Review of Sustainable Design Principles for Leed Certified Buildings: The Case of Turkey

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Abstract
The negative impacts caused by inefficient use of natural resources around the world, global warming and climate change have become a global threat, thereby considerably amplifying in recent years the importance of the concept of 'sustainable development', which led to the emergence of the concept of „green buildings‟ in the construction sector. Being green in the construction sector means designing and constructing buildings in such a way as to reduce the negative impact of the building and its users on the environment, climate and human health throughout the building‟s lifetime. Following the early examples of green building projects, Green Building Certification Systems were created with the aim of certifying, promoting and mainstreaming the environmentally-friendly properties of such buildings. Seven LEED certified buildings were selected for the sample and were evaluated with respect to the sustainable design principles. Analyses conducted on the sample, it was concluded that sustainable design principles must be taken into consideration as a whole in designing green buildings. It has become important for architects to be knowledgeable about sustainable design principles to design projects.

Keywords
Sustainability, LEED, Sustainable Design, Green Building, Green Building Certification Systems.

1. Introduction

It appears that an ecological awareness has arisen all around the world as a result of such ecological problems as global warming, climate change, drought, environmental pollution, and rapid depletion of natural resources. It is a known fact that buildings have an impact on the environment too. Ecological awareness has propelled the construction sector into finding solutions to mitigate carbon emissions and negative environmental impacts of buildings. Construction sector has started a green transformation to combat climate change. The idea is to build environmentally- and ecologically-friendly buildings. This growing interest in environmentally-friendly buildings has led to the emergence of the concept of "green building" (Akca, 2011).

Such reasons as the low energy and water consumption and waste management benefits of green buildings, the minimization of the effects on the ecosystem of green building projects, and an increase in the use of environmentally-friendly materials in construction have rendered high-performance green buildings attractive in the eyes of investors. Certification systems have played an active role in the expansion of green buildings and in the tangible identification of building performance. Becoming more and more widespread all around the world, Green Building Rating Systems have created a new approach and a new sector. BREEAM (England), LEED (U.S.A.), Green Star (Australia), CASBEE (Japan), SBtool (Canada) ve DGNB(Germany) are common systems.

One may encounter many recent articles relating to sustainable design and certification systems in a review of the literature. However, it has not been possible to find studies that look into the buildings specifically in terms of certification criteria and sustainable design criteria regardless of the type of the building. The objective set by this study is to look into the LEED-certified buildings in Turkey, LEED being the most widespread of the green certification systems; to assess the sampled buildings in terms of sustainable design criteria; and as a result, to enhance the contribution to the design process of the architect, who is the most important member of the design team.

2. Design Principles for Sustainable Buildings

Sustainable design should be regarded from a perspective of ensuring a healthy cycle within the nature-human/society whole. Sustainable design takes into account climatic characteristics and includes a series of physical criteria which start with the positioning of the building and the building design layout, and go on to include the form of the building, spatial organization, materials selection, sanitary fittings, appropriate vegetation, etc. (Tonuk, 2001).

Tonuk (2001) lists design principles in ecological architecture as follows:

- Minimize damage to natural resources in design and use of built environment,
- Position the building in a way that is appropriate for the existing topography and respectful of the soil, water, air, and existing green texture,
- A design that is compatible with nature, climatic conditions, and topographic characteristics,
- q
- Design the circulation elements and bathrooms as much in the northern direction as possible in the horizontal design of functional space groups,
- Take into consideration ecological principles with respect to both horizontal distribution and vertical distribution,
- Ensure that the design allows for flexibility and variability and that spaces are multifunctional,
- Designs that utilize solar power,
- Develop design principles for smart buildings, which is an interdisciplinary design study area where modern technology is predominantly used (Tonuk, 2001).

Krusche, Gabriel, and Althaus (1982) summarize the points to consider in ecological design as follows:

- Positioning of the building, building design approaches, the form of the building, building design layout, the organization of spatial programmes and functions, material selection, sanitary fittings, and goal-oriented vegetation should be rational in terms of the environment and energy issues,
- Minimize use of energy and scarce resources in the construction and use of the building,
- Rational use of natural environmental systems (utilizing solar power, natural air conditioning, green cover, etc.),
- Minimize pollution of the soil and water resources by thermal, liquid, and solid waste,
- Protect and increase in quantity and variety the flora and fauna potential in the region,
- Seat the building in a way that would minimize the damage to the natural environment, and therefore create a healthy residential and work environment (Krusche et al., 1982).

According to CEDBIK (Turkish Green Building Council), which has made important contributions to the improvement of the Turkish construction sector in light of sustainable principles, green buildings, which appear in many names including eco-friendly, green, and environmentally-friendly buildings, are buildings that are compatible with nature, and which are designed in a holistic manner and in a socially and environmentally responsible way, with the design process starting from the selection of the site on which the green building is to be built and covers the whole lifecycle of the building. ÇEDBİK further defines green buildings as compatible with climatic characteristics and the specific conditions of their environment, consuming only as much as they need, making use of renewable energy resources, promoting the use of natural building materials that do not produce waste, and being sensitive to the ecosystem (Tonguc, 2012).

Contributing to the mitigation of the environmental impacts of buildings, certification systems guide design professionals in the production process and in the implementation. These certification systems have been developed by green building associations and certain research institutions so as to support sustainable building design (Yavasbatmaz, 2012). The general objective of these systems is to mitigate the environmental impacts of buildings and construction activities in a lifecycle approach. Having been developed for the conditions of the countries they have originated in, these models can now also be implemented in developing countries directly or after necessary adjustments. The subjects that are common to BREEAM, LEED, and CASBEE green building certification systens are sustainable sites, water conservation, indoor air quality, selection of appropriate materials and building elements, water efficiency, and energy and atmosphere (Tonguc, 2012).

Yavasbatmaz (2012) and Tonguç (2012) categorize sustainability into economic, ecological, and social/cultural sustainability components. However, these three components are not separable and function as a whole. That is why one criterion can be included in multiple components. However, in this study, each criterion has been classified in accordance with the component with which it most associated. Classification for sustainable design principles are indicated in the Table 1.

- **Review of Sustainable Design Principles for Leed Certified Buildings in Turkey (Case Study)**

Seven LEED-certified buildings in Turkey have been selected for examination in the study. Distribution of LEED-certified buildings in Turkey has been taken into consideration in the selection of the buildings. Hence, two Platinum Certified New Buildings, four Gold Certified New Buildings, and one Silver Certified New Building have been examined. These buildings are; Erke Green Academy, Eser Holding Headquaters, Sabancı University Nanotechnology Center, Sisecam ARGE Building, Basf Dilovası Management Building, Ozyegin University Engineering Building and Li-Fung Center. The objective of the study is to assess the selected buildings in terms of ecological, economic, and socio-cultural sustainable design principles, and as a result, enhance the contribution to the design process of the architect, who is the most important member of the design team.

Sustainable design principles need to be observed in all stages of the building, starting with design, continuing with construction and use, and ending with demolition. Sustainable design principles cover a wide array of matters including the building site, the climate of the region, the position of the building and its compatibility with the environment surrounding it, storey height and number, size of storey spaces, ventilation and lighting systems, load-bearing system, construction materials to be used, construction methods, the aesthetic qualities of the building, etc. In this context, for ecologically sustainable design, sustainable sites, water use efficiency, energy and atmosphere, materials and resources should be put at the forefront; for economically sustainable design, efficient use of resources and low costs of use from design till demolition should be at the foreground; and for socio-culturally sustainable design, indoor life quality and innovation and design process should be focused on.

Table 1: Principles of Sustainable Design

	Measures	Methods
Ecologic	**Sustainable Sites**	Compatibility with topography. Site selection in accordance with residential density. Creation of transport and car park systems. Reducing heat island effect. Compatibility with landform. Effective use of building spaces. Improvement of urban sites. Protection of natural habitats. Protection of fertile soil.
	Water Use Efficiency	Use of water-efficient fittings and equipment. Selection of plants that require little water and care in landscape design. Reuse of waste water and rainwater.
	Energy and Atmosphere	Use of solar cells in electricity generation. Use of sunlight in lighting. Use of solar collectors in water heating. Use of wind energy in ventilation and cooling. Selection of energy-efficient construction materials. Selection of local materials. Use of light coloured construction materials for façades. Use of high-performance joinery and glass. Energy efficiency by means of effective insulation systems. Establishment of systems for the building to self-power.
	Materials and Resources	Procurement of construction materials from the near environment. Use of standardized construction materials that do not cause health problems or pollution. Development of a material management plan to prevent resource loss and waste creation. Selection of recyclable and reusable construction materials. Use of quickly self-renewable construction materials. Selection of construction materials that are economical, aesthetically pleasing, high-erformance and that have a producer's warranty and user satisfaction certificate. Avoiding the use of construction materials whose production may have damaged the ecosystem.
	Transport	Establishment of transport axes. Devising alternative transport paths and car parks. Minimization of car park areas. Designing bicycle parks and pedestrian crossings. Prioritization of easy and safe public transport vehicles. Prioritization of the use of high-capacity, low carbon emission service vehicles.
Econom	**Building Form**	Design of the width and length of the building taking into consideration climatic data. Reduction of the size of the exterior surface of the building. Designation of the storey height of the building to capitalize on natural lighting. Designation of the number of storeys in the building taking into consideration the users of the building. Design of the indentations in the building form for shading purposes.
	Efficient Use of Resources	Ensuring resource efficiency through the use of recyclable construction materials. Selection of construction materials with long-term usability.
	Spatial Organization	Allowing variable and flexible spatial designs through the use of mobile elements such as replaceable mobile panels. Designing accurately oriented transitional spaces to make appropriate use of sunlight. Allowing for designs that can change in line with future needs through modular designs. Standardization of construction elements and details.
	Building Envelope	Use of wide windows on façades that could make the best use of natural lighting and use of narrower windows on façades in the prevailing wind direction. Greening of façades and roofs. Designing solar control equipment in line with the type of glass to be used, the orientation and site of the building. Optimum level of insulation on the roof, walls and coverings.
	Low Cost of Use	Reduction in costs by ensuring energy and resource efficiency in production. Choosing local construction materials, hence lowering costs for transport to the construction site. Economic design through cost analysis.
Social/Cultura	**Interior Space Life Quality**	Establishing appropriate comfort conditions in interior spaces. Ensuring interior air quality. Avoiding construction materials containing toxic substances. Prevention of air pollution.
	Innovation and Design Process	Establishing a visual contact with the outdoor environment. Designing buildings that use little energy in construction and operation. Designing buildings that make efficient use of interior spaces. Taking into consideration climatic data in design.

In this scope, in this section of the dissertation, seven LEED-certified new buildings which are currently in use have been selected, and their design principles have been assessed in the application assessment tables. In these application assessment tables; s ustainable design principles that are applied in the buildings are awarded "+", those that are partially applied are awarded "±", and those that are not applied are awarded "-". An assessment method has been used to identify the effectiveness of LEED-certified buildings with respect to sustainable design. In this assessment method, first, the Ecological Sustainable Design (ESD), Economic Sustainable Design (ECSD), and Socio-cultural Sustainable Design (SCSD) principles applied in each of these buildings have been compared. Then, the buildings have been compared within the scope of ESD, ECSD, and SCSD principles, and findings from the assessment have been interpreted.

An objective method has been used to assess the effectiveness of the buildings in terms of sustainable design. As the recommended assessment method, the sustainable design principles presented in Chapter 2 have been used as the assessment criteria. The assessment criteria have been objectively given scores. The table shows the assessment indicator for the scoring of the buildings examined in the study. In these this indicator; sustainable design principles that are applied in the buildings are awarded "+", those that are partially applied are awarded "±", and those that are not applied are awarded "-". The signs "+", "±", and "-" are respectively accorded 2, 1, and 0 points.

Table 2: Assessment Indicator

Application Symbol	Application Situation	Point
+	Applied	2
±	Partially applied	1
-	Not applied	0

At the end of the assessment, assessment principles are scored in accordance with the assessment indicator provided in the Table 2, and the effectiveness of the buildings in terms of sustainable design is ascertained in percentage terms. This assessment is provided in the assessment part of the Table 3. In accordance with the assessment table presented, it is seen that LEED certified buildings are successful applying sustainable design principles. It can be concluded that ecological, economic, and socio-cultural sustainable design principles have been implemented to a great extent in the LEED certified buildings that have been studied.

4. Evaluation of the Sample

Certification points and sustainable design points of the sampled buildings are compared on a percentage basis in Table 4. Upon comparison of the certification points and sustainable design points of LEED certified buildings, it can be seen that the building ranking does not change. Therefore, it can be said that LEED certified buildings apply sustainable design principles. However, there is a difference between LEED assessment and sustainable design criteria points. Although the ranking stays the same, it is observed that each building has scored higher on sustainable design criteria on a 100 point basis, and that they satisfy sustainable design principles to a great extent.

As a result of the analyses and studies conducted, it can be said that while a thorough assessment of compatibility with the environment constitutes and important part of sustainable design criteria, LEED assessment criteria attach a great deal of importance to mechanical features. This makes it clear as to why score distribution in the criteria is different. Therefore, the reason why there is a slight drop in scores when certified buildings are assessed for sustainable design criteria becomes apparent. While buildings are assessed for energy and atmosphere, materials and resources, indoor air quality, sustainable sites, water efficiency, and innovation and design criteria in LEED assessment system; sustainable design criteria additionally assess the form of the building, efficient use of resources, spatial organization, building envelope, and low building use cost. These criteria make up 27% of the assessment for sustainable design criteria (Celik, 2016).

Tablo 3: Assesment Table of LEED Certified Buildings In Terms of Sustainable Design

			Eser Holding Headquarters	Erke Green Academy	Sabanci University Nanotechnology Center	Sisecam ARGE Building	Ozyegin University Engineering Building	Basf Dilovası Management Building	Li-Fung Center
ESD	ESD1	ESD1.1	2	2	2	2	2	1	1
		ESD1.2	2	2	2	2	2	2	2
		ESD1.3	2	1	0	0	1	1	1
		ESD1.4	2	2	2	2	2	2	2
		ESD1.5	2	2	2	2	1	1	1
		ESD1.6	2	2	2	2	2	1	2
		ESD1.7	2	2	2	0	1	1	1
	ESD2	ESD2.1	2	2	2	2	2	1	1
		ESD2.2	2	2	1	1	1	2	2
		ESD2.3	2	2	1	1	1	1	2
	ESD3	ESD3.1	2	2	0	2	0	0	0
		ESD3.2	2	2	2	2	2	2	2
		ESD3.3	2	2	2	1	0	0	0
		ESD3.4	2	2	2	2	0	0	0
		ESD3.5	2	2	2	2	2	2	2
		ESD3.6	2	2	2	2	2	2	2
		ESD3.7	2	2	2	2	2	1	1
		ESD3.8	2	2	2	2	2	2	2
		ESD3.9	2	2	2	2	2	2	2
		ESD3.10	2	2	0	2	1	0	0
	ESD4	ESD4.1	2	0	0	0	2	2	1
		ESD4.6	2	2	2	2	1	2	1
		ESD4.7	2	1	2	1	1	1	1
	ESD5	ESD5.1	2	2	2	2	2	2	2
		ESD5.2	2	1	1	1	1	2	1
		ESD5.3	2	2	0	0	2	2	2
		ESD5.4	2	0	1	0	1	0	2
		ESD5.5	2	1	2	2	2	2	0
		ESD5.6	2	1	2	2	1	1	0
	ESD6	ESD6.1	2	2	2	2	1	2	2
		ESD6.2	2	2	2	2	2	2	2
		ESD6.3	0	2	2	2	1	1	0
		ESD6.4	2	2	2	2	2	2	2
		ESD6.5	0	2	0	0	2	0	0
		ESD6.6	2	2	2	0	2	2	2
		ESD6.7	2	2	2	2	1	2	1
Point (../80)			76	67	62	59	58	54	50
Percentage Point (.../100)			95	84	78	74	73	68	63

			Eser Holding Headquarters	Erke Green Academy	Sabanci University Nanotechnology Center	Sisecam ARGE Building	Ozyegin University Engineering Building	Basf Dilovası Management Building	Li-Fung Center
ECSD	ECSD1	ECSD1.1	2	2	2	2	2	2	2
		ECSD1.2	2	2	2	2	1	2	2
		ECSD1.3	2	2	2	2	2	2	2
		ECSD1.4	2	2	2	2	2	2	2
		ECSD1.5	2	2	2	2	1	2	1
	ECSD2	EKST2.1	2	2	2	2	2	2	2
		EKST2.2	2	2	2	2	2	2	1
	ECSD3	ECSD3.1	2	0	0	0	0	0	0
		ECSD3.2	2	2	2	2	2	2	2
		ECSD3.3	0	0	0	0	0	0	0
		ECSD3.4	2	2	2	2	2	2	2
	ECSD4	ECSD4.1	0	2	2	1	1	2	2
		ECSD4.2	2	0	0	2	2	0	0
		ECSD4.3	2	2	2	2	1	2	2
		ECSD4.4	2	2	2	2	2	2	2
	ECSD5	ECSD5.1	2	2	2	2	2	2	1
		ECSD5.2	2	2	2	2	2	2	2
		ECSD5.3	2	2	1	1	1	1	1
Point		(../36)	32	30	29	30	27	29	26
Percentage Point (.../100)			89	83	81	83	75	81	72
			Eser Holding Headquarters	Erke Green Academy	Sabanci University Nanotechnology Center	Sisecam ARGE Building	Ozyegin University Engineering Building	Basf Dilovası Management Building	Li-Fung Center
SCSD	SCSD1	SCSD1.1	2	2	2	2	2	2	2
		SCSD1.2	2	2	2	2	2	2	2
		SCSD1.3	2	2	2	2	2	2	2
		SCSD1.4	2	2	2	2	2	2	2
	SCSD2	SCSD2.1	2	2	2	2	2	2	2
		SCSD2.2	2	2	2	2	2	2	2
		SCSD2.3	2	2	2	2	2	2	2
		SCSD2.4	2	2	2	2	2	2	2
Point (../16)			16	16	16	16	16	16	16
Percentage Point (.../100)			100	100	100	100	100	100	100

The sampled buildings have been designed with the objective of less energy consumption. Solar control has been ensured through façade design features. These design features include horizontal glass sunshades, a second façade, and solar panels. Special attention has been paid to recyclable and local material use in design. Perforated metal meshes, façade panels, and glass materials have been used for the façade and roof. Spaces in the buildings have been designed to receive the best sunlight. Use of renewable energy resources is on the forefront; solar power is used for water heating, and wind energy for ventilation and cooling. Only local plants have been used in landscape design. The buildings have green roofs. Rainwater is recovered and used for irrigation. The water systems in use enable water saving. All the buildings have been designed with the environment and human health in mind, and the design is based on light and transparency (Celik, 2016).

Table 4. Evaluation of the sample

	Eser HoldingHeadquarters	**Erke Green Academy**	Sabanci UniversityNanotechnologyCenter	Sisecam ARGEBuilding	Ozyegn UniversityEngineeringBuilding	Basf DilovasıManagementBuilding	**Li-Fung Center**
Certification Point (…/110)	92	82	79	76	72	72	54
Certification Point (…/100)	**83**	**74**	**71**	**69**	**65**	**65**	**49**
Total Sustainable Design Point (…/132)	124	113	107	105	101	99	92
Total Sustainable Design Point (…/100)	**94**	**86**	**81**	**80**	**77**	**75**	**70**

Mechanic systems make up the superior features of the buildings which have achieved high scores. For example, Eser Holding Headquarters has created a clean air feed system by installing CO_2 sensors. Temperature control systems have been installed. Sun tubes have been used for the roof floor. VRV has been used as the heating-cooling medium. Earth source heat pumps and cogeneration units have been installed. Furthermore, there are superior features in sustainable sites criteria as well. An example is the consideration for the creation of bicycle parks and bus stops in addition to the car park. Additionally, use of exterior lighting to minimize light pollution is another superior detail.

5. Results and Conclusion

Being green in the construction sector means designing and constructing buildings with a view to minimizing the damage to the environment, climate, and human health for the whole lifecycle of a building. This is not a decision that solely concerns construction technology. Sometimes, decisions taken right at the beginning of the design process can be the most important decisions in terms of being green. Therefore, decisions taken right at the beginning of the design process, if they do not take into account green building principles, might cause the costs of use of the building (energy costs, etc.) to climb up in the future. Ecologically-friendly design improves the quality of products and services with better design and at the same time minimizes the environmental impact of the building throughout its lifecycle.

Sustainable design aims to build green buildings which are “environmentally responsible, profitable, and healthy for working and residential purposes". Today, the concept of “eco-design” has become a part of the framework drawn by the "design for sustainability". In this context, designers interested in sustainable design should create designs that do not disrupt ecological cycles.

The study assesses the LEED certification systems and the practices in Turkey, implemented within the scope of sustainable design principles, to control the negative environmental impacts of buildings. The objective set by this study is to look at the LEED-certified buildings in Turkey, LEED being the most widespread of the green certification systems; to assess the buildings selected as examples in terms of sustainable design criteria; and as a result, to enhance the contribution to the design process of the architect, who is the most important member of the design team.

Sustainable design sets mitigation of environmental impacts as its primary objective. With the decisions architects make at the design stage, buildings that provide the necessary comfort conditions and consume minimum energy can be designed. The implementation of sustainable design principles makes it possible to construct ecologically, economically, and socio-culturally sustainable buildings. Buildings successful in implementing sustainable design principles are successful in terms of certification systems too. However, it is an important fact that the selection of mechanical systems make a large part of the success in certification scores and therefore increase the score of the building.

LEED assessment criteria and sustainable design principles should be taken as a whole in green building design. It has become important that architects be knowledgeable about sustainable design principles and certification systems criteria, that they design in accordance with those principles and criteria, and that they will be familiar with the mechanical systems that have emerged as a necessity of the certification systems criteria. This way, buildings that minimize the impact on the environment, climate, and human health of the building and its users can be designed and constructed.

Certification systems have played an active role in the expansion of green buildings and in the tangible identification of building performance. Becoming more and more widespread all around the world, Green Building Rating Systems have created a new approach and a new sector. The number of LEED certified buildings increase significantly each year. According to CEBDIK data, while Turkey had 76 certified buildings and 230 certification candidates in November 2014, there were 172 certified buildings and 404 certification candidates in Turkey in August 2016 (http://www.cedbik.org). This result shows that the demand for the certification systems which provide a concrete manifestation of building performance is rapidly increasing, and that certification has become a sector. Therefore, it is important that architects, one of the most important actors of the construction process, have sufficient knowledge of sustainable design and certification systems.

If there are sustainable design courses in undergraduate education, this will help form a new architectural perspective and consolidate the understanding of green buildings for architects. Hence, applied design trainings can be added to undergraduate architectural curriculum, and elective courses may be opened. Architects who are trained with this awareness in mind, would approach LEED assessment criteria and sustainable design principles in a holistic manner, and would create widely recognized certified building designs. Therefore, the environmental impact of buildings would be diminished with the construction of buildings which use low energy and consume little water, have waste management, have minimum impact on the ecosystem, and which are constructed with environmentally-friendly materials.

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