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DETERMINATION OF IDEAL CRITERIA FOR DEVELOPMENT OF SUSTAINABLE BUILDING RATING SYSTEM IN IRAN'S COLD AND DRY CLIMATE (DENA)

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Abstract

Today, standards can be considered as reliable methods to be used in sustainable design of buildings. The aim of creating building rating systems is to provide a standard in the building exploitation step to be able to evaluate the building with the determined criteria. Nowadays, scoring and rating systems of sustainable buildings have been developed as a method for building environmental evaluation. On the other hand, one of the challenges for development and use of such systems is to select criteria and weight them, and no ideal instrument can be designed regardless of climatic conditions, geographical condition and special environmental priorities. Hence, regional rating system development has been welcomed significantly more than international systems. In this study, with the aim of achievement of a rating system in consistence with climatic conditions and environmental limitations of dry and cold climate, a comprehensive study is firstly conducted on available rating systems. Then, indicator portfolio and the classification of the indicators are done based on climate and the regional needs and problems. Also, for weighting purpose, indicators and sub-indicators are codified using Delphi method.

INTRODUCTION

Sustainable development [1-3], although a widely used phrase and idea, has many different meanings and therefore provokes many different responses. In broad terms, the concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socio-economic issues. Sustainable development has the potential to address fundamental challenges for humanity, now and into the future. However, it needs more clarity of meaning, concentrating on sustainable livelihoods and well-being rather than well-having, and long term environmental sustainability, which requires a strong basis in principles that link the social and environmental to human equity [4]. In fact, sustainable development is a general and wide expanded concept, which can be measured using various dimensions; although it could be mentioned that providing scoring system is one of the best options for measurement [5]. Grace states that sustainable evaluation methods include special range of criteria and using one-dimensional methods including participation of key stockholders and decision makers is strong methodology producing both qualitative and quantitative criteria of evaluation. In fact, development of all evaluation methods of the world is based on consultation with some experts with the aim of achievement to the most reliable criteria of building evaluation [6]. Also, using implementable criteria and weighting systems can simplify evaluation of sustainable development. However, scoring systems and popular evaluation methods are not adequate for Iran.

Although many rating systems have been designed, still evaluation of some scales with systematic stability for evaluation is a main challenge. Metric design can evaluate the effect of each factor properly and can at the same time define a perfect and comprehensive framework. Using the term "metric" refers to quantitative determination of desired parametric value. Shane and Graedel [7] defined a provisional set of urban environmental sustainability metrics, chosen to cover the spectrum of issues related to urban areas, and to be drawn from data that are customarily available. They devised a technique to communicate efficiently the results of a metrics evaluation to a variety of stakeholders. The approach was illustrated by applying the metrics set to Vancouver, Canada.

Various studies have been conducted in different countries and have led to codification of regulations called as sustainable development such as LEED [8, 9], CASBEE [10] and BREEAM [11, 12]. Maybe the regulations and principles of other countries can be used at the beginning of studies and the principles of sustainable development may be same across the world; although different living conditions can lead to take special approaches according to environmental conditions to have better concept of sustainable buildings and development [13]. In some systems like LEED, an appraisal is conducted at the end of each phase to check whether each phase of the project conforms with the LEED criteria. In contrast, in some works, no facts are given regarding how a project moves from one phase to another [14, 15]; in some cases [16, 17], appraisal is done at the end of the construction phase when it is too late and costly to apply any changes. The goal of sustainability assessment tools is to provide vital information for the stakeholders to facilitate the process of decision making within various phases of a building's life cycle [18]. By using an integrated design approach and in an effort to minimize the detrimental impacts of buildings on the environment and occupants, green building provides an opportunity to construct environmentally friendly buildings [16]. Bunz et al. [19] compared sustainable design programs based on the life cycle of a building in North America, Europe, and Asia. In their work, tables comparing programs from these three regions were provided for each phase in the life cycle of a building. These tables can be used by building design professionals as a reference guide to sustainable design around the world. Key assessment indicators (KAIs) for assessing the sustainability performance of an infrastructure project were introduced by Shen and his associates [18]. In this study, the data used for analysis were collected from a questionnaire survey given to three groups of experts, including government officials, professionals, and clients in the Chinese construction industry. The fuzzy set theory was employed to determine KAIs. A case of Salisbury University's Perdue School of Business building study was performed by Azhar et al. [20] in order to demonstrate the use of Building Information Modeling (BIM) for sustainable design and the LEED certification process. The results of this study indicate that documentation supporting LEED credits may be directly or indirectly prepared using the results of BIM-based sustainability analyses software. Rastogi et al. [21] investigated impact of different LEED versions for green building certification and energy efficiency rating system. Haapio and Viitaniemi [22] reported a critical review of building environmental assessment tools. Since the field of building environmental assessment tools is vast, the aim of their study was to clarify that field by analyzing and categorizing existing tools.

Based on our finding, the gap of survey on sustainable development and green building can be felt in Iran. Investigating green factors in the other systems, the aim of the work done by Shad et al. [23] 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. In their work, 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. Roodgar et al. [24] carried out a detailed comparison between modern and traditional housings by considering sustainability in energy and resource consumptions, architectural topology and green building evaluations in Kashan as a hot-arid region of Iran. This work puts forward a set of recommendation to enhance the sustainability of future Kashan buildings.

Iranian standards have mainly energy approach in limited range. Standards and ultimately, regulations of Iran encounter special gap in various fields. Hence, it seems that the most key practical solution for energy optimization in building and construction of buildings in consistence with sustainable development concepts, especially in cold and dry regions with most consumption of fossil fuel in Iran, can be codification of a model for evaluating and rating buildings and careful implementation of existing regulations. However, the aim of present study is to carry out a survey on sustainability and green building assessment tools, with the consideration of climatic conditions and environmental limitations of dry and cold climate.

PREFERENCE OF REGIONAL RATING COMPARED TO INTERNATIONAL RATING

The evaluation methods of countries can't be generalized to each other. The hypothesis in this study is that international environmental evaluation models used currently like LEED, BREEAM and CASBEE can't cope with climatic diversity and social, cultural and regional conditions of Iran's environment. The restrictions include lack of identification of regional change and variety such as restriction of existing resources, local and traditional architecture, special environmental conditions and other important social and economic factors. Under the pervasive hypothesis, some special items such as building evaluation and international project criteria can't be applicable. In addition to this weighting system, popular evaluation methods used currently are not in consistence with prioritization of cities and artificial texture of Iran. With determination of role of regional variables and indicators, the evaluation system specified to cold and dry climate of Iran can be designed.

METHODOLOGY

In this study, social, environmental and climatic conditions of housing and buildings in cold and dry climate of Iran and rating the criteria and existing evaluation systems at the world are presented. Then, the indicators are obtained with analysis of the criteria. Rating indicators are determined using multivariate decision making method according to determined criteria and through weighting the criteria. In terms of purpose, this study is an applied research and in terms of data collection method, which is a descriptive survey study. This research are conducted on a real time issue and the results can be used practically. In order to obtain information, library methods are used in first step and then, field method and Delphi techniques are employed in second step. TOPSIS technique [25, 26] is utilized to measure and weight indicators.

RESULTS

- ***Comparing Existing Sustainability Evaluation Systems***

In each building, a unique combination of factors can affect decision making to follow one or more rating systems of green building. According to the comparisons of existing systems, this section is associated with identification of factors adding tendency of owners and users of building to use evaluation and rating systems [27]. In general, factors affecting use of green building sustainability evaluation systems are as follows:

1. Legislation requirements
2. Investor, owner or tenant
3. Creating economy
4. Market dynamism
5. Motivation
6. Risk management

When there is more than one stimulant, understanding the stimulants and the way of fulfilling them perfectly can increase possibility of increased profit and decreased cost. For instance, a developer may be firstly focused on economics of optimized building; although the goal may be a special rating system (e.g. LEED or Green Star). Under such conditions, developer takes a dual advantage with forcing the design team to achieve least number of credits in each category of energy reduction or water consumption reduction as a part of scores needed to achieve such certificate.

- ***Comparing Systems in Terms of Nature***

Essence of all evaluation systems is based on principles of sustainability. However, what can cause variety of such systems can be regional problem and national approaches and priorities. For example, the existing projects and systems at the world have been compared in the tables in appendix.

Majority of rating systems try to have a comprehensive approach to efficiency and function of building or society. Although some of these systems consider just some aspects, which can be easily achieved and evaluated. Rating system helps users to set goals and make decision and encourage the owners and residents to work with each other. These systems may provide some suggestions simultaneously on how to combine green elements in designation and implementation of buildings with flexible criteria. For the first time in 1990, BREEAM system was developed for evaluation of performance of buildings in England and could provide a framework to allocate confirmation certificate to green buildings.

One of the most underlying differences of systems can be their general approach. From this perspective, they can be classified in 3 classes of first generation, second generation and third generation systems. First generation systems are same early systems like LEED and BREAM and HQE, which assess mainly issues such as energy, water and materials. Second generation systems like DGNB and CASBEE assess the quality obtained from 3 factors including energy, water and materials. Third generation systems, also seen as new versions of first generation systems and in QSAS [28] and Estidama [29], pay specific attention to local and regional issues in addition to the quality obtained from spaces. However, many systems of third generation can be affected by evaluation systems of first and second generation.

On the other hand, evaluation systems can be divided to two classes of holistic and reductionism systems. Holistic systems are focused on lifetime of building and servicing and function. Also, the emphasis of these systems is on details of implementation and architecture and their ideals can be achieved by means of details and architecture. Reductionism systems consider the utilization time and their ideals can be mainly achieved in establishment fields. Careful comparison of 20 existing systems for sustainability evaluation are presented in the appendix.

- ***Climatic Design in Iran's Dry and Cold Area***

Climatic design in Iran's dry and cold area can be taken using following factor:

a) Building Direction

In general, in cold areas and in high altitudes with cold weather, buildings should be built in the direction which can get maximum solar energy over the year. In cold areas, wide range of directions are suitable in terms of getting solar energy: south directions up to 30º of east (30º deviation from south to east). The climate of the region can be described with very cold winters and hot summers and significant difference between the weather of day and night and heavy snowfall. In this climate, the building should be formed in such way that it can get maximum warmness in winter and maintain that and gain least heat in summer. Traditional buildings in cold climate such as Central Plateau of Iran have central courtyard and other parts are arranged around the yard. As the mountainous areas are cold or very cold in most days of the years, majority of daily activities may be done at rooms. Hence, the dimensions of yards in these areas are smaller than Central Plateau of Iran.

b) Construction Materials

The materials used at the region should have high thermal capacity to maintain the heat of the internal space. Hence, the body of this building is made of rock (or wood, mortar, clay and brick) and the ceiling and roof are made of wooden beams and thatch to act as thermal insulation. The buildings use rock and resistance and heavy materials to make foundation of the building and in some points; cathedra is made with heavy materials to prevent humidity; although the buildings in these regions are generally built on the ground.

c) Building Elements

All elements of building in cold areas should be designed carefully, so that they help designation of sub-climate. The heat influenced in a building is depended on the type of floor, ceiling and walls. Carefulness in inner decoration of building has significant effect on sub-climate. Compressed decoration with several spaces in underground space can be suitable to use the heat of the ground. Open spaces such as parking lot should be located in west of building to be used as an insulation for exit of heat and entrance of cold weather (from the direction less exposed to hot weather). It is better to embed water and wastewater pipes in outer part of walls, especially northwest and southeast walls.

d) Wind Control Methods

City location should be selected in lower part of height and opposite to wind direction. City should be open to ideal winds and prevent the unfavorable winds. The main wind control methods include wind tunnel prevention, windshield, suitable layout for wind direction and dust avoidance.

With analysis of regional priorities of cold and dry climate of Iran and classification of the priorities in sustainability principles, ideal weighted coefficient has been calculated according to existing evaluation systems in the following diagram. According to the priorities in Iran's dry and cold area and its comparison to existing evaluation systems, TOPSIS model are employed to find closeness coefficient of each system to ideal solution to design Dena system. Fig. 2 represents closeness coefficient of each evaluation and rating system with regional priorities of Iran and dry and cold climate.

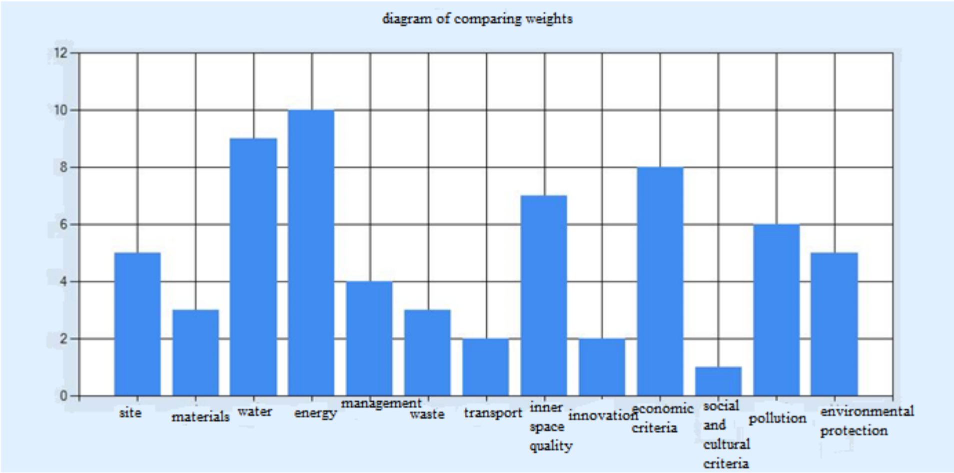

Fig. 1 Weighting Sustainability Indices According to Iran's dry and Cold Climate

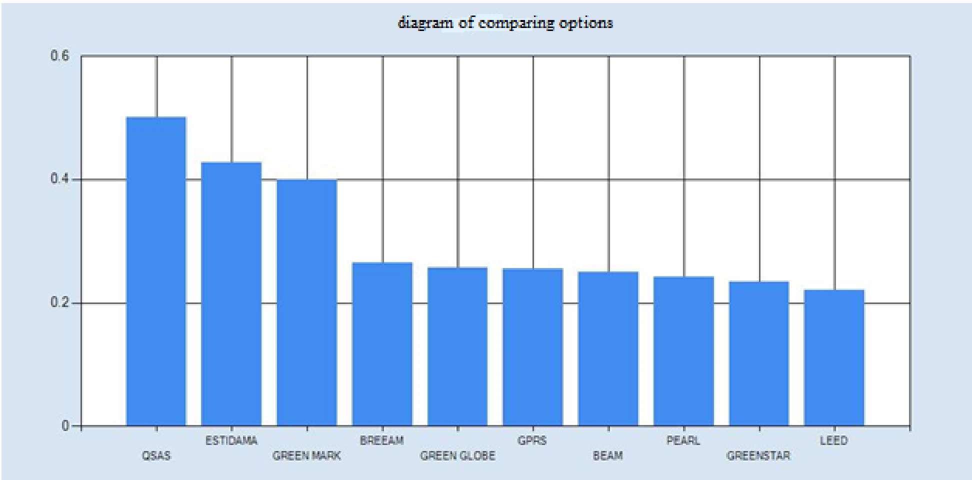

Fig. 2 Diagram of closeness of selected evaluation systems for ideal solution to design Dena system

CONCLUDING REMARKS

There are some difference and similarity points in all evaluation systems and each system has special restrictions and it is impossible to use them for all regional projects and other special aspects such as inner space quality. These systems use mainly different evaluation criteria, methods and steps. Each system has special advantages and defects [30]. However, according to their differences, majority of these systems use similar criteria for evaluation and rating purpose.

The similarities include:

1. Energy consumption reduction
2. Greenhouse gas production level
3. Regulating weighting based on use

The differences include:

1. Difference of criteria
2. Difference in weighting patterns
3. Scoring pattern

Each system has its special restrictions and it is impossible to use them for all regional projects and other special aspects of inner space quality. Among introduced systems, CASBEE, GREEN GLOBE, BREEAM and LEED are more popular than other systems in terms of overall building evaluation, being measurable and being usable for different types of building.

To achieve a comprehensive attitude in Dena Rating System design, evaluation criteria can be classified in four classes:

1. Criteria showing the effect of building construction based on environment: Sustainable site, materials, water, energy, management, waste.
2. Criteria showing the effect of construction on human:
   Inner space quality (thermal comfort, visual comfort and acoustic), health and safety.
3. Criteria caused by the effect of outside space on sustainability:
   Innovation in design, climatic design, local and traditional design.
4. Economic criteria:
   With scoring above mentioned indices and sub-indices and determination of closeness coefficient according to weighted coefficient obtained from comparison of existing evaluation systems (Fig. 2), rating system of sustainable buildings of dry and cold climate of Iran can be designed.

APPENDIX

Table A Comparing existing evaluation system in terms of nature

System	Rating projects	Classifications
BREEAM	Courts, associations, health houses, offices, industries, residences, prisons, retails and other buildings	Energy Health and being healthy Using land and environment Management Materials Water Transportation
LEED	Buildings in construction and design steps and reconstruction operations, neighborhood development, houses	Knowledge and education Energy and atmosphere Inner space quality Innovation in project Place and accesses Materials Regional priority

		Considerable sites Water efficiency
GREEN GLOBE	Existing buildings, new buildings	Wastewater and its effects Energy Inner space quality Project Management Resources Site Water
GREEN STAR	Renovation and designation of existing buildings, rating instruments, training healthcare, industrial, residential, administrative, internal, center and retail and public buildings	Management Environmental quality Energy Transportation Water Materials Using land and environment Sewage distribution Acceptable design Economics Welfare Environment
BREEAM	Existing buildings, new buildings	Analysis of aspects of site, materials, energy consumption, inner space quality, creativity and innovation
EEWH	New buildings	Biodiversity Reduction of CO2 emission Energy savage Green space protection Inner space quality Washing and waste materials Water system behavior Wastage reduction Water resources
GBCS	Hotel, multipurpose residential town, school buildings	Energy utilization Burden of environment Inner space quality Land use Transport and environment
CASBEE	Existing buildings, urban area and urban building renovation	Inner space quality Service quality Outside space Environment in site Energy Materials Environment
GREEN MARK	Residential buildings, nonresidential buildings, existing buildings, inner space, offices, villa house, new and existing parks, infrastructural projects	Energy efficiency Environmental protection Inner space quality Innovation Water efficiency
S1-5281	Offices, residential buildings, educational buildings, retail, public buildings, hospitals	Site Water Materials Healthcare Waste materials Transportation Construction Management

		Innovation
IGBC	Residential buildings, green schools, factories and industrial centers, green transport system at cities, green landscape	Sustainable design and architecture Choosing site Planning to select species for the landscape Transport Water planning Energy utilization protection Making materials and resources Inner space quality Health Healthcare and medication Operations and maintenance Green education Innovation and development
Lider A	Types of building	Environmental efficiency Management and innovation Loading effects Resources and consumption Site Socioeconomics Consistency
HQE	Third-rank residential buildings, buildings in step of construction and renovation	Comfort and rest Economic construction Economic management Health
3-STAR	Commercial-residential	Saving land use Energy saving Water saving Inner space quality Operators Management Preferred materials
GRIHA	Educational, health and medication, residential towns, offices, inner space of offices, commercial centers	Choosing site and planning for site Making construction plan Making operations and repair and maintenance Innovation

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