A Research on Selecting the Green Building Certification System Suitable for Turkey[1]

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Abstract

Since the sustainable development is considered one of the most significant global concerns, its goals are legislated by several countries to guarantee the project compliance. Therefore, the important issue of development is to ensure the project compliance with the sustainability requirements. With this paper, a research is conducted for selecting a green building certification system for Turkey. Moreover a methodology is presented based on the strategy to find the most important standards and criteria which must be considered in the development of a green building certification system in Turkey. The Analytic Hierarchy Process (AHP) technique has been adopted by determining criteria and sub-criteria from the literature. Furthermore, interviews and surveys have been implemented with experts whom are from different backgrounds, i) academicians, ii) professional consultants and iii) decision makers for the government. By the use of criteria and sub-criteria which are considered significant in line with the green building and sustainability studies, the questionnaire has been developed based on AHP is completed by the experts and analysed with a software. Depending on the outcomes of the research; any of the existing certification systems do not fit perfectly for Turkey, therefore, it is concluded that a new national certification system should be developed. Moreover, based on survey results, economy (cost) and effectiveness are considered the most significant standards for the green building certification system in Turkey. Whereas, assessment success, registration and certification costs, adaptability and reliability are the most significant sub-criteria.

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Türkiye İçin Uygun Yeşil Bina Sertifika Sisteminin Seçilmesi Üzerine Bir Araştirma[1]

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Öz

Sürdürülebilir kalkınma en önemli küresel kaygılardan biridir ve hedefleri birçok ülke tarafından projelerde uyumluluğu garanti altına almak için yasal olarak düzenlenmektedir. Bu sebeple kalkınmanın önemli sorunu, projelerin sürdürülebilirlik şartlarına uygun elde edilmesini sağlamaktır. Bu makale Türkiye için uygun yeşil bina sertifika sisteminin seçilmesini araştırmaktadır. Bununla birlikte Türkiye'de yeşil bina sertifikasyon sisteminin geliştirilmesinde göz önünde bulundurulması gereken en önemli standartları ve ölçütleri bulma stratejisine dayalı bir metodoloji sunulmaktadır. Analitik Hiyerarşi Prosesi (AHP) tabanlı yöntem, kaynak taramasına bağlı belirlenen ölçütlerin değerlendirilmesi için önerilmektedir. Değerlendirme için i) akademisyenler, ii) profesyonel danışmanlar ve iii) hükümet için karar vericiler gibi farklı alanlardan gelen uzmanlarla görüşmeler ve anket çalışması yapılmıştır. Yeşil bina ve sürdürülebilirlik çalışmaları doğrultusunda önemli sayılan ölçüt ve alt ölçütler kullanılarak, AHP tabanlı anket çalışması uzmanlar tarafından doldurulmuş, bir yazılım aracılığı ile analiz edilmiştir. Yapılan araştırmaya bağlı olarak mevcut sertifika sistemlerinden herhangi birinin Türkiye için en uygun seçenek olmadığı, bu sebeple ulusal yeni bir sertifika sisteminin geliştirilmesi gerektiği sonucuna varılmıştır. Bununla birlikte Türkiye'deki yeşil bina sertifikalandırma sistemi için ekonomi (maliyet) ve etkinliğin en önemli standartlar olarak kabul gördüğü yapılan anket çalışmalarından çıkarılmıştır. Değerleme başarısı, kayıt ve belgelendirme maliyetleri, uyumluluk ve tutarlılık ise gözetilmesi gereken alt kriterler olarak tespit edilmiştir.

Bu makale Fatma S. Said'in 2017 tarihli, Çankaya Üniversitesi'nde, Yrd. Doç. Dr. Timuçin Harputlugil danışmanlığındaki yüksek lisans tezinden üretilmiştir.

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1. INTRODUCTION

The price of energy has increased as a result of the reduction of fossil fuels supply all around the world. In response, countries around the world have started sustainable strategies through the creation of policy instruments. Almost all the sectors including business, manufacturing, construction, transportation have included sustainable strategies into their existing business plans to insure environmental safety (Kibert, 2016). According to researchers and scientists, one of the ways to reduce the harm to the environment is to make buildings more sustainable and more energy effective. When it comes to the design stage, the architect designs the building through advanced tools which predicts, calculates and estimates the environmental performance characteristics of a building (Morledge & Jackson, 2001). The environmental assessment tools for buildings have been developed to provide an objective evaluation of indoor environmental quality, resource use, and ecological loadings, etc. (Cole, 2005). These tools present various methods to define criteria of green buildings. They connect large number of environmental issues and combine them into overall judgments. Those issues addressed by the tools may influence environmental policies, designs and building practices. The methodologies of assessment play several roles; they facilitate understanding the effect of buildings on natural systems, marketing green buildings, as well as addressing sustainability (Cole, 2005). They also help politicians and decision makers in environmental management, primarily in architectural projects (Gluch & Stenberg, 2006). Accordingly, construction sector becomes the potential contributor to the achievement of sustainable development at a great level.

Thus, the assessment tools for green buildings are important subjects in the field of construction. For that reason, it is necessary to investigate the green certification systems acknowledged world-wide such as: Leadership in Energy and Environmental Design' (LEED), 'Building Research Establishment's Environmental Assessment Method' (BREEAM), 'Comprehensive Assessment System for Built Environment Efficiency'(CASBEE), 'High Quality of Environment'(HQE), 'Deutsche Gesellschaft für Nachhaltiges Bauen'(DGNB) and Turkish system Çevre Dostu Yeşil Binalar Derneği, House Certificate (ÇEDBİK-Konut Sertifikası) to understand the content and the context.

Thus, the purpose of this paper is to determine the most important criteria and sub-criteria that influence the choice of a green building certification system for Turkey and to investigate the most compatible certification system based on these criteria.

2. LITERATURE REVIEW

2.1 Sustainability

The concept of sustainability could be defined by several ways; the most common definition was by the World Commission of Environment and Development (WCED) in 1987;"sustainability is addressing the needs of the present without undermining the needs of the future" (Brundtland, 1987). Defined sustainability as "addressing the needs of the present without undermining the needs of the future" (Chichilnisky, 2011). Sustainability has its roots since the period of recognizing the impacts of global warming. Since 1960s, the concept of sustainability has emerged in response of the concerns associated with the environmental degradation and the resource utilization (Becker, 2012). It was acknowledged that the impacts of these aspects would result in limiting the daily life activities as the global ecosphere would have finite productivity along with affecting the geological availability of fossil fuels and minerals as well. The most significant contribution in this area is regarded as the book "Limits to Growth" that was published in 1972 (Bartlett, 2012). The book presented the computer simulations of the economic changes across the globe in two timeframes. Initially the situational analysis of the global economy was carried out for 1900-1970, incorporating the elements of population, natural resources, agricultural production, industrial production, and pollution (Bartlett, 2012).

2.2 Sustainable Development.

In the field of real estate, sustainability has been considerably implemented. Based on the possible impact of different factors, the importance of employing sustainability as a prime priority has been recognized by developers, owners, investors, and the public sector. The sustainability is considered as a continuous process of sustainable development to achieve a stable state among the environmental, economic and social aspects, as can be seen in Figure 1.

According to the Balaras et al. (2005), accepting the structural demands of buildings; it was noted that the effects on design, construction and management of these built environments could also be affected to a considerable extent.

The CO2 emission, energy and raw material consumption, water usage, and solid wastes have negative impacts on the climate change. In this context, the OECD report of 2011 stated that the construction sector contributes significantly to the sustainable development (Balaras et al., 2005). Therefore, it is known as the keystone of sustainability. Moreover, not taking sufficient actions would cost more than the cost of taking actions (Fankhauser, 2013). Sustainable development was defined by Hopwood, et al, as; "The concept of sustainable development is an attempt to combine growing concerns about a range of environmental issues with socio-economic issues" (Hopwood, Mellor & O'Brien, 2005). However, this concept cannot be generalized as it involves responsibility towards securing the future of current generation. Therefore, the approach of sustainable development is based on the collaborative impacts of ecology and economic development (Chichilnisky, 2011).

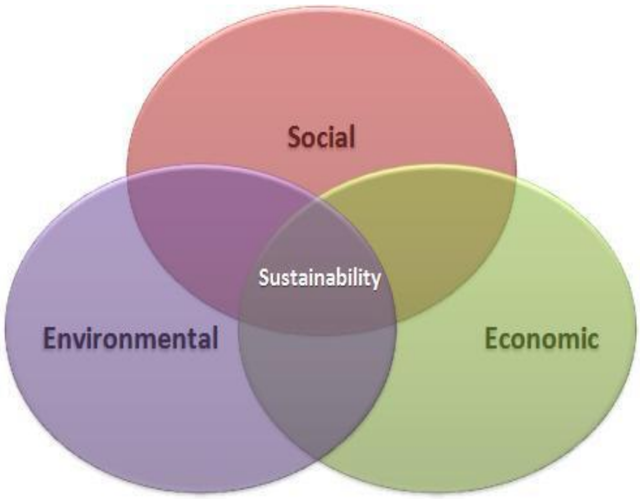


Figure 1 Elements that form sustainable development (Younan, 2011)

2.3 Green Buildings and Sustainability

The green buildings concept is not a recent concept, and the techniques related to this concept have developed with time (Emmitt & Gorse, 2010). A Green Building is designed to be more efficient than the traditional building, regarding the building construction, use of construction materials, functionality of building system, performance, energy and water efficiency, indoor quality; which involves air quality, thermal comfort, lighting, site disturbance, waste management, air emissions, water management, and adaptability in terms of change in user needs and options for occupants transportation (Paumgartten, 2003). The use of Green Building principles gives a possibility to decrease environmental damage (Eno, 2005).

With respect to the environment, green buildings offer enhanced and protected ecosystem and biodiversity. Water and air quality are improved along with reduced waste streams (Kuhlman & Farrington, 2010). As a result, natural resources are conserved and restored. While considering the economic benefits, green buildings result in reduced operating costs, along with improving occupant productivity (Reed et al., 2009).

2.4 The Need of Green Buildings in Turkey

The green buildings were welcomed worldwide. According to the research conducted by Manioglu and Yilmaz (2006), Turkey employs this green strategy and acknowledges its historical presence and architectural importance. 'The House of Mardin' contains one of the first green building projects in Turkey, which is more energy-efficient compared to traditional houses. It also reflects the concept of modern construction in terms of area selection, orientation, distance and the form of the building. The Turkish Green Building Association was founded for the impacts of green strategy and sustainability principles. Training programs have been implemented with pilot projects in order to encourage green buildings and raise awareness (Manioğlu & Yılmaz, 2006).

Turkey has used the innovations of modern technologies to make important changes related to the future impacts of globalization; where several actions have been taken to employ the energy resources to achieve economic improvements through modern solutions adaptation. According to the USGBC yearly report, Turkey is ranked ninth in the application of green building tools (USGBC Report, n.d.).

3. COMPARISON OF GREEN BUILDING CERTIFICATION SYSTEMS

There are various green building certification systems developed worldwide since the last quarter of 20th century. The chosen certification systems or assessment tools are capable of meeting the requirements of sustainability efficiently, in a way that facilitates the spread of 'Green Buildings' all over Turkey. In this section, a comprehensive comparison will be made between the key characteristics of these assessment tools. Furthermore, certain features such as the international recognition, notion of seniority, and other features make some tools desirable over the others (Bowd, McKay & Shaw, 2015) (Hamedani & Huber, 2012). Diverse tools have been examined and further explored with taking in consideration the effects of their particular countries. Thus, the chosen assessment tools take into consideration the economic, social, cultural and environmental aspects. In this paper a detailed comparison for LEED, BREEAM, HQE, CASBEE, DGNB and ÇEDBİK is presented (Table 1, Table 2). Distinctions between tools and the characteristics that distinguish each evaluation certification system as well as their strengths and weaknesses are discussed. Thus, different tools have different criteria describing the concept and extent of green for a building, as numerous environmental concerns are brought under consideration to yield proficient and efficient solutions. It is noted that the effectiveness of assessment tools is governed from multiple aspects and also these tools provide necessary understanding of the effects of building approaches on the natural environment, based on the concept of sustainability (Nguyen & Altan, 2011) (Wangel et al., 2106).

Table 1: The certification systems comparison (Giama, & Papadopoulos, 2012; ÇEDBIK, 2016; Mattoni, et al, 2018; Said, 2017)

Environmental aspects	BREEAM	LEED	HQE	DGNB	CASBEE	ÇEDBIK
Management	✓	✓	Not as a separate aspect, but included in the assessment targets	✓	✓	✓
Energy efficiency	✓	✓	✓	✓	✓	✓
Transport	✓	Included in the environmental aspect 'sustainable sites'	Not as a separate aspect, but included in the assessment targets	Included in the environmental aspect 'sustainable sites and functional quality '	✓	-
Sustainable	✓	✓	✓	✓	✓	-
Indoor environmental quality	✓	✓	✓	Not as a separate aspect, but included in the aspect 'sustainable sites and functional quality '	✓	✓
Water efficiency	✓	✓	✓	✓	✓	✓
Materials	✓	✓	✓	✓	✓	✓
Socio-economic aspects	-	-	✓	✓	✓	✓
Innovation	✓	✓	-	-	-	✓
Environmental impacts	Not as a separate aspect, but included in the assessment criteria (pollution, land use and ecology)	✓	✓	Included in the environmental aspect 'ecological quality'	✓	-

Table 2 A Broad comparison of the certification system (Yusoff & Wen, 2014; Giama, & Papadopoulos, 2012; Said, 2017; Bernardi et al., 2017; Beardsley et al.,2017; Zhivov, 2018; DGNB System, 2017)

Criteria	BREEAM	LEED	HQE	DGNB	CASBEE	ÇEDBİK
Country	UK	USA	France	Germany	Japan	Turkey
Certification Body, year	BRE 1990	USGBC 1998	HQE Association 1994	DGNB auditors 2007	JSBC 2001	TGBA 2007
Main type of examined buildings	New/existing Renewed Commercial Retail Education Homes Hospitals	New/existing Renewed Commercial Retail Education Homes Hospitals	New/existing Offices Logistics, Hospitals Education Hospitality Buildings Commercial	New/existing Offices , Retail Shopping Buildings Laboratories Schools, Industrial Homes Mixed Use, Hospitals	New/Existing Renewed Urban development Cities Residential Property appraisal	Residential
Certification	Pass. Good. Very Good. Excellent Outstanding	Certified. Silver. Gold. Platinum	Good (1 to 4 stars). Very good (5-8 stars).Excellent (9-11 stars).Exceptional (12 stars and higher)	Bronze (35%) Sliver (50%) Gold (at least 65%)	S, A, B+, B and C.	Approved, Good, Very Good, Excellent
Building Phases	Design Maintenance Construction Operation Renewal	Design Maintenance Construction Operation Renewal	Design Maintenance Construction Operation Renewal	Maintenance Construction De-construction Operation Renewal	Design Operation De-construction Construction	Design, construction maintenance and operation
Assessment types	Design & procurement Operation & Management Post-construction	Construction review Design Review Combined design & construction review	Construction review Design Review Combined design & construction review	Maintenance Construction De-construction Operation Renewal	Planning Pre-design design Renewal	Construction review Design Review Combined design & construction review

Table 2 (continued)

Criteria	BREEAM	LEED	HQE	DGNB	CASBEE	ÇEDBİK
Categories	Health &Comfort - 15% Management-12% Transportation 9% Energy- 15% Water-7% Materials-13.5% Pollution-10% Land Use & Ecology-10% Resources Waste- 8.5% Additional credit for innovation -10%	Energy & Atmosphere: 35 pts Materials & Resources: 14 pts Indoor environmental quality: 15 pts Innovation & Design Process: 6 pts Regional credits: 4 pts	Eco-construction Health Well-being Management	Economical quality: 22. 5% Sociocultural quality: 22.5% Process quality: 10% Separately: Site use	Environmental, Quality (Q). Environmental Load (L). Indoor Environment Quality of Service, Outdoor Environment., BEE (Building Environmental Efficiency) = Q/L. Energy, Resources and Materials, Off-site Environment	Integrated Green Project Management, Land use, Water use, Energy use, Health and comfort, Material usage, Living in the residence, Operation and maintenance, Innovation
International Versions and National Adaptations	**International Versions** USA, Netherlands Norway, Spain, Sweden, Germany, Austria, Switzerland	**International versions:** LEED Canada LEED India	**International versions:** Non-residential building in operation 2015 Infrastructures 2015, Habitat and environment Non-residential building under construction 2015 Residential building under construction 2015 Management system for urban planning projects 2016	**International version** Core 14 **National adaptation:** Austria, Bulgaria China, Denmark Germany Switzerland Thailand	N/A	N/A

Table 2 shows the different green building certification systems compared in this research in terms of their establishing country, system establishment date and certification body. Furthermore, the table shows the different types of buildings covered under each system. The assessment scale domains are also shown, which varies in its inclusions and complexity. Further information is shown such as the certification types, building phases covered under each system, and the assessment strategy types.

Based on a comparison between the included alternatives in this research, there are general comparison points between the certification systems as the following (Said, 2017; Bernardi et al., 2017; Zhivov, 2018**;** European Union knowledge Network, 2017; Erten, Henderson, & Kobas, 2009; CASBEE, 2017.; Illankoon et al., 2017). The whole rating systems which are used in order to evaluate the environmental effect of buildings are appropriate for both the new and existing building except ÇEDBİK which certifies only new buildings for houses.

1. The most considered main criteria cover solid waste management, material, energy performance and water.
2. Regarding the categories assessed by the schemes, energy performance, solid waste management, material, and water are the most considered categories from a quantitative perspective; the categories that are considered less are resistance against natural disasters, earthquake prevention, and olfactory comfort.
3. CASBEE is the most technical system, and heavily based on criteria specific to Japan's urban context; CASBEE is the certification that expire on five year cycles, with an option to renew.
4. Some of the green building certification systems offer over-scale-points for innovation such as BREEAM and LEED.
5. BREEAM provides online resources for assessment. However, the agents are more used in the design process.
6. DGNB gives importance weight on the management of technical features.
7. BREEAM and ÇEDBİK have some prerequisites, so that some criteria are mandatory for certification.
8. CASBEE rating tool does not allocate points to each credit criteria however, each credit point is evaluated based on a scale ranging from level 1 to level 5.

In summary, it must be mentioned that these schemes are basically accepted and commonly used in the building sector. The desirable features of these schemes in the future can be explained as follow:

- Completeness which refers to the analysis in a suitable method the whole factors which characterize the building and its life cycle.
- They can be represented in clear method the system of weighting and supporting the counting system with complete evidence.

Furthermore, certification systems such as DGNB has several advantages with an early stage assessment that helps the project to stay on track within the required completion time. DGNB is considered one of the mature systems that covers not only the environmental aspects of the projects, but also the economic, social, cultural, and functional aspects (Miranda, 2013).

As for the Energy category, are one of the most important topics in all of the certification system; provides aspects related to the heating and cooling loads control, energy monitoring, storage systems and renewable energy production however, the approach may vary from one system to another (Banani, Vahdati & Elmualim, 2011) (Mattoni, et al, 2018). LEED v4, which is the latest version released in 2013, seems to address new sectors unlike previous versions, has increased technical requisites, shows improvements in environmental issues such as climate change and supports optimization in energy and water consumption (Uğur & Leblebici, 2017). BREEAM the most recent version was developed in 2016 and covers the entire life cycle of buildings, starting from the design stage, to in-use retrofitting (Mattoni, et al, 2018).

Another factor that is different between the different certification systems is the ease of international adaption. Certification system such as DGNB are highly flexible for international use from climatic, regulatory, and cultural perspectives, where its indicators are balanced to reflect the importance of all the input factors (Reith & Orova, 2015). BREEAM is considered one of the international standards which can be adopted, operated and applied by a set of the international professionals. The operation of BREEAM by the clients work on decreasing the environmental impacts of the buildings. BREEAM has been applied in more than 77 countries in order to certify more than 563,616 building evaluations over the life cycle of building (BREEAM, n.d.).

There are other certification systems which have their own unique way of assessment, such as CASBEE, which was developed from scratch without depending on any other certification systems. The weighing system used in CASBEE is relatively different from other systems, which forces the designers and implementors to account for all the green building requirements in its manual (Fauzi & Malek, 2013). The LEED standard is one of the most prevalent international building certification standards, with 80,000 registered projects across 162 countries (Shutter & Tufts, 2016) (Zhivov, 2018). A major conceptual difference between LEED and BREEAM is that LEED uses a single uniform rating system independent of location whereas BREEAM is tailored to specific countries depending on climate, local standards and codes, and culture (Zhivov, 2018). Some certification systems require a third party that reviews the compliance of the project against the set criteria and issues a report to the certifying body for review and issuance (Hamedani & Huber, 2012).

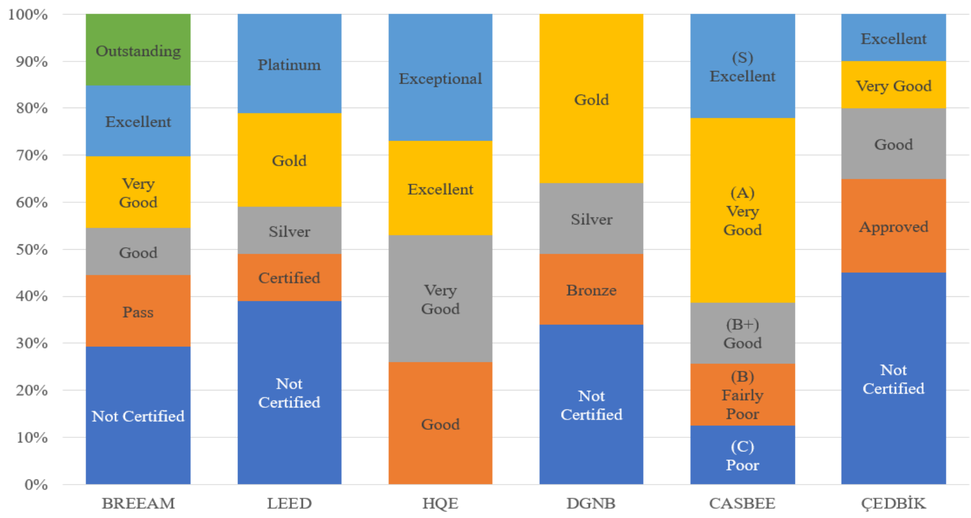


Figure 2: Comparison between green building certification systems according to scoring (Said, 2017).

Figure 2 shows the weights comparison between the different green building certification systems and the certification scoring scale, respectively. It is shown through the graph that the scoring system, the certifications start with a buffer where projects that do not achieve the minimum points are not certified or labelled as poor ranging between 12% to 45% depending on the system. The scoring scale divisions also vary between the different systems. While DGNB and HQE has three certification scoring categories, BREEAM has five scoring categories as the largest division among the compared systems. Each of LEED, CASBEE and ÇEDBİK have four scoring categories.

4. MATERIAL AND METHOD

In order to choose the best strategy and approach for a green building certification system for Turkey based on the best most important criteria and sub-criteria, the Analytic Hierarchy Process (AHP) technique has been adopted. As a type of multi-criteria decision-making (MCDM) methodology, the AHP method is chosen for this research as it can be used for individual and group participants, which makes the interpretation of the results possible in both cases. Moreover AHP provides consistent data from surveys of a limited groups of expertise participants.

The AHP method uses a hierarchical structure in building the case and depends on comparing each criterion with its counterpart individually on a scale that decides the importance of each criterion in comparison with another criterion. The AHP method breaks the complex decision-making problem into simpler decisions to be taken on a criterion per criterion basis. Therefore, this method is used for complex decision making, where several criteria contribute into the final decision.

One of the most important advantages of using the AHP methodology is its flexibility, ease of use and adaptability to different problem types. The AHP method has simple steps that builds the comparison case, which develops into matrices for the different criteria. In developing the criteria, the types of criteria used can be tangible and intangible, which makes its use more possible for more problems in comparison with other MCDM methods that have constraints on the types of criteria. One of the most important advantages of the AHP method is having the consistency measurement, which ensures that the results from different participants are consistent with each other, as well as using linear mathematical model for ease of interpretation. Furthermore, using the AHP method in order to differentiate between the different criteria and sub-criteria according to their priority and importance to Turkey through the incorporation of the opinion of different specialist, ensures that all the factors are taken into consideration for the certification system development process. The method itself is considered reliable for this type of research and provides consistent results. Therefore the flow of the research can be summarized as:

1. A literature review, where the basic criteria of the certification systems are out together as shown in Table 1, 2.
2. Questionnaire is conducted with nine experts from Turkey, distributed equally into three categories professionals from Government Decision Makers (experts from the related ministries), Consultants from sustainability companies in Turkey, and Academicians in Turkish Universities as shown in Table 3. For the objectivity of the research names of participants are assigned to letters randomly. These three sectors are expected to represent different opinions reflecting ideas of sustainability. It also gives for this study strength to deal with the construction policies of Turkey. The aim is to obtain a field feedback on the tools and their practical advantages and disadvantages.

Although six certification systems are reviewed, the five certification systems are put through comparison from the experts' perspective in Turkey. ÇEDBİK-House Certification is not included in comparison matrixes since its limited use (due to building typology and phases) and lack of implemented assessment data. An AHP approach is adapted in order to assign a certain scoring for each criterion according to its importance for the country. The AHP method is chosen amongst the MCDM methods since it can be easily used for individual and group decision making processes by creating hierarchical structure and pairwise comparison matrices. Moreover, AHP is known for its flexibility, ease of use, adaptability and ability to analyse with limited number of decision makers. The AHP makes consistency checks, as it uses a pair wise comparison of tangible and intangible criteria and provides consistent results for every decision-making process (Harputlugil et al.,2014). Table 4 below illustrates the chosen main criteria and the sub-criteria that will be used in the assessment. The criteria and their sub-criteria were chosen based literature review.

Table 3. Experts participating in the study

Names	Expert Background
A	Government Decision Makers
B	
C	
D	Consultants
E	
F	
G	Academicians
H	
I	

Table 4. Selected Criteria and sub-criteria for AHP analysis

Criteria	Sub-Criteria	Reference
Efficiency	Coverage of variety of building types	(Driedger, 2009; Portalatin et al., 2010; Kleist, Dorßt, 2010;Markelj et al,2014;BREEAM, 2011)
	Coverage of Building process (Pre-design to in use)	
	Overall success for assessment (success for reducing wastes& increasing energy efficiency)	
Economy	Cost for registration & certification	(Driedger, 2009; Nicolow, 2008; Ding, 2008; Birgisdottir& Hansen, 2011)
	Cost for Implementation added costs	
	Cost for consultancy	
Usage	Ease of use i. Ease of Calculations ii. Ease of labelling	(Driedger, 2009; Portalatin et al., 2010; Wang, Fowler & Sullivan, 2012)
	Adaptability & Reliability	
	Clarity of Criteria &Sub-criteria	
Time	Certification time	(Markelj et al.,2014)
	Labelling time	
	Effects on design & construction	
Accordance with Turkish Legislation	Accordance with Turkish Legislation	(Markelj et al.,2014; Seinre, Kurnitski & Voll, 2014)
	Accordance with legislations	
	Accordance with procedures	

Methodology allows a panoramic assessment of the Green Building certification systems from a theoretical, practical and analytical perspectives, which provides the comprehensive judgement aimed by the study (Figure 3).

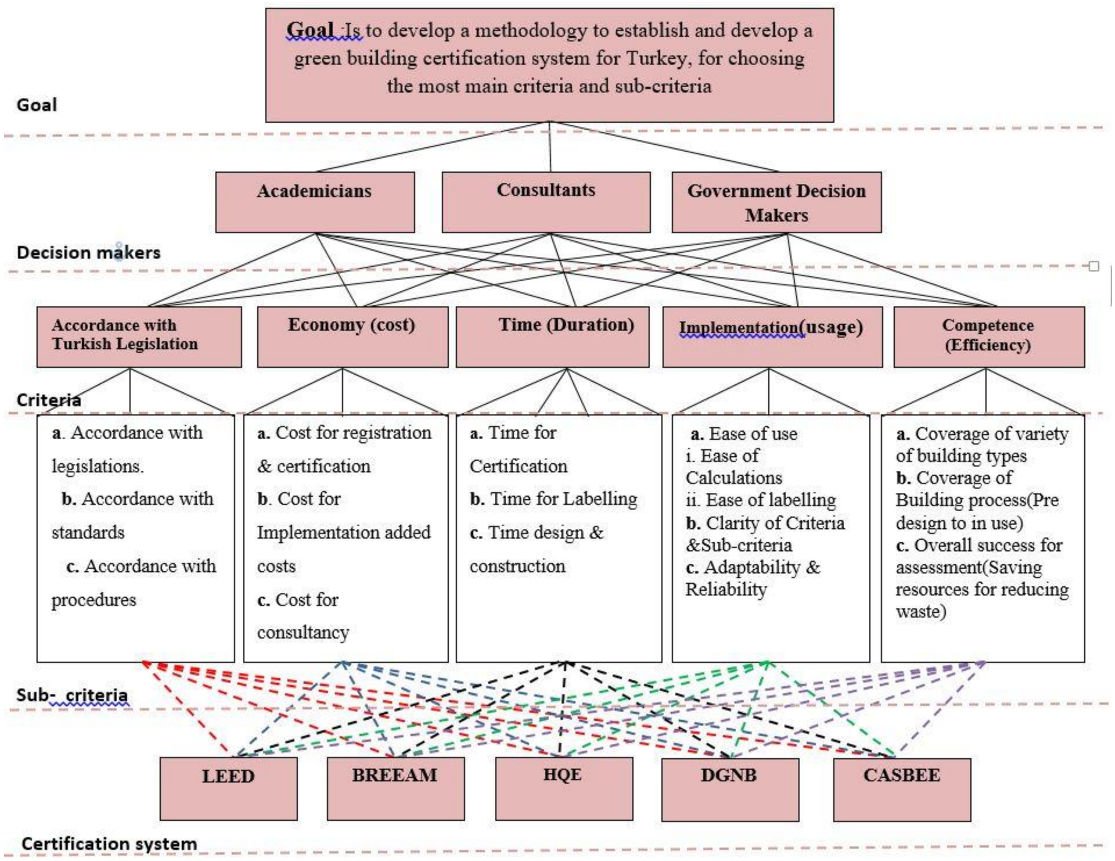


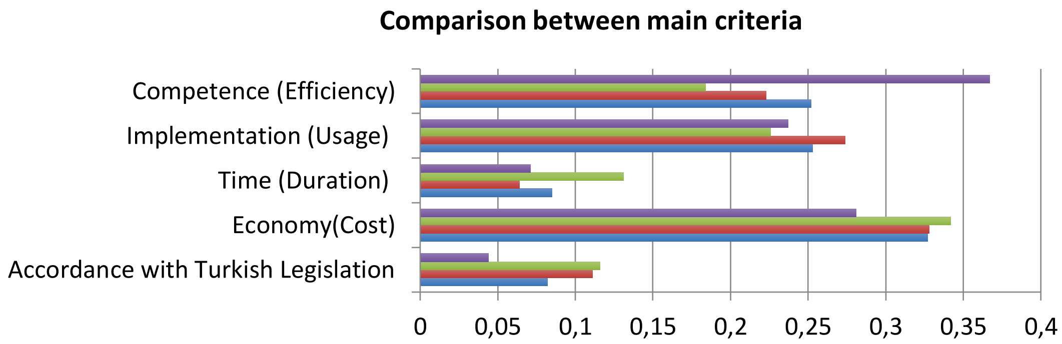
Figure 3: Analytic Hierarchy Process Method (AHP)

5. DISCUSSION

Based on the surveys analysed by the software (Expert choice 11.5 academic version); according to the main criteria pairwise comparison by the study groups, the most important and influential criteria in choosing the best fit green building certification system are as the following:

5.1. Assessment of Government Decision Makers.

As shown in Figure 4 the main criterion is most important for each variable, and these standards are competence (efficiency), implementation (usage), time (duration), economy (cost) and according to with Turkey legislation. As in Figure 4 shows that the main criterion is most important for each variable. The names are assigned to numbers for objectivity and privacy reasons as shown in Figure 4,5,6 the Government Decision Makers are assigned to letters for (A, B and C) and Consultants for (D, E and F) and Academicians for (G , H and I).



	Accordance with Turkish Legislation	Economy(Cost)	Time (Duration)	Implementati on (Usage)	Competence (Efficiency)
A	0,044	0,281	0,071	0,237	0,367
B	0,116	0,342	0,131	0,226	0,184
C	0,111	0,328	0,064	0,274	0,223
TOTAL AVERAGE	0,082	0,327	0,085	0,253	0,252

Figure 4. Comparison between main criteria

According to criteria comparison shown in Figure 4, Specialist A classified efficiency as the most important criteria with 36.7%, followed by Economy (28.1%), implementation (23.7%), time (7.1%), and finally accordance with Turkish legislations (4.4%). Moreover, Specialist B classified the economy factor as the most important criteria with 34.2 %, followed by implementation (22.6%), efficiency (18.4%), time (13.1%), and accordance with Turkish legislations (11.6%). Specialist, given the identification code C classified economy as the most important criteria with 32.8%, while implementation (27.4%), efficiency (22.3%), accordance with Turkish legislations (11.1%), and time (6.4%) have followed respectively.

5.2. Assessment of Consultants

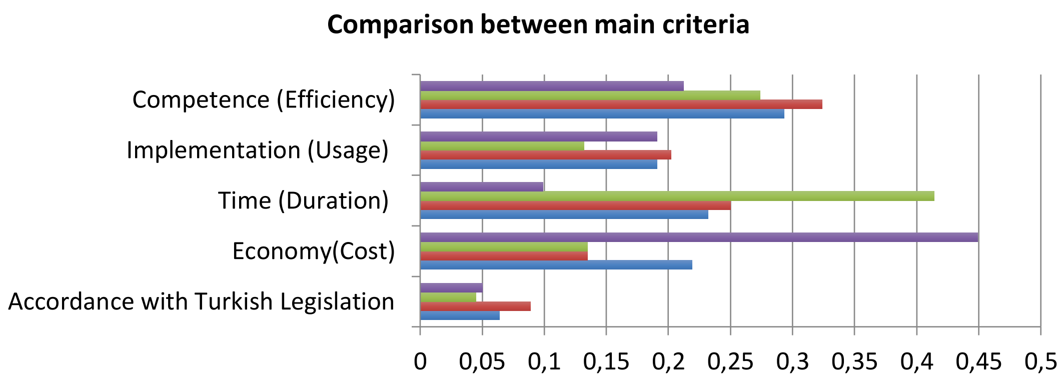
The consultants have also provided their assessment for the criteria and sub-criteria that were compiled for the research. In comparing the main criteria, Figure 5, specialist F gave the highest importance for efficiency with 32.4%, followed by time (25%), implementation (20.2%), economy (13.5%) and accordance with Turkish legislations (8.9%). Moreover, specialist E assigned the highest importance for the time criterion with 41.4%, followed by efficiency (27.4%), economy (13.5%), implementation (13.2%), and accordance with Turkish legislation (4.5%). The last consultant specialist, assigned to code D, assessed the economy criterion to the highest importance with 44.9%, which is followed by efficiency (21.2%), implementation (19.1%), time (9.9%), and accordance with Turkish legislations (5%). The average score for the main criteria was compiled as the following:

1. First rank: efficiency (29.3%)
2. Second rank: time (23.2%)
3. Third rank: economy (21.9%)
4. Fourth rank: implementation (19.1%)
5. Fifth rank: accordance with Turkish legislations (6.4%)

5.3. Assessment by Academicians

The third evaluation group is formed by academicians who have extensive experience in the sustainability and green building assessment studies in Turkey. The first assessment is made for the main criteria of the study, as shown in Figure 6. Specialist I indicated that economy is the most important criteria with 37.9%, followed by efficiency (32.2%), implementation (20%), time (6.3%) and accordance with Turkish legislations (3.5%). Specialist H indicated that accordance with Turkish regulations is the most important main criterion with 36.9%, followed by efficiency (22.3%), implementation (18.2%), economy (14.3%), and time (8.3%). Moreover, specialist G have stated that the economy is the most important factor with 31.7%, closely followed by implementation (28.1%), then efficiency (23.1%), time (13.4%), and accordance with Turkish legislations (3.8%). Thus, the overall assessment for academics of the main criteria is as the following:

- First rank: economy (28.5%)
- Second rank: efficiency (27.8%)
- Third rank: implementation (24.7%)
- Forth rank: time (10%)
- Fifth rank: accordance with Turkish legislations (8.9%)

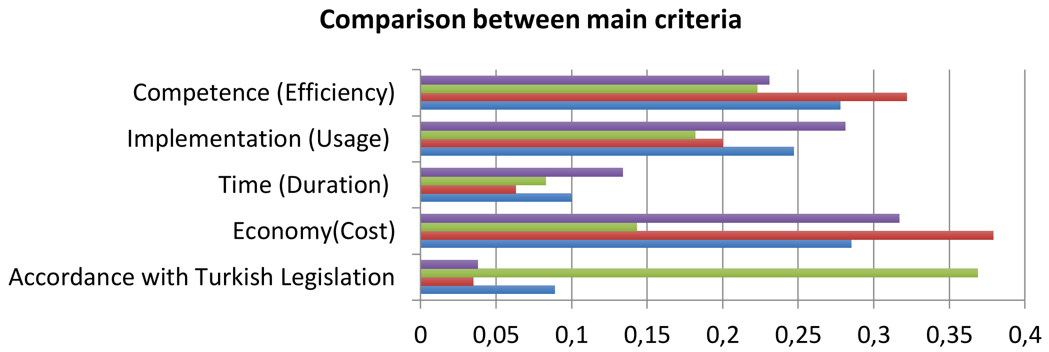


	Accordance with Turkish Legislation	Economy(Cost)	Time (Duration)	Implementation (Usage)	Competence (Efficiency)
D	0,05	0,449	0,099	0,191	0,212
E	0,045	0,135	0,414	0,132	0,274
F	0,089	0,135	0,25	0,202	0,324
TOTAL AVERAGE	0,064	0,219	0,232	0,191	0,293

Figure 5: Comparison between main criteria

According to the main criteria pairwise comparison by the study groups, the most important and influential criteria in choosing the best fit green building certification system are as the following:

1. The government decision makers from the ministry of environment and urbanization have indicated that the economy main criterion is the most influential factor with 32.7%, which indicates the impact of this factor on achieving sustainable development.
2. The consultants have indicated that the efficiency factor is the most influential main criterion with 29.3%.
3. The academicians have indicated that the economy factor is the most influential main criterion with 28.5%.

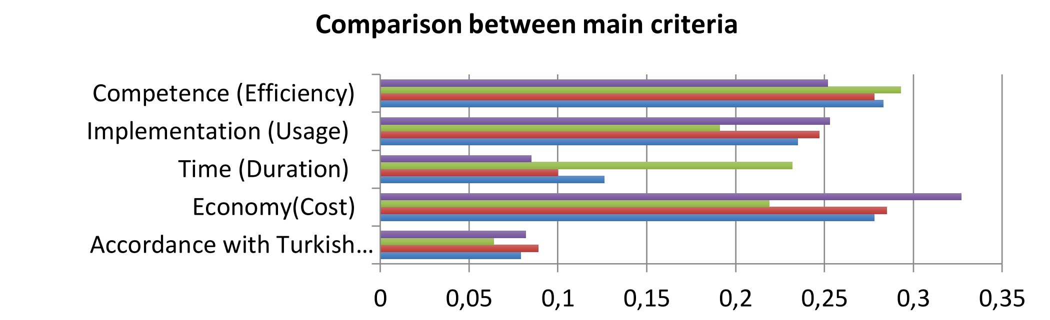


	Accordance with Turkish Legislation	Economy(Cost)	Time (Duration)	Implementation (Usage)	Competence (Efficiency)
G	0,038	0,317	0,134	0,281	0,231
H	0,369	0,143	0,083	0,182	0,223
I	0,035	0,379	0,063	0,2	0,322
TOTAL AVERAGE	0,089	0,285	0,1	0,247	0,278

Figure 6. Comparison between main criteria

Therefore, the overall assessment of the study groups results shows that efficiency is the most influential main criterion in choosing the best fit green building certification system for Turkey with 28.3%, followed by economy (27.8%), implementation (23.5%), time (12.6%), and accordance with Turkish legislations (7.9%). The overall results of the main criteria are shown in Figure 7 and Figure 8 below show the overall results of the study of criteria, sub-criteria and alternatives with respect to each study group.

In figure 8, five chosen Green Building Certification Systems (LEED, BREEAM, CASBEE, HQE, DGNB) listed as the alternatives are assigned to numbers 1,2,3,4 and 5 randomly. The certification systems are listed numerically instead of their names since the aim of the research is not to promote any of these systems nor highlight one of them. Based on the outcomes of survey results, none of the systems is considered fully convenient for use in Turkey. It is important to understand that there is no specific international certification system that perfectly fits to Turkey. Therefore, as an outcome of this research; it is required to develop a unique certification system for Turkey dependent on the criteria that are concluded in this study.



	Accordance with Turkish Legislation	Economy(Cost)	Time (Duration)	Implementation (Usage)	Competence (Efficiency)
Government decision makers	0,082	0,327	0,085	0,253	0,252
Consultants	0,064	0,219	0,232	0,191	0,293
Academicians	0,089	0,285	0,1	0,247	0,278
TOTAL AVERAGE	0,079	0,278	0,126	0,235	0,283

Figure 7. Overall comparison for government decision makers, consultants, and academicians for main criteria

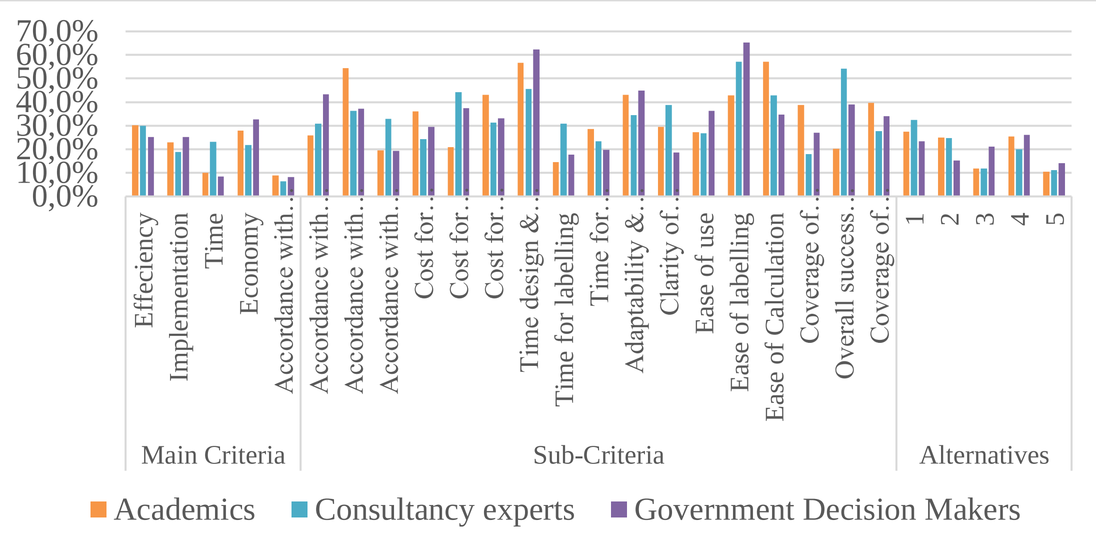


Figure 8. Overall results of the study

Furthermore, using the AHP method in order to differentiate between the different criteria and sub-criteria according to their priority and importance to Turkey through the incorporation of the opinion of different specialist, ensures that all the factors are taken into consideration for the certification system development process. The method itself is considered reliable for this type of research and provides consistent results.

6. CONCLUSION

This paper reviews methodology based on the strategy to find the most important standards and sub-criteria which must be considered in the development of a green building certification system in Turkey. These standards are increasingly being developed in some countries as a result of increased awareness of environmental, economic and social issues. It is evident in the construction and development industries that sustainable development is one of the hot topics within the sector due to awakened awareness towards energy consumption and the ecological impacts that the development have imposed. As voluntary standards, there are a number of environmental accreditations for buildings around the world. The most popular accreditations are BREEAM (Building Research Establishment Environmental Assessment Method), LEED (Leadership in Energy and Environmental Design), HQE (High quality of environment), CASBEE (Comprehensive Assessment System for Built Environment Efficiency) and DGNB (German Sustainable Building Council). These tools were chosen based on their popularity, magnitude of use, the sustainability development in the tools developing countries and also in order to understand the nature of certification systems.

Moreover, this the study adopts the Analytic Hierarchy Process (AHP) method by identifying the criteria and sub-criteria from the literature, as well as interviewing experts from different background; academicians, consultants and government decision makers. Using criteria and sub-criteria that are considered important according to the green building and sustainability studies, the questionnaire developed by the AHP software (Expert choice 11.5 academic version) is filled by the experts.

Based on the outcomes of the research; it is important to understand that there is no specific international certification system that perfectly fits to Turkey. It is believed that Turkey should develop its own certification system. The new certification system should be structured to meet with the needs of Turkey. The new system should cover certification for all building phases with different building typologies. Flexibility and adaptability should be an important concern. Thus, this paper works also on providing important data to create a new certification system for Turkey through understanding the most important criteria and sub-criteria that shall be considered in the development process.

Since the numbers of the experts are limited in the research, there is no possibility of an assessment depending solely on the results of this study. However, the overall assessment of the limited study groups results shows that economy (cost) and efficiency are considered the most important criteria for the green building certification system in Turkey, while overall assessment success, registration and certification costs, adaptability and reliability are the most important sub-criteria.

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REFERENCES

Balaras, C. A., Droutsa, K., Dascalaki, E. & Kontoyiannidis, S. (2005). Heating Energy Consumption and Resulting Environmental Impact of European Apartment Buildings, Energy and buildings, 37(5), 429-442.

Banani, R., Vahdati, S. D. M. & Elmualim, A. (2011). A Sustainable Assessment Method for Non-Residential Buildings in Saudi Arabia: Development of Criteria, School of Construction Management and Engineering, Unpublished Doctoral Transfer Report, University of Reading.

Bartlett, A. A. (2012). The meaning of sustainability. Teachers Clearinghouse for Science and Society Education Newsletter, 31(1), 1-14.

Beardsley, E., Burroughs, S., Crowhurst, D., Yates, A., Ward, C.,Dari, K. & Ilomäki, A. (2017). Building Sustainability Assessment And Benchmarking-An Introduction.

Becker, C. U. (2012). The meaning of sustainability, In Sustainability Ethics and Sustainability Research, 9-15, Springer, Netherlands.

Bernardi, E., Carlucci, S., Cornaro, C. & Bohne, R. A. (2017). An Analysis of the Most Adopted Rating Systems for Assessing the Environmental Impact of Building, Sustainability, 9(7), 12-26.

Birgisdottir, H. & Hansen, K. (2011). Test of BREEAM, DGNB, HQE and LEED on two Danish Office Buildings, In World Sustainable Building Conference-SB11, RIL-Finnish Association of Civil Engineers, Helsinki, 879-887.

Bowd, D., McKay, C. & Shaw, W. S. (2015). Urban Greening: Environmentalism or Marketable Aesthetics, AIMS Environmental Science, 2(4), 935-949.

BREEAM, B. N. C., & Buildings, N. D. (2011). Technical Manual. SD5073, 2, 20-22.

Brundtland, G. H. (1987). Report of the World Commission on Environment and Development: our Common Future, United Nations. 8-9.

Chichilnisky, G. (2011). What is sustainability?, International Journal of Sustainable Economy, 3(2), 125-140.

Cole, R. J. (2005). Building Environmental Assessment Methods: Redefining Intentionsand Roles, Building Research & Information, 33(5), 455-467.

Ding, G. K. (2008). Sustainable Construction, the Role of Environmental Assessment Tools", Journal of environmental management, 86(3), 451-464.

Driedger, M. (2009). Choosing The Right Green Building Rating System: An Analysis of Six Rating Systems and How They Measure Energy, Perkins & Will Research Journal 1(1), 22-41.

Emmitt, S., & Gorse, C. (2010). Barry's advanced construction of buildings. John Wiley & Sons.

Eno, D. D. (2005). Implementing sustainable development policies at the municipal level: identification of strategies for overcoming barriers, 22-26, MSc Thesis, University of Manitoba, Faculty of Architecture, Canada.

Erten, D., Henderson, K. & Kobas, B. (2009). A Review of International Green Building Certification Methods: A Roadmap for a Certification System in Turkey, Fifth International Conference on Construction in the 21st Century (CITC-V), Collaboration and Integration in Engineering, Management and Technology, Istanbul-Turkey, 1-10.

Fankhauser, S. (2013). Valuing Climate Change: The Economics of the Greenhouse, Routledge, London.

Fauzi, M. A. & Malek, N. A. (2013). Green Building Assessment Tools: Evaluating Different Tools for Green Roof System, International Journal of Education and Research, 1(11), 1-14.

Giama, E. & Papadopoulos, A. M. (2012). Sustainable Building Management: Overview of Certification Schemes and Standards, Advances in Building Energy Research, 6(2), 242-258.

Gluch, P., Stenberg, A. C. (2006). How Do Trade Media Influence Green Building Practice?, Building Research & Information, 34(2), 104-117.

Hamedani, A. Z. & Huber, F. (2012). A Comparative Study of DGNB, LEED and BREEAM Certificate Systems in Urban Sustainability, the Sustainable City VII: Urban Regeneration and Sustainability, 11-21.

Harputlugil, T., Gültekin, A. T., Prins, M. & Topcu, Y. I. (2014). Architectural Design Quality Assessment Based on Analytic Hierarchy Process: A Case Study", METU Journal of the Faculty of Architecture, 31(2),139-161.

Hopwood, B., Mellor, M., & O'Brien, G. (2005). Sustainable Development: Mapping Different Approaches, Sustainable Development, 13(1), 38-52.

Illankoon, I. C. S., Tam, V. W., Le, K. N. & Shen, L. (2017). Key Credit Criteria Among International Green Building Rating Tools, Journal of Cleaner Production, 164, 209-220.

Internet: BREEAM, Retrieved from the web page https://www.breeam.com/, last accessed 2017

Internet: CASBEE, Reetrieved from the webpage

http://www.ibec.or.jp/CASBEE/english/overviewE.htm, last accessed 2017

Internet: ÇEDBİK Retrieved from the webpage https://cedbik.org/ , last accessed 2017

Internet: DGNB, DGNB System - Sustainable and Green Building, Online. Retrieved from the web page http://www.dgnb-system.de/en/ , last accessed 2017.

Internet: European Union knowledge Network, Sustainable Neighborhood Ranking Systems, Retrieved from the webpage https://www.eukn.eu/ , last accessed 2017.

Internet : USGBC Report, Retrieved from the webpage

https://www.usgbc.org/articles/usgbc-announces-international-rankings-top-10-countries-leed-green-building, last accessed 2017

Kibert, C. J. (2016). Sustainable Construction: Green Building Design and Delivery, John Wiley & Sons United States.

Kleist, T. & Dorßt, T. (2010). Der DGNB Auditierungsprozess, Consense 2010–Internationaler Kongressfürnachhaltiges Bauen, Retrieved from the webpage: http://www.dgnb international.com/fileadmin/consense/, last accessed 2017

Kuhlman, T., & Farrington, J. (2010). What is Sustainability?, Sustainability, 2(11), 3436-3448.

Manioğlu G., Yılmaz, Z. (2006). Energy Efficient Design Strategies in the Hot Dry area of Turkey, Building and Environment", 43(2008), 1301-1309.

Markelj, J., KitekKuzman, M., Grošelj, P. & Zbašnik-Senegačnik, M. (2014). A Simplified Method for Evaluating Building Sustainability in the Early Design Phase for Architects, Sustainability, 6(12), 8775-8795.

Mattoni, B., Guattari, C., Evangelisti, L., Bisegna, F., Gori, P. & Asdrubali, F. (2018). Critical Review and Methodological Approach to Evaluate the Differences Among International Green Building Rating Tools, Renewable and Sustainable Energy Reviews, 82, 950-960.

Miranda, J. A. P. (2013). Weighting Factors for the Criteria of a Building Sustainability Assessment Tool (DGNB), 34-45, MSc Thesis, Especialização Em Construções, Portugal.

Morledge, R., Jackson, F. (2001). Reducing Environmental Pollution Caused By Construction Plan, Environmental Management and Health, 12(2), 191-206.

Nguyen, B. K. & Altan, H. (2011). Comparative Review of Five Sustainable Rating Systems, Procedia Engineering, 21, 376-386.

Nicolow, J. (2008). Measuring The Cost To Become LEED Certified. Retrieved from the webpage http://www.facilitiesnet.com/green/article/Measuring-The-Cost-To-Become-LEED-Certified-Facilities-Management-Green-Feature--10057, last accessed 2017.

Paumgartten P. (2003). The Business Case for High-Performance Green Buildings: Sustainability and Its Financial Impact, Journal of Facilities Management, 2(1), 26-34.

Portalatin, M., Koepke, K., Roskoski, M. & Shouse, T. (2010). Sustainability, How-To Guide Series. Green Building Rating Systems.

Reed, R., Bilos, A., Wilkinson, S., & Schulte, K. W. (2009) International Comparison of Sustainable Rating Tools, Journal of Sustainable Real Estate: JOSRE, 1(1), 1-22.

Reith, A. & Orova, M. (2015). Do Green Neighborhood Ratings Cover Sustainability?, Ecological Indicators, 48, 660-672.

Said, F. (2017). Analytic Hierarchy Process (AHP) Based Approach to Identify the Best Fit Green Building Certification System for Turkey", MSc Thesis, Çankaya University, Institute of Science and Technology.

Seinre, E., Kurnitski, J. & Voll, H. (2014). Building Sustainability Objective Assessment in Estonian Context and A Comparative Evaluation with LEED and BREEAM, Building and Environment, 82, 110-120.

Shutter, C. &Tufts, R. (2016). LEED by the Numbers: 16 Years of Steady Growth | U.S. Green Building Council. Retrieved from the webpage http://www.usgbc.org/articles/leed-numbers-16-years-steady-growth

Uğur, L. O., & Leblebici, N. (2017). An Examination of the LEED Green Building Certification System in Terms of Construction Costs, Renewable and Sustainable Energy Reviews, 1476-1483.

Younan, V. A. (2011). Developing a Green Building Rating System for Egypt, PhD. Thesis, American University in Cairo, Dept. of Construction and Architectural Engineering, Cairo, 22-30.

Yusoff, W. Z. W. & Wen, W. R. (2014). Analysis of the International Sustainable Building Rating Systems (SBRSS) For Sustainable Development With Special Focused On Green

Building Index (GBI) Malaysia, Journal of Environmental Conservation Research, 11, 11-26.

Wang, N., Fowler, K. M. & Sullivan, R. S. (2012). Green Building Certification System Review, US Department of Energy.

Wangel, J., Wallhagen, M., Malmqvist, T. & Finnveden, G. (2016). Certification Systems For Sustainable Neighborhoods: What Do They Really Certify. Environmental Impact Assessment Review, 56, 200-213.

Zhivov, M. (2018) Enhanced Life-Cycle Cost Analysis of Sustainable Office Buildings, 34-36, MSc Thesis, Aalborg University, School of Engineering and Science, Copenhagen.

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