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Evaluation and Comparison of LEED, BREEAM, and the 19th issue of National Building Regulations of Iran (NBRI) in Perspective of Sustainability by (MCDM) TOPSIS Method

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Abstract

In this research, the features of LEED, BREEAM, and NBRI also, their principles, are reviewed, evaluated, and compared from the aspects of the sustainability. The compliance items of standards with the principles of sustainability determine that their goals are well matched. By comparing the different and shared principles, it discovered how each standard has succeeded from the aspect of the sustainable design also, the shortcomings in the 19th issue of NBRI were appeared. The evaluation of standards with sustainability principles is done by applying (MCDM) TOPSIS. Furthermore, by ranking each sub-item of standards from weak to excellent, the respect of sustainability principle is recognized. plus, according to the TOPSIS and analyzing the data, any items of each standard has the most sustainability feature are considered. The alignment with the leading tools can result in the promotion of the Iranian regulations. Findings of this research provide suggestions for completing and localizing the criteria that are part of the LEED and BREEAM in energy section which are neglected in the 19th issue. Applying these solutions and paying more attention to all of building's sustainable aspects in Iran will lead to the success of the country to be adopted with the global counterparts.

Keywords: Comparative Analogy, Sustainable assessment tools, LEED, BREEAM, 19th issue of the National Building Regulations of Iran (NBRI), (MCDM) TOPSIS method

1. Introduction

Increase awareness of the destructive effects of buildings on the environment has led to particular tendencies towards sustainable design and construction. Nowadays, in most parts of the world, energy labeling of buildings is performed, whose main role is the comprehensive assessment of the environmental performance of the building [1, 2]. Builders, landlords, and tenants are all beneficiaries of these buildings, which are now known as green buildings. LEED and BREEAM are two main world-renowned energy auditing methods. Devised by the United States Green Building Council (USGBC), LEED is a rating system for evaluation of the environmental performance of a building. BREEAM, which published by the UK Building Research Establishment (BRE) in 1990, is a method for

rating, assessing, and certifying the sustainability of buildings. The assumption of the research is that during the recent years the scoring principles of the two mentioned methods have become very convergent and close, but there are still fundamental differences in their principles that are originated from the country of origin [3]. However, there are some principles and rules contained in the mentioned systems which can be localized and complete the principles and rules of the 19th issue of National Building Regulations of Iran.

All three standards are followed sustainability principles, but individual standards priorities are ranked MCDM TOPSIS method to illustrate the

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focused sustainability point of each standard. The Multi-Criteria Decision Making (MCDM) methods are mathematical tools allowing to solve a decision problem through the selection of the optimal alternative meeting a given number of criteria. Therefore, a multi-criteria analysis is the formulation of the convenience opinion of an intervention according to most criteria, examined independently or interactively. the TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method has been used thanks to its application easy. This method represents the various alternatives as points of a vector space having dimensions equal to the criteria number, so that the different solutions performances become the coordinates in the assumed vector space. Therefore, with this very practical method, both the better alternative is identified and an alternative ranking is defined [4].

1.1. Background

1.1.1. Background of the Sustainable Architecture

Since 1980s, various definitions of sustainability have been raised, including: the United Nations Environment Program (UNEP), which defines strategies for protecting the environment, wildlife, and natural resources; the report of the World Commission on Environment and Development in 1987 entitled "Our Common Future"; the United Nations Conference on Environment and Development in Rio de Janeiro, 1992; the Social Dialogue for Sustainable Development in Johannesburg, 2002; and many others which aim to global warming prevention, earth resource management, cost savings, and design in alignment with nature [4-6].

The terms “sustainable architecture” and "environmental protection movement “were first introduced by William Morris and John Ruskin in the 19th century. In the Book of the Seven Lamps of Architecture, Ruskin suggests the use of nature's harmony as a template for the growth and development [7]. Morris always advocated the return to self-sufficiency in local production and also the return to the green space [8]. In agreement with this issue, in one of his announcements, Letabi has asked architects to appreciate the beauty of the nature [9]. All of these pioneers have often used the term "nature", which today can be replaced by the term "sustainable architecture" [10]. Years later, in the early 20th century, architects such as Frank Lloyd Wright, Peter Eisenman, and others have developed the ideas so that this process has continuously been evolved.

1.1.2. A brief history of assessment tools

Since about 30 years ago, researchers have paid a special attention to the environmental performance of buildings. Due to the multiplicity of available standards in this field, researchers have introduced and compared quantitative and qualitative aspects of each standard. Researchers in many different countries have benefited from the strengths of these standards and, at the same time, tried to localize them in their own countries. Table 1 represents some of the main researches in this field. Despite the differences in the methodology and achievements, all studies have tried to examine and adopt a number of standards related to the housing industry. Examination of the commonly applied methods of construction scaling standards in different countries, particularly in the area of evaluation process of the individual buildings, is one of the areas which has been also referred to in the research of W.L. Lee. The main goal here is to measure the environmental performance of the buildings systematically and objectively [11]. Kamali et al, examined the performance of sustainability standards of residential buildings in 16 countries. According to Kamali, sustainability standards are among the strictest comparative tools [12]. Similarly, having introduced different standards, A, Rivera, 2009, compared and contrasted LEED and BREEAM considering into account many different factors such as costs, technical needs, flexibility level, compatibility with climate and geographical conditions in order to find the best approach to scale the intended project [13]. In addition, Bernardi et al., 2017 examined six construction scaling standards, including BREEAM, LEED, DGNB, CASBEE, HQE™, so that the performance of each standard to design a building could be identified objectively [14]. Recent studies in this regard have particularly focused on identification, examination and review of the construction scaling standards and tools [15-17].

B. K. Nguyen compared the construction scaling standards of six countries in order to both introduce the standards and identify the technical similarities. Main objective was to provide the designers with the best available construction scaling standard [18]. A. Forsberg’s research, unlike Nguyen's study, did not aimed to find the best system among other ones, but to identify the advantages and disadvantages of scaling sub-standards through making a quantitative comparison among five evaluation tools to measure the performance of environmental construction standards [19]. Also, in the Middle East, Ali et al and M. Mehranrad et al, from Jordan and Iran respectively, identified the shortcomings of the available sustainability measurement tools and national construction standards at small and large scales. Both studies took into consideration commonly applied construction scaling standards in Europe and the United States [20, 21].

G.A. Waidyasekara, having examined and compared the sustainability measurement tool, specifically in the field of water efficiency and construction, in 11 developed countries of the world, identified the strong and weak points of the standards and, like Nguyen, proposed a comprehensive model [22]. W, Ramalho, examined one of the sub-standards of construction scaling, Indoor Air Quality (IAQ), in 30 countries. His objective was how the substandard, as a sub-set of Indoor Environment Quality (IEQ), worked in construction scaling standards [23].

Also, certain studies focused on ingredients of the sustainable materials, on their environmental compatibility as well as on how they were selected correctly. G. Demir, based on applying the sustainable measurement tool of LEED Institute, tried to make sustainable construction materials out of construction wastes in Turkey. He then compared the recycled materials with those used in buildings with golden license [24]. In a similar study, A.P. Gurgun compared the regulations for sustainable materials applied in India and Abu Dhabi with those of LEED. [25]. In addition, S.A. Hosseiniju et al, in a case study, studied the different approaches to select and evaluate the sustainable materials based on Social Life Cycle Assessment (SLCA) [26]. Still, in another investigation, L. Florez simulated the factors playing a major role in sustainability of the materials and formulated them in a model [27]. The qualities of materials formulated in the model have been defined in Leed Standard. R. Rahardjati et al., addressed the system for evaluating sustainable materials in Green Building Index (GBI) and Green ship Standards respectively in Malaysia and Indonesia [28]. Also, J. Park, having examined the parameters of sustainable materials as specified in well-known construction scaling standards, proposed a comprehensive index to select materials considering three factors, namely, Environment, Economy and Society [29]. In addition, MSDSS, Topsis, AHP, MCDM and VIKOR have been among the soft wares applied in other studies related to selection of correct materials [30- 37].

2. Research Methodology

The research methodology in the present investigation was the study of the assumptions' attributes by referring to books, articles, and documents. Then, with the qualitative analogy of the findings by TOPSIS the contents of each standard with the sustainability are evaluated and the quantitative compliance of each item of standards with the principles of sustainable design was obtained. At last, the solutions and suggestions are presented. All steps of the research are described graphically in Figure 1 as the hierarchy of the study. As the paper objects the promotion of the Iranian standard, in conclusion, the positive criteria of LEED and BREEAM Standards that are neglected in the NBRI will be prepared to be adopted and localized in the Iranian Building Regulations.

3. Features of the Sustainable Architecture

3.1. Principle 1 - Coordination with the Climate

Global warming is a clear translation of climate change [48]. The design should not create any disparity in the climate and resources in the site of the project. The first intergovernmental panel on climate change (IPCC) in 1988, in its 1990 report claimed that the effects of greenhouse gases and the growth of concentrated CO_2 in the atmosphere is due to the human activities [49]. In general, the location of the site of the project, the orientation of the building, the shape and the main form of building, and materials used in the building must be based on the macro- and sub-climate of each region

Table 1

Research Backgrounds Related to Green Building Standards

Author(s)	Year	Purpose	**Compared standards**	**Outcomes**
Ball [38]	2002	Evaluation of new energy management methods for sustainable development	ISO 14000 Eco-labeling	Discovering the consistency of new energy management methods with sustainability
W.L. Lee & J. Burnett [39]	2007	Reviewing, comparison, and statistical evaluation of the energy consumption in 60 important office buildings in Hong Kong	LEED, BREAM, HK-BEAM	Evaluation of the amount of energy consumption associated with each standard
L. Perez-Lombard et al [40]	2008	Investigation of the roots and backgrounds of building rating plans by defining and developing a green building validation method.	-	Providing solutions and suggestions for implementation of building rating criteria
H.H Ali et al [41]	2009	Investigating and detecting deficiencies in building sustainability measurement tools in Jordan	LEED, BREAM, GB tool, CASBEE	Creating a rating system for evaluating green buildings used for residential homes in Jordan
H. John & Reposa Jr [42]	2009	Comparative analogy of the environmental assessment methods of residential buildings	LEED, NAHB	Identifying similarities and differences in standards
A, Rivera [43]	2009	Investigating differences and similarities in terms of cost, technical requirements, flexibility, and adaptability to climate, geographic, and ideological conditions.	LEED, BREAM	Achieving the most appropriate rating method
Roderik et al [44]	2009	Simulation of new office buildings through advanced software	LEED, BREAM, Green Star	Discovering the similarities, differences, and efficiency of energy
Asdrubali et al [45]	2015	Assessment of the energy performance of two sustainable residential buildings in Italy	LEED, ITACA	Introducing and comparison
Bernardi et al [46]	2017	Emphasizing differences between six rating systems to better understand and extract the main consequences to building design.	LEED, BREEAM, CASBEE, DGNB HQE, SBTool	Attempts to summarize in a user-friendly form the vast and fragmented assortment of information that is available today
Zarghami et al [47]	2018	Customize the categories and criteria points of well-known sustainability assessment tools	LEED, BREEAM, CASBEE, SBTool	Develop an Iranian sustainability assessment tool suitable for residential buildings

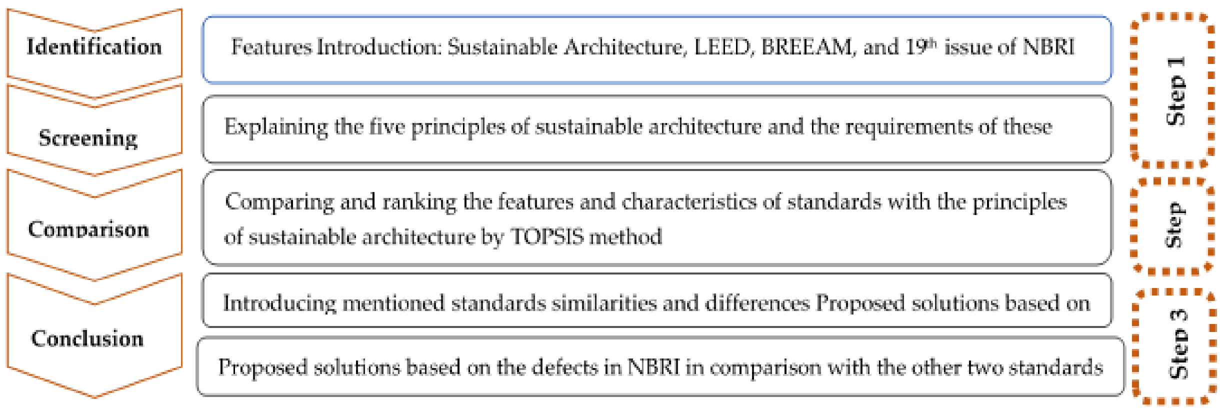

Fig. 1. Hierarchy of the study

3.2. Principle 2 - attention to materials, structures, and manufacturing techniques

Since the extraction and use of raw materials, as natural resources of the planet, has a direct impact on natural resources and the ecosystem, and changes the natural form of the earth [50], the use of domestic and durable materials that have a longer life span, is a step toward the sustainability. In terms of materials, the most effective method of sustainability is the use of recyclable and recycled materials, which prevents excessive consumption of resources. Also, removing the substances that cause environmental pollution and replacing them with domestic and durable materials is a resource-saving solution. It is recommended that in the first phase of design, in which the type, quality, and amount of materials are determined, their environmental and economic impacts be fully examined [51].

3.3. Principle 3 - energy conservation

The performance analysis of a building over its useful life shows that 85-95 percent of the energy consumption in the building is spent on heating, cooling, air conditioning, and hot water production, all of which are important factors in CO_2 emissions [52]. One of the most effective ways of reducing the energy consumption of a building is to increase the building productivity by its adaptation to the environment through the use of active design methods [53, 54].

3.4. Principle four - human welfare

The comfort and ease of mankind is definitely the ultimate goal of any sustainable construction [55], and it is necessary that the sustainable design be tailored to the needs, culture, and customs of the inhabitants. The following three strategies, which are related to the design, contribute to the promotion of co-existence between buildings, environment and its inhabitants:

•Maintaining the natural ecosystem

Earth is a limited and non- renewable resource [56]. The architecture should design in such a way that the construction has the minimum effect on the local ecological conditions (e.g. topography, plants, wildlife, etc.). Generally, prevention of the unnecessary expansion of the artificial environment, especially in special areas, is the best way to combat the land degradation [57].

•Urban design and site planning

The use of land for the development of urban spaces was first identified by Uher as an emerging issue in developed and developing countries, such as Iran [58]. Neglecting this rapid expansion can endanger the resources, such as water and non-renewable energy sources, and, conversely, paying attention to this issue and efficient management of that, in the international level, will make the urban environment more pleasant and less polluting.

•Comfort and human well-being

Nowadays in modern societies, people spend more than 90 percent of their time in indoor environments, 70 percent of which include staying at home [59]. Therefore, sustainable design should be in such a way that does not interfere with human comfort. The design should improve the quality of working and living environments. This will increase the productivity and reduce the psychological pressures and the health and comfort of people will be affected [60].

3.5. Principle five - harmony with the nature

One of the key principles in sustainable design is respecting to Gaia and protection of the nature. In this regard, experts and specialists have raised some main issues that are necessary to be notified [61]:

- Attention to green and blue conditions
- Interlocking with wildlife and animals
- Paying attention to the shape and form of the earth
- Paying attention to the issue that how to combine the building and the surrounding environment
- Paying attention to the vision and perspective
- Collecting rainwater and recycling of fresh water
- Efficient recycling of wastewater

The most important point in sustainable design is to consider the building as a small part of the environment and the surrounded ecosystem. Moving towards the sustain design of buildings, demands not only sufficient knowledge and awareness, but also all individual building activities are important in this regard [62, 63].

4. An introduction to LEED, BREEAM, and NBRI

4.1. LEED rating system

In 1993, Rich Fedrizzi, David Gottfried, and Mike Italiano, launched the Green Building Council of the United States for implementation of the sustainability in the construction industry. The program is an efficient tool for the assessment of the building components on the environment [2]. The program is the result of the collective thinking of the Green Building Council of the United States in 1998, when representatives from about 60 nonprofit companies and institutions at the American Institute of Architects to found this council [64].

In 2000, this important action was officially released. Every day, hundreds of thousands of square meters of construction from all over the world join to this council to obtain environmental standards [65]. This system is a rating program of buildings, that is designed and regulated so that the key principles of which are consistent with the principles of sustainable architecture. LEED rating system leads the project towards sustainability in various aspects, including design, construction, operation, and maintenance. Of the positive points, it provides sustainable solutions for specific projects. The possibility of providing sustainable solutions for specific projects is one of LEED system's strengths [43].

The program includes 12 prerequisites in the following sections:

Sustainable Site, Indoor Environmental Quality, Water Efficiency, Energy and Atmosphere, and materials and resources. In the case of their acquisition, the project succeeds in obtaining one of the following ratings [65]:

- Certified (40-49 points)
- Silver (50 - 59 points)
- Gold (60 - 79 points)
- Platinum (More than 80points)
- LEED rating system is divided into eight sub-categories [65]:
- Location and Transportation (16 points)
- Sustainable Site (10 points)
- Water Efficiency (11 points)
- Energy and Atmosphere (33 points)
- Materials and Resources (13 points)
- Indoor Environmental Quality (16 points)
- Innovation (6 points)
- Regional priority (+4 points)

All of the above items have several perquisites, which scoring of that stage begins only if they are provided. In this rating system, the project and its implementing team must first be registered to the system, fill the key forms, and pay the registration fees. In the early stages of implementation, LEED and BREEAM rating systems do not have the financial benefits for the project [66]. In the next step, the project's characteristics will be examined by an approved evaluator in the site of the project. In the third step, the project team is required to provide all relevant documents, calculations, and project information to the evaluator. At this stage, the building plan is reviewed and evaluated by the Green Council, and finally it is decided about the project rating level. Indeed, in this system, the final certificate is presented after the completion of the design and construction phase [43]. Although the simplicity of the LEED process has been accepted by many employers and project managers, there are still doubts about its 100% efficiency [67].

4.2.BREEAM Rating System

The BREEAM is the world's foremost method for the assessment of the environmental performance of the buildings, which started its formal activity in 1990 in the United Kingdom. This system is the oldest and most sophisticated method among other similar systems [67]. Providing new solutions for special buildings or buildings in special climates and regions, which is called "International BREEAM" is one of its strengths [68]. This system evaluates the sustainability value of a building in different aspects, from energy to the environment, based on the principles of sustainable architecture [69]. Each of these categories is known based on their most influential characteristics, including designing in such a way that has the least impact on the environment, reducing carbon dioxide emissions, sustainability in design and flexibility, adapting to climate change and environmental values, and biodiversity conservation. Paying more attention to these cases will increase the score in the rating process.
The process of assessment in this system includes planning, design, construction, and operation.
This program includes 15 prerequisites in the areas of Management, health, Well-being, Materials, and Waste, which if they are addressed, one of the following grades will be obtained [69]:

- Pass (equal to or greater than 30 points)
- Good (equal to or greater than 45 points)
- Very good (equal or more than 55 points)
- Excellent (equal to or greater than 70 points)
- Outstanding (equal to or greater than 85 points)
- The rating system is divided into ten sub-categories [69]:
- Management (20 points)
- Health and Well-being (21 points)
- Energy (34 points)
- Transport (11 points)
- Water (13 points)
- Materials (14 points)
- Waste (13 points)
- Land use and Ecology (5 points)
- Pollution (7 points)
- Innovation (incentive rating of up to 10%)

It should be noted that for obtaining a specific score in the system it is required to address minimum standards of environmental protection, which is variable depending on the requested score for the building of interest. The project registration process in this rating system is very similar to the steps of LEED. However, there is one difference: on the BREEAM website, there is smart matching software that the project design team can enter some features such as: the amount of demanded energy, the amount of consumed energy, etc., as it really is and as it is desired by the design team. Finally, the system determines the current rating score of the building [69]. This system highlights the importance of the environmental issues in the construction industry to relevant professionals [64].

4.2. An introduction to the 19th Issue of NBRI

Then National Building Regulations of Iran provides a set of technical, executive, and legal regulations for the implementation of design, supervision, and execution of construction projects, including destruction, renovation, development, repair, maintenance, alteration, and operation of the building, in order to provide safety, efficiency, comfort, health, and cost-effectiveness. The first edition of the 19th issue of NBRI, entitled energy saving, was drafted in 1991. Then, new modified and updated versions of this document were released in 1999 and 2002. The topics of the document include recommendations for building design, designing criteria, calculating and implementing thermal insulation of external shell, thermal and cooling installation systems, ventilation, air conditioning, hot water supply, and designing lighting system in buildings [70]. The main goal of the 19th National Building Regulations compilation is the building's consistent compliance with the standards of sustainable architecture.

The 19th issue of NBRI is divided into four main categories:

- General rules for design and implementation
- External shell of the building
- Mechanical installations
- Systems of the lighting and electrical energy

Recently, the requirement to obtain a license for the completion of a construction project is utilizing the provisions of the 19th National Building Regulations. Correct implementation of these rules from the start to the end of the project is fully evaluated by supervisory system. What distinguishes the national building regulations from other technical documents and building regulations, building standards, attached technical specifications of contracts and guidance and training publications that are developed and published by various organizations in Iran is that these rules are mandatory, abbreviated, and compatible with the conditions of the country in terms of skilled and efficient manpower, the quality and quantity of building materials, economic power, climate, and environment [70].

5. Results

5.1. Similarities from comparison of LEED, BREEAM, and the 19th Issue of NBRI

According to table 2, there are many similarities in the three systems in terms of the organization and objectives, such as:

- Reduction of environmental damage from the construction sector and sustainable development in terms of economic, social, and environmental indicators. Project approval is performed by an independent third party, which is selected by the institution.

- Being evolved and updated over time.

- Having special program for various buildings with specific conditions and usage.

Although there are common points in all three systems, still there are significant differences between LEED and BREEAM systems compared to the 19th issue. Table 2 shows that out of the 25 common points between LEED and BREEAM systems, only 10 cases of them are present in the 19th issue of the NBRI, which include: requirements for mechanical installations, requirements for lighting and electrical systems, and requirements for the prevention of heat exchange in mechanical installations, Isolation of meters, General principals and recommendations on building design, General principles and recommendations on ventilation and mechanical installation.

5.2. Similarities of the LEED and BREEAM systems

The process of rating and giving energy labels. The three-step evaluation stage (the steps include: the end of the design phase, the completion of construction and after construction, and the maintenance phase) and the assessment of the energy efficiency of the building at each stage with a high accuracy. Common items of the LEED and BREEAM standards, which are lacking in Iran's standard, include: access to Public Transport, Bicycle Facilities, Transport System Savings, Reduced Parking Footprint, Use of Green Vehicles, Evaluation and Selection of the Site, Environmental Development of the Site Ecology, Management and Control of Surface Water, Reducing Water Consumption Inside and Outside the Building, Management of the Cooling Devices and the Effects of Refrigerant, Collecting, Storage and Managing the Recyclable Wastes from Construction, Reducing the Impact of Buildings and its Materials on the Environment, the Environmental Optimization of the Construction Product and the Use of Approved Resources, Acoustic Performance, and Innovation.

5.3. Differences between the LEED, BREEAM and the 19th issue

The structural contradictions of the three standards are as follows:

LEED

- The main rating criterion in this system is based only on well-known American standards, such as ASHRAE and Imperial units.
- Participation of a third party trained by LEED in the rating process
- Need to provide the prerequisites for each section at each stage of the scoring

BREEAM

- The main rating criterion is based on the international rules and harmonization for different climates and regulations of different parts of the world, resulting in more standardized flexibility.
- Necessity of the presence of BREEAM-international licensed assessor in international projects outside the UK.

To meet prerequisites only in the international sector, in order to achieve higher rankings. The 19th issue of NBRI

- No need for prerequisites
- Capability to adapt to different conditions of the country, in terms of skilled manpower, quantity and quality of building materials, economic power, climate, and environment.
- Applying the latest changes and modifications to the requirements is performed by the National Building Regulations Committee with the participation of the National Engineering Community, specialized committees, professional engineering organizations, engineering organizations of the provinces, and municipalities throughout the country.

According to Table 2, which presents the results of the comparison of the common principles of the three systems, there are15 important and vital principles related to environmental issues which are present in LEED and BREEAM systems, but not in the 19th issue.

There are some items specific to the LEED standard, which are not included in the 19th issue. These include Neighborhood Development Location, Sensitive Land Protection, High Priority Site, Surrounding Density and Diverse Uses, Open Space, Cooling tower Water Use, Optimize Energy Performance, Renewable Energy Production, Building Product Disclosure and Optimization – Sourcing of raw materials, Indoor Air Quality Assessment, Interior Lighting, and Daylight.

There are also some characteristic specific to BREEAM standard which are not included in the 19th issue. These include the Visual Comfort, Accessibility, Private Space, Water Quality, External Lighting, Energy Efficient Cold Storage, Drying Space, Proximity to Amenities, Travel Plan, Home Office, Water Leak Detection and Prevention, Water Efficient Equipment, Hard Landscaping and Boundary Protection, Insulation, Construction Waste Management, Ecological Value of the Site and Protection of Ecological Features, Minimizing Impact on Existing Site Ecology, Long-term Impact on Biodiversity, and Reduction of Noise Pollution.

6. Evaluation standards by TOPSIS method

6.1. TOPSIS method

The TOPSIS method creates two additional ideal alternatives that guide the decision maker (DM) to choose the optimal alternative among those considered. These two ideal alternatives are the optimal solution (N), having the paramount performance over all criteria, and the worst one (A-). So, the decision problem solution is represented by the alternative having, at the same time, the minimum distance from N and the maximum distance from A- [4].

The method is calculated as follows:

Table 2

Similarities and differences between LEED, BREAM, and the 19th issue of NBRI

LEED's Requirements	BREEAM's Requirements	19th issue of NBRI's Requirements
Access to quality transit	Public transport accessibility	×
Bicycle facilities	Alternative modes of transport	×
Reduced parking footprint	Maximum car parking capacity	×
Green vehicles	Alternative modes of transport	×
Site assessment	Site selection	×
Site development – protect or restore habitat	Enhance site ecology	×
Rainwater Management	Surface water run-off	×
Heat island reduction	NOx emissions	Requirements for mechanical installations
Light pollution reduction	Reduction of night time light pollution	Requirements for Lighting and Electrical systems
Water metering	Water monitoring	×
	Water consumption	
Optimize energy performance	Reduction of energy use and carbon emissions	Requirements for preventing of heat exchange in mechanical installations
Advanced energy metering	Energy monitoring	Isolation of meters
Demand response	Designing for durability and resilience	General principles and recommendations on building design
Fundamental Refrigerant Management	Energy efficient cold storage	×
Green power and carbon offsets	Low carbon design	Requirements for mechanical installations
Storage and collection of recyclables	Construction waste management	×
Building life – cycle impact reduction	Long term impact on biodiversity	×
Building product disclosure and optimization – material ingredients	Responsible sourcing of construction products	×
Enhanced IAQ strategies	Indoor air quality	General principles and recommendations on designing building
Low – emitting materials	Material efficiency	General principles and recommendations on designing

		building
Thermal comfort	Thermal comfort	General principles and recommendations on ventilation and mechanical installation
Acoustic performance	Acoustic performance	×
Innovation	Innovation	×
Regional priority	Adaptation to climate change	General principles and recommendations on designing building

Step 1. Create an evaluation matrix consisting of m alternatives and n criteria, with the intersection of each alternative and criteria given as {displaystyle x_{ij}} xi j, we therefore have a matrix {display style

(x_{ij})_{m\times n}}(xi j) m*n.

In this study, standards items are evaluated in respect of sustainability principles. Each intersection of one item and principle is in range of 1 to 5 (5 sustainable architecture principles) according to somehow the item consider each principle.

Step 2: The matrix (xi j) m*n is normalized via R= (r i j) m*n, using normalized method to create normalized decision (ND):

i= 1, 2, 3, …, m and j= 1, 2, 3,…, n

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{n} x}} \quad (1)$$

rij: stands for the score of each parameter which has been none scaled.

xij: is stands for utility of each parameter.

i= the items of each standard

j= the sustainability principles, rank to 1 to 5.

Step 3. Weighted normalized decision matrix is formed:

V=Nd*Wn (2)

V: stands for the none scaled weight matrix

In this study, because of equal importance of all 5 sustainability principles, all weight is supposed 0.2.

Step 4. Positive ideal solution (PIS) and negative ideal solution (NIS) are determined:

PIS =A+ = {(maxVij), (max Vij), i,j =1,2,..,m}={V1+,V2+,…Vn+}	(3)
NIS=A- = {(minVij), (min Vij), i=1, 2..., m}={V1-,V2-,…Vn-}	(4)

In this study, as previously mentioned, just PIS are evaluated.

Step 5. The distance of each alternative from PIS are calculated:

Calculate the L2-distance between the target alternative I {\displaystyle i} and the worst condition Aw.

i= 1, 2, 3, …, m

$$d_{iw} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{wj})^2} \quad (5)$$

and the distance between the alternative {\displaystyle i}i and the best condition {\displaystyle A_{b}}Ab.

i= 1, 2, 3, …, m

$$d_{ib} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_{bj})^2} \quad (6)$$

Where d iw {\displaystyle d_{iw}} and {\displaystyle d_{ib}} d ib are L2-norm distances from the target alternative {\displaystyle i}I to the worst and best conditions, respectively.

Step 6. The closeness coefficient of each alternative is calculated:

Siw+= diw / (diw + dib), 0 ≤ Siw ≤ 1, I = 1, 2, …, m. (7)

Siw = 1 if and only if the alternative solution has the best condition; and Siw = 0 if and only if the alternative solution has the worst condition. Step 7. Rank the alternatives according to Siw (i=1,2, …, m excellent). All steps that are done, are shown as the numerical results in the Table 3 (Step 2, 4, 5, 6, and 7) and Table 4 shows Step 3 to confirm A+ and A – as the Positive ideal solution (PIS) and negative ideal solution (NIS).

6.2. Applying TOPSIS method in the study (Step 1 to Step 6)

TOPSIS is based on the concept that the chosen alternative should have the shortest geometric distance from the Positive Ideal Solution (PIS) [71]. and the longest geometric distance from the Negative Ideal Solution (NIS). In most cases NIS consists of criteria such as cost, that by increasing them the geometric distance is growing up. In this study, because of disregarding NIS, this is omitted from the TOPSIS process. TOPSIS is a method of compensatory aggregation that compares a set of alternatives by identifying weights for each criterion, normalizing scores for each criterion and calculating the geometric distance between each alternative and the ideal alternative, which is the best score in each criterion. An assumption of TOPSIS is that the criteria are monotonically increasing or decreasing. Normalization is usually required as the parameters or criteria are often of incongruous dimensions in multi-criteria problems [72].

As the TOPSIS is a method for ranking the parameters in this paper, all three standards' prerequisites are ranked in the range of one to five to evaluate each item priorities (weak to excellent) in case of sustainable architecture principles, and the most significant principle that is respected by evaluated standards. results of the ranking are shown in Figure 2.

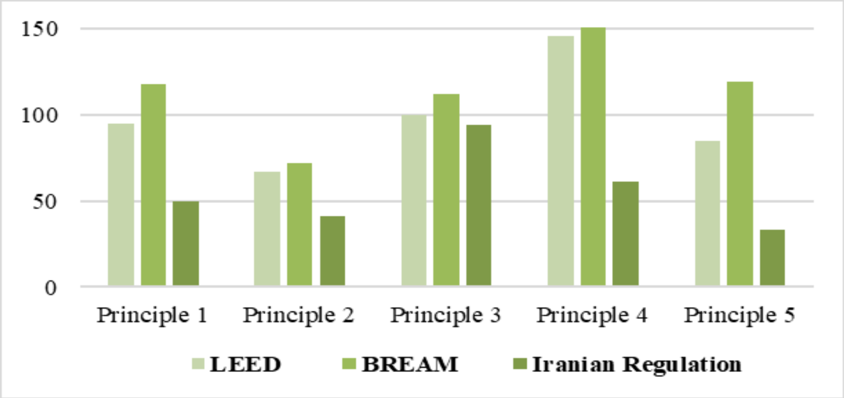

Fig. 2. Comparison of consistency of the LEED, BREEAM and 19th issue of NBRI with the five principles of sustainable architecture by ranking in the first step of TOPSIS method.

By comparison of the three mentioned systems with sustainable design principles by ranking them in Step 1 of TOPSIS, the following results were obtained:

As it can be seen in the graph 1, the energy audit system of the BREEAM standard has gained the highest rating and privilege in the five principles of sustainable architecture, and only in the third principle it is in line with LEED and the 19th. In the second, third and fourth principles, the index of the LEED system is slightly different from the BREEAM.

Overall, the 19th issue is of the lowest importance and compliance with the principles of sustainable architecture. The biggest difference between this system and two other systems is related to the 4th and 5th principles. It seems that in only one case, the third principle, the 19th issue is approaching the LEED and BREEAM systems, Levels of the LEED and BREEAM rating systems are very close together. The points earned by BREEAM in principles 1,2, 3, 4, and 5 are higher than the LEED. The 19th issue has the lowest distance to the LEED in the third principle, and apparently, it is the only tip which is close to the LEED system. It is clear that the degree of compliance of the US and UK energy auditing standards with the principles of sustainable architecture is significantly higher than the 19th issue.

The numerical results of step 2 (normalized decision, ND), step3 (weighted normalized decision), step 4 (Positive ideal solution (PIS) and negative ideal solution (NIS)), step 5 (The distance of each alternative from PIS, consists of step 5-1(d iw) and step 5-2 (d ib)), and finally step 6 (the closeness coefficient of each alternative) are illustrated in Table 3, and Step 4, is showed in Table 4. Furthermore, the achievement of applying TOPSIS – step6- is signalized in Figure 2 too.

Table 3

Compliance of the LEED, BREEAM, and 19th issue of NBRI with the five principles of sustainable architecture by TOPSIS. (Steps2, 3, 5, and 6)

LEED items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2		Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 6
	Step 2						Step 3					Step5		
LEED for Neighborhood Development Location	0.110	0.075	0.110	0.196	0.130	0.022	0.015		0.022	0.039	0.026	0.0854	0.0374	0.3048
Sensitive Land Protection	0.110	0.075	0.055	0.196	0.196	0.022	0.015		0.011	0.039	0.039	0.0853	0.0423	0.3315
High Priority Site	0.055	0.075	0.110	0.196	0.196	0.011	0.015		0.022	0.039	0.039	0.0854	0.0423	0.3313
Surrounding Density and Diverse Uses	0.165	0.075	0.110	0.196	0.196	0.033	0.015		0.022	0.039	0.039	0.0763	0.0477	0.3846
Access to Quality Transit	0.221	0.075	0.165	0.196	0.130	0.044	0.015		0.033	0.039	0.026	0.0756	0.0523	0.4090
Bicycle Facilities	0.165	0.075	0.110	0.196	0.065	0.033	0.015		0.022	0.039	0.013	0.0887	0.0399	0.3104
Reduced Parking Footprint	0.165	0.149	0.110	0.196	0.261	0.033	0.030		0.022	0.039	0.052	0.0613	0.0579	0.4858
Green Vehicles	0.276	0.075	0.220	0.118	0.130	0.055	0.015		0.044	0.024	0.026	0.0740	0.0587	0.4424
Site Assessment	0.110	0.149	0.220	0.196	0.196	0.022	0.030		0.044	0.039	0.039	0.0625	0.0557	0.4710
Site Development - Protect or Restore Habitat	0.055	0.149	0.055	0.196	0.261	0.011	0.030		0.011	0.039	0.052	0.0778	0.0524	0.4023
Open Space	0.055	0.075	0.055	0.196	0.196	0.011	0.015		0.011	0.039	0.039	0.0902	0.0408	0.3118

BREEAM items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 6
	Step 2					Step 3					Step5		
Visual Comfort	0.147	0.073	0.074	0.186	0.097	0.029	0.015	0.015	0.037	0.019	0.071	0.038	0.345
Indoor Air Quality	0.197	0.073	0.149	0.186	0.097	0.039	0.015	0.030	0.037	0.019	0.066	0.048	0.423
Thermal Comfort	0.147	0.073	0.186	0.149	0.097	0.029	0.015	0.037	0.030	0.019	0.068	0.043	0.387
Acoustic Performance	0.049	0.073	0.037	0.186	0.049	0.010	0.015	0.007	0.037	0.010	0.086	0.030	0.258
Accessibility	0.049	0.073	0.037	0.186	0.049	0.010	0.015	0.007	0.037	0.010	0.086	0.030	0.258
Private Spaces	0.049	0.073	0.037	0.186	0.049	0.010	0.015	0.007	0.037	0.010	0.086	0.030	0.258
Water Quality	0.049	0.073	0.074	0.186	0.049	0.010	0.015	0.015	0.037	0.010	0.083	0.031	0.269
Reduction of Energy Use and Carbon Emissions	0.246	0.218	0.186	0.186	0.146	0.049	0.044	0.037	0.037	0.029	0.035	0.067	0.658
Energy Monitoring	0.197	0.073	0.186	0.074	0.244	0.039	0.015	0.037	0.015	0.049	0.063	0.058	0.478
External Lighting	0.049	0.073	0.186	0.149	0.097	0.010	0.015	0.037	0.030	0.019	0.076	0.038	0.335
Low Carbon Design	0.147	0.073	0.186	0.111	0.049	0.029	0.015	0.037	0.022	0.010	0.074	0.039	0.342

NBRI items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step5-2	Step 6
	Step 2						Step 3					Step5	
Avoid Thermal Exchange	0.331	0.370	0.242	0.066	0.248	0.066	0.074	0.048	0.013	0.050	0.075	0.088	0.539
Therma Insulation of The External Walls	0.166	0.370	0.242	0.066	0.124	0.033	0.074	0.048	0.013	0.025	0.099	0.070	0.413
Building Orientation	0.248	0.092	0.194	0.332	0.248	0.050	0.018	0.039	0.066	0.050	0.091	0.073	0.446
Shape and Volume of Building	0.248	0.092	0.194	0.133	0.248	0.050	0.018	0.039	0.027	0.050	0.099	0.052	0.345
Locating Internal Spaces	0.083	0.185	0.242	0.133	0.496	0.017	0.037	0.048	0.027	0.099	0.084	0.087	0.507
Glazing	0.331	0.462	0.194	0.066	0.124	0.066	0.092	0.039	0.013	0.025	0.092	0.094	0.505
Shadings	0.083	0.092	0.145	0.332	0.124	0.017	0.018	0.029	0.066	0.025	0.118	0.057	0.324
Thermal Inertia	0.083	0.277	0.242	0.066	0.124	0.017	0.055	0.048	0.013	0.025	0.110	0.054	0.327
Natural Ventilation	0.166	0.092	0.242	0.265	0.372	0.033	0.018	0.048	0.053	0.074	0.086	0.076	0.471
Heating and Cooling Supplements	0.166	0.092	0.242	0.199	0.124	0.033	0.018	0.048	0.040	0.025	0.113	0.050	0.306
Distribution Circuits	0.248	0.092	0.145	0.332	0.124	0.050	0.018	0.029	0.066	0.025	0.108	0.066	0.378

LEED items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2		Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 6
	Step 2						Step 3					Step5		
Rainwater Management	0.055	0.075	0.055	0.118	0.326	0.011	0.015		0.011	0.024	0.065	0.0877	0.0545	0.3832
Heat Island Reduction	0.110	0.299	0.165	0.118	0.130	0.022	0.060		0.033	0.024	0.026	0.0598	0.0551	0.4793
Light pollution reduction	0.055	0.075	0.110	0.196	0.196	0.011	0.015		0.022	0.039	0.039	0.0854	0.0423	0.3313
Outdoor Water Use Reduction	0.055	0.075	0.055	0.118	0.326	0.011	0.015		0.011	0.024	0.065	0.0877	0.0545	0.3832
Indoor Water Use Reduction	0.055	0.075	0.165	0.196	0.130	0.011	0.015		0.033	0.039	0.026	0.0868	0.0405	0.3181
Cooling Tower Water Use	0.055	0.075	0.274	0.196	0.065	0.011	0.015		0.055	0.039	0.013	0.0908	0.0540	0.3729
Water Metering	0.055	0.075	0.274	0.196	0.196	0.011	0.015		0.055	0.039	0.039	0.0787	0.0600	0.4323
Fundamental Commissioning and Verification	0.055	0.075	0.165	0.196	0.196	0.011	0.015		0.033	0.039	0.039	0.0818	0.0464	0.3619
Optimize Energy Performance	0.221	0.299	0.274	0.118	0.130	0.044	0.060		0.055	0.024	0.026	0.0461	0.0738	0.6157
Advanced Energy Metering	0.221	0.075	0.274	0.157	0.130	0.044	0.015		0.055	0.031	0.026	0.0727	0.0612	0.4570
Demand Response	0.110	0.075	0.274	0.118	0.065	0.022	0.015		0.055	0.024	0.013	0.0874	0.0479	0.3541

BREEAM items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 6
	Step 2					Step 3					Step5		
Energy Efficient Cold Storage	0.246	0.073	0.074	0.111	0.097	0.049	0.015	0.015	0.022	0.019	0.070	0.044	0.384
Energy Efficient Transport System	0.147	0.073	0.186	0.149	0.049	0.029	0.015	0.037	0.030	0.010	0.073	0.042	0.365
Energy Efficient Equipment	0.147	0.073	0.186	0.074	0.097	0.029	0.015	0.037	0.015	0.019	0.071	0.038	0.345
Drying Spaces	0.049	0.073	0.037	0.149	0.244	0.010	0.015	0.007	0.030	0.049	0.076	0.045	0.370
Public Transport Accessibility	0.197	0.073	0.111	0.186	0.244	0.039	0.015	0.022	0.037	0.049	0.061	0.059	0.493
Proximity to Amenities	0.246	0.073	0.074	0.074	0.049	0.049	0.015	0.015	0.015	0.010	0.077	0.041	0.347
Alternatives Modes of Transport	0.197	0.073	0.111	0.186	0.049	0.039	0.015	0.022	0.037	0.010	0.072	0.044	0.381
Maximum Car Parking Capacity	0.049	0.218	0.037	0.186	0.146	0.010	0.044	0.007	0.037	0.029	0.060	0.046	0.432
Travel Plan	0.246	0.073	0.111	0.186	0.049	0.049	0.015	0.022	0.037	0.010	0.071	0.051	0.419
Home Office	0.147	0.073	0.111	0.186	0.049	0.029	0.015	0.022	0.037	0.010	0.074	0.039	0.342
Water Consumption	0.049	0.073	0.037	0.111	0.244	0.010	0.015	0.007	0.022	0.049	0.078	0.042	0.350

NBRI items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 6
	Step 2						Step 3					Step5	
Cooling and Heating Terminals	0.083	0.092	0.242	0.066	0.124	0.017	0.018	0.048	0.013	0.025	0.128	0.039	0.233
Fresh Air Supplying	0.248	0.092	0.145	0.332	0.124	0.050	0.018	0.029	0.066	0.025	0.108	0.066	0.378
Sealing Quality of Openings	0.083	0.462	0.242	0.133	0.124	0.017	0.092	0.048	0.027	0.025	0.098	0.085	0.463
Hot Water Utility	0.331	0.092	0.242	0.133	0.124	0.066	0.018	0.048	0.027	0.025	0.112	0.064	0.365
Lighting Systems Control	0.083	0.092	0.194	0.332	0.372	0.017	0.018	0.039	0.066	0.074	0.093	0.078	0.457
Brightness Control	0.083	0.185	0.242	0.199	0.124	0.017	0.037	0.048	0.040	0.025	0.109	0.050	0.317
Lighting Intensity Control	0.083	0.092	0.145	0.332	0.124	0.017	0.018	0.029	0.066	0.025	0.118	0.057	0.324

LEED items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2		Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 7	BREEAM items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step5-1	Step5-2	Step 7	NBRI items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 7
	Step 2						Step 3					Step5				Step 2					Step 3					Step5				Step 2						Step 3					Step5	
Renewable Energy Production	0.165	0.075	0.274	0.118	0.065	0.033	0.015		0.055	0.024	0.013	0.0839	0.0516	0.3809	Water Monitoring	0.049	0.073	0.074	0.186	0.097	0.010	0.015	0.015	0.037	0.019	0.079	0.032	0.289														
Enhanced Refrigerant Management	0.276	0.075	0.055	0.039	0.196	0.055	0.015		0.011	0.008	0.039	0.0847	0.0512	0.3770	Water Efficient Equipment	0.049	0.073	0.037	0.186	0.195	0.010	0.015	0.007	0.037	0.039	0.077	0.042	0.352														
Green Power and Carbon Offsets	0.276	0.075	0.220	0.079	0.065	0.055	0.015		0.044	0.016	0.013	0.0835	0.0556	0.3997	Water Leak Detection and Prevention	0.049	0.073	0.111	0.186	0.195	0.010	0.015	0.022	0.037	0.039	0.072	0.044	0.380														
Building Life- Cycle Impact Reduction	0.276	0.299	0.110	0.039	0.130	0.055	0.060		0.022	0.008	0.026	0.0619	0.0652	0.5130	Life Cycle Impacts	0.197	0.363	0.074	0.037	0.049	0.039	0.073	0.015	0.007	0.010	0.055	0.066	0.545														
Building Product Disclosure and Optimization Environmental Product Declarations	0.276	0.299	0.110	0.039	0.130	0.055	0.060		0.022	0.008	0.026	0.0619	0.0652	0.5130	Responsible Sourcing of Construction Production	0.147	0.363	0.074	0.037	0.097	0.029	0.073	0.015	0.007	0.019	0.051	0.062	0.550														
Building Product Disclosure and Optimization - Sourcing of Raw Materials	0.276	0.299	0.110	0.039	0.130	0.055	0.060		0.022	0.008	0.026	0.0619	0.0652	0.5130	Insulation	0.147	0.290	0.074	0.149	0.097	0.029	0.058	0.015	0.030	0.019	0.045	0.054	0.547														
Building Product Disclosure and Optimization - Material Ingredients	0.276	0.299	0.110	0.039	0.130	0.055	0.060		0.022	0.008	0.026	0.0619	0.0652	0.5130	Designing for Durability and Resilience	0.147	0.290	0.074	0.149	0.097	0.029	0.058	0.015	0.030	0.019	0.045	0.054	0.547														
Construction and Demolition Waste Management	0.221	0.299	0.055	0.118	0.130	0.044	0.060		0.011	0.024	0.026	0.0637	0.0594	0.4825	Material Efficiency	0.147	0.363	0.037	0.074	0.097	0.029	0.073	0.007	0.015	0.019	0.051	0.062	0.550														
Enhanced IAQ strategies	0.055	0.075	0.110	0.196	0.065	0.011	0.015		0.022	0.039	0.013	0.0966	0.0333	0.2563	Construction Waste Management	0.246	0.073	0.111	0.111	0.049	0.049	0.015	0.022	0.022	0.010	0.073	0.045	0.379														
Low- Emitting Materials	0.165	0.374	0.110	0.039	0.130	0.033	0.075		0.022	0.008	0.026	0.0640	0.0660	0.5078	Recycled Wastes	0.147	0.363	0.074	0.074	0.049	0.029	0.073	0.015	0.015	0.010	0.054	0.062	0.536														
Indoor Environmental Quality	0.165	0.149	0.110	0.196	0.065	0.033	0.030		0.022	0.039	0.013	0.0794	0.0426	0.3494	Operational Waste	0.246	0.073	0.111	0.037	0.244	0.049	0.015	0.022	0.007	0.049	0.067	0.057	0.462														

LEED items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2		Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 7	BREEAM items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step5-1	Step5-2	Step 7	NBRI items	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Principle 1	Principle 2	Principle 3	Principle 4	Principle 5	Step 5-1	Step 5-2	Step 7
	Step 2						Step 3					Step5				Step 2					Step 3					Step5				Step 2						Step 3					Step5	
Interior quality Evaluation	0.055	0.075	0.110	0.196	0.065	0.011	0.015		0.022	0.039	0.013	0.0966	0.0333	0.2563	Adaptation to Climate Change	0.246	0.145	0.111	0.037	0.244	0.049	0.029	0.022	0.007	0.049	0.055	0.059	0.519														
Thermal Comfort	0.055	0.075	0.220	0.196	0.065	0.011	0.015		0.044	0.039	0.013	0.0915	0.0455	0.3323	Functional Adaptability	0.049	0.073	0.037	0.037	0.244	0.010	0.015	0.007	0.007	0.049	0.082	0.039	0.323														
Interior Lighting	0.055	0.075	0.165	0.196	0.065	0.011	0.015		0.033	0.039	0.013	0.0934	0.0383	0.2910	Site Selection	0.147	0.073	0.074	0.186	0.146	0.029	0.015	0.015	0.037	0.029	0.068	0.041	0.378														
Daylight	0.055	0.075	0.165	0.196	0.196	0.011	0.015		0.033	0.039	0.039	0.0818	0.0464	0.3619	Ecological Value of Site and Protection of Ecological Features	0.049	0.073	0.037	0.149	0.244	0.010	0.015	0.007	0.030	0.049	0.076	0.045	0.370														
Acoustic Performance	0.055	0.075	0.055	0.196	0.065	0.011	0.015		0.011	0.039	0.013	0.1009	0.0314	0.2376	Minimizing Impact on Existing Site Ecology	0.049	0.073	0.037	0.186	0.195	0.010	0.015	0.007	0.037	0.039	0.077	0.042	0.352														
															Enhancing Site Ecology	0.049	0.073	0.037	0.186	0.195	0.010	0.015	0.007	0.037	0.039	0.077	0.042	0.352														
															Long-term Impact on Bio Diversity	0.049	0.073	0.037	0.186	0.244	0.010	0.015	0.007	0.037	0.049	0.076	0.049	0.392														
															Energy Efficient Cold Storage	0.197	0.073	0.186	0.037	0.146	0.039	0.015	0.037	0.007	0.029	0.069	0.046	0.402														
															NOx Emissions	0.197	0.073	0.186	0.037	0.146	0.039	0.015	0.037	0.007	0.029	0.069	0.046	0.402														
															Surface Water Run - Off	0.049	0.073	0.037	0.186	0.244	0.010	0.015	0.007	0.037	0.049	0.076	0.049	0.392														
															Reduction of Night Time Light Pollution	0.049	0.073	0.074	0.186	0.097	0.010	0.015	0.015	0.037	0.019	0.079	0.032	0.289														
															Reduction of Noise Pollution	0.049	0.073	0.037	0.186	0.049	0.010	0.015	0.007	0.037	0.010	0.086	0.030	0.258														

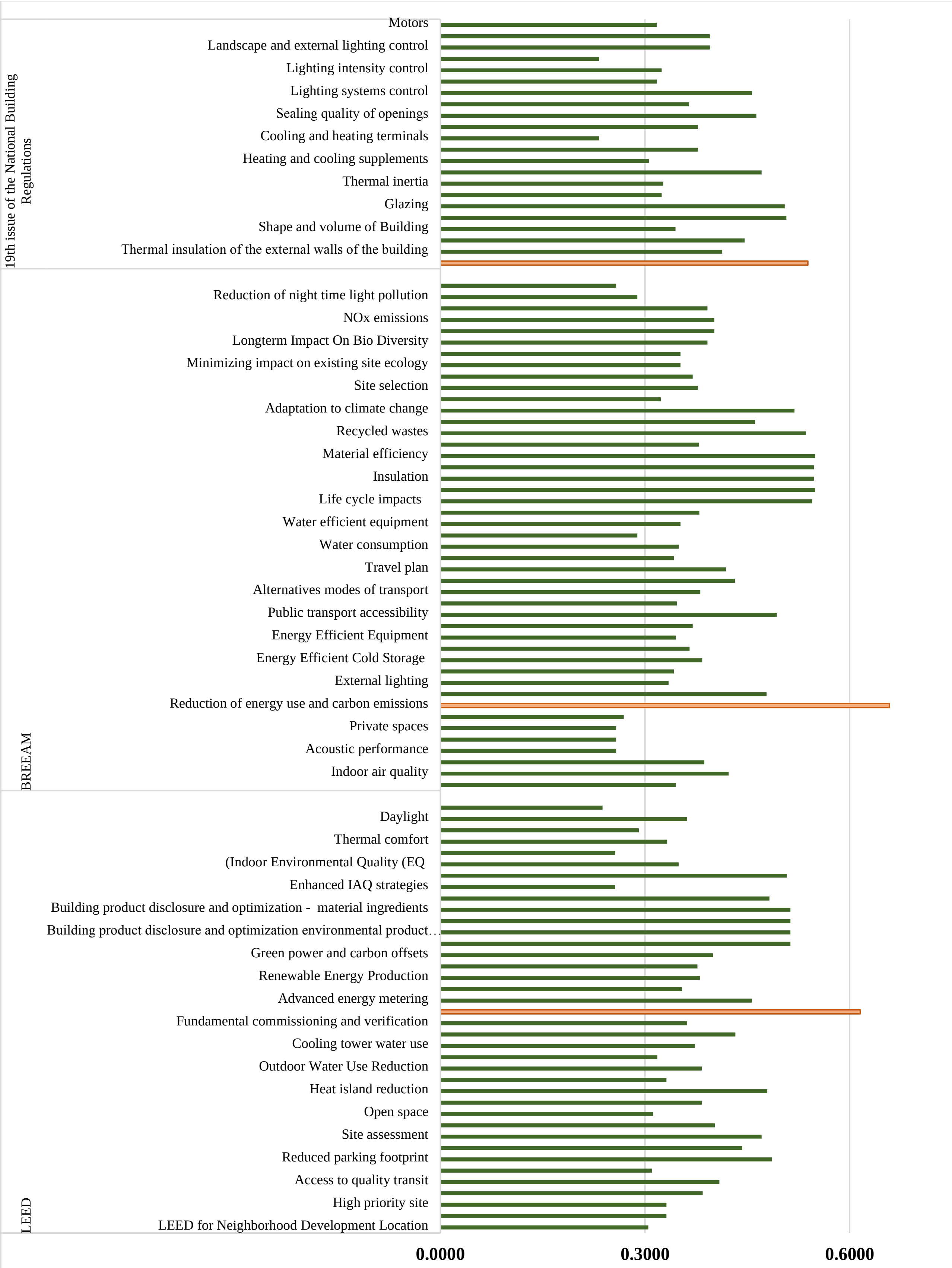

Fig.3. The results of the comparison of LEED and BREEAM and 19th issue common and uncommon principles, according to TOPSIS method. (step 6)

7. Discussion

7.1. The results of the comparison LEED and BREEAM and 19th issue common and uncommon principles, according to TOPSIS method

To find out the degree of flexibility and the level of scoring of each of the common parts in the LEED, BREEAM and NBRI 19th issue, a comparison is made in Figure 3, which gives more information about the details of the principles of rating and scoring of these three systems.

The Figure 3 shows that the three, has spent most heavily on the similar tasks like Waste, Materials, Transport and Energy. Almost in every case, BREEAM and LEED spending are considerably higher than that of NBRI. Only in the case of energy saving and thermal exchange does Iranian regulations come closer.

In contrast, NBRI is generally the lowest spender. This is most evident in Indoor Qualities Such as Lightings, Cooling and Heating Terminals and etc. where Iran spends much less than LEED. Meanwhile, United States and Britain generally maintain middle positions, averaging approximately similar spending overall. Especially, LEED appends more on Materials and Resources, Energy and Atmosphere, Sustainable Sites, Location and Transportation. but less on Acoustic Performance, Indoor Environment and its related Qualities than BREEAM does. Its spending on Reduction of energy use and carbon emissions Marginally greater than that of others, while spending on Lifecycle Impact, some topics of Materials, Energy Metering, and Climate adoptability matters are equal between the two. Because of the achieved data, it is clear that there are some significant differences in green building assessment tools – LEED and BREEAM- within NBRI's 19th issue. And the most sustainable items are in respectively in BREEAM, LEED and NBRI. They are Reduction of energy and carbon emission, avoid thermal exchange, and optimize energy performance.

8. Conclusions

This research proposes a comparative analysis between LEED, BREEAM and 19th issue of National Building Regulations of Iran (NBRI) by the Multi-Criteria Decision Making (MCDM) TOPSIS method. Both assessment tools illustrate a sophisticated rating system evaluation from planning and designing process to construction and operation of the building from the aspects of sustainability considering: Energy efficiency, reduction of CO_2, adapting to climate change, indoor and outdoor qualities etc. by contrast, 19th issue takes less or no attention to mentioned tasks. According to the main subject of the present study, first of all, main striking features of the sustainable architecture are being categorized and labeled based on books, articles, and documents as five main principles discovering their impact on each standard.

Second of all, after introducing the standards' traits with their sub-principles, which are vital to doing from the design stage to operation process. Entire items of three systems were matched with each other one by one by the descriptive methodology to find out their similarities and differences as follows: there are 25 common items in LEED and BREEAM, 10 related items in LEED, BREEAM, and NBRI, 15 completely uncommon items in NBRI compared with two others.

In addition, the presentation of TOPSIS as a practical Decision-Making method, each standards' sub-principles, consisting: 38 LEED, 45 BREEAM, and 18 NBRI tasks as case studies along with five sustainable architecture principles as criteria of decision making in order to find the ideal items of all three tools are scored. Results are shown this way : At first step of TOPSIS method, BREEAM cached the highest point (588 credits), and after that LEED with (493 credits) achieved second place, and among others, NBRI reaches the third place with (279 credits). Results show the importance of sustainability in both assessment tools and NBRI 19th issue. Regarding above evaluation, Iran doesn't assist enough with sustainable architecture principles as U.S. and Britain do.

Eventually, the strategy of the ranking calculation by TOPSIS is proximate the target options to the positive choices than negative ideal ones. At the final step of this method, top items of each standard, which could hit the excellent point in the process are presented as the most accordance tasks with sustainability. For instance: Reduction of Energy and Carbon Emission in BREEAM, Avoid

Thermal Exchange in LEED, and Optimize Energy Performance in NBRI, mentioned is compliance with five sustainable architecture principles. Also, according to the achievements of TOPSIS in the study these following results are obtained: in terms of importance to the sustainable architecture principles U.S. LEED and Britain BREEAM rating systems have relatively closed-relation with the following topics: Energy and Atmosphere, Materials and Resources, Sustainable Site, Waste, and Transportation. Which, are not considered anymore in Iranian building standards. And, just Energy and Avoid Thermal Exchange of NBRI tasks are similar with others. Whereas, focused items of mentioned principle are: Glazing, Sealing Quality of Opening, Natural Ventilation, Lighting System Control and Location Internal Spaces. These comparisons show NBRI 19th issue, unlike LEED and BREEAM, neglected other aspects of Environmental subjects in Its policy overall levels of construction . In conclusion, according to the present study, it is recommended that researchers and specialists examine the contents of each of the themes mentioned in above sections and give the results to the relevant legislature organizations. It is the task of the planners, policymakers, and implementers of various environmental related and energy-optimized sectors to pay more attention to these issues and make the right decisions to stepping up with the world in the direction of sustainable architecture.

Declarations

List of abbreviations

LEED:leadership in energy and environmental design; BREEAM: Building Research Establishment Environmental Assessment Method; NBRI: National Building Regulations of Iran; CASBEE: The Comprehensive Assessment System for Built Environment Efficiency; DGNB: The Deutsche Gesellschaft für Nachhaltiges Bauen; HQETM: The Haute Qualité Environnementale; SBTool: The Sustainable Building Tool; MCDM: Multi-Criteria Decision Making; NAHB: National Association of Home Builders; TOPSIS: Technique for Order Preference by Similarity to Ideal Solution; USGBC: United States Green Building Council; BRE: UK Building Research Establishment; UNEP: United Nations Environment Program; WCED: World Commission on Environment and Development; WWF: Worldwide Fund for Nature; IUCNNR: International Union for Conservation of Nature and Natural Resources; WSSD: World Summit on Sustainable Development; HK-BEAM: Hong Kong Building Environmental Assessment Method; GB tool: Green Building Rating tool; CASBEE: Comprehensive Assessment System for Built Environment Efficiency; NAHB: National Association of Home Builders; ITACA: Istituto per l'innovazione e Trasparenza degli Appalti e la Compatibilità Ambientale; IPCC: intergovernmental panel on climate change; AP: Accredited Professional; DM: decision maker; PIS: Positive ideal solution; NIS: negative ideal solution; ND: normalized decision.

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Authors' contributions

MM and MJM originally initiated the paper and performed the qualitative analysis of the framework (case study) and intensive discussion and contributed to the design of the paper; NER and MJM contributed to the design of the study, to the calculation and review of MCDM of TOPSIS method challenges, and to the properties and the methodology. MM and MJM contributed to the review of challenges, in particular the challenge of uncertainty; all authors engaged in the initial design of the analysis; All authors read and approved the final manuscript.

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