, 2008; Häkkinen, 2012; Illankoon et al., 2017). These systems have been developed independently, thus one can expect that they are not well harmonized with each other, and to some extent lack consistency. The variation among these assessment systems can be explained by several factors, among them differences between different regions and their needs, and the lack of an acceptable structured procedures that guides and controls the selection of a suitable set of indicators that cover the various SB attributes.

This research aims to examine the usage of indicators and the attributes they measure in 11 well-established and renowned SB assessment systems using a structured comprehensive analysis framework. The focus is on examining the extent to which the existing SB assessment systems capture and assess the various dimensions of building's sustainability. The data presented here is part of a larger ongoing research project that aims to develop a SB assessment system appropriate for Saudi Arabia. As reported in the literature, the first step in such a project is to identify and establish the key indicators used to assess and evaluate the building's sustainability and the extent to which these indicators capture and assess the various dimensions of sustainability (Li et al., 2017).

SB assessment: indicators, categories and subcategories

There is lack of consensus on the definition of sustainability in the built environment (Doan et al., 2017; Komeily & Srinivasan 2015; Berardi, 2013, 2011; Evans & Jones, 2008; Hopwood, Mellor, & O'Brien, 2005; Cole, 2004). Literature shows that there is no universally accepted definition of the term 'sustainable building (SB)' (Doan et al., 2017; Komeily & Srinivasan 2015; Berardi, 2013; Kibert, 2012; Cole, 2004; Fowke & Prasad, 1996). Although SB is a widely used term, the available definitions for it seem elusive, vague, incomplete and difficult to measure. However, despite the lack of a universally shared definition of SBs, there is general agreement to conceptualize building's sustainability as consisting of three distinct dimensions: environmental, social and economic (Langston & Ding, 2001; UNEP-SBCI, 2009; Zuo & Zhao, 2014). In addition, the increased use and adoption of SB assessment systems in the building industry worldwide is giving hope to reach more consensus on the definition of sustainability in buildings.

Indicator-based SB assessment systems are composed of sets of *indicators, grouped in categories and subcategories*, which used to assess and evaluate building performance. In general, an indicator is a measurable variable that its role in monitoring and evaluating a phenomenon has been established. SB indicators are measurable attributes or parameters of a building that are proved to contribute significantly to sustainability in buildings (Li et al., 2017; Nessa, Urbel-Piirsalua, Anderbergd, & Olssona, 2007). Ideally, an indicator should incorporate all variables that contribute to the attribute being measured although in many cases it is an impossible or very difficult task. SB assessment systems and research studies usually group indicators in a three-level hierarchical structure: indicators, subcategories and categories (Berardi, 2012, 2011; Illankoon et al., 2017; Li et al., 2017; Pintér, Hardi, & Bartelmus, 2005; Yu, Li, Yang, & Wang, 2015). Categories, which represent the common themes or

Data in Figure 4(c) also demonstrates that the comprehensiveness of coverage in the economic-related categories shows the highest variance (i.e. between 0% and 100%) compared to the other two dimensions of building sustainability (i.e. economic and social). It is clear that economic-related indicators and categories are still underrepresented in all of the examined SB assessment systems.

All dimensions of sustainability

Examining the comprehensiveness of coverage across the all three core dimensions of building sustainability reveals that most of the systems (i.e. 9 out of 11) reflect a low to adequate comprehensive coverage, as each one of those systems covers 60% or more of the sustainability categories specified in CLoSBI. Figure 4(d) shows that SBTool has the most comprehensive coverage of categories as it includes 96% (23 out of 24) of CLoSBI categories, while Green Mark system demonstrates the least comprehensive coverage of categories as it covers only 10 categories. A closer examination of Green Mark system which has the least comprehensive coverage of categories, reveals that it excludes over 58% (14 out of 24) of all categories, among them all the economic-related categories and about 57% of the social- and environment-related categories. This severe lack of comprehensive coverage raises major concerns about whether this system is truly a comprehensive multidimensional one, as it does not cover a wide range of important attributes of building sustainability. it is clear that 22 indicators are very little to capture all aspects of a complex phenomenon as SB. Another interesting observation is that GSAS covers 67% of sustainability categories with 58 indicators, compared to BEAM which covers 54% of the categories with 67 indicators. This finding suggests that the effective use of indicators is not about increasing their number but rather about the adequate distribution to ensure a proper coverage of all, or most, sustainability attributes across all categories and subcategories.

Conclusion and further work

The coverage analysis results reveal wide variations in the usage of SB indicators across examined systems. The results indicate a lack of consensus among examined SB assessment systems on the set of indicators used, the optimal number of indicators, and the SB attributes they measure/assess. The fact that 81.7% of the unique indicators are utilized in only one assessment system shows that most of the systems are using almost incompatible sets of indicators. Thus, it will not be a surprise that one building can rank highly on one system and yet perform lowly on another. The high variation level may suggest that these systems measure different sustainability constructs, which raises serious questions about their reliability and validity. These results support recent trends that call to some level of comparability among various SB systems by adopting a minimum common SB indicators (Li et al., 2017; Mattoni et al., 2018). This result reflects the fact that most of these systems, if not all, are developed independently and driven by data availability and market needs in different regions rather than by well-established model of building sustainability.

In general, the results reveal unbalanced coverage of SB attributes in most of the examined systems. In terms of *comprehensiveness of coverage*, most of the examined systems (i.e. 9 out of 11) reflect a low to adequate comprehensive coverage; as each one of them covers 60% or more of the sustainability categories. The highest comprehensive coverage is found among environmental categories where 8 out of 11 examined systems revealed adequate to high comprehensive coverage of environmental categories; each of those systems covers 82% or more of all environment-related categories specified in CLoSBI. Less comprehensive coverage is found in the social dimension where 4 out of 11 systems shows high comprehensive coverage; each of those systems covers 82% or more of the social-related categories. 6 of the 11 systems showed low comprehensive coverage of social dimension categories, where each of those systems cover less than 60% of the social categories. Regarding the economic dimension of sustainability, most of the systems (10 out of

11) shows absence or severe lack of comprehensive coverage; as these systems either have no indicators in the economic categories or cover less than 50% of those categories.

In terms of *representativeness of coverage*, results show that most of the examined systems (91% or 10 out of 11) reflect a very low representative coverage; as each one of them covers only 60% or less of the building sustainability attributes as specified in CLoSBI. These systems suffer from low representative coverage, with different levels, of the environment, social and economic sustainability attributes. 64% (8) and 73% (7) of the examined systems revealed low representative coverage in the environment- and social-related subcategories, respectively. The economic dimensions show a severe lack of representative coverage in 10 (out of 11) systems. As such, the economic dimension reflects the lowest comprehensive and representative coverage compared to the environmental and social dimensions of building's sustainability across all systems. The results also suggest that while *deep coverage* is a desirable characteristic to obtain a more accurate assessment of specific SB attributes, in many cases, especially with systems of fewer indicators, it comes at the cost of under-representing some important sustainability attributes and possible overweighting other attributes. The results suggest the need to strike balance between depth and breadth of coverage.

In addition to identifying some of the coverage problems and deficiencies inherent in the currently used SB assessment systems, the results of the study demonstrate the usefulness of using the developed coverage analysis and CLoSBI as a structured and more efficient approach for evaluating the appropriateness of a set of indicators in a sample of SB assessment systems. The coverage analysis approach developed in this research represents a significant step that can be built upon to bridge the knowledge gap reported in the literature regarding the lack of and need for structured, systematic procedure that enables the effective design and selection of appropriate SB indicators. The developed approach is also very useful as a tool to identify key common SB performance indicators across various assessment systems, thus can helpful in responding to recent calls to identify and use a minimum common set of indicators across all SB assessment systems (Li et al., 2017; Mattoni et al., 2018). Further work is needed to develop and formalize the developed systematic approach for selecting SB indicators.

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