A Qualitative Approach Towards the Implementation of Urban Sustainability in Tehran

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Abstract

Sustainability as a predominant paradigm of 21st century, is adopted as the best approach to tackle the issues which threat the environment and people's well-being. As cities in the world are places in which most of the population in the world settles, the best way of ensuring sustainability would be by observing a set of rules and regulations. There are various sets of urban regulations, rating systems, about sustainability in the globe with different names. In this article, six rating systems of ISCA, BREEAM, LEED-ND, CASBEE, Green star, DGNB were chosen to be evaluated. By this evaluation, one may determine their features as well as finding the most fitting rating system which can be employed to ameliorate present situation of Tehran which is a megalopolis and the capital of Iran. The rating systems were analyzed based on the ASTM E2432-17. The methodology selected for this research was qualitative since the research was exploratory, so structured interviewing applied to do so. Finally, the LEED-ND was recognized as the best rating system which is able to mitigate unsustainable issues of Tehran. Consequently, related rules and regulations in Iranian legal system were investigated to find out if there is anything on which one can rely on implement urban sustainable development or prevent urban unsustainability. Although the comprehensive plan of Tehran can cover a lot of ground of LEED-ND, it is absolutely essential that parliament of Iran pass special acts supporting urban sustainable development, because the regulations passed by authorities other than parliament cannot give a full guarantee to implement urban sustainable development.

Keywords: Sustainable development; Rating system; Structured interview; Pile sorting technique; Sustainable development obstacles; Tehran.

1. Introduction

Development is a well-recognized phenomenon for human society. However, it is a concept which has manifested itself in the past five decades, from the introduction of the sustainable development idea at the Stockholm conference in 1972 (Avilés, 2014). Cities are complex hybrid socioeconomic–natural ecosystems, representing the densest concentrations of human activity (Wang et al., 2011). For cities to grow sustainably, spatial plans of development and infrastructure must consider a large number of objectives. These objectives can be spatially complex, and meeting objectives in isolation can lead to conflict between others (Caparros-Midwood, Dawson and Barr; 2019). In many developing countries, residential neighborhoods most disadvantaged neighborhoods are relatively neglected in the sustainability initiatives. In essence, there are different types of neighborhoods (e.g. advantaged vs. disadvantaged; low income vs. middle-income vs. high income; core vs. peripheral; affluent vs. poor; developing countries vs. developed countries; etc.) as well as across different scales (region, country and global) signified by the different degrees of sustainability initiatives. A consistent upsurge of interest is basically present to convey a message that urban settings are still unbalanced and outstandingly conjoined to urbanization effects which manifest in socio-economic and spatial segregation, poverty and environmental degradation. The concept of sustainable development cannot exist without the existence of balanced growth (Moroke and Schoeman, 2019). 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 (Riley, 2001a). Different indicators and methods have been suggested or used in varied contexts and for diverse purposes (Riley, 2001b). 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 to provide a tool for guidance in sustainable policies and communication to the public (Spangenberg et al., 2002).

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Measure of well-being in the city in the context of sustainability is fundamental. Sustainability efforts deal with environmental resources and conditions that are part of regional and global systems but have local effects. Since the future and interests of a city are tied to the future of the region and the world, sustainability cannot be parochial (Haruna; Mohd and Ahmad, 2019). Cities are responsible for 70% of global CO2 emissions (UN-Habitat, 2016), resulting from the use of resources such as fuels, minerals and metals, as well as food, soil, water, air, biomass and ecosystems (European Environment Agency, 2015), Therefore the buildings sector is key for low-cost climate mitigation worldwide. Construction section has the second place as the largest carbon dioxide (CO2) emitter after industry, almost 33% of the global total (Price et al., 2006). 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 (AGIC, 2012).

Implementation of urban sustainability policies is complex, considering the multitude of urban interdependencies between economics, culture, infrastructure, natural resources, and other social and environmental challenges, with associated public and private actors on local-national-regional levels (Kalantari; Ferreira; Page; Golderberg; Plson and Destouni, 2019). The 21st century has been called the urban century because more than half of the world population lives in towns and cities (Keivani 2010). Zhao (2010) predicted that almost 70% of the world's population will live in cities until 2050. Therefore, the most supply consumption occurs in cities. It is obvious that there should be a limitation for human activities or living cannot be possible anymore in future. Moreover, Tehran as the capital of Iran is a city which is on the edge of unsustainability and is coping with multiple challenges such as: air pollution, lack of greenery, appearance of brownfield sites, congested traffic, increase in the rate of crimes, appearance of racial and social inequity, health problems, cultural and heritage conflicts, community mismanagements … so finding a fitting approach to address these problems is undeniable.

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

1.1. 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.

1.1.1. 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 (ISO 21929-1, 2011).

1.1.2. 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, in order to facilitate clarity in the presentation of the general principles of sustainability relative to buildings they are discussed individually (figure1).

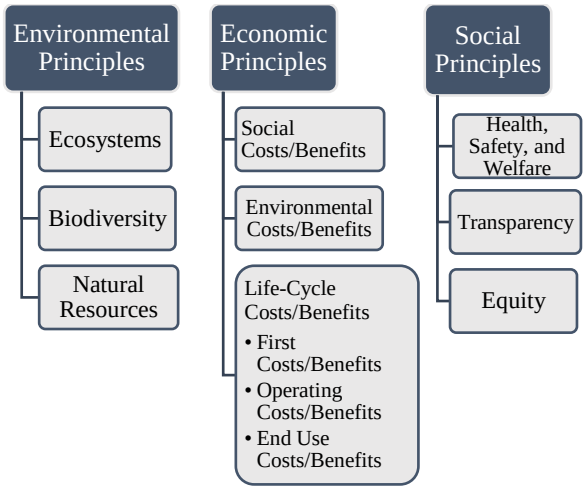

Fig. 1. ASTM E2432 principles for sustainable development in buildings

a) *Environmental Principles*—Buildings impacts on 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, neighbors, and the public throughout the building 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.

1.2. Selected Framework

Selecting a framework for sustainable development between the ISO 21929 and ASTM 2432 is an issue of preferences. ASTM 2432 introduces two 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, two issues of transparency and biodiversity are the current issues which their deficiency is felt dominantly for Iran as a developing country.

1.3. Rating Systems

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

1.3.1. BREEAM Communities

BREEAM was first launched in 1990; BREEAM was the world 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. Over the years, BREEAM has been regularly updated and applied to an ever growing range of development types, designs and lifecycle stages. BREEAM is now applied in its various forms in over 50 countries.

The issues within this manual are grouped into five assessment categories which are considered through appropriate criteria. It is difficult to categories sustainability issues definitively, as they often affect all three dimensions of sustainability (social, environmental and economic). By assigning categories, BREEAM seeks to provide some clarity about the intention of each issue. A sixth category promotes the adoption and dissemination of innovative solutions. The categories are listed below with a brief description of their overall aims:

- *Governance(GO)*

Promotes community involvement in decisions affecting the design, construction, operation and long-term stewardship of the development.

- *Social and economic wellbeing (SE)*

Considers societal and economic factors affecting health and wellbeing such as inclusive design, cohesion, adequate housing and access to 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 transport and movement infrastructure to encourage the use of sustainable modes of transport.

- *Innovation (Inn)*

Recognizes and promotes the adoption of innovative solutions within the overall rating where these are likely to result in environmental, social and/or economic benefit in a way which is not recognized elsewhere in the scheme.

BREEAM aims to ensure that its standards provide social and economic benefits whilst mitigating the environmental impacts of the built environment. In doing so, BREEAM enables developments to be recognized according to their sustainability benefits and stimulates demand for sustainable development.

BREEM provides a framework for considering the issues and opportunities that affect sustainability at the earliest stage of the design process for a development. The scheme addresses key environmental, social and economic sustainability objectives that have an impact on large-scale development projects (Table 1).

1.3.2. LEED-ND

LEED was developed by the USGBC in 2000. Since its inception, LEED has grown to encompass more than 14,000 projects in the USA and more than 30 countries (Nguyen and Altan, 2011). 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 (Renard, 2013). 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.

The U.S. Green Building Council (USGBC), the Congress for the New Urbanism (CNU), and the Natural Resources Defense Council (NRDC)—organizations that represent leading design professionals, progressive builders and developers, and the environmental community—have come together to develop a rating system for neighborhood 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 neighborhood development practices within the framework of the LEED Green Building Rating System. The result of their effort was named LEED-ND. The LEED-ND criteria for sustainable neighborhoods in cities is mentioned in table 1.

1.3.3. CASBEE for cities

Comprehensive Assessment System for Built Environment Efficiency (CASBEE) is a method for evaluating and rating the environmental performance of buildings and the built environment. CASBEE was developed 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 (CASBEE, 2014).

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

1.3.4. Green star

Green Star, developed 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 (Roderick et al., 2009). 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 (Anthony et al, 2017).

Criteria of Green Star are shown in table 2.

1.3.5. 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 (DGNB, 2017).

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

BREEAM		**LEED-ND**		**CASBEE**	
Criterion	**Scor**	Criterion	**Scor**	Criterion	**Scor**
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	7	reduction of sewage discharge	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	1	In-area resource circulation	1.39
Delivery of services, facilities and	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	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	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	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	0.92
Ecology strategy	3.2	Existing Building Reuse	1	distance to educational facility	0.92
Land use	2.1	Historic Resource Preservation and	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	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	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	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**	**S**
Life cycle impact assessment	7.9	Green Star Accredited	1	Management Systems	1
Local environmental impact	3.4	Design Review	8	Procurement and	5
Responsible procurement	1.1	Engagement	6	Climate Change	5
Life cycle assessment- Energy	5.6	Adaptation and Resilience	4	Energy & Carbon	1
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
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	1
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	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	2		
Sound insulation	4.1	Integrated Water Cycle	7		
Building envelope quality	4.1	Greenhouse Gas Strategy	6		
Adaptability of technical	2	Materials	5		
Cleaning and maintenance	4.1	Sustainable Transport and	3		
Deconstruction and	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	0				
Transport access	0				
Access to amenities	0				

The criteria DGNB considers for sustainable development are listed in the table 2.

1.3.6. 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 facilitation of 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.
The major additions and updates to the IS content is summarized in Table 2.

2. Methodology

Evaluating rating systems needs an exploratory approach, since issue of sustainable development is related to social science so the authors believed that qualitative methodology is the best strategy. 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 comes from exploring the totality of the situation (e.g., phenomenology, symbolic interactionism), often with access to large amounts of "hard data". 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.

2.1. 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 used for interviewing was “Probing closed questions”. In this technique interviewer calls for an expert to choose answer from a list. 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 was selected in the interview. 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 and without any bias. Therefore, a formal data collection method of pile sorting recognized to be appropriate for the study. In a pile sort task, a number of experts are selected and are 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; and 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.

2.2. 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 (Weller, S. C. & Romney, A. K.; 1988). Therefore sample size used in the interview was 20. Interviewers' characteristics 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

2.3. Data Analysis

When data collecting was finished, a matrix was created for each expert. For instance, for ISCA rating system, a matrix of 14x9 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 (Weller,

S. C. & Romney, A. K.; 1988). 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 obtained 6 matrices which each one were the summation of 20 matrices every expert assessed each rating system.

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.

3. Results

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 that 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.
The categorization of criteria of each rating system based on pile sorting of experts' opinions is shown in table 9 in the appendix.

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 important to choosr 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, but it puts less stress on the other aspects of sustainable development in cities. As it is obvious in Table 17, ISCA has very weak economic criteria.

- BREEAM

The most important characteristic of BREEAM is its emphasis on economy which is shown in table 16 and 18. 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 look to sustainable development in cities; it almost satisfies all the principles of ASTM E2432.

- CASBEE

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

- DGNB

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

I

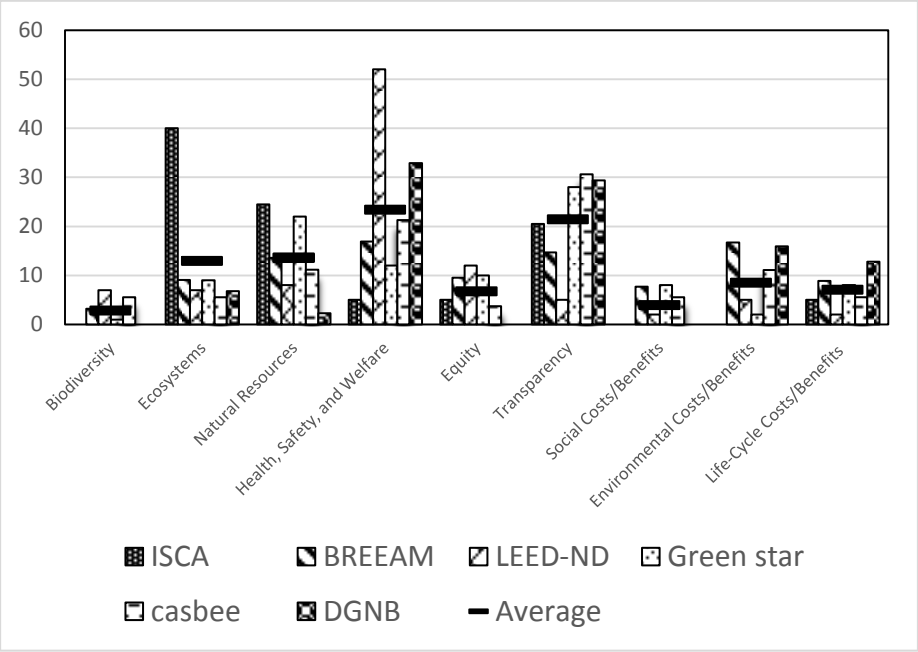

Fig. 2. Status of rating systems in each principle by analogy with the average

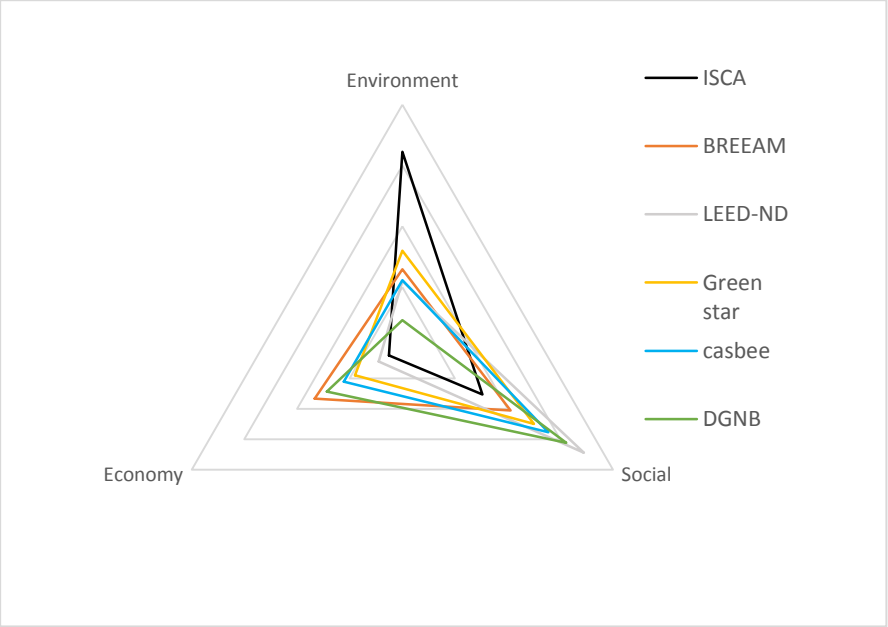

Fig. 3. Priorities of each rating system

4. Discussion

Tehran is one of the most populous cities in the world. Development of Tehran is strongly influenced by political, economic and cultural factors. This city has devoured a good deal of ecological and energy resources. Many research studies have conducted concerning obstacles in the path of urban sustainable development in Tehran. In this article, authors concluded to reap the benefit of the results published by Tehran municipality (RPC, 2018). Urban research and planning center of Tehran municipality evaluated the key issues of districts of Tehran. The center used SWOT analysis to identify the most difficult issues. When the results are summed up, the status of each pillar of sustainable development are cited in the table 8.

Table 8
Status of the pillars of sustainable development in Tehran

	Ecosystem	Society	Economy
Issues of Tehran	9%	86%	5%

The most fitting rating system which can deal with the obstacles of Tehran is the one that underscore the issues of Tehran. The most important of them are as follows: society, ecosystem and economy. The stress laid on the society must be far more than the ecosystem and the stress put on the ecosystem must be as twice as the economy. It is blindingly obvious that the most appropriate rating system between the above mentioned ones is LEED-ND.

4.1. Legal obstacles in the path of conducting LEED-ND in Tehran

The main regulation, which is not an act of parliament, regarding implementation of urban sustainable development is the main regulation of Iran Supreme council of urban planning and architecture accepted on March 13th, 1973. According to this regulation, Iran Supreme council of urban planning and architecture have authority to adopt and implement policies and regulate comprehensive and coordinated plans to achieve optimum balance between population and urban space across the country. Tehran comprehensive coordinated plan was issued in 2007. It is drafted in nine chapters and includes planning regulations which should be observed in Tehran. The investigation conducted by the authors revealed that Tehran comprehensive coordinated plan may cover a vast range of items in LEED-ND which is the most fitting rating system for Tehran.

Yet, reports have pictured a bleak picture of Tehran for unsustainability found in this city. The authors believe that Iran council of urban planning and architecture is a part of government body. Being in a position of authority, government and consequently its subsections are able to infringe the regulations. There are many urban construction cases which no permission could be granted by individuals, but these cases are overruled by corruptions. In other words, regulations in this level are in danger of misuse and cannot establish total authority.

Lack of rules legislated by parliament is undeniable, and there are only few articles in some regulations like five-year economic development acts that cannot give a full guarantee to implement urban sustainable development.

5. Conclusion

While development is an indisputable phenomenon in the globe, environment protection and improving individual's well-being are the matters of concern. The prevailing paradigm to fulfill above-mentioned concerns is

Table 9
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

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

sustainability. This paradigm has officially been embarked on since Brundtland commission. The ground which is covered by sustainable development, falls into different categories, one of which is urban sustainable development. There are many rating systems in the globe concerning urban sustainable development. In this research six rating systems of ISCA, LEED-ND, BREEAM, Green Star, CASBEE and DGNB were investigated to reveal the fitness of their features. Having known the features of each rating system and unsustainable issues of a city, the city planner can choose the most fitting rating system amongst them. Structured interview which is a qualitative method, was applied to determine features of each rating system.

The second phase of the research was to choose the most fitting rating system for Tehran. Unsustainable issues of Tehran were introduced and based on them LEED-ND was the most fitting rating system for Tehran.

Finally, urban sustainable development was investigated in the context of legal affairs in the laws of Iran. Based on the findings, the comprehensive plan of Tehran is a good match for LEED-ND; however, regulations made by authorities other than parliament cannot give a full guarantee to implement the sustainable development according to legal experts opinion. Therefore, the authors strongly recommend that rules and regulations regarding sustainable development must be passed directly by parliament to be able to leave overwhelming impression on the society.

References

1) AGIC (2012). "Australian Green Infrastructure Council – IS Rating Scheme", Australian Green Infrastructure Council (AGIC), Sydney :<www.agic.net.au/ISratingscheme1.htm> (January 7, 2013).
2) Avilés, Luis A. "Sustainable Development and Environmental Legal Protection in the European Union: A Model for Mexican Courts to Follow?" Mexican Law Review 6, no. 2 (January 2014): 251–272. doi: 10.1016/s1870-0578(16)30014-2.
3) Bauwer, K. "ISCA and the IS rating scheme, Infra structure sustainability council of Australia." <https://www.eianz.org/document/item/3422> (Sep 30, 2017).
4) "BREEAM Communities technical manual." (2016). technical manual: version: SD202, http://www.breeam.com/communitiesmanual/ (Oct. 14, 2017)
5) CASBEE. (2014). "CASBEE for cities." <http://www.ibec.or.jp/CASBEE/english/downloadE.htm> (Mar. 14, 2017)
6) Caparros-Midwood, D.; Dawson, R.; Barr, S (2019). "Low Carbon, Low Risk, Low Density: Resolving choices about sustainable development in cities", Cities, 89, June 2019, 252-267 https://doi.org/10.1016/j.cities.2019.02.018
7) DGNB. (2017). "The DGNB sustainability concept. The new quality of building. The German Sustainable Building Council (DGNB)." <http://www.dgnb-system.de/en/system/dgnb-sustainability_concept/> (Sep. 20, 2017).
8) European Environment Agency (2015). Urban sustainability issues — what is a resourceefficient city? Luxembourg: Publications Office of the European Union https://doi.org/10.2800/389017.
9) Fernández-Sánchez, G., Rodríguez-López, F. (2010). "A methodology to identify sustainability indicators in construction project management—Application to infrastructure projects in Spain", Ecological Indicators J. 10(6), 1193-1201.
10) "Communities Guide for Local Government." (2012). <http://www.gbca.org.au/uploads/189/2749/Green_Star_Communities_Guide_for_Local_Government_For_Web.pdf.> (June 9, 2017).
11) Hargroves, K. (2014). "ISCA 'Infrastructure Sustainability' Rating Tool and Low Carbon Tendering: A Report to the Sustainable Built Environment National Research Centre and the CRC for Low Carbon Living", Curtin University Sustainability Policy Institute, Curtin University.
12) Haruna, M.; Mohd, Y. and Ahmad, A. (2019) "Delphi exploration of subjective well-being indicators for strategic urban planning towards sustainable development in Malaysia" Journal of urban management, 8, 24-41. https://doi.org/10.1016/j.jum.2018.08.001
13) ISCA. (2007). "IS Rating Scheme Categories and Credits." Infrastructure sustainability council of Australia, <https://isca.org.au/is-rating-scheme/about-is/item/68-is-rating-tool> (Aug. 1, 2017).
14) ISO. (2008). "Sustainability in building construction — General principles." ISO 15392.
15) ISO. (2011). "Sustainability in building construction —Sustainability indicators, Part 1: Framework for the development of indicators and a core set of indicators for buildings", ISO 21929-1.
16) ISO. (2014). "Sustainable development of communities — Indicators for city services and quality of life", ISO 37120.
17) Kalantari, Z.; Ferreira, C. ; Page, J.; Goldenberg, R.; Olson, J.; Destouni, G. (2019) "Meeting sustainable development challenges in growing cities: Coupled social-ecological systems modeling of land use and water changes", Journal of Environmental Management, 245, 471-480 https://doi.org/10.1016/j.jenvman.2019.05.086
18) Keivani, R. (2010). "A review of the main challenges to urban sustainability." Int. J. Urban Sustainable Dev., 1(1–2), 5–16.

19) LEED. (2009). "Checklist: LEED v2009 Neighborhood Development." <https://www.usgbc.org/resources/neighborhood development-v2009-checklist-xls> (September 3, 2017).
20) LEED. "LEED for Cities Pilot | Performance Score to LEED Certification." <https://www.usgbc.org/cityperformance> (September 3, 2017).
21) LEED ND. (2014). "LEED 2009 for Neighborhood Development Rating System. Congress for the New Urbanism." Natural Resources, Defense Council, and the U.S. Green Building Council.
22) Lemaitre C. (2014) Measuring Sustainability in the Construction and Real Estate Sector: A Case Study of the DGNB Certification System. In: Schmitz-Hoffmann C., Schmidt M., Hansmann B., Palekhov D. (eds) Voluntary Standard Systems. Natural Resource Management in Transition, vol. 1. Springer, Berlin, Heidelberg, https://doi.org/10.1007/978-3-642-35716-9_23
23) Mitchell, L.M. (2010), Green Star and NABERS: learning from the Australian experience with green building rating tools. in Bose, R.K. (Ed.), Energy Efficient Cities: Assessment Tools and Benchmarking Practices, The International Bank for Reconstruction and Development/The World Bank, Washington, DC, 93-124.
24) Moroke, T., and Schoeman, I.,Developing a neighbourhood sustainability assessment model: An approach to sustainable urban development, Sustainable Cities and Society (2019), https://doi.org/10.1016/j.scs.2019.101433
25) Morris, A., Zuo, J., Wang, Y., Wang, J. (2017). "Readiness for sustainable community: A case study of Green Star Communities" J. of Cleaner Production, 10.1016/j.jclepro.2017.03.190
26) Nguyen, B.K. and Altan, H. (2011). "Comparative review of five sustainable rating systems." Procedia Engineering, 21, 376-386.
27) Noblit G. W., Hare RD. (1988). Meta-ethnography: synthesizing qualitative studies. Newbury Park (CA): Sage.
28) Price, L., De la Rue du Can, S., Sinton, J., Worrell, E. (2006). Sectoral Trends in Global Energy Use and GHG Emissions. Lawrence Berkeley National Laboratory, Berkeley, CA.
29) Siew, R. Y. J., Balatbat, M. C. A., Carmichael, D. G. (2013). "A review of building/infrastructure sustainability reporting tools (SRTs)." Smart and Sustainable Built Environment, 2(2), 106-139. https://doi.org/10.1108/SASBE-03-2013-0010
30) Riley, J. (2001a). "Indicator quality for assessment of impact of multidisciplinary systems." Agr. Ecosyst. Environ. 87, 121–128.
31) Riley, J. (2001b). "The indicator explosion: local needs and international challenges." Agr. Ecosyst. Environ. 87, 119-120.
32) Roderick, Y., McEwan, D., Wheatley, C. and Alonso, C. (2009). "Comparison of energy performance assessment between LEED, BREEAM and Green Star." 11th International IBPSA Conference, Glasgow, 27-30.
33) RPC (Tehran Urban research and planning center) http://rpc.tehran.ir/Default.aspx?tabid=218 (December 26, 2018)
34) Schreiber, R., Crooks, D., Stern, PN. (1997). Qualitative meta-analysis. In: Morse JM, editor. Completing a qualitative project. Thousand Oaks (CA): Sage Publications; 311–26.
35) Spangenberg, J.H., Pfahl, S., Deller, K. (2002). "Towards indicators for institutional sustainability: lessons from an analysis of Agenda 21." Ecol. Indic. 2, 61–77.
36) (United Nations Environmental Programme). (2007). "Buildings and Climate Change: Status, Challenges, and Opportunities." UNEP.
37) UN-Habitat (2016). Urbanization and development: Emerging futures – World cities report 2016Kenya, Nairobi: United Nations Human Settlements Programme (UN-Habitat).
38) Zhao, P. (2010). "Sustainable urban expansion and transportation in a growing megacity: Consequences of urban sprawl for mobility on the urban fringe of Beijing." Habitat Int., 34(2), 236–243
39) Wang, R.S., Li, F., Hu, D., Li, B.L. (2011). "Understanding eco-complexity: Social-Economic-Natural Complex Ecosystem approach." Ecol. Complex, 8(1), 15-29.
40) Weller, S. C. & Romney, A. K. (1988). Qualitative Research Methods: Systematic data collection Newbury Park, CA: SAGE Publications Ltd. doi: 10.4135/9781412986069
41) Whittemore R., Chase SK., Mandle CL. (2001). Validity in qualitative research. Qual. Health Res. 11(4), 522–37.