



Customizing well-known sustainability assessment tools for Iranian residential buildings using Fuzzy Analytic Hierarchy Process



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ABSTRACT

The aim of this research is to customize the categories and criteria points of well-known sustainability assessment tools regarding the priorities in sustainability concerns of Iran in order to develop an Iranian sustainability assessment tool suitable for residential buildings. Therefore, common sustainability indicators of LEED, BREEAM, CASBEE and SBTool will be used as benchmarks for the evaluation process by Iranian professional experts to revise the points allocated in Iranian assessment tool. For the revision of the points in accordance with Iranian sustainability needs, FAHP method (Fuzzy Analytical Hierarchy Process) will be conducted. Afterwards, Iranian sustainability assessment tool, consisting of six levels of certification with categories and criteria points, has been designed to promote sustainability in the residential buildings. The reliability of the assessment tool has been confirmed by comparing performance sensitivity with the existing assessment tools in terms of the points given to each category. This will encourage Iranian construction practitioners to be more aware of worldwide sustainability assessment tools and of the way to implement sustainability in their residential building projects. Results can be a basis for further investigations on other indicators which are crucial for sustainability concerns of Iran and would provide a platform for inspiration of further sustainability solutions. Introduction of the priority weights of sustainability fundamentals will be a reference for further developing a more holistic assessment tool, considering more dimensions such as economic and social sustainability issues regarding Iranian residential buildings.

1. Introduction

Nowadays sustainability concept has gained worldwide recognition in the building industry by considering sustainability issues in construction [1–3]. The reason behind this fact lies in its major impact on natural environment [4]. For instance, building industry generates one third of CO₂ emission [5]. Moreover, United Nations has reported that this sector is responsible for nearly 33% and 25% of green house gas (GHG) emission and waste production, respectively.

In Iran, the large segment of building industry, which is formed by residential buildings, accounts for 40% of used energy [6]. Therefore, sustainable building concept considered a recent response to address environmental issues for the reduction of building impacts on natural environment [7,8]. In Iranian contemporary buildings, very small amounts of renewable energy sources have been used. However, sustainability of buildings necessitates cleaner energy sources for countries, especially developing ones [9]. Therefore, in order to practically consider sustainability in the buildings of developing countries [10], sustainability indicators should be incorporated in construction process

[7,11], exactly like the developed countries. Accordingly, for the creation of information concerning the environmental impacts of buildings [12], systematic and practical approaches must be implemented [13]. In such approaches, sustainability indicators act as a profitable guidance for planning or policy system. This guidance can also act as a tool providing information to ease decision making processes for better results. This helps to judge the sustainability of buildings and reduce the chance of arbitrary decisions in building construction [14]. The movements of developed countries toward the establishment of sustainability indicator list, which is called assessment tools, leads to different indicators and weighting scores suited for that country [15]. These assessment tools became references for building practitioners to promote sustainability of buildings by quantifying environmental performance [12,16] as well as collecting information for decision making in different phases of construction [13]. This helps to attain sustainable buildings which have situated crucial sustainability issues in the output. Sustainability assessment tools are not only beneficial for buildings, but also lead to healthier occupants. Since occupants spend nearly 90% of their time indoors [17], the air quality of

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indoors can influence the overall health of occupants [18]. These tools create healthier buildings for occupants by considering the quality of indoor environments, lowering building costs for energy and water use throughout the lifecycle of buildings (economical benefit), and attracting residents. Moreover, these tools consider physical health of occupants by encouraging materials and products with low volatile organic compounds. These materials will have minimal to no off-gassing and occupants can breathe easier and feel healthier [19]. Therefore, a building can improve the air and increase the overall long-term health of occupants. For occupant attraction, the sustainable aspect of buildings in the world are becoming a selling point for many costumers. In other words, sustainability assessment tools show tenants the commitment that a developer has to the environment, is in line with their ideals [19].

The tools, which gained a rapid worldwide recognition, are LEED (Leadership in Energy and Environmental Design), BREEAM (Building Research Establishment Environmental Assessment Method), SBTool (Sustainable Building Tool), and CASBEE (Comprehensive Assessment System for Built Environment Efficiency) [20]. Despite the fact that these tools have originated from developed countries, they are used or adapted for use in several other countries [21–26]. For instance, LEED assessment tool is used in more than 164 countries [27]. However, it should be noted that these tools are based on the local priorities of sustainability issues [12] and have been developed by local construction experts and stakeholders. Since the consideration of sustainability objective has become a priority in developing countries nowadays [28], these countries have started to use the common indicators of the well-known assessment tools as a starting point and a contribution to redevelop and revise assessment tools in accordance with regional sustainability requirements [12]. For instance, Ferreira et al., [16] developed Portuguese sustainable building assessment tool benchmarked with BREEAM and LEED, or Lee & Burnett [23] customized SBTool for Hong Kong. Vyas and Jha [29], evaluated widely used green building assessment tools such as BREEAM, LEED, SBTool, CASBEE, etc. to develop a suitable assessment tool for India. Ali and Al Nsairat [28] designed an assessment tool suitable for Jordanian context through interviews with local experts, with a focus on LEED, BREEAM and SBTool, to determine assessment indicators respecting the local conditions. Therefore, by adapting international assessment tools to local contexts, it became possible to implement sustainable building programs as references for construction in such countries [24]. There are a few researches regarding sustainability assessment tools in Iran. For instance, Namini et al. [30] introduced a new criteria-based sustainability assessment tool for residential buildings in Iran by considering the ‘project management body of knowledge’ as a reference for developing categories and a guideline to define a framework for evaluating different phases of construction. Moreover, Nemati et al. [25] endeavored to develop a theoretical model to describe views of sustainable architecture in Iran. Although these researches tried to introduce sustainability assessment tools, there is a lack of research study regarding the customization of “international sustainability assessment tools” according to sustainability concerns of Iran [31] in terms of well-known categories of such tools for residential buildings.

Just as other developing countries, as a starting point, Iran needs to employ international assessment tools for buildings, especially in residential sector, to prioritize sustainability issues adapted to sustainability requirements of Iran. As a result, a revision of common indicators of well-known assessment tools should be conducted by professional experts of Iran. Therefore, the aim of this research is to develop residential sustainability assessment tool suitable for Iranian context with a focus on common sustainability indicators of LEED, BREEAM, CASBEE and SBTool, to determine new assessment indicators respecting the local conditions.

Although, sustainability of a building can include many issues, the development of Iranian sustainability assessment tool will be based on common categories of international assessment tools. Considering the

fact that sustainability is a new subject in Iran and since only a few researches regarding the development of sustainability assessment tool for Iranian residential buildings exist, the proposed tool is aimed to be developed on the basis of categories which are considered as global concerns of the sustainability. It should be noted that the newness of sustainability subject in Iran has led to less awareness about the aforementioned subject among the building practitioners. Accordingly, awareness raising for all the practitioners requires the development of a tool as a starting point for the assessment of sustainability in residential buildings in Iran. With the help of common categories, the information on complex issues for Iranian building practitioners, can be revealed in simplified and comprehensible formats. This action will not only raise public awareness of the key categories of worldwide sustainability issues among building practitioners of Iran, but also will be a solid basis on which Iranian assessment tool will be further modified in the future. It should be noted that according to the most of studies, which have compared widely used international assessment tools with each other, all of these tools have been developed on the basis of the common categories [32–35]. For instance, the comparison of BREEAM, LEED, CASBEE, SBTool etc. has showed that common categories are situated in these tools and such categories are found to be the basis for most of international assessment tools [36].

Moreover, the research compared and benchmarked the new assessment tools with the aforementioned assessment tools in terms of their indicator rankings and priorities.

Since the evaluation of indicators is a multi-criteria decision problem and decision-making is often a much more fuzzy process [37–39], the multi-criteria decision-making (MCDM) method of Fuzzy-AHP has been employed to weight the indicators based on sustainability concerns of Iran. It should be noted that multi-criteria decision-making method is considered an excellent choice for sustainability assessment problems [40]. This method is currently amongst the mostly used methods in sustainability assessment e.g. Refs. [41–43].

The objectives of this research are as follows:

- 1 Investigating the common indicators of well-known sustainability assessment tools to develop a minimum sustainability requirement for residential buildings of Iran.
- 2 Pairwise comparison and evaluation of common indicators based on Iranian sustainability concerns, using Fuzzy-AHP method.
- 3 Comparing the new assessment tool with LEED, BREEAM, CASBEE and SBTool as well as investigating the performance sensitivity of international assessment tools in terms of the newly developed Iranian assessment tool.

This will encourage Iranian construction practitioners to be more aware of worldwide sustainability assessment tools and of the way to implement sustainability in their residential building projects. Moreover, this action will lead to further investigations for other indicators crucial for Iranian sustainability concerns and will provide a platform for inspiration of further sustainability solutions. Introduction of the priority weights of sustainability fundamentals will be a reference for further development of a more holistic assessment tool considering more dimensions (such as economic and social sustainability issues regarding Iranian residential buildings).

2. Literature review

2.1. Sustainability residential buildings specific to the context of Iran

In the developing countries, environmental problems continue to escalate in a way that necessitates advanced measures for sustainability promotions [31]. For instance, the conventional buildings in Iran consume a large quantity of natural resources [44]. Despite the unsustainability of modern buildings, traditional houses are of the prominent examples of sustainability specific to the context of Iran, which

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