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Regional Priorities for Sustainable Architectural Design in Tehran City Using the LEED Method (District 22, Tehran)

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Abstract

Implementing appropriate design approaches for reaching the goals of sustainable architecture, establishing a residential complex relying on clean energies and considering the climatic characteristics and utilizing different technologies are among the most important needs of the country based on the outlook documents for the next ten years of architecture. Localization or adjusting measuring approaches and then realizing global sustainable architectural standards are of utmost importance in this regard. Therefore, this study has adopted the LEED method for realizing the standards. In measuring the LEED indicators, the most important one is the regional scores indicator which must be extracted and introduced in the process of assessing the regional sustainability priorities. There was no such assessment in District 22, Tehran. Therefore, the main objective of the current study is to achieve the ranking of strategic priorities responsive to the climatic conditions of Tehran so that it can be used as a reference for measuring the success of sustainability projects and similar designs. So, by assessing and investigating the regions which have such scores, including some instances in south California, projects in India, Arizona, and a lot of other regions it was concluded that the regional priority credits are determined based on their sub measures. Accordingly, 50 questionnaires were distributed as a survey among architectural and civil engineers in graduate and doctoral programs. After gathering the questionnaires, using descriptive and inferential statistics in SPSS software application, the credits with the highest frequency percentage were selected as the regional priorities. These priorities were (1) reducing water consumption, (2) renewable energies on site, (3) optimizing energy consumption, (4) optimizing water consumption, (5) waste management, and (6) green energies.

Keywords: LEED, regional priority, credit, clean energies

1- Introduction

In the modern world, each building must be designed in a way that the need for fossil fuels is minimized. Energy productivity in modern buildings is the most important objective for improving energy consumption. High costs of energy and serious environmental impacts have increased the demand for designing sustainable buildings. Many developed countries are now using some set of standards for increasing the efficiency of the buildings by making them more compatible with the surrounding environment. On the other hand, these standards have created a competition with other types of buildings in the market.

Accordingly, a wide variety of tools for assessing and evaluating green buildings and the protocol has been used in the last twenty years by the developed countries in order to reduce the energy consumption levels and the environmental effects [1].

Leadership in Energy and Environmental Design (LEED) system has been developed by the council for green construction in the United States [2].

The LEED system is currently used in 41 countries besides the U.S. including Canada, Brazil, Mexico, India, and so on. Those buildings which have a LEED certificate are not only compatible with the environment, but also cost-effective. The statistics gathered by this council shows that green buildings with the average consumption of roughly 40 percent less water and energy compared to regular buildings can easily compensate for their construction cost in the lifetime of the building. These buildings also save about 50 to 70 percent in creating construction waste [3].

In 2006, USGBC (U.S. Green Building Council) established the New Buildings Institute (NBI) for assessing and investigating the energy consumption of commercial buildings certified under the second plan for new constructions (NC) or LEED. The NBIs completed their studies in 2008 and concluded that LEED certificate had led to average 25 to 30 percentage savings [4].

Other studies also show that building designs with the golden ranking and higher in the LEED system can save more than 50 percent in energy consumption [5].

Based on the statistical information, the LEED system can have a huge impact on saving energy. Accordingly, a design objective for a residential complex based on LEED was selected for the current study. However, for District 22 of Tehran, there is no regional priority indicator based on LEED. Therefore, based on other studies for other regions where the LEED system has defined credits based on the other subscales of LEED, the credits of this scale can be determined. The necessity of determining this indicator is because of getting the score for both LEED items. For instance, if reducing water consumption gains a score in the subscale of regional priority, it will also gains a score in its own subscale; namely, water efficiency, which increases its score as well as the attention given to the building's regional requirements. Accordingly, the statistical information of these priorities can be ranked and classified as well as defined for this scale.

2- Research Literature

In 1993, U.S. Green Building Association was established under the supervision of Environmental Committee of Architectural Institute of America. This association needed a tool for managing and evaluating sustainable buildings. In 1998, the first version of the LEED certificate was used for evaluating green buildings [6].

Using universal principles of energy and the environment and according to the performed consultancies, the LEED system entered this field and has since tried to become an intermediary for creating an acceptable balance between scientific experiments and theoretical concepts [7].

Since the beginning, many researchers performed studies regarding the impacts of the LEED certificate. For instance, establishing new buildings shows that LEED buildings consume 25 to 30 percent less energy on average and higher credit certificates, such as gold and platinum, consume 45 percent less energy compared to buildings without a LEED certificate [8].

Information acquired from 100 LEED certificates in Newsham and Mancini showed 25 to 35 percent energy savings compared to non-LEED buildings [9].

Statistical information on four levels of the LEED certificate based on the statistics acquired from 100 scores is classified in the fo llowing table based on the year, the location, and the ranking of the certificate.

Table 1- The Number of Buildings with LEED Certificates Based on the Year, Location, and the Ranking of the Certificate [10]

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	Total
Number	44	74	101	197	279	586	1413	1988	4489	7169
Region	CA	TX	NY	FL	IL	PA	MA	WA	Other	Total
Number	1019	448	360	323	296	291	268	267	3825	7196
Ranking	Certificate (40-49)		Silver (50-59)		Gold (60-79)		Platinum (80 and more)		Total	
Number	1287 (18%)		2533 (35%)		2500 (36%)		749 (11%)		7169	

Moreover, a study analyzed the energy performance of green plants in buildings with high occupancy which had gold LEED certificates in Canada. This analysis shows that the energy item in green buildings decreases 96.5 percent of heat absorption in green walls and decreases 68 percent heat absorption in ceilings with complete green plant coverage in the summer. However, this coverage is not cost-effective in the winter. Nevertheless, it increases the energy score in the LEED certificate [11]. Furthermore, Kim Huan has performed several studies on the regional priority credit which investigated the effects of this credit on the buildings which possess it. These studies show that if a LEED building has a high credit in the scale of regional priority, the environmental positive effects and environmental benefits will also be higher. These studies show that this indicator in the certificate pays attention to all the aspects of a building ranging from design to construction and this indicator is a good measure for the efficiency of a building [12].

3- Methodology

Based on previous studies carried out on buildings designed and constructed with a LEED certificate, it can be said that buildings with LEED certificates, particularly with higher rankings, have a higher energy saving. Therefore, a residential complex was designed based on this indicator. What is needed in this study is the regional priorities for District 22 of Tehran City. Considering the fact that the regional priority information for this district is not available, a questionnaire was designed based on LEED items which was distributed as a survey among architectural scholars. The acquired data were analyzed using descriptive and inferential statistics in SPSS software application. Finally, the priorities with the highest frequency percentage and credits for the regional priority scale were considered.

4- Analysis

Based on the samples studied, the regional priorities were as follows:

- ✓ **South California**

1. Public transportation (SSC 4.1) (sustainable site subscale)
2. Designing water ways for directing surface water (quantity control) (SSC 6.1) (sustainable site subscale)
3. Reducing water consumption (WEC3) (water efficiency subscale)
4. Consuming minimum amount of energy in the building (EAC1) (energy and atmosphere subscale)
5. Using renewable energy on the site (EAC2) (energy and atmosphere subscale)
6. Heat-design comfort (IEQC7) (internal environment quality subscale) [13]

- ✓ **Arizona**

1. Reaching optimum density in constructed spaces and closeness to urban networks (SSC2) (sustainable site subscale)
2. Providing appropriate parking spaces (SSC4.1) (sustainable site subscale)

3. Preventing heat islands except for the ceiling (SSC7.1) (sustainable site subscale)
4. Optimizing water consumption for watering the outside space (WEC1) (water efficiency subscale)
5. Reducing water consumption (WEC3) (water efficiency subscale)
6. 6. Using renewable energy sources on site (EAC2) (energy and atmosphere subscale) [14]

- ✓ **A Region in India**

1. Saving in water consumption of irrigation systems (WE4) (water efficiency subscale)
2. Innovative wastewater treatment (WEC2) (water efficiency subscale)
3. Reducing water consumption (WEC3) (water efficiency subscale)
4. Consuming minimum energy in the building (EAC4) (energy and atmosphere subscale)
5. Air purification (EAC3) (energy and atmosphere subscale)
6. Measuring and auditing energy consumption in the building (EAC5) (energy and atmosphere subscale) [15]

In order to find the analysis results from all the subscales for LEED, a questionnaire was prepared and distributed among graduate and doctoral students. After gathering the questionnaires, the data were prepared for comparing and analyzing the research hypotheses. In analyzing the data, a researcher searches the desired results about the selected population through observations extracted from the sample. Accordingly, using some statistical methods, the data are first described and then the obtained results are analyzed and interpreted. In this study, the extraction of desired results is carried out using SPSS software application. Therefore, considering these issues, the tables and data analyses are presented as follows.

The findings are divided into two parts:

- Descriptive findings;
- Inferential findings.

In the descriptive section, frequency distribution and charts for each one of the research variables are presented. In the inferential section, using statistical tests, it is determined which one of the hypotheses are confirmed. Inferential statistics indicate whether the patterns and processes found in the sample are applicable in the statistical population or not (Duas, 1997: 138).

4-1- Descriptive Findings

Descriptive statistics are a set of methods for organizing, summarizing, tabulating, and describing the data gathered from the statistical sample. In fact, in this section, characteristics of the statistical sample of the study are considered and two dimensional tables are used for describing the variables. In the following table, descriptive statistics measures related to each one of the main issues (measures and indicators) of the study are shown.

Table 2- Descriptive Statistics Measures

Measure	Number	Average	Standard Deviation	Minimum	Maximum
Quality of internal space	50	3.7246	0.541	2.08	4.54
Water efficiency	50	4.1933	0.967	1.00	5.00
Energy and atmosphere	50	3.6467	0.557	2.20	4.73
Sustainable site	50	4.0033	0.698	2.00	4.67
Materials and sources	50	3.4550	0.677	2.00	4.25

In order to rank the factors present in the questionnaire based on their importance and significance, one-way analysis of variance (one-way ANOVA) and Duncan's post hoc test are used. One-way ANOVA test compares the averages of multiple variables (here, the average scores for the factors in the questionnaire) in a pre-determined significance level (here, 95 percent) and indicates the significance or insignificance of their difference. The results for one-way ANOVA test are presented in the following table.

Table 3- ANOVA Test Results

	Sum of squares	df	Mean square	F	Sig
Between groups	191.398	44	4.350	3.668	0.001

Within groups	2615.080	2205	1.186		
Total	2806.478	2249			

The results of the test show that there is a significant difference between the average scores of the factors. In other words, based on the significance level obtained from one-way ANOVA (0.001) and the fact that it is smaller than 0.05, it can be concluded that in the significance level of 95 percent, the difference between factors' averages is significant.

4-2- Results of Freedman's Ranking Test

Since the sample size (50) is higher than 30, it can be concluded that based on the central limit theorem, when the sample size is larger than 30, parametric tests (here, one-way ANOVA) are used instead of non-parametric tests (Freedman's ranking test).

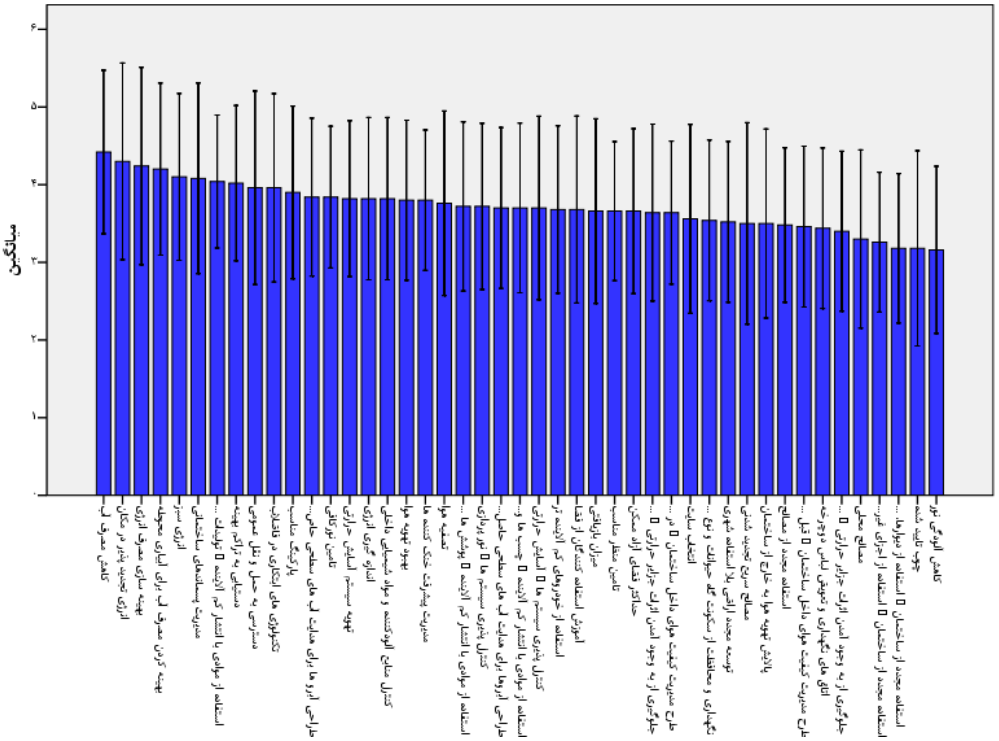

Chart 1- Results for Freedman's Ranking Test

From the obtained results, it can be discerned that the following factors have higher rankings: optimizing energy consumption, optimizing water consumption for watering outside spaces, green energy, managing construction wastes, using materials with low pollutant levels such as products from plant and wood fibers, reaching optimal density, accessing public transportation, and innovative technologies of wastewater treatment.

Table 4-Results for Freedman Test

Reducing water consumption	32.69
Renewable energy on site	30.89
Optimizing energy consumption	30.37
Optimizing water consumption for watering the outside spaces	29.85
Managing construction wastes	27.89
Green energy	27.17
Reaching optimal density	26.7
Accessibility to public transportation	26.35
Innovative wastewater treatment technologies	26.18
Using materials with low pollutant emission- plant and wood fibers	26.16
Appropriate parking space	25.56
Designing waterways for directing surface waters of rainfalls- quality	24.89

Controlling pollution sources and internal chemical material	24.86
Measuring energy	24.61
Purifying air	23.97
Managing the development of coolers	23.69
Providing sufficient lighting	23.58
Using materials with low pollutant emission- covers and colors	23.51
Using materials with low pollutant emission- glues and sealers	23.46
Heat comfort of the AC system	23.41
Improving the AC system	23.21
Controllability of systems- heat comfort	23.13
Controllability of systems- lights	22.82
Using cars with lower pollution levels	22.7
Designing waterways for directing surface waters of rainfalls- quantity	22.18
Preventing the effects of heat islands- ceiling	22.17
Highly renewable materials	21.66
Training the users of the space	21.55
Recycling level	21.51
Plan for managing the quality of the air inside the building- during construction	21.47
Filtering the air conditioning outside the building	20.46
Maximum possible free space	21.41
Site selection	20.97
Providing suitable landscape	20.59
Maintaining and protecting animal habitats and the plant species of the region	20.48
Developing abandoned urban land	20.24
Reusing materials	19.77
Rooms for storing and changing biking clothes	19.75
Plan for managing the quality of the air inside the building- before the residents are settled	19.2
Preventing the effects of heat islands- outside space	18.99
Local material	17.69
Reusing the building- using non-structural components available inside the building	17.32
Reducing light pollution	16.91
Certified wood	16.76
Reusing the building- using available walls, floors, and ceilings	16.27

In order to evaluate the significance of mean difference for each one of the general measures of the study (i.e. quality of internal space, water efficiency, sustainable site, energy and atmosphere, and materials and sources), again the one-way analysis of variance (one-way ANOVA) test is used. The results for this test are presented in the following table.

Table 5- ANOVA Test

	Sum of squares	df	Mean square	F	Sig
Between groups	17.208	4	4.302	8.659	0.001
Within groups	121.721	245	0.497		
Total	138.929	249			

The results of the test show that there is a significant difference between the average scores of the factors. In other words, based on the significance level obtained from one-way ANOVA (0.001) and the fact that it is smaller than 0.05, it can be concluded that in the significance level of 95 percent, the difference between factors' averages is significant.

4-3- Freedman Test Results

Table 6- Freedman Test Results

Measure	Rank
Water efficiency	3.92
Energy and atmosphere	3.64
Internal space quality	2.79
Sustainable site	2.59
Materials and sources	2.06

Number	50
Chi square	47.80
Significance level	0.001

Considering limited rainfall in recent years and the presence of a relative drought, selecting the credit of reducing water consumption as the first priority in the performed tests of the study can be justified for the issue of regional priorities. Hence, observing this phenomenon, planning some measures for design and construction of the future buildings seems necessary. The ranking of renewable energies on site indicates that tendency to use clean energies and identifying the potential of the region is an invaluable part of building construction. Considering the limited resources of fossil energy and high levels of pollution due to these resources renders this issue, very important. Selecting renewable energies on site indicates that tendency to use clean energies and identifying the potential of the region is an integral part of building construction.

Considering the ranking of optimizing energy consumption, it is worth mentioning that in recent years in Iran, higher prices of energy has moved us towards optimizing consumption, so selecting this factor among LEED items is justifiable.

Considering the selection of optimizing water consumption for watering the outside spaces, it is worth mentioning that in Iran, families often use drinking water for the site consumptions too. Hence, selecting this item indicates the concern about this issue and the fact that we have to consider serious measures for using grey waters with treatment plans to be used on site. Finally, the ranking of waste management credit as a high priority item is because in our country there are no sufficient plans for investing and planning in this regard, which must be one of the main issues considered in designing and organizing the buildings plans.

5- Conclusions

Considering the statistics and the rankings of credits including reducing the water consumption, utilizing renewable energies on site, optimizing water consumption, waste management, green energy, and reaching optimal density it can be concluded that the priorities in District 22 of Tehran City indicate the fact that serious measures must be taken concerning the issue of water consumption including the reduction of water usage and using it on site or optimizing water usage at the stage of designing and construction. It seems that this issue is very important for the entire City of Tehran since 75 percent of wastewater in Tehran goes untreated, the city is faced with energy-related challenges, and the problem of air pollution is rampant all around Tehran. Nevertheless, this study shows that we have to move towards using renewable energies, water management methods and waste management strategies by considering them more in constructing new buildings compared to other credits. Based on the results, such LEED items must be considered for designing buildings in District 22 of Tehran City. It can be concluded that the LEED standard is an immediate necessity for modern buildings. Hence, using standards for measuring energy consumption and optimizing energy usage is necessary for a city like Tehran where a standard which considers all the environmental aspects has never been utilized before.

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