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# Developing an Iranian green building assessment tool using decision making methods and geographical information system: Case study in Mashhad city

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ABSTRACT

Regarding the sustainable schemes, green building may be considered as an alternative for managing the energy use in developing countries such as Iran. Investigating green factors in the other systems, the aim of the present study was to propose a new set of comprehensive factors suits assessing green buildings and to evaluate them in the Iranian context to contribute a new aggregated rating tool for offices. Therefore, 8 major and 61 minor stakeholders were defined to cover all required criteria respecting previous studies, expert opinions and questionnaire forms. The defined criteria were weighted using multi criteria decision methods consisting of analytical hierarchy process, weighted harmonic mean and Shannon's entropy. Then, Iranian Green Building assessment Tool (IGBT), consisting five certification levels, was developed based on weighted factors to improve environmental, social and economic aspects in the construction process. After that, aggregating IGBT, Geographical Information System (GIS) and multi-criteria decision methods, the practical application of the proposed tool was implemented on 48 offices through a case study in the municipality of Mashhad, Iran. For this purpose, a spatial database of 612 land uses was prepared to determine certification levels of the office buildings in the study area. The assessment procedure, applied in GIS, demonstrated five certified office buildings. Results of designing IGBT showed that the energy efficiency and the water efficiency, with the total score of 39%, are the most significant factors for assessing green office buildings with respect to the vital circumstances of energy and water conservation. Also, comparing performance sensitivity to the five representative green building rating systems confirmed the reliability of the suggested tool based on measuring the criteria deviations. The outcomes provide a valuable reference to the policy makers in Iran and also could be a considerable suggestion to the future studies.



**Contents**



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## 1. Introduction

Today, the world is in a critical situation in energy conservation, carbon reduction and green house gas emissions reduction [1]. So, both academic and professional fields are trying to find new technologies, renewable resources and useful strategies to decrease $CO_2$ emissions [2]. Based on their achievements, buildings are responsible for more than one third of the total world energy use and greenhouse gas emissions. In the life cycle of buildings, the construction process, the operation step and the disposal procedure, effect on carbon gas emissions and energy consumption directly and indirectly [3,4]. Accordingly, energy management, waste minimization and environmental performance of buildings are heavily debated topics in the construction process [5]. Thus, the governments, research institutes and universities in developing and developed countries have done various researches to present suitable assessment standards and rating tools evaluating building's life cycle steps [6,7]. The results of these researches showed that developing standards can play a significant role in controlling energy consumption and reducing carbon emission [8–10]. Also, they indicate that modeling the behavior of buildings, as energy profiles, is a considerable matter in the long-term and short-term sustainability development strategies [11]. So, some developed countries such as the United Kingdom, the United States and Japan developed building's Life Cycle Assessment (LCA) standards to find suitable energy advice schemes and support green building design [7,12]. With respect to LCAs, a sustainable building or a green building refers to a friendly environment structure with an efficient energy consumption [13]. In addition, the process of green building design decreases operating costs, improves occupant productivity and assists to create a sustainable society [14]. On the other hand, green buildings bring together a large number of different practices, methods and abilities to reduce the impacts of structures on the human health and environment [1]. The sustainable design can be applied on different land uses such as residential, commercial, industrial, educational and official buildings [1,15,16]. Previous studies in the developed countries showed that office buildings are likely to have higher energy and comfort demands, especially in the urban areas. The design of sustainable office buildings emphasizes taking advantage of renewable resources and directly addresses the target of reducing operating energy [17,18]. The green design of office buildings includes finding the balance between the structure and the sustainable environment and needs close cooperation of the management team, the researchers, the architects, the engineers and the customers at all project steps [17].

Many national and regional certification systems were established for assessing green buildings in specific regions due to the differences in geographical properties, climatic conditions, cultural variations and potential energy resources. Certification systems such as BREEAM (Building Research Establishment Environmental Assessment Method) of the UK, CASBEE (Comprehensive Assessment System for Building Environmental Efficiency) of Japan, GBTool (Green Building Tool) of Multinational Cooperation, LEED (Leadership in Energy and Environmental Design) of the USA, BEAM (Building Environmental Assessment Method) of Hong Kong, GBL-ASGB (Green Building Labeling-Assessment Standard for Green Building) of China, SABA of Jordan, G-SEED (Green Standard for Energy and Environmental Design) of South Korea and Green Star (Green Star Rating Tools) of the Australia, all aim to determine the environmental performance grade of green buildings [3,13,19–22]. The existing methods provide different ranking criteria to evaluate energy efficiency. For example, weighted assessment system in BREEAM prioritizes environmental problems, while simple additive algorithm is used in LEED [8,14].

These assessment tools may not be adapted for the Iranian context because of the differences in standard practice or cultures, economic conditions and environmental issues. According to the reports, Iran benefits oil (around 15.9% of the world reservoirs) and natural gas (around 9.1% of the world reservoirs). However, the contribution of renewable and sustainable energy is less than 1% in this country [23,24]. Considering the international reports on ESI (Environmental Sustainable Index), Iran is among the lower ranking countries in terms of high $CO_2$ emissions. The percentage of total energy use and greenhouse gas emissions is reported higher than the world average for building sectors in Iran [24].

Analyzing the well-known systems, it can be identified that they do not involve the enough accurate factors for evaluation of green buildings in the Middle East countries with high level of energy resources. Popularizing factors and specification of weighting guidelines are extremely important for designers, architects and engineers to obtain common level of understanding through the green building design process. Also, these systems do not consider the spatial relations in the assessing process of green buildings. For example, the extent of an area and the pollution distribution may effect on the evaluation process of factors and their weights. Hence, it seems better to apply a spatial framework using Geographic Information System (GIS) considering a comprehensive technical point of view [25]. Many researchers have carried out lots of studies within the GIS environment to weight the spatial factors [26,27]. Combining GIS and Multi Criteria Decision Analysis (MCDA) provides a high level assessment tool to collect a large volume of green building spatial data based on standards. This aggregation can evaluate effective green factors considering environmental, technical and economic differences in a specific region. Also, the MCDA is a framework to simplify complex relations in the real multiple criteria problems for ranking selected options based on the best scenarios [28]. Taking the