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Sustainable Development in Cities: A Qualitative Approach to Evaluate Rating Systems

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Abstract

Sustainable development paradigm is one of the dominant paradigms of the century. In 1987, "Our Common Future," the Brundtland Commission adopted the concept of "sustainable development" to challenge the dominant paradigm of development as equivalent to economic growth. Using rating systems is like a plan in order to implement sustainable development. Moreover, Tehran as the capital of Iran and a megalopolis needs an appropriate rating system to be assessed in context of sustainable development. Be that as it may, Selection of a rating system pivots on the paradigm of the planner that how the planner describes the development and what are the planner's preferences; and also on the priorities of the city planned to be developed. This research has tried to evaluate rating systems to unveil their qualities to afford city planners an opportunity to use an appropriate approach of sustainable development. Authors of this research hold the opinion that if planners' preferences and priorities of a city can be in step with a rating system, the best result will occur. Furthermore, it was decided to do the evaluation in the context of ASTM E2432. In this research rating systems of ISCA, BREEAM, LEED-ND, CASBEE, Green star, DGNB were chosen to be evaluated. On the other hand, the obstacles of implementing sustainable development in Tehran were identified. Finally, LEED-ND was identified as the best rating system among above-mentioned ones. Since the research was exploratory research, a qualitative approach was selected to do the evaluation. Consequently, structured interviewing was applied as a fitting method and the technique of pile sorting was used to collect data in interviews as well.

Keywords: Sustainable Development in City; Rating System; Structured Interview; Pile Sorting Technique; Obstacles of Sustainable Development in Tehran.

1. Introduction

Cities are complex hybrid socioeconomic–natural ecosystems, representing the densest concentrations of human activity [1]. Urban sustainable development does not target only one specific aspect. Studies mainly focus on trying to balance the development of economic growth, social progress, ecological construction, and environmental protection [2]. Different indicators and methods have been suggested or used in varied contexts and for diverse purposes [3]. Developing countries are going through a stage of rapid economic development, on the other hand developed countries focus on equity and participation, adaptability, and the value of natural capital and resources for future generations. The main purpose of indicators is to satisfy the particular needs and goals of cities and provide a tool for guidance in sustainable policies and communication to the public [4]. While always a core issue concerns the extent to which government intervention in the form of penalties, incentives or compensation is needed [5], there is not an individual

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definite criterion of selection always, which means designers or architects have to take into account a large number of selection factors. Therefore, the available information or data must be constantly assessed to make well-considered and justifiable choices [6].

Sustainability is an ideal. The practical application of the general principles of sustainability relies upon balancing environmental, economic, and social impacts and committing to continual improvement to approach this ideal [7]. The building and construction sector is highly important for sustainable development because: a) it is a key sector in national economies; b) it has a significant interface with poverty reduction through the basic economic and social services provided in the built environment and the potential opportunities for the poor to be engaged in construction, operation and maintenance; c) it is one of the single largest industrial sectors and, while providing value and employment, it absorbs considerable resources, with consequential impacts on economic and social conditions and the environment; d) it creates the built environment, which represents a significant share of the economic assets of individuals, organizations and nations, providing societies with their physical and functional environment; e) it has considerable opportunity to show improvement relative to its economic, environmental and social impacts [8].

A large body of literature suggests that the buildings sector is key for low-cost climate mitigation worldwide [9, 10]. Construction section has the second place as the largest carbon dioxide (CO_2) emitter after industry, almost 33% of the global total [11]. A wide range of best practices and cases demonstrate energy savings in buildings as high as 80% at little or no extra cost [12]. Therefore, there should be a framework to control and limit construction sector. The best way is to implement sustainable development in buildings through creating a framework for construction projects in cities. Besides, to be truly sustainable, infrastructures must deliver economic outcomes in the long-term whilst also promoting societal wellbeing and preserving environmental resources. That is to say, benefits arise when a holistic triple bottom line approach is embedded in an infrastructure project. Infrastructure includes transport (roads and bridges, bus and cycle ways, footpaths, railways), water (sewage and drainage, water storage and supply), energy (transmission and distribution) and communication (transmission and distribution) among others [13].

The 21st century has been called the urban century because more than half of the world’s population lives in towns and cities [14]. Zhao (2010) predicted that until 2050 almost 70% of the world’s population will live in cities. Therefore, the most consumption of supplies occurs in cities. It is obvious there should be a limitation for human's activities or living cannot be possible anymore in future. With the appearance of Agenda 21 at the 1992 Earth Summit, the need to apply sustainability to cities at a strategic level arose. Furthermore, there are nowadays more than 70 tools for evaluating and classifying building projects in the building sector, based on sustainability indicator systems [15].

Consequently, and keeping in mind that the construction sector is evolving towards an increase and a development of the number and type of social, economic and environmental indicators [16], there is a need to establish a methodology for the identification of sustainability indicators from the project management point of view.

The ISO-21929 establishes boundaries and defines what is meant by a sustainability indicator: “Indicators are figures or other measures, which enable information on a complex phenomenon like environmental impact to be simplified into a form that is relatively easy to use and understand. The three main functions of indicators are quantification, simplification and communication” [17].

While sustainable development has come a long way, there is a lack of research evidence on evaluating the green building rating tools in terms of credit point allocation for each of the triple bottom line parameters [18]. Moreover, relying on the case studies of developed countries and following their approaches might be confusing. Having reviewed the most common rating systems, the authors came to conclusion that there should be a way to find the rating system which is in step with the condition of a city and its culture which would appear as a paradigm in planners' mind. As to this topic is a part of urbanism and sociology, a qualitative approach to analyse this topic was absolutely essential; however, this topic had rarely been looked at from this point of view. This research is quite a novelty since although the methodology used is based on qualitative approach, quantitative methods were applied as well to substantiate it.

In this article two reliable codes of ASTM E2432–17 and ISO 21929 are introduced in order to choose a framework for evaluating rating systems. The rating systems evaluated are six well-known rating systems of sustainable development in cities on a global scale.

2. Examples of Sustainable Development in the World

There are various examples of how sustainable development has brought about a revolution in cities all around the world. One need only look at the Mohammed Bin Rashid Smart Learning Program in the UAE. The program, launched in 2012, presents a comprehensive approach inclusive of students, teachers, parents and principals to work collaboratively to build future leaders. Another example is the action is proposed by the European commission to create a “resource-efficient” Europe and promote awareness on the sustainable use of water resources. This program is based on the 6th goal of sustainable development agenda which is "clear water and sanitation". In harmony with the 7^{th} goal of the agenda which is "affordable and clean energy", the "Power Matching" concept was implemented in Groningen, in the Netherlands, as a demonstration project of a future energy-infrastructure called Power Matching City. Twenty-five households with smart appliances, such as micro-combined-heat-power systems that match their energy use in real time based upon the available energy generation, were connected [19]. For decent Work and Economic Growth, the Government of Pakistan has regularly introduced suitable laws and regulations which are bound to facilitate the growth of the banking sector and improve its security in future. Moreover, adequate infrastructure plays a crucial role in following sustainable development, so the city administration of Ahmedabad in India has set out its vision to "Provide efficient, affordable, equitable and customized governance for citizens of Ahmedabad" and the project conceived under smart mobility is a reflection of the vision. African countries are struggling to tackle the problems concerning health and education which has led to existence of inequalities; however, through implementing sustainable development programs, African are provided with support and expertise for handling the Super Specialty healthcare facilities at the international level. Another perfect case in point for sustainable cities and communities would be "smart Dubai program", through this program, in 2017, Dubai, a city of 2.5 million inhabitants and one of seven emirates of the UAE, has one of the highest levels of digitization of services in the region, both by the public and the government. The 13th goal of sustainable development is climate action and there are many different reported benefits for using green materials in construction, one of these benefits is the potential for reducing G.H.G emission to be able to protect the environment and reduce global warming. In order to solve real world problems and improve environmental protection while maintaining the financial growth, using of local and recycled materials as a raw material for products is a way to ameliorate the problem [6]. The last but not least, partnership for the goals is of paramount importance. The "United for Smart Sustainable Cities" (U4SSC) is a UN initiative serves as the global platform to advocate for public policy and to encourage the use of ICTs to facilitate and ease the transition to smart sustainable cities [20].

3. Construction Sustainable Development Framework

Two codes of ASTM E2432 and ISO 21929 are introduced to find an appropriate framework to apply the evaluation of rating systems in the corresponding context.

3.1. ISO 21929

ISO 21929 describes and gives guidelines for the development of sustainability indicators related to buildings and defines the aspects of buildings to consider when developing systems of sustainability indicators.

Indicators shall represent the aspects of a building that have a potential impact on protection areas of sustainable development. The core areas of protection relevant to a building are: 1) ecosystem; 2) natural resources; 3) health and well-being; 4) social equity; 5) cultural heritage; 6) economic prosperity; 7) economic capital.

The main aspects of a building that are seen as having an impact on the areas of protection are categorized as follows: a) emissions to air; b) use of non-renewable resources; c) fresh water consumption; d) waste generation; e) change of land use; f) access to services; g) accessibility; h) indoor conditions and air quality; i) adaptability; j) costs; k) maintainability; l) safety; m) serviceability; n) aesthetic quality [17].

3.2. ASTM E2432–17

ASTM E2432 has also offered a framework for sustainable development in buildings which has been revised three times. ASTM E2432 states general principles of sustainability— environmental, economic, and social— are interrelated. Decisions founded on the opportunities and challenges of any of the principles will have impacts relative to all of the principles. However, to facilitate clarity in the presentation of the general principles of sustainability relative to buildings they are discussed individually (Figure1).

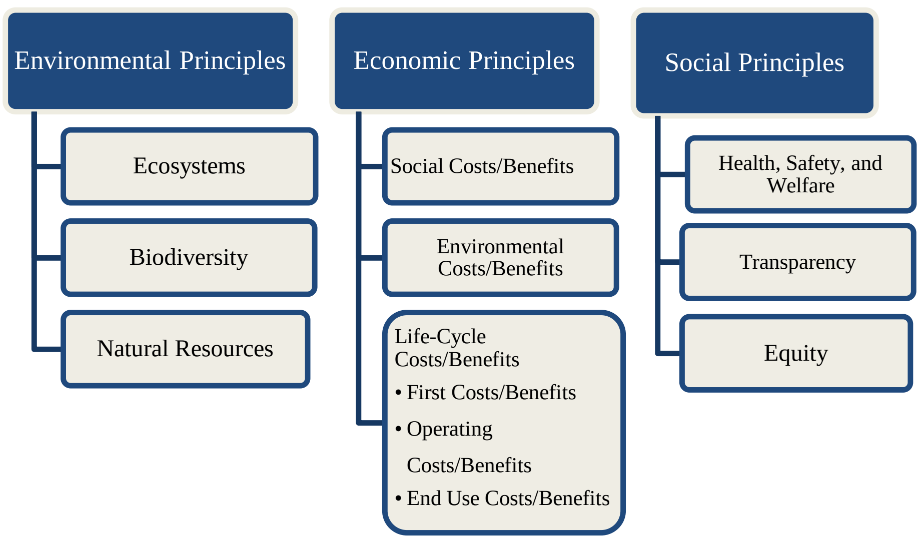

Figure 1. ASTM E2432 principles for sustainable development in buildings

a) **Environmental Principles**—Buildings impact the environment.

a-1- Ecosystems—Sustainable buildings contain features that protect or enhance local, regional, and global ecosystems.

a-2- Biodiversity—Sustainable buildings contain features that protect or enhance species' habitats.

a-3- Natural Resources—Sustainable buildings maximize the effective use of resources. Sustainable buildings preserve or enhance the quality of resources and do not adversely alter the balance between renewable resources and their rate of consumption for building-related purposes.

b) **Economic Principles**—Buildings have both direct and indirect economic impacts that are inherent to the process of their acquisition, construction, use, maintenance, and disposition. Direct economic impacts are those associated with the life-cycle costs/benefits of materials, land, and labor directly attributable to the building. Direct costs/benefits are typically evaluated using life-cycle cost (LCC) methods. Indirect economic impacts are those associated with external costs/benefits. External costs/benefits accrue to those indirectly impacted by the building. In order to advance sustainability, it is necessary to quantify and optimize direct and indirect economic impacts to the greatest extent possible.

b-1- External Costs/Benefits

b-1-1. Social Costs/Benefits— Sustainable buildings enhance the building industry and create and provide healthy and productive workplaces.

b-1-2. Environmental Costs/Benefits— Sustainable buildings have reduced environmental costs and provide environmental benefits to society. For example, landscaping with indigenous plants can contribute to wildlife corridors.

b-2- Life-Cycle Costs/Benefits

b-2-1. First Costs/Benefits— Sustainable buildings do not need to be more expensive than other buildings when measured on a first cost basis. Integrating features early in the planning and design.

b-2-2. Operating Costs/Benefits— the use of sustainable building practices applies efficiencies of operation, reducing associated operating costs.

b-2-3. End Use Costs/Benefits— Reduces the use of sustainable building practices applies DfE (Design for the Environment) and reduce potential regulatory and liability costs.

c) **Social Principles**

c-1- Health, Safety, and Welfare—Sustainable buildings protect and enhance the health, safety, and welfare of building occupants, neighbours, and the public throughout the building's life.

c-2- Transparency—Sustainable buildings demand inclusiveness and transparency of purpose and method. Those who are potentially affected by the building should be provided with information and the means to contribute to the decision-making.

c-3- Equity—Sustainable buildings protect and may contribute to local social and cultural values, traditions, and institutions. In addition, design and operation decisions can have impacts that extend far beyond the local community and have regional or global impact. These consequences of building-related choices should be identified. Sustainable building strives to minimize and equitably distribute local, regional, and global social impacts that occur throughout a building's life.

4. Selected Framework

Selecting a framework for sustainable development between the ISO 21929 and ASTM 2432 is an issue of preferences. ASTM 2432 introduces 2 categories of transparency and biodiversity while ISO 21929 doesn't put them in its main principles. Therefore the authors tended to continue their research by choosing the ASTM 2432 as the framework of sustainable development in cities in their study. It is believed by the authors for Iran as a developing country, 2 issues of transparency and biodiversity are the current issues which their deficiency is felt dominantly.

5. Rating Systems

After discussing sustainable development framework, six well-known rating systems come from all around the world is introduced.

5.1. BREEAM Communities

BREEAM was initially introduced in 1990; BREEAM was the world's first environmental assessment method for new building designs. It uses a balanced scorecard approach with tradable credits to enable the market to decide how to achieve optimum environmental performance for the project. BREEAM has now come a long and it is now employed on a global scale.

The subjects in this manual are fallen into five assessment categories which are contemplated through suitable criteria. Classifying sustainability issues is hard to come by, as they often influence all three aspects of sustainability (social, environmental and economic). The goal of BREEAM is to shed light on the intention of each issue by evaluating categories. A sixth category promotes innovation which shows the importance of it. The categories are as follows with a brief description of their overall goals:

- *Governance(GO)*

Promotes the involvement of community in decision making regarding the development comes under influence of the design, construction, and operation.

- *Social and economic wellbeing (SE)*

Contemplates societal and economic factors influence health and wellbeing such as sufficient housing and availability of employment.

- *Resources and energy (RE)*

Addresses the sustainable use of natural resources and the reduction of carbon emissions.

- *Land use and ecology (LE)*

Encourages sustainable land use and ecological enhancement

- *Transport and movement (TM)*

Addresses the design and provision of transportation and movement infrastructure to promote using sustainable means of transportation.

- *Innovation (Inn)*

Promotes employing innovative solutions in the rating where they help obtain environmental, social and/or economic benefit in a way which is not looked at elsewhere in the scheme.

BREEAM aims to ensure that its standards provide social and economic benefits whilst ameliorating the environmental impacts of the built environment. As a result, BREEAM is especially likely to put a value on developments according to their sustainability benefits.

BREEAM highlights the issues and opportunities that bring about a revolution in a development at the earliest stage of the design process. The rating system addresses major environmental, social and economic sustainability objectives that have an impact on large-scale development projects [21] (Table 1).

5.2. LEED-ND

USGBC launched LEED in 2000. Since its inception, LEED has grown to encompass more than 14,000 projects in the USA and more than 30 countries [24]. This tool promotes sustainable building and development practices through a suite of reporting, and recognizes projects which are committed to better environmental and health performance [30]. LEED intends to encourage all cities to measure and improve performance, focusing on outcomes from ongoing sustainability efforts. To leverage a globally consistent method of performance measurement for a streamlined and data-based pathway to LEED certification for cities [22].

The U.S. Green Building Council (USGBC), the Congress for the New Urbanism (CNU), and the Natural Resources Defence Council (NRDC)—organizations that represent leading design professionals, progressive builders and developers, and the environmental community—have collaborated to design a rating system for neighbourhood planning and development based on the combined principles of smart growth, New Urbanism, and green infrastructure and building. The goal of this partnership is to establish a national leadership standard for assessing and rewarding environmentally superior green neighbourhood development practices within the framework of the LEED® Green Building Rating System™. The result of their effort was named LEED-ND [23]. The LEED-ND criteria for sustainable neighbourhoods [24] in cities are cited in Table 1.

5.3. CASBEE for Cities

Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is a method for assessing and scoring the environmental performance of buildings and the built environment. CASBEE was introduced by a research committee established in 2001 through the collaboration of academia, industry and national and local governments, which established the Japan Sustainable Building Consortium (JSBC) under the auspice of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT). CASBEE for urban development is a tool for assessment of comprehensive area development project including a group of buildings [25].

CASBEE follows triple bottom lines concept, which is one of the important framework for assessment and identification of sustainability through the three classifications of environment, society and economy. Overviews of the assessment items are displayed in Table 1.

5.4. Green star

Green Star, launched by the Green Building Council of Australia (GBCA), is a comprehensive voluntary building SRT. It was initially developed to accommodate the need for buildings operating in hot climatic areas [30]. It incorporates ideas from other tools, such as BREEAM, ISO, ASTM and LEED, and other environmental criteria specific to the Australian environment. According to GBCA Green Star was developed for the property industry in order to: establish a common language; set a standard of measurements for built environment sustainability; promote integrated, holistic design; recognize environmental leadership; identify and improve life-cycle impacts; and raise awareness of the benefits of sustainable design, construction and urban planning [26]. Criteria of Green Star are shown in Table 2.

5.6. DGNB

The German Sustainable Building Council (DGNB– Deutsche Gesellschaft für Nachhaltiges Bauen e.V.) was founded in 2007 from various subject areas within the construction and real-estate sectors. The aim was to promote sustainable and economically efficient building even more strongly in future [27]. The criteria DGNB considers for sustainable development are listed in the Table 2.

5.7. ISCA

The Infrastructure Sustainability Council of Australia (ISCA) is a member-based not-for-profit public and private industry council. ISCA specialize in the facilitation and development of industry-led performance based integrated triple-bottom-line governance and reporting frameworks, decision tools and rating tools; generating communities of practice throughout the lifecycle from funding, planning, procurement, design and delivery to operations and maintenance. ISCA is advancing sustainability outcomes in infrastructure through the development and using the Infrastructure Sustainability (IS) rating scheme. The IS rating scheme is an industry-compiled voluntary sustainability performance rating scheme evaluating planning, design, construction and operation of all infrastructure asset classes in all sectors linking industry, communities and commerce beyond regulatory standards [28]. The major additions and updates to the IS content is summarized in Table 2.

Table 1. The criteria of rating systems of BREEAM, LEED-ND and CASBEE

BREEAM		**LEED-ND**		**CASBEE**	
Criterion	**Score**	**Criterion**	**Score**	**Criterion**	**Score**
Consultation plan	2.3	preferred Locations	10	rain water utilization	1.39
Consultation and engagement	3.5	brownfield Redevelopment	2	treated water	1.39
Design review	2.3	Locations with Reduced Automobile Dependence	7	reduction of sewage discharge amount	1.39
Community management of facilities	1.2	Bicycle Network and Storage	1	reduction of rain water discharge	0.70
Economic impact	8.9	Housing and Jobs Proximity	3	reduction of rain water discharge: rain water permeation surface and permeation facility	0.70
Demographic needs and priorities	2.7	Steep Slope Protection	1	wood material	1.39
Flood Risk Assessment	1.8	Site Design for Habitat or Wetland and Water Body Conservation	1	recycled material	1.39
Noise pollution	1.8	Restoration of Habitat or Wetlands and Water Bodies	1	garbage separation	1.39
Housing provision	2.7	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies	1	In-area resource circulation	1.39
Delivery of services, facilities and amenities	2.7	Walkable Streets	12	Greening of ground surface	2.78
Public realm	2.7	Compact Development	6	rooftop greening	1.39
Microclimate	1.8	Mixed-Use Neighborhood Centers	4	wall greening	1.39
Utilities	0.9	Mixed-Income Diverse Communities	7	natural resources	1.39
Adapting to climate change	2.7	Reduced Parking Footprint	1	Terrain	1.39
Green infrastructure	1.8	Street Network	2	Patch (planar) quality: Habitat space of species	0.70
Local parking	0.9	Transit Facilities	1	Patch (planar) quality: consideration for regionality	0.70
Flood risk management	1.8	Transportation Demand Management	2	corridor (network) quality	1.39
Local vernacular	0.9	Access to Civic and Public Spaces	1	Environmentally friendly buildings	11.1
Inclusive design	1.8	Access to Recreation Facilities	1	Compliance	5.56
Light pollution	0.9	Visitability and Universal Design	1	area management	5.56

Training and skills	5.9	Community Outreach and Involvement	2	understanding of hazard map	0.92
Energy strategy	4.1	Local Food Production	1	Disaster prevention of various infrastructures	0.92
Existing buildings and infrastructure	2.7	Tree-Lined and Shaded Streets	2	Disaster prevention vacant space and evacuation route	0.92
Water strategy	2.7	Neighborhood Schools	1	Continuity of business and life in the block	0.92
Sustainable buildings	4.1	Certified Green Buildings	5	Traffic safety	3.70
Low impact materials	2.7	Building Energy Efficiency	2	Crime prevention	3.70
Resource efficiency	2.7	Building Water Efficiency	1	Convenience	2.78
Transport carbon emissions	2.7	Water-Efficient Landscaping	1	Distance to medical and health and welfare facility	0.92
Ecology strategy	3.2	Existing Building Reuse	1	distance to educational facility	0.92
Land use	2.1	Historic Resource Preservation and Adaptive Use	1	time distance to cultural facility	0.92
Water pollution	1.1	Minimized Site Disturbance in Design and Construction	1	History and culture	2.78
Enhancement of ecological value	3.2	Storm water Management	4	Consideration of formation of townscape and landscape in the district	1.39
Landscape	2.1	Heat Island Reduction	1	Harmonization with the periphery	1.39
Rainwater harvesting	1.1	Solar Orientation	1	Traffic facilities in the district	1.39
Transport assessment	3.2	On-Site Renewable Energy Sources	3	Usability of public transportation	1.39
Safe and appealing streets	3.2	District Heating and Cooling	2	Logistic management	2.78
Cycling network	2.1	Infrastructure Energy Efficiency	1	consistency with and complementing of upper level planning	2.78
Access to public transport	2.1	Wastewater Management	2	Utilization level of standard floor area ratio	2.78
Cycling facilities	1.1	Recycled Content in Infrastructure	1	Handling of brownfield site	0.00
Public transport facilities	2.1	Solid Waste Management Infrastructure	1	Inhabitant population	2.78
Innovation	7	Light Pollution Reduction	1	Staying population	2.78
		Innovation and Exemplary Performance	5	Housing	0.00
		LEED® Accredited Professional	1	Non-housing	5.56
		Regional Priority	4	information service performance	2.78
				Block management	2.78
				Possibility to make demand and supply system smart	2.78
				Updatability and expandability	2.78

Table 2. The criteria of rating systems of DGNB, Green Star and ISCA

DGNB		Green Star		ISCA	
Criterion	**Score**	**Criterion**	**Score**	**Criterion**	**Score**
Life cycle impact assessment	7.9	Green Star Accredited Professional	1	Management Systems	10.5
Local environmental impact	3.4	Design Review	8	Procurement and Purchasing	5
Responsible procurement	1.1	Engagement	6	Climate Change Adaptation	5
Life cycle assessment- Energy	5.6	Adaptation and Resilience	4	Energy & Carbon	10.5
Drinking water demand and waste water volume	2.3	Corporate Responsibility	3	Water	7
Land use	2.3	Sustainability Awareness	2	Materials	7
Life cycle cost	9.6	Community Participation and Governance	2	Discharges to Air, Land & Water	10.5
Flexibility and adaptability	9.6	Environmental Management	2	Land	7
Commercial viability	3.2	Healthy and Active Living	5	Waste	7
Thermal comfort	4.3	Community Development	4	Ecology	10.5
Indoor air quality	2.6	Sustainable Buildings	4	Community Health, Well-being and Safety	5
Acoustic comfort	0.9	Culture, Heritage and Identity	3	Heritage	5
Visual comfort	2.6	Walkable Access to Amenities	2	Stakeholder Participation	5
User control	1.7	Access to Fresh Food	2	Urban & Landscape Design	5
Quality of outdoor spaces	0.9	Safe Places	2	Innovation	5

Safety and security	0.9	Community Investment	4
Design for all	1.7	Affordability	4
Public access	1.7	Employment and Economic Resilience	2
Cyclist facilities	0.9	Education and Skills Development	3
Design and urban quality	2.6	Return on Investment	2
Integrated public art	0.9	Incentive Programs	2
Layout quality	0.9	Digital Infrastructure	2
Fire safety	4.1	Peak Electricity Demand Reduction	2
Sound insulation	4.1	Integrated Water Cycle	7
Building envelope quality	4.1	Greenhouse Gas Strategy	6
Adaptability of technical systems	2	Materials	5
Cleaning and maintenance	4.1	Sustainable Transport and Movement	3
Deconstruction and disassembly	4.1	Sustainable Sites	2
Sound emissions	0	Ecological Value	2
Comprehensive project brief	1.4	Waste Management	2
Integrated design	1.4	Heat Island Effect	1
Design concepts	1.4	Light Pollution	1
Sustainability aspects in tender phase	1	Innovation (Bonus)	10
Documentation for facility management	1		
Environmental impact of construction	1		
Construction quality assurance	1.4		
Systematic commissioning	1.4		
Local environment	0		
Public image and social conditions	0		
Transport access	0		
Access to amenities	0		

6. Methodology

Since sustainable development is a matter of social science so the authors believed that qualitative methodology is the fitting approach. Qualitative research is a method of inquiry employed in many different academic disciplines. A qualitative researcher holds that understanding of a phenomenon or situation or event originates from exploring the totality of the situation (e.g., phenomenology, symbolic interactionism), often with access to large amounts of "hard data" [29]. A popular method of qualitative research is the Interviewing which is the verbal conversation between two people with the objective of collecting relevant information for the purpose of research.

6.1. Structured Interviewing

In structured interviewing, the interviewer asks all respondents the same series of pre-established questions with a limited set of response categories. The technique commonly used for interviewing was “Probing closed questions”. In this technique interviewer calls for an expert to choose answer from a list; however, The expert might not like to pick an answer from the list and wants to give his own answer; to avoid this situation pile sorting technique [30] was employed instead. An expert should sort a couple of cards into pre-determined piles. The expert can ask questions about the meaning of the cards and the interviewer must answer it according to the documents of the research per se and without any bias. In a pile sort task, a number of experts are selected and asked to sort cards, each containing the name of an item, into piles. Each expert were introduced to nine piles of: 1) Ecosystems ; 2) Biodiversity; 3) Natural Resources ; 4) Social Costs/Benefits; 5) Environmental Costs/Benefits; 6) Life-Cycle Costs/Benefits; 7) Health, Safety, and Welfare; 8) Transparency; 9) Equity. Then the criteria of each rating system which were written on a card were handed to experts separately. After that each expert was asked to put the cards of each rating system into one of the nine piles he distinguishes is the most relevant pile for the card.

If the researcher would like to ask the experts why they have sorted the items as they have, he or she should wait until the informant is finished sorting before asking. Questioning before or during the sorting process might interfere with the categories the informant was going to make and thus bias the results. When the informant is finished, the researcher can ask "Why are these together in a pile?" Descriptive answers can be used to interpret final results.

6.2. Statistical Population

In the research, technique of pile sorting was used. Pile sort data tend to be "sparse", requiring more experts (say, 20 or more) to obtain stable results [31]. Therefore sample size used in the interview was 20. Characteristics of interviewees are depicted in Table 3.

Table 3. Sample size and distribution based on age and education and affiliation

Age category		Education category		Affiliation category	
Age	No.	Education.	No.	Affiliation	No.
40 to 50	10	MSc.	12	University	10
51 to 60	6	PhD	8	Industry	10
Over 60	4				
Total	20	Total	20	Total	20

6.3. Data Analysis

When data collecting was finished, a matrix was created for each expert. For instance for ISCA rating system, a matrix of 14 × 9 was created (Table 4), since there are nine principle which are the principles of ASTM E2432 and fourteen criteria which are the criteria of ISCA rating system. When expert "n" puts the card containing criteria Cj in the pile Pi, the value of Aij will turn to 1 while the first value of it was zero. Therefore after an expert finishes pile sorting of ISCA rating system, there will be a matrix which 14 elements of it turns to "one" while the other elements are still zero. Each expert has six matrices because there are six rating system should be evaluated.

Pile sort data also tend to be "sparse", requiring more experts (say, 20 or more) to obtain stable results. In this research 20 experts were asked to participate in the pile sorting. So there were created 6 matrices for each expert or for every rating system there were created 20 matrices. Finally there were 6 matrices and each one was the summation of 20 matrices.

Table 4. The matrix was created for ISCA rating system for each expert

	P1	P2	P3	P4	P5	P6	P7	P8	P9
C1									
C2									
⋮									
C14									

After calculating the summation of opinions of 20 experts, 6 matrices were created as follows:

- A (9 x 14) matrix for ISCA
- A (9 x 40) matrix for BREEAM
- A (9 x 41) matrix for LEED-ND
- A (9 x 32) matrix for Green Star
- A (9 x 47) matrix for CASBEE
- A (9 x 41) matrix for DGNB

For each matrix, the mode value appears in every row of matrix was found then the corresponding column of mode element was considered as the chosen pile by the opinion of experts. Detailed results are showed in the Appendix.

7. Findings of the Research

After sorting criteria of rating systems into predetermined principles of ASTM E2432, an analogy could be made between rating systems. The score of each criterion was defined by each rating system per se. The score each rating system gained in each principle is depicted in Table 5. Table 6 shows the status of rating systems in each principle by analogy with the average. The average is the mean value of six rating systems in each principle.

Table 5. The score each rating system gained in each principle

	Environment			Social			Economic			Total
	Biodiversity	Ecosystems	Natural Resources	Health, Safety, and Welfare	Equity	Transparency	Social Costs/Benefits	Environmental Costs/Benefits	Life-Cycle Costs/Benefits	
ISCA	0.00	40.00	24.50	5.00	5.00	20.50	0.00	0.00	5.00	100
BREEAM	3.20	9.10	13.60	16.90	9.50	14.70	7.70	16.70	8.90	100
LEED-ND	10.00	7.00	8.00	49.00	12.00	5.00	2.00	5.00	2.00	100
Green star	1.00	9.00	22.00	12.00	10.00	28.00	8.00	2.00	8.00	100
CASBEE	5.57	5.56	11.13	21.26	3.70	30.58	5.56	11.11	5.56	100
DGNB	0.00	6.80	2.30	32.90	0.00	29.40	0.00	15.90	12.80	100
Average	3.30	12.91	13.59	22.84	6.70	21.36	3.88	8.45	7.04	100

Table 6. Status of rating systems in each principle by analogy with the average (B.A.: below the average, ×: the score gained is zero, ✓: above the average)

	Environment			Social			Economic		
	Biodiversity	Ecosystems	Natural Resources	Health, Safety, and Welfare	Equity	Transparency	Social Costs/Benefits	Environmental Costs/Benefits	Life-Cycle Costs/Benefits
ISCA	×	✓	✓	B. A.	B. A.	B. A.	×	×	B. A.
BREEAM	✓	B. A.	✓	B. A.	✓	B. A.	✓	✓	✓
LEED-ND	✓	B. A.	B. A.	✓	✓	B. A.	B. A.	B. A.	B. A.
Green star	B. A.	B. A.	✓	B. A.	✓	✓	✓	B. A.	✓
CASBEE	✓	B. A.	B. A.	B. A.	B. A.	✓	✓	✓	B. A.
DGNB	×	B. A.	B. A.	✓	×	✓	×	✓	✓

A column chart was drawn (Table 7) with the scores of rating systems (Figure 2). All of rating systems emphasized the most on social principles except for ISCA which accepted Environmental principles as the primary one.

Table 7. Status of rating systems in three piles of sustainable development

	Environment	Social	Economy
ISCA	64.50	30.50	5.00
BREEAM	25.90	41.10	33.30
LEED-ND	25.00	66.00	9.00
Green star	32.00	50.00	18.00
CASBEE	22.26	55.54	22.23
DGNB	9.10	62.30	28.70
Average	29.79	50.91	19.37

Principles of rating systems were sorted in a descending order to see the priorities of each rating system (Figure 3).

ISCA: Environment > Social > Economy

BREEAM: Social > Economy > Environment

LEED-ND: Social > Environment > Economy

Green star: Social > Environment > Economy

CASBEE: Social; > Economy = Environment

DGNB: Social > Economy > Environment

This implies that each rating system has an exclusive paradigm. It is of importance in choosing a rating system the paradigm of the client should be close to the paradigm of the rating system; otherwise the success of the project implementing with this rating system will be in doubt.

In evaluating each rating system individually, the following results were deduced:

- ISCA

Despite ISCA has the most emphasis on Environment among the other rating systems, it puts less stress on the other aspects of sustainable development in cities. As it is obvious in Table 7, ISCA has very weak economic criteria.

- BREEAM

The most important characteristic of BREEAM is its emphasis on Economy which is obvious in Table 5 and 7. Furthermore, even though BREEAM gained a score near the average but its criteria for "Health, safety and welfare" and "Transparency" are not sufficient.

- LEED-ND

LEED-ND gained the maximum score of social principle among the others. This weight placed on Social principle weaken the rest of the criteria.

- Green Star

Green star has a comprehensive outlook towards sustainable development in cities; it almost satisfies all the principles of ASTM E2432.

- CASBEE

CASBEE has a comprehensive outlook towards sustainable development in cities; it almost satisfies all the principles of ASTM E2432.

- DGNB

Despite of the score this rating system gained in social and economic principles, it showed the least interest in environmental principles.

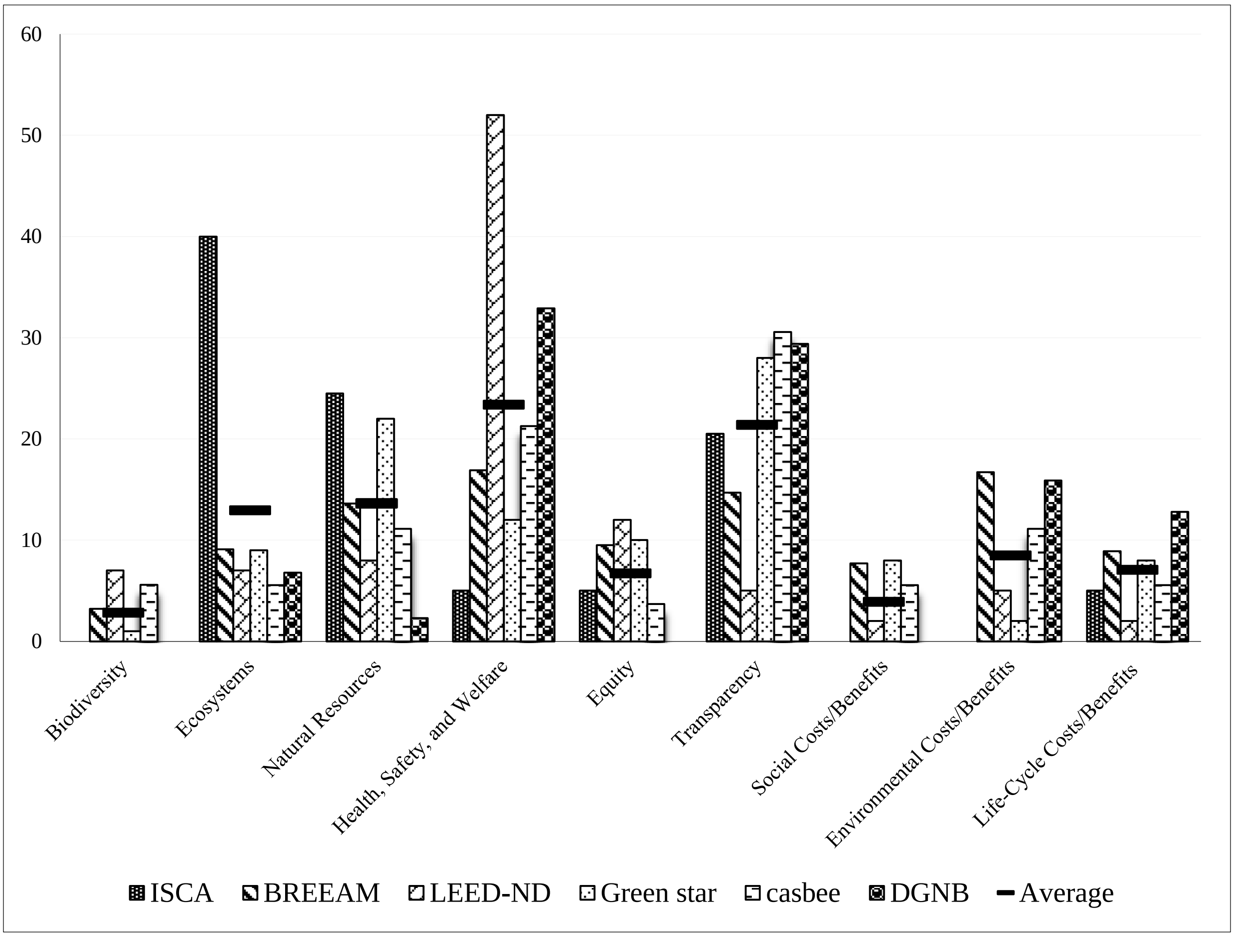

Figure 2. Status of rating systems in each principle by analogy with the average

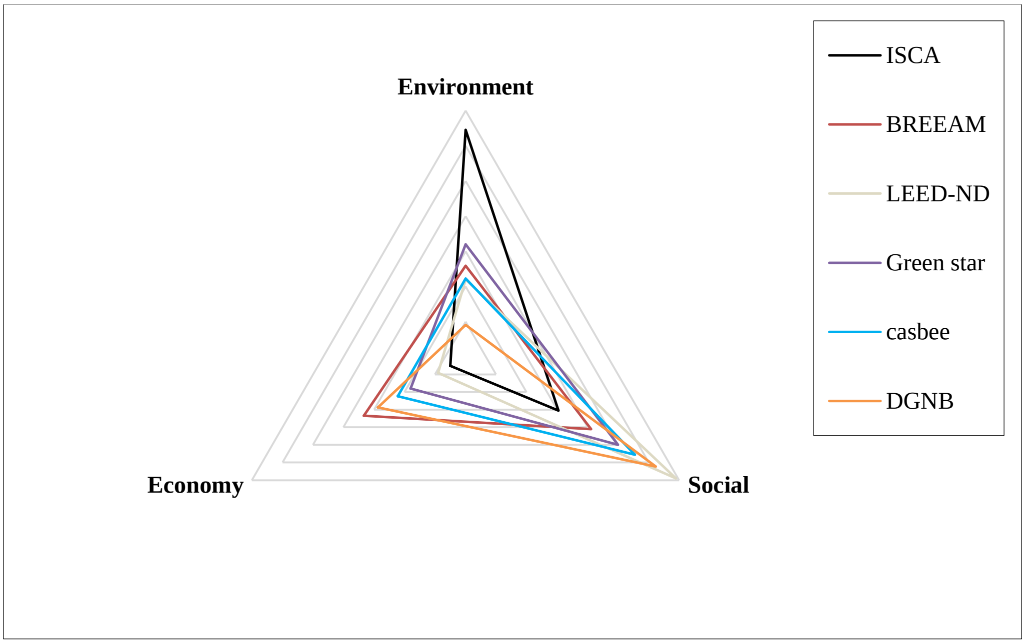

Figure 3. Priorities of each rating system

8. Conclusion

Selecting a best rating system for developing a city in a sustainable manner is a goal for city planners. Selection of a fitting rating system plays a crucial role in the betterment of the condition of a city, and to reach this goal not only should it be in step with the condition of a city but also it should be in harmony with the planer's wishes. Having chosen the ASTM E2432 as an appropriate framework to evaluate the selected rating systems, authors came to conclusion that criteria of each rating system should fall into 9 categories as the ASTM E2432 had introduced. Every rating system has its own scoring system so the value of each category was determined through them. The only missing link here was how to categorize criteria of each rating system according to ASTM E2432. The authors hold the belief that a qualitative approach must be employed and the best way to do so is to seek advice from the experts and this stems from the exploratory virtues of qualitative research. As a result 20 experts were interviewed to weigh the evidence of each criterion to find out to which category it belongs. Finally each rating system was weighed against the 9 basic categories of sustainable development stated by ASTM E2432. In other words, accentuation of rating systems was cleared out so it affords a window of opportunity for city planners to choose the best rating system based on their point of view and shortcomings of a city come to their attention.

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10. Conflict of Interest

The author declares no conflicts of interest.

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Appendix I: Categorization of criteria of each rating system based on pile sorting of experts' opinions.

	Biodiversity	Ecosystems	Natural Resources	Health, Safety, and Welfare	Equity	Transparency	Social Costs/Benefits	Environmental Costs/Benefits	Life-Cycle Costs/Benefits
ISCA	-	Climate Change Adaptation Discharges to Air, Land & Water Land Waste Ecology	Energy & Carbon Water Materials	Community Health, Well-being and Safety	Heritage	Management Systems Stakeholder Participation Urban & Landscape Design	-	-	Procurement and Purchasing
BREEAM	Ecology strategy	Transport carbon emissions Land use Water pollution Landscape Rainwater harvesting	Energy strategy Existing buildings and infrastructure Water strategy Sustainable buildings	Delivery of services, facilities and amenities Microclimate Utilities Light pollution Safe and appealing streets Cycling network Access to public transport Cycling facilities Public transport facilities	Public realm Local vernacular Training and skills	Consultation plan Consultation and engagement Design review Community management of facilities Housing provision Local parking Inclusive design	Demographic needs and priorities Green infrastructure Transport assessment	Adapting to climate change Flood Risk Assessment Noise pollution Flood risk management Low impact materials Resource efficiency Enhancement of ecological value	Economic impact
LEED-ND	Steep Slope Protection Site Design for Habitat or Wetland and Water Body Conservation Restoration of Habitat or Wetlands and Water Bodies Compact Development Heat Island Reduction	Brownfield Remediation Building Energy Efficiency Building Water Efficiency Water-Efficient Landscaping Minimized Site Disturbance in Design and Construction	Storm water Management Wastewater Management Recycled Content in Infrastructure Solid Waste Management Infrastructure 1	Preferred Locations Locations with Reduced Automobile Dependence Bicycle Network and Storage Walkable Streets Mixed-Use Neighborhood Centers Reduced Parking Footprint Tree-Lined and Shaded Streets Neighborhood Schools Certified Green Buildings Light Pollution Reduction	Housing and Jobs Proximity Mixed-Income Diverse Communities Visitability and Universal Design Historic Resource Preservation and Adaptive Use	Long-Term Conservation Management of Habitat or Wetlands and Water Bodies Transportation Demand Management Community Outreach and Involvement	District Heating and Cooling	Local Food Production Solar Orientation O n-Site Renewable Energy Sources	Existing Building Reuse Infrastructure Energy Efficiency
Green Star	Heat Island Effect	Sustainable Transport and Movement Sustainable Sites Ecological Value Waste Management	Integrated Water Cycle Greenhouse Gas Strategy Materials Sustainable Buildings	Healthy and Active Living Walkable Access to Amenities Access to Fresh Food Safe Places Light Pollution	Community Development Culture, Heritage and Identity Education and Skills Development	Green Star Accredited Professional Design Review Engagement Adaptation and Resilience Corporate Responsibility Sustainability Awareness Community Participation and Governance Environmental Management	Community Investment Employment and Economic Resilience Incentive Programs	Peak Electricity Demand Reduction	Affordability Return on Investment Digital Infrastructure
CASBEE	Patch (planar) quality: Habitat space of species Patch (planar) quality: consideration for regionality corridor (network) quality natural resources Terrain	Greening of ground surface rooftop greening wall greening Handling of brownfield site	rain water utilization treated water reduction of sewage discharge amount reduction of rain water discharge reduction of rain water discharge: rain water permeation surface and permeation facility wood material recycled material garbage separation In-area resource circulation	understanding of hazard map Disaster prevention of various infrastructures Disaster prevention vacant space and evacuation route Continuity of business and life in the block Traffic safety Crime prevention Convenience Distance to medical and health and welfare facility distance to educational facility Consideration of formation of townscape and landscape in the district Harmonization with the periphery Traffic facilities in the district Usability of public transportation	History and culture time distance to cultural facility	Compliance area management Logistic management consistency with and complementing of upper level planning Utilization level of standard floor area ratio information service performance Block management Possibility to make demand and supply system smart Updatability and expandability	Inhabitant population Staying population	Environmentally friendly buildings	Housing Non-housing

CASBEE	Patch (planar) quality: Habitat space of species Patch (planar) quality: consideration for regionality corridor (network) quality natural resources Terrain	Greening of ground surface rooftop greening wall greening Handling of brownfield site	rain water utilization treated water reduction of sewage discharge amount reduction of rain water discharge reduction of rain water discharge: rain water permeation surface and permeation facility wood material recycled material garbage separation In-area resource circulation	understanding of hazard map Disaster prevention of various infrastructures Disaster prevention vacant space and evacuation route Continuity of business and life in the block Traffic safety Crime prevention Convenience Distance to medical and health and welfare facility distance to educational facility Consideration of formation of townscape and landscape in the district Harmonization with the periphery Traffic facilities in the district Usability of public transportation	History and culture time distance to cultural facility	Compliance area management Logistic management consistency with and complementing of upper level planning Utilization level of standard floor area ratio information service performance Block management Possibility to make demand and supply system smart Updatability and expandability	Inhabitant population Staying population	Environmentally friendly buildings	Housing Non-housing
DGNB	-	Local environmental impact Responsible procurement Land use Local environment	Drinking water demand and waste water volume	Thermal comfort Indoor air quality Acoustic comfort Visual comfort User control Quality of outdoor spaces Safety and security Public access Cyclist facilities Fire safety Sound insulation Building envelope quality Cleaning and maintenance Sound emissions Transport access Access to amenities	Public image and social conditions	Flexibility and adaptability Design for all Design and urban quality Integrated public art Layout quality Adaptability of technical systems Deconstruction and disassembly Comprehensive project brief Integrated design Design concepts Sustainability aspects in tender phase Documentation for facility management Systematic commissioning		Life cycle impact assessment Life cycle assessment-Energy Environmental impact of construction Construction quality assurance	Life cycle cost Commercial viability