Journal of Cleaner Production 251 (2020) 119622

Contents lists available at ScienceDirect

Journal of Cleaner Production

journal homepage: www.elsevier.com/locate/jclepro

Comparative study of city-level sustainability assessment standards in China and the United States

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ARTICLE INFO

Article history:
Received 25 February 2019
Received in revised form
26 October 2019
Accepted 8 December 2019
Available online xxx

Handling editor: Yutao Wang

Keywords:
Sustainability assessment standards
City-level
Green buildings
Rating system
Comparative study
China

ABSTRACT

In analyses of urban environments, city-level sustainability assessments standards have received a lot of attention. Many countries, particularly in the developed world, have developed the standards to measure the performance of neighborhoods, districts, and cities in achieving sustainable development goals. In this study, four standards from China and the United States were selected and analyzed within the scope of green and sustainable development. China's new Assessment Standard for Green Eco-districts (ASGE) targets to support China's New-type Urbanization Plan from the conceptual stage to the concrete implementation. LEED® rating systems are one of the important references for the development of ASGE. By comparing ASGE with the advanced standards it draws from, this study aimed to evaluate ASGE's work in adapting to China's national conditions; pointing out the strengths and weaknesses and proposing improvements. The study results indicate that the rating systems of ASGE are in line with China's national conditions, and that some non-technical indicators are forward-looking, but that there is still room for improvement in terms of implementation paths, weight assignment, number of indicators, and index system. Based on these explorations, this study provides suggestions for aspects of principles and methods that could be used for the construction of similar standards in developing countries.

1. Introduction

Following two centuries of unprecedented and rapid urbanization, nearly 55% of the world's population lives in urban areas (United Nations, 2018). This trend is expected to continue: the number of city-dwellers will increase to 6 billion by 2045 (United Nations, 2014). As large and high-density human settlements, cities consume close to two-thirds of the world's energy and produce more than 70% of global greenhouse gas emissions (World Bank, 2019). Urbanization has had profound consequences on the global environment (James et al., 2015). Since the *Brundtland Report* of 1987, more and more regions and countries are using sustainability as a basis for development; that is, seeking *socially inclusive and environmentally sustainable economic growth* (Sachs, 2015).

Standards that assess sustainability are the essential technical strategies for moving sustainable development from a concept to actual construction. The Sustainability Assessment Standard (SAS) is a tool that "evaluates the performance of a given building, community or city against a multi-layered indicator set, to specify how successful they are in achieving the sustainability goals" (Sharifi and Murayama, 2014). Initially, SASs appeared in developed countries and were developed for single buildings. The Building Research Establishment published the Building Research Establishment Environmental Assessment Method (BREEAM) (United Kingdom) in 1990 (BRE, 2014). Later, some developed countries released and continuously updated similar tools to improve building environmental performance (Retzlaff, 2008). However, cities are complex systems comprised of multiple sub-systems with

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https://doi.org/10.1016/j.jclepro.2019.119622
0959-6526/

dynamic structures, so a city's sustainability cannot be equated with the simple aggregation of green buildings. Over the past two decades SASs enlarged the assessment scale to cover communities and cities (Yildız et al., 2016), for improving, measuring and certifying the sustainability of large-scale development plans (BRE, 2018). Widely used examples include Comprehensive Assessment Systems for Building Environmental Efficiency (CASBEE) for Urban Development (Japan), Leadership in Energy and Environmental Design for Neighborhood Development (LEED-ND) (United States), and BREEAM Communities and HQE^{2}R (Europe), among others (Haapio, 2012). The LEED for Cities and LEED for Communities pilots—the latest-generations of the SASs—were released on December 2016 (USGBC, 2017).

Developing countries have not yet developed any internationally influential SASs, and their domestic standards are largely based on the existing rating systems in developed countries. The known city-level sustainability assessment standards in developing countries include the Green Building Index (GBI) for Township in 2011 (Malaysia), Indian Green Building Council (IGBC) for Green Township in 2010 (India), the Green Rating for Integrated Habitat Assessment (GRIHA) for Large Development in 2015 (India), and others (Kaur and Garg, 2019). The development of city-level SASs in developing countries is still in its infancy, with small numbers and limited impact. However, 90% of global urban growth now takes place in developing regions, which would triple their built-up urban areas between 2000 and 2030 (World Bank, 2014). Taking China as an example, its urbanization scale is unprecedented in human history (Seto, 2013). Between 1992 and 2015, urban land in China increased in size of nearly fivefold, almost 2.5 times as rapid as the global average (Xu et al., 2016). By 2014, 3,000 new urban districts above the county level were under construction or planned for development (Peng and Ou, 2016). China's urbanization has led to a significant resource crisis and environmental pressure. In 2015, 18 of the world's 20 most polluted cities were located in China (Lozano-Gracia and Soppelsa, 2019). In today's global integration, such a large-scale development will have a non-negligible impact on the global environment and economy. Therefore, as the tools for monitoring, evaluating, and guiding urban development, city-level SASs in developing countries should receive more attention.

China, the world's largest developing country, launched the Assessment Standard for Green Eco-district (ASGE) to address the challenges of rapid urbanization in April 2018. As the first national assessment standard for eco-districts, ASGE will inevitably have a considerable impact on the construction of Chinese cities that have always been dominated by the government. In this study, four city-level sustainability assessment standards, from both China and the United States, were selected for comparative research. These standards are ASGE (China), LEED-ND (United States), LEED for Cities (United States), and LEED for Communities (United States). They can be seen as representatives of similar tools in developing and developed countries. LEED certifications are recognized and followed worldwide for their sophisticated and comprehensive rating systems. China has become the most significant market outside the United States for LEED certifications (Stanley, 2019). As of the end of 2018, China's LEED-ND-certified projects exceeded those in Canada, accounting for 40.35% of LEED-ND overseas certifications (Fig. 1). The LEED rating systems are also an important reference for the building of ASGE (MOHURD, 2018) and still occupy a high market share in China. LEED standards and ASGE will continue to play a role in the sustainable development of China's urban areas. Such a relationship between national standards and advanced overseas standards in China is also typical in other developing countries.

The main purpose of this study was to conduct comprehensive evaluation of Chinese standards and draw successful experience of eco-district development. By comparing ASGE with the advanced standards it draws from, we sought to point out ASGE's work in adapting to China's national conditions and evaluate this part of work. We hope such a comparison can illustrate the priorities for developing countries and developed countries on the construction of their green communities and cities. These explorations are not only positive for the improvement of ASGE, they also provide references and suggestions of aspects of principles and methods that can be used to construct similar standards in developing countries.

2. Literature review

2.1. Sustainability assessment standards in the literature

The literature in this research field can be divided into two categories. In the first category are the studies of the effectiveness of a single assessment standard. Nicola A. Szibbo assessed four North American neighborhoods to examine the role of livability and social sustainability in LEED-ND (Nicola, 2016). Miriam Aranoff examined LEED-ND's criteria for neighborhood pattern and design in a case study of the Duboce Triangle neighborhood in San Francisco (Clark et al., 2013). Robert B. Stevens and Barbara B. Brown analyzed the moderate-to-vigorous physical activity among students in LEED-ND communities and provided a reference for walkable community design (Stevens and Brown, 2011). There are limited existing literature on comprehensive eco-district development standards, even though abundant context can be found on this concept general introduction.

The second category consists of comparative studies of different SASs:

- A comparison of the rating systems: Braulio-Gonzalo et al. comprehensively reviewed the indicators of 13 tools, which were developed to assess urban sustainability, and proposed a new, locally adapted structure of indicators (Braulio-Gonzalo et al., 2015).
- A comparison of the certain points: Jungwon Yoon and Jiyoung Park did a comparative analysis of the material criteria embedded for sustainable urban design in BREEAM Communities, LEED-ND, and CASBEE-UD (Yoon and Park, 2015).
- Validating SAS performance with case studies: Sharifi and Murayama explored the uptake of sustainability criteria in certified projects by examining three cases that have been highly ranked under LEED-ND, BREEAM Communities, and CASBEE-UD (Sharifi and Murayama, 2014).

There are few studies of the city-level SASs of developing countries. The existing literature focuses on how to build rating systems that suit their national context. Yigitcanlar et al. developed a Neighborhood Sustainability Assessment tool and applied it to compare the sustainability levels of three residential types in Malaysia (Yigitcanlar et al., 2015). Harsimran and Garg compared the widely used SASs in developed countries with India's own IGBC Township and GRIHA-LD, to identify the gaps and to propose recommendations for improvements (Kaur and Garg, 2019).

Though some research has been done in the area of SASs at the city level, relatively few studies have evaluated sustainability assessment standards in developing countries. Also, relatively few comparative studies have explored the impetus for the development of criteria in different countries. Finally, relatively few studies have analyzed the strategies and implementation paths of sustainability in different countries mapped by these standards. In an attempt to fill this research gap, this study looked at the standards, including ASGE, LEED-ND, and LEED-Cities/Communities, to expand the comparative study.

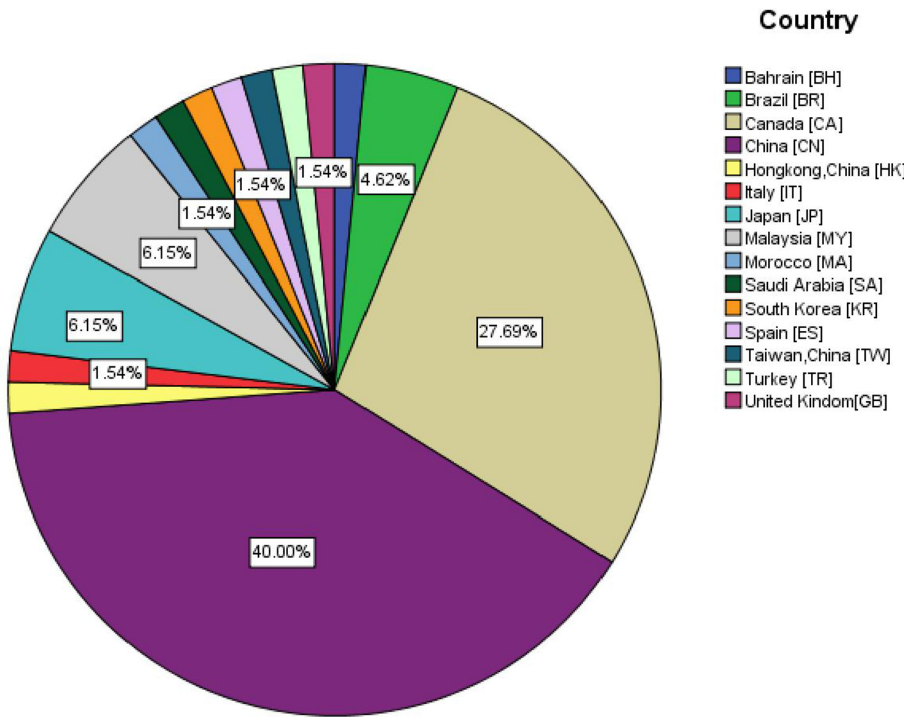


Fig. 1. Distribution of LEED-ND overseas certificated projects as of December 2018 (based on data from the Public LEED Project Directory [USGBC, 2019]).

2.2. Goals of this study

The primary purposes of this study were to review the four standards identified above and to apply lessons learned from LEED's mature rating systems to ASGE, exploring the advantages and disadvantages of the ASGE and proposing suggestions for improving it. Specific objectives were to:

- evaluate the progress made in the city-level SASs in both China and the United States.
- compare core issues caused by urbanization and the strategies for sustainability in China and the United States.
- identify the differences, commonalities, strengths, and weaknesses of these standards through their cross-comparison.
- discuss solutions to the problems and challenges, including refinements needed to enhance the efficiency of ASGE.
- provide recommendations for building and improving city-level SASs in developing countries.

2.3. Analysis framework

The analysis framework for this study followed the same steps and content as that used to build an assessment standard itself. That is, to analyze the background, applicable project scales and types, rating and certification levels, index system, and weights assignment. First, the framework includes the main aspects of an assessment standard. Second, each part of the research formulates the basis for the next part study. In sequence, this exploration included: the purposes of these standards, the validity of the index systems, and the sustainable urban development strategies and implementation paths in China and the United States. The specific focuses of this study are on how these index systems fit within the idea of sustainable development, how they address the challenges of current urban development, and the resulting difference and emphasis. This study uses comparative research and content analysis with a combination of qualitative and quantitative methods. The paper is based on the review of a large number of previous studies and contrasting the new Chinese standard with existing studies. Frequency statistics and cluster analysis are used to quantify the sustainability coverage, connotation, concerns, and deficiencies of the rating systems used in these assessment tools. Data used for statistical analysis in the text is mainly derived from the standards and guides of the selected rating tools, as well as the certified projects' score tables published on the U.S. Green Building Council website (USGBC.org).

3. Descriptions of the selected standards

3.1. Assessment Standard for Green Eco-district

The Ministry of Housing and Urban-Rural Development of the People's Republic of China prepared and launched the ASGE in April 2018. Several scientific research institutions directly under the State of China participated in the development of this standard. The team included design companies, urban planning agencies, research institutions, universities, and energy foundations (MOHURD, 2018). ASGE is of great significance because, for the first time, it defines the eco-district in China through detailed qualitative and quantitative strategies systems (see Table 1 for more details).

LEED for Neighborhood Development LEED-ND is the first LEED rating system to focus beyond the building level and evaluate multi-building projects or whole neighborhoods (NRDC, 2011). It contains a set of measurable criteria such as preferred location, walkable street, socio-economics, and green infrastructure to evaluate the sustainability of neighborhoods (NRDC, 2011). This standards is a collaboration between the USGBC, the Congress for the New Urbanism, and the Natural Resources Defense Council (Katz, 2011), launched in May 2009 after four years of development

Table 1
Overview of the selected sustainability assessment standards (MOHURD, 2018; USGBC, 2018; USGBC, 2016).

	Assessment Standard for Green Eco-district (China)	LEED-ND	LEED for Cities/Communities
Developer	Ministry of Housing and Urban-Rural Development of the People's Republic of China	U.S. Green Building Council; Congress for the New Urbanism; Natural Resources Defense Council;	U.S. Green Building Council
Date of launch	Pilot Version: April, 2018	May 2009	Pilot Version: December, 2016
Examined version	Pilot Version, 2018	V4, 2018	Pilot Version, 2016
Categories	Major categories: 1 Land Utilization 2 Ecological Environment 3 Green Building 4 Resource and Carbon 5 Green Transportation 6 Informatization Management 7 Industry and Economy 8 Humanity Additional Categories: 1 Technical Innovation	Major categories: 1 Smart location and Linkage 2 Neighborhood Pattern & Design 3 Green Infrastructure & Buildings Additional Categories: 1 Innovation and Design Process 2 Regional Priority Credits	1 Energy 2 Water 3 Waste 4 Transportation 5 Human Experience: Education Equitability Prosperity Health & Safety

and pilot testing.

3.2. LEED for cities and LEED for communities pilot

LEED for Cities and LEED for Communities pilot are two new certification programs issued by the USGBC. Actually, these two standards have the same data-driven rating system that uses metrics to measure the sustainability of cities and communities and to monitor progress and track improvements (Pearson, 2017). By focusing on integrated performance, cities and communities are able to revolutionize the way their buildings, communities and cities are planned, developed and operated; improve the quality of life of their citizens; open the door for new business and new residents; and stimulate a robust, green economy.

4. Rating systems comparison

4.1. Background of the construction of selected standards

The sustainability assessment standards were developed by using weighted and hierarchical index systems that respond to current urban development issues. Therefore, knowledge of how the standards are constructed is the basis for understanding and evaluating the index system of a rating system, and the fit between the two is essential evidence for measuring the effectiveness of an assessment standard.

Table 2 lists the major urban development issues in China and the United States. The impetus for the construction of the standards in China and the United States has similarities and differences. Urbanization inevitably brought about urban expansion, which led to the reduction of cultivated land, animal habitats, and environmental quality, but the resource and energy crises facing in China are more urgent and severe than in the United States. The contradiction between China's economic development and environmental protection, as well as the imbalance between urban and rural development, are the core problems that plague China's current urban development (Yusuf and Saich, 2008). To solve these issues, in 2014, as a national strategy, the Chinese government issued the New-type of Urbanization Plan (2014–2020) (Griffiths and Schiavone, 2016). The plan put forward six aspects of urban district development in a green city, which became the construction basis for the ASGE index system (MOHURD, 2018).

In contrast, the urbanization rate of the United States reached 80% in the 1990s (USCB, 2010); urban-rural integration has already been realized. Due to the high prosperity of automobile manufacturing, the typical low-density urban sprawl appeared in the 1920s (Barrington-Leigh and Millard-Ballb, 2015). People's lives and work are built on a highly developed private car transportation network. The cities are dissected by highways, the vitality of the city centers are reduced, and the original community structures have disintegrated. Also, spatial separation caused by ethnicity and social class differences has led to negative social and economic consequences. To face these critical issues and challenges in urban development, LEED-ND puts focus on neighborhoods which are the fundamental units of urban renewal, and integrates the principles of new urbanism, smart growth, and green building into a national system (Welch, 2011).

LEED for Cities/Communities is an improvement of the LEED certifications to address current development of the times. LEED for Cities/Communities provides a globally consistent method and standard for assessing continuous performance and progress toward a more sustainable human civilization. It measures progress with validated—and actionable—data. By drawing connections to and between data points, connections that ensure that the sustainability journeys of cities are designed to result in smarter, more transparent, more resilient, and more socially just outcomes.

The background is the basis for the intent and principles of establishing an indicator system of SASs (Fig. 2).

4.2. Types and scales of applicable projects

ASGE and LEED-ND are available for both planned projects and built projects. The initial pilot LEED for Cities/Communities can only be used in built environments. ASGE focuses on urban districts, especially new districts which can be immediately adjacent to the existing urban areas. According to the ASGE, the new districts that apply for certifications must be within the planning scope of the original city. That is, the city's overall planning and detailed planning must contain the new urban area. Projects applying for LEED-ND certifications may be at any stage of the development process, from conceptual plan through construction. LEED-ND can be applied to both urban and rural neighborhoods. LEED for Cities and LEED for Communities are available to broader applicable project types, including cities, districts, communities, townships, and counties (Long, 2018).

There are no clear and strict spatial scales specified for applicable projects in these standards, but some explanations or recommendations can be obtained from the regulations, guides, and handbooks of the standards (Table 3). LEED certifications show more flexibility than ASGE in scales and types of applicable projects. The scales of the applicants and certified projects of LEED for Cities and LEED for Communities range from a few square

Table 2
Issues caused by urbanization in China and the United States.

	China	United States
Similarity issues	Resource, energy and environmental issues caused by urban expansion: Agricultural land loss, and low land use efficiency. Increased energy consumption. Water and air pollution. Reduced wetlands and animal habitats. Reduced animal diversity.	
Different issues (characteristic)	I Rapid and large-scale process of urban expansion with low land use efficiency: Between 1992 and 2015, with urban land increasing from 1.22 × 104 km^2 to 7.29 × 104 km^2 (Xu, 2016).	I Urban sprawl: Patterns of low-density development outward from the city, transforming rural—green field—land into new suburban areas (Batty et al., 2003).
	II The number and scale of new districts are enormous: There were about 25 new urban districts which area was exceeding 1,000 km^2 (Xu, 2016).	II Highly automobile-dependent, led to the decline of public transport represented by trains (Newman and Kenworthy, 2006).
	III Uneven development of urban and rural (Wu, 2007).	III Downtown decline: Between 1950 and 1980, the data pointed to declining central-city populations and expanding suburban ones in nearly every American metropolitan area (Polèse, 2014).
	IV High building volume ratio; superblocks and gated communities (Ryan and Vale, 2016).	IV Low-density, single-use communities; the disintegration of the original community structure.
	V Resource crisis is extremely prominent, much higher than in the developed countries: Massive cropland loss, with mean annual reductions of 2,000 km^2 between 2000 and 2010 (Kong, 2014). China contains almost 20% of the world's population, only 7% of the world's fresh water (Shemie and Vigerstol, 2018).	V Multi-ethnic, class division lead to urban spatial segregation (Greenstein et al., 2000): Uneven spatial distribution of public service facilities caused by segregation resulting in poor inner-city populations. Social cohesion loss and the increased crime rate.
	VI Serious environmental pollution, the crisis is much higher than developed countries: 73% of the watersheds that supply water to China's 30 fast-growing cities face medium to high pollution levels. Serious air pollution events contribute to 1.6 million deaths per year (Rohde and Muller, 2015)	VI Cities are cut by the highway networks: Neighborhoods and cities torn down or isolated by huge interchanges and wide ribbons of asphalt. Stromberg (2016).
	VII Energy consumption and carbon emissions are huge: China has topped the world in energy consumption (since 2010) and CO_2 emissions (since 2008) (Jiang, 2012).	

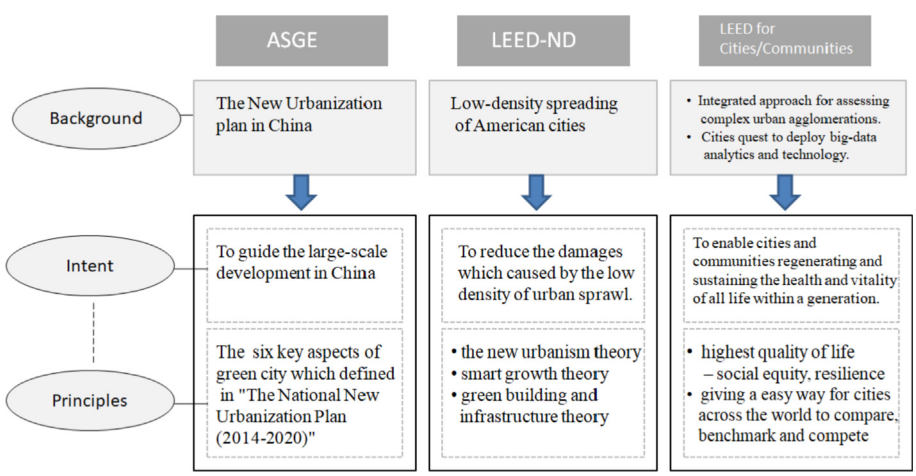


Fig. 2. Background, construction intent, and principles of the indicator system of the selected standards (MOHURD, 2018; USGBC, 2011; USGBC, 2016).

kilometers to several hundred square kilometers (km^2). Among the certificated projects of LEED-ND, the smallest one is 0.0015 km^2 (0.37 acres), and the largest one is 4.65 km^2 (1,140 acres) (USGBC, 2019)—a nearly 3,100 times area difference. The flexibility reflects the market-driven feature of the LEED-certifications. In contrast, ASGE's applicable projects are of a single type with a similar scale. ASGE is more like one of the government's supervisory and management tools in urban district construction.

4.3. Rating and certification levels

ASGE and LEED-ND are similar, offering traditional strategy-based green building rating systems that prescribe particular techniques for achieving specific outcomes. In contrast, the LEED for Cities/Communities pilot defines a set of specific metrics to evaluate a community's performance, but they do not dictate what a community or city should do to improve performance.

ASGE and LEED-ND programs adopt the pattern made by the major categories and additional categories (first-level indicators, shown in Table 4). Each major category contains a combination of required prerequisites and optional credits (second-level indicators) to evaluate projects based on a 100-point base scale with 10 particular points focusing on innovation and regional priorities. The prerequisites are the preconditions for the accredited projects to be certified—the threshold conditions. Projects seeking certification must meet all prerequisites and earn the minimum points

Table 3
Types and scales of the selected standards.

	ASGE [a]	LEED-ND [b]	LEED for Cities/Communities (Pilot)[b]
Types			
Classified by construction stages	The projects at the Planning stages; The projects at the Operation management stages.	Plan; Built Projects.	Existing communities (from individual neighborhoods up to entire cities)
Classified by Users (owners)	Government	For-profit and non-profit Organization; Corporate: privately held; Government; Community development corporations; Individual; Investor: investment manager; University (public & private)	Government; Public-private partnership Non-profit organization Corporate: privately held Business Improvement District.
Classified by Locations	New districts developments (mainly including Economic and Technological Development Zone); Old districts renovations.	Urban infill; Suburban retrofit; Small communities; Brownfield redevelopment; Greenfield development adjacent to existing urban development; Transit oriented development (USGBC, 2011)	City development. Communities' development (including industrial zones, business districts, airport areas, educational center, special investment regions, and etc.)
Classified by region	Urban area: District	Urban area & Rural area: Neighborhood; District; Communities; Villages.	Urban area & Rural area: Entire city; District; County; Township.
Scales			USGBC (2016)
Regulations	No-limit	No-limit smaller than 6.1 km^2 (1,500 acres) and larger than one building (USGBC, 2014)	No limit
Cases	1 m^2 is the fundamental evaluation unit for applications Pilot testing cases: Shanghai Hongqiao Central Business District: 86 km^2 Suzhou Taihu New District: 180 km^2 Guangdong Yunfu New District: 535 km^2 Ningbo Hangzhou Bay New District: 353 km^2 Beijing Future Technology City: 10 km^2	Solea Condominiums (U.S.): 0.0015 km^2 (0.37 acres)[c]; South Chicago LEED ND initiative (U.S.): 4.65 km^2 (1,140 acres)[c] South Lake Union Urban Center (U.S.): 1.38 km^2 (340 acres)[c]; Cornfields/Arroyo Seco Specific Plan (U.S.): 2.67 km^2 (660 acres)[c]; Beijing Olympic Village (China): 0.65 km^2 (160 acres)[c]	San Jose (U.S.): 467 km^2 (180.5 sq. mi)[c] Pueblo County (U.S.): 6211 km^2 (2,398 sq. mi)[c]; Songdo International Business District (Korea): 6 km^2 (1,500 acres)[c]; Beijing Daxing International Airport Area (China): 52 km^2 (2,398 sq. mi)[c]; Newark, NJ (U.S.): 67.6 km^2 (26 sq. mi)[c] Abington Township (U.S., PA): 40.1 km^2 (15.5 sq. mi)[c]

Notes.
[a] Information in each row of ASGE is from *The Guide of Assessment Standard for Green Eco-district* (MOHURD, 2018).
[b] In addition to the listed references, LEED-ND and LEED information for each column of the city/community comes from the Public LEED Project Directory downloaded from the LEED website (USGBC, 2019).
[c] Raw data for imperial data from the Public LEED Project Directory (USGBC, 2019).

Table 4
Rating and certification levels (MOHURD, 2018; USGBC, 2014; USGBC, 2016).

Program	ASGE	LEED-ND	LEED for Cities/Communities
Requirements	Achieve a minimum 50 points out of 110 possible (points based on 103 metrics)	Achieve a minimum 40 points out of 110 possible (points based on 47 metrics)	Achieve a minimum 40 points out of 100 possible (including 10 base points) (points based on 14 metrics)
Categories	8 + 1*[a]	3 + 2* [a]	5
Prerequisite items	23	12	6 (PreCertification becomes prerequisite for certification)
Credit items	90 + 13* [a]	41 + 6* [a]	14
Certification level s	1 One-Star: 50–64 points 2 Two-Star: 65–79 points 3 Three-Star: 80 points or more	1 Certification level: 40–49 points 2 Silver level: 50–59 points 3 Gold level: 60–79 points 4 Platinum level: 80 points or more	1 Certification level: 40–49 points 2 Silver level: 50–59 points 3 Gold level: 60–79 points 4 Platinum level: 80 points or more
Evaluation method	Professional	Professional	Third-party Professional Reviewers

Notes.
[a] * indicates the numbers of additional categories or additional credit items.

required by the standards. The total marks for different thresholds correspond to different certification levels.

The LEED for Cities and LEED for Communities programs offer PreCertification (it becomes a prerequisite for certification), and the certification levels and the corresponding total score requirements are the same as all LEED rating systems. To become certified, a building must meet all of the LEED v4 for existing buildings prerequisites (GBC, 2017). The most significant difference in LEED for Cities' evaluation method compared to the other two standards is the use of the Arc platform—a robust data collection and analysis tool allowing a community/city to try different strategies and measure the effectiveness of each (USGBC, 2016). Performance of cities/communities is continuously tracked through Arc that links all sustainability progress in one place and generates a Performance Score (0–100) (Long, 2018).

The Green Business Certification Inc. (GBCI) created Arc at the end of 2016, synchronizing with the release of LEED for Cities/Communities (GBC, 2017). Although ARC serves as the platform to earn the LEED certifications for existing projects from buildings to cities, only the LEED for Cities/Communities pilot adopts the same rating system as ARC's (i.e., its rating system is identical to ARC's). This makes the LEED for Cities/Communities pilot the first LEED certification to incorporate performance-based and data-driven standards. This valuable standard deserves attention and discussion.

4.4. Sustainability coverage

The index system of multilayered indicators is the core of an assessment standard, as it is directly related to the rating system's validity. The validity represents whether the indicators are representative, typical, and comprehensive, and to what extent it achieves the purpose of building a rating system. The 2005 World Summit on Social Development identified sustainable development goals that include three dimensions: economic development, social development, and environmental protection (UNGA, 2005). The three dimensions have served a common base for the sustainability assessment standards (Manning et al., 2011). This research explored two aspects on the validity of rating system: (1) how the indicators fit with the connotation of sustainable development, and (2) whether the indicators respond to urban development issues effectively.

First, we explored the distribution of second-level indicators of selected standards in the three dimensions of sustainability. The connotation of the environmental sustainability, social sustainability, and economic sustainability is the basis for the classification of indicators. The indicator division also follows the following principles: (a) only credit items are classified. Credit items form the main body of index system, and Prerequisite items, as the necessary condition of authentication, are largely duplicated with the Credit items to a great extent. (b) The division is made strictly according to the indicator intention mentioned in the standard guidelines. It provides a feasible comparative basis and the clear principle of classification for different countries and different classification naming methods. For example, in LEED for Cities/Communities, there are two metrics in the Human Experience category—the *Gini coefficient* and the *Median Gross Rent as% of Household Income*—-which can be classified as economical as well as social indicators, but the standard makes clear that they are to measure social equality. Thus, the two indicators are ranked as social ones. (3) An indicator can be distributed across one to three dimensions. For example, in LEED-ND, *Preferred Location* can be counted toward three aspects at the same time: society, economy, and environment. (4) The expert group revised the classification. Members included energy experts, policy experts, government administrators, city planners, and architects. The result is shown in Table 5.

Indicators of each standard have similar distribution in three dimensions of sustainability (Fig. 3). The distribution of indicators is not balanced. One-half to three-quarters of the indicators are related to environmental sustainability. One-fifth to one-third of the indicators involve social sustainability, but fewer indicators are concerned with economic sustainability (less than 10% in ASGE and LEED-ND). Environmental sustainability is still the aspect with which similar standards are most concerned. Most of the indicators still point to resolve the contradiction between urban construction and nature, energy, and resources.

4.5. Commonalities and focus

To seek the differences, commonalities, and focuses of the selected standards in environmental sustainability, social sustainability, and economic sustainability, we subdivided the three

Table 5
Sustainability coverage in the index systems.

	Environmental Sustainability[a]		Economic Sustainability[b]		Social Sustainability[c]	
	F	P	F	P	F	P
ASGE						
1 Land Utilization	8	8.6%	1	1.1%	4	4.3%
2 Ecological Environment	12	12.9%	0	0.0%	0	0.0%
3 Green Building	8	8.6%	0	0.0%	0	0.0%
4 Resource and Carbon	14	15.1%	0	0.0%	0	0.0%
5 Green Transportation	10	10.8%	0	0.0%	2	2.2%
6 Informatization Management	8	8.6%	0	0.0%	3	3.2%
7 Industry and Economy	4	4.3%	4	4.3%	0	0.0%
8 Humanity	4	4.3%	0	0.0%	11	11.8%
In total	68	73.1%	5	5.4%	20	21.5%
LEED-ND						
1 Smart location and Linkage	7	13.7%	2	3.9%	3	5.9%
2 Neighborhood Pattern and Design	7	13.7%	2	3.9%	11	21.5%
3 Green Infrastructure and Building	17	33.3%	1	2.0%	1	2.0%
In total	31	60.8%	5	9.8%	15	29.4%
LEED for Cities/Communities						
1 Energy	1	7.1%	0	0%	0	0%
2 Water	1	7.1%	0	0%	0	0%
3 Waste	2	14.3%	0	0%	0	0%
4 Transportation	1	7.1%	0	0%	0	0%
5 Human Experience	2	14.3%	2	14.3%	5	35.7%
In total	7	50%	2	14.3%	5	35.7%

Notes.
[a] Indicators related to energy, water, materials, land-use, air, ecosystem, biodiversity. resources conservation, waste, etc. (Sharif and Murayama, 2013 Turcu, 2012; Berardi, 2013).
[b] Indicators related to business, local jobs and economy, employment, finance, investment, industry, housing affordability, etc. (Sharifi and Murayama, 2014; Turcu, 2012; Berardi, 2013).
[c] Indicators related to inclusive communities, safety, community well-being; community outreach; heritage; education; residents health and life convenience, etc. (Sharifi and Murayama, 2014; Turcu, 2012; Berardi, 2013).

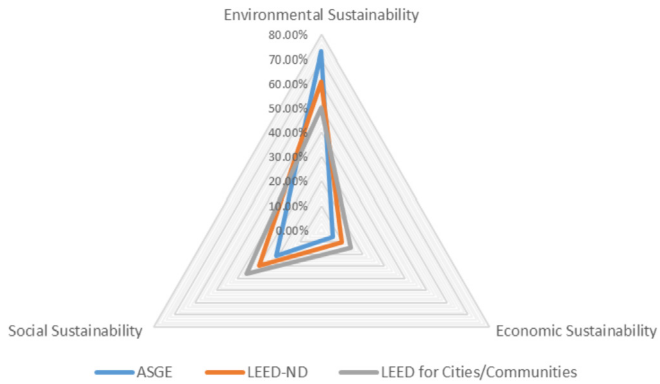


Fig. 3. Distribution of Credit Items (second-level indicators) of the selected standards in three pillars of sustainability.

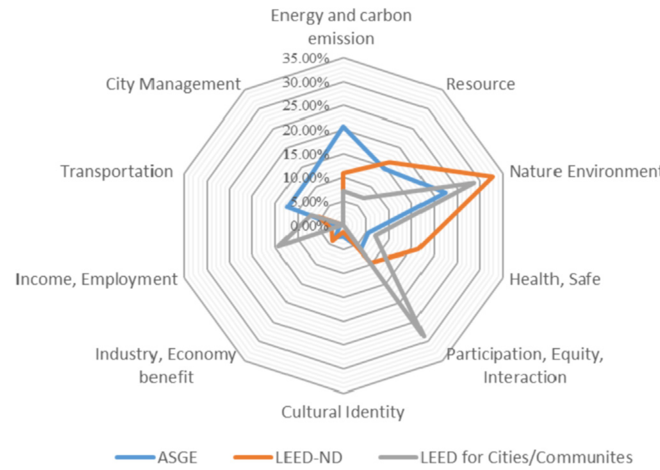


Fig. 4. Distribution of credit items in the subdivided categories of selected standards.

dimensions of sustainability and then explored the distribution characteristic of selected standards' credit items in the new categories (Table 6). The principles for the division of the indicators are as same as they were in Section 4.4.

Environmental sustainability can be divided into Energy and Carbon Emissions, Resources, and Natural Environment. Social sustainability is ranked according to human need from low to high, and can be reflected in Health & Safety (involving basic requirements for human survival, such as public health, personal and property safety, etc.), Participation, Interaction & Equity (involving the need for respect, educational opportunities, and participation—the basis for forming a community structure), and Cultural Identity (involving community identity, inheritance of non-material and material heritage, etc.—related to the formation and continuation of urban and community cultural characteristics). Economic sustainability, for individuals, is reflected in Income & Employment (involving income and employment opportunities, etc.). For cities, economic sustainability is reflected in Industry & Economic Benefit (involving industrial structure optimization, industrial chain, and job-housing balance, etc.). Transportation efficiency and urban supervision ability were separated from the three dimensions of economy, environment, and society to check how much the selected standards attach importance to City Management (Table 6).

As Fig. 4 shows, all of the selected assessment standards give priority to the natural environment; however, they have different focuses on environmental, economic, and social dimensions. ASGE emphasizes the importance of regulation and macro-control for sustainable development, while LEED certification is more focused on promoting community or city renewal from a bottom-up approach. For example, regarding economic sustainability, ASGE highlights macro-industrial restructuring, while LEED certifications measure income, employment, and community economy.

To be specific, ASGE has the largest proportion of energy and carbon emissions-related indicators. Indicators aimed at improving energy use, resource conservation, and environmental protection fall into almost all categories, including Industry, Economy, and Humanity. Also, ASGE pays more attention to city management capabilities and traffic efficiency, such as: improving the public transportation system and building transportation hubs; using information technology to monitor urban environmental quality, water resources, etc. in real-time; and emphasizing the use of effective regulatory measures to ensure the construction of green buildings and development of eco-cities. In terms of social sustainability, ASGE proposes a green lifestyle and educates the public about energy conservation. To avoid further loss of urban characteristics in large-scale city development, an indicator, City Style, is added by ASGE. Regarding economy sustainability, ASGE has proposed to optimize the industrial structure, develop high-tech and new-type industries, and plan a circular economic chain of industrial parks.

The index system of LEED-ND is outstanding in the areas of the natural environment, public health, community participation, community vitality, and social equality. Regarding environmental sustainability, many indicators (e.g., Preferred Location, Access to Quality Transit, Mixed-use Neighborhoods) point to the containment of urban sprawl and the reduction of automobile dependence to prevent development pressure beyond the limits of existing development, reduce greenhouse gas emissions, protect farmland and habitat, and more. One of the apparent features of LEED-ND is

Table 6
Distribution of credit items in the subdivided categories.

	ASGE		LEED-ND		LEED for Cities/ Communities	
	F	P	F	P	F	P
Energy and Carbon Emissions	27	20.7%	8	11.0%	1	7.1%
Resource	19	14.6%	12	16.4%	1	7.1%
Nature Environment	29	22.3%	24	32.9%	4	28.6%
Health, Safety	7	5.4%	12	16.4%	1	7.1%
Participation, Interaction	8	6.2%	7	9.6%	4	28.6%
Cultural Identity	3	2.3%	1	1.4%	0	0.0%
Industry, Economy benefit	4	3.1%	3	4.1%	0	0.0%
Income, Employment	1	0.8%	2	2.7%	2	14.3%
Transportation	16	12.3%	4	5.5%	1	7.1%
City Management	16	12.3%	0	0%	0	0%*

the use of social sustainability as an essential basis for planning or renewing neighborhoods. This is demonstrated in multiple indicators (e.g., Walkable Street, Compact Development, and Housing Types and Affordability) repeatedly public health, community participation, and social equity. Unique indicators, such as Local Food Production, are added to increase community identity, reflecting that LEED-ND considers neighborhoods to be the basic units for urban renewal and urban problem-solving.

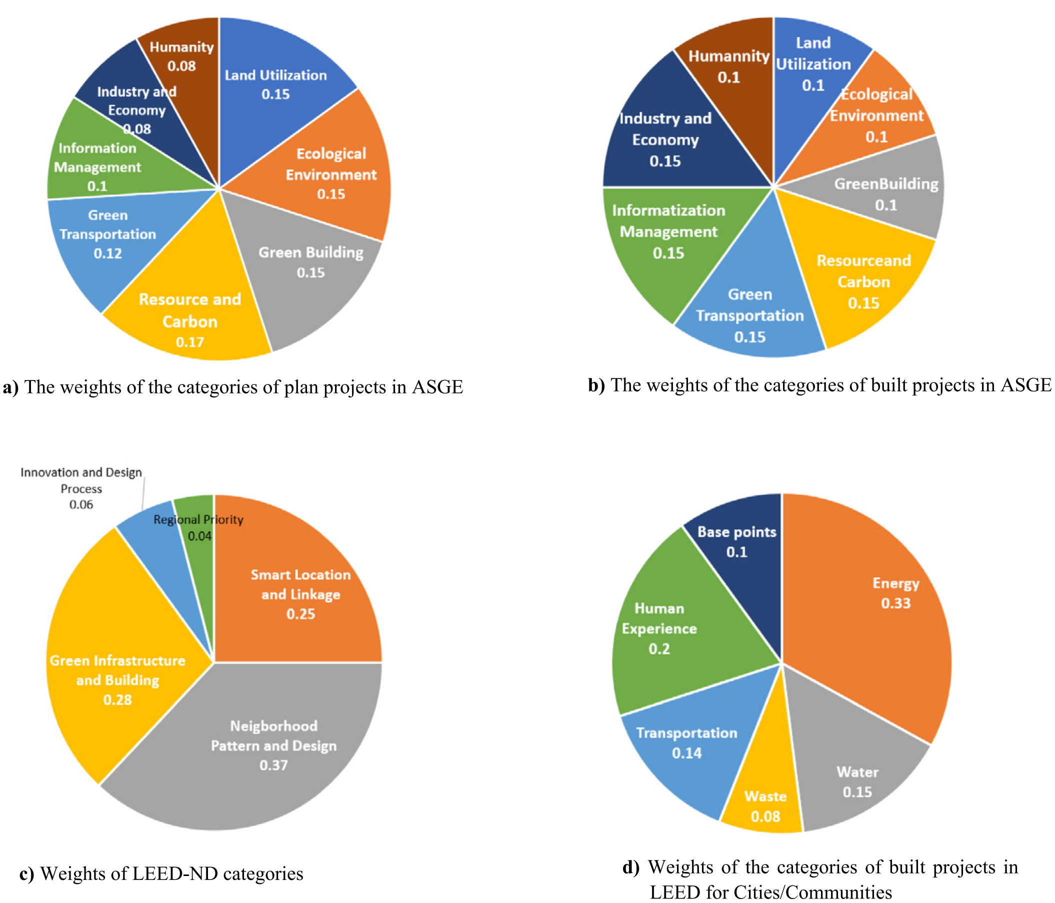
LEED for Cities/Communities embodies people-oriented features that underline *human experience,* including education, equitability, income and employment, and health and safety. Indicators have the characteristics of internationalization, generality, and representativeness. For example, air quality, water consumption, vehicle miles traveled in individual vehicles, and waste generation and recycling that are related to the essential survival environment of human beings are set to measure environmental sustainability. Median Household Income and Unemployment Rate are utilized to assess the urban economic development level; whereas, Base Score and PreCertification offer the opportunity for cities and communities to get credit for their ongoing efforts in developing robust plans and practices. Therefore, this standard can evaluate the city/community performance of both developed and developing countries from a unified platform.

The setting of the index system is similar to the problem-solving process; that is, how to solve urban issues to achieve sustainability. The indicators of the selected standards basically respond to the corresponding issues in Section 4.1, reflecting their construction background.

4.6. Targets: indicators weights assignment

The index weight indicates the relative importance of the index in the rating system. In this study, the weight reflects the importance of the strategy or city performance examined in the standards toward achieving the sustainable development goals. According to the statistical principle, the sum of the weights of all indicators in a rating system is 1 (100%). The index weight expressed in decimals is called the *weight value* or *weight coefficient.* Correspondingly, the weights also form a hierarchical system due to the hierarchical structure of the index system. The weight value of the second-level indicator for the overall target is the product of the weight value of this indicator for the second-level objective multiplied by the weight coefficient of the first-level indicator to which it belongs. With this principle and method, we separately defined the weights of the categories (first-level indicators) and credit items (second-level indicators) in the selected standards' index systems for the overall targets. Fig. 5 shows the weights' coefficients of the selected standards' categories, which the ASGE gives directly in its guidance. LEED certifications calculated each category's weight factors by using the sum of the highest score available for the each credit item divided by the total credits.

We explored the weight distribution characteristics of the second-level indicators for the overall target with the cluster analysis to analyze the goals and focuses of the standards. The weights' allocation of LEED for Cities is not discussed in this section (three of the five first-level indexes in the standard do not have second-level indexes, so it is impossible to compare the weights of



a) The weights of the categories of plan projects in ASGE

b) The weights of the categories of built projects in ASGE

c) Weights of LEED-ND categories

d) Weights of the categories of built projects in LEED for Cities/Communities

Fig. 5. Weights of Categories in the selected standards (data based on the ASGE (MOHURD, 2018), LEED v4 ND scorecard (USGBC, 2014), and the guide of LEED for Cities/Communities [USGBC, 2016]).

Table 7
Clusters of the second-level indicators' (Credit Items') weights.

	Numbers F (P)	Cluster Center	Min.	Max.	Sum	SD
ASGE (Plan Projects)						
Cluster 1	1 (1.1%)	0.0300	0.0300	0.0300	0.0300	0.0000
Cluster 2	3 (3.3%)	0.0225	0.0225	0.0225	0.0675	0.0000
Cluster 3	44 (48.9%)	0.0142	0.0119	0.0180	0.6265	0.0017
Cluster4	42 (46.7%)	0.0066	0.0040	0.0102	0.2770	0.0018
ASGE (Built Projects)						
Cluster 1	1 (1.1%)	0.0300	0.0300	0.0300	0.0300	0.0000
Cluster 2	10 (11.1%)	0.0205	0.0180	0.0225	0.2045	0.0019
Cluster 3	41 (45.6%)	0.0122	0.0100	0.0150	0.4990	0.0024
Cluster4	38 (42.2%)	0.0068	0.0045	0.0090	0.2595	0.0014
LEED-ND (Plan & Built Projects)						
Cluster 1	2 (4.3%)	0.0864	0.0864	0.0909	0.1727	0.0064
Cluster 2	3 (6.4%)	0.0493	0.0545	0.0636	0.1817	0.0053
Cluster 3	6 (12.8%)	0.0367	0.0273	0.0455	0.2182	0.0081
Cluster 4	36 (76.6%)	0.0119	0.0091	0.0182	0.4277	0.0043

different levels). Through the K-means cluster analysis of IBM Statistical Product and Service Solutions (SPSS), the credit items of the other two standards can be divided into four ranks (from Cluster 1 to Cluster 4, the weights' values reduced in turn) (Table 7).

As shown in Fig. 6, the index weights of LEED-ND show a more obvious gradient distribution than that of ASGE. In LEED-ND and ASGE, the ratio of the index weights in Cluster 1 to Cluster 4 is 7.2 times and 4.5 times, respectively. 76.6% of the indexes in LEED-ND are concentrated in Cluster 4 with the smallest weights value (Table 7). Meanwhile, the weight of a single index in LEED-ND is significantly higher than that in ASGE.

The average up to the possible points of a single index in Cluster 1 reaches 23.75% of the lowest points for certification (Fig. 7), while the comparison data in ASGE are only 6%. In LEED certification, indexes are invisibly divided into main indexes and secondary indexes through the weight allocation. It is an effective way to earn certification: first, to win the points in the main indexes, and then to get the points in more secondary indexes based on the actual conditions.

Existing studies have shown that heavier weighted criteria are more appealing for developers to achieve (Komeily and Srinivasan, 2015; Garde, 2009). For example, according to different versions and samples, 96%–100% projects have earned points from the *Preferred Locations* (Komeily and Srinivasan, 2015). The average points of the certified projects in this indicator is 7.65–7.94 (of up to 10 possible points), which is close to one-fifth of the lowest minimum points for certification. As a low-weight indicator of comparison, such as *District Heating and Cooling*, the projects that received any points in this indicator only account for 5.56%–6.32% of the total. The average scores are only 0.06–0.11 (of up to 1 or 2 possible points), which slightly affects the overall certification. Through the biasedness setting, the LEED-ND incentive applications first implement the strategies and measures included in the high-weight indicators. Under the premise that the basic requirements are met, projects can seek a variety of ways to achieve certification. This approach not only strengthens the guiding role of the standard but also makes the standard more adaptable and flexible.

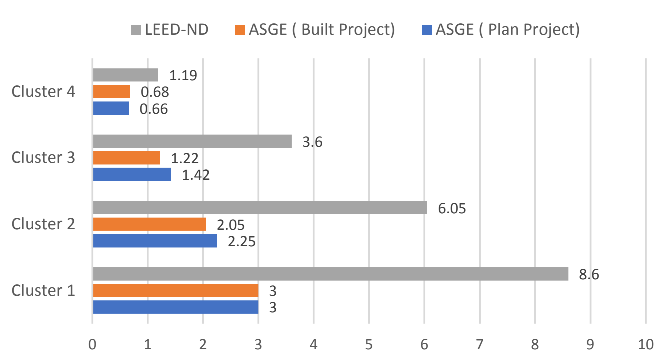


Fig. 6. The average up to the most possible points of a single indicator in different clusters.

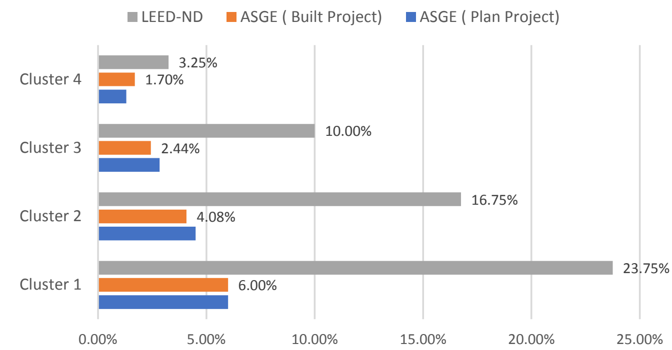


Fig. 7. The percentage of the average up to the most possible points of a single indicator in different clusters compared to the lowest points for certification.

Table 8 lists some specific information about the credit items in Cluster 1 and Cluster 2 of ASGE and LEED-ND. In addition to *industrial building technology*, ASGE's allocations of credit item weights in the two phases of planning and operations management are completely different. ASGE's secondary-level indicators are twice as many as LEED-ND, and cover almost all aspects related to urban development. However, due to the lack of a biased weights assignment, ASGE's orientation and focus are not as clear as that of LEED-ND.

5. Discussion

In this section, we will discuss some interesting points found in the above comparative studies. These points are crucial for the formation of the research conclusions. In particular, this knowledge is of value to identify the principles and methods for the construction or improvement of city-level SASs in developing countries.

5.1. Top-down and bottom-up implementation paths of sustainable development

As a means of guaranteeing and implementing sustainable development, the city-level SASs in China and the United States can reflect the different paths of sustainable development in the two countries. ASGE is a typical government-driven rating system. The scales of ASGE's applicable projects far exceed the capabilities of a private developer. The purpose of the ASGE is to provide standards and implementation strategies for urban construction to local government. Many second-level indicators in ASGE emphasize the importance of administrative supervision and management in ensuring the development of green buildings and eco-cities. During the urban and rural structural transition, facing the acute conflicts between economic growth and environmental protection (Cao et al., 2012), China cannot rely solely on the market to solve severe ecological, social, and economic problems. The spatial distribution of LEED-ND projects is uneven, with little to no activity in almost half the United States (Russell, 2015), which shows the limitation of a market-driven approach to some extent. China takes a top-down approach to achieve sustainable development, which

Table 8
The indicators of Cluster 1 and 2 in ASGE and LEED-ND.

	Indicator Number [a]	Indicator Name	Up to possible points (of 110 points)
ASGE (Plan Projects)			
Cluster 1	GB-4	Industrial construction technology	3
Cluster 2	LU -5	Access to public service facility	2.25
	GB -2	Two-star or more green building ratio	2.25
	GB-7	Implementation of the green buildings operation and management	2.25
ASGE (Built Projects)			
Cluster 1	IE-4	The tertiary industry, high-tech, and new-type industries account for the proportion of regional GDP	3
Cluster 2	GT-1	Green transportation system	2.25
	GB-4	Industrial construction technology	2.25
	GT-2	Public transportation system	1.8
	IM-1	Urban public safety system	2.1
	IM-2	Environmental monitoring system	2.1
	IM-3	Water Information Management	2.1
	IM-4	Road monitoring and traffic management	1.8
	IM-6	City sanitation information management	1.8
	IE-1	Energy consumption per unit of GDP is lower than the energy conservation assessment standard of the provinces and cities	2.25
	IE-2	Water consumption of the GDP of the unit area is lower than the water saving assessment standards of the provinces and cities where it is located	2.25
LEED-ND (plan and built projects)			
Cluster 1	SLL-1	Preferred Location	10
	NPD-1	Walkable Street	9
Cluster 2	SLL-3	Access to Quality Transit	7
	NPD-4	Housing Types and Affordability	7
	NPD-2	Compact Development	6

[a] In this column: GB: Green Building; LU: Land Utilization; IE: Industry and Economy; GT: Green Transportation; IM: Informatization Management; SLL: Smart Location and Linkage; NPD: Neighborhood Pattern and Design.

may maximizes implementation of sustainability assessment standards. For example, China has implemented the mandatory certification of the Green Building Energy Labeling for large public construction above the provincial capital (Qin, 2015).

The type and scale of the LEED program's applicable projects vary greatly, with high flexibility to enable stakeholders to pursue economic benefits and market acceptance. The LEED rating systems are the typical types of market-driven assessment standards developed by a non-government organization. The political system in the United States differs greatly from that in China. In addition, government administration and urban planning systems vary in each state (Knaap and Nedovic-Budic, 2013). The governments did not take the leading role in the development of assessment standards. Developers, communities, and local governments can benefit from the certification, which is the main reason the standards developed and worked effectively, as well as the reason why they are accepted globally (USGBC, 2015). These standards can attract and mobilize private capital for urban construction and present a constant vitality.

In contrast, China's government-driven standards are perhaps somewhat closed off from industry, which may be one reason for an initial slow uptake (Khanna et al., 2014). The path of sustainable urban development in the United States offers a bottom-up approach, with the diversified participants, including governments, civil institutions, and the public. Also, LEED-ND reflects the idea that neighborhoods are the basic units of urban renewal. All these promote urban sustainability in a bottom-up path that conforms to the law of self-organization development of the city as a complex system (Portugali, 2000).

5.2. Strategy-based and performance-based assessment standards

Based on the difference in rating methods, the selected assessment standards can be classified into two categories: strategy-based and performance-based.

ASGE and LEED-ND offer a series of objectives and strategies for the construction of communities and cities and guide urban development by encouraging projects to obtain points in indexes. Such strategy-based standards can provide city managers, planners, architects, and others with a basis for urban planning, design, development, and construction (Castanheira and Bragança, 2014). In contrast, LEED for Cities/Communities are performance-based standards that encourage communities to deploy strategies, policies, and means that are suitable for their particular conditions for sustainable development. A data-driven rating system can assess and trace the urban performance, and offers an objective basis for urban management decisions by collecting and comparing data. For example, the digital platform might connect to the Global Protocol for Cities or Clear Path (Pearson, 2017). A city with a large population will earn a higher energy score if it produces fewer emissions compared to other cities with a similar population (Pearson, 2017). The data are representative, typical, and easy to collect, so this standard applies to a wide range of projects and is not geographically restricted (Sparks, 2016).

Although performance-based standards with the digital platform have tremendous potential for growth, especially in assessing the actual performance of the built environment, we believe that the strategy-based and performance-based assessment tools have different functions and cannot be substituted for each other. LEED for Cities/Communities can provide the strategies for reference through the database, but achieving sustainable development still requires systematic specific strategies, methods, implementation steps, and quantitative evaluation criteria, which are more for developing countries.

5.3. Constructing an index: Background

The selected standards reflect the background of their construction to varying degrees. When establishing the city-level sustainability assessment standards, China first focused on the urban districts, especially the new districts, which are linked to China's large-scale urban development. China is still in the process of rapid urbanization, and new districts become its economic growth pole (Peng and Ou, 2016). Since China faces a deep and enduring energy and environmental crisis, ASGE has the largest number of indicators involving energy use and carbon emissions among the selected tools, and thus is suitable for China in current state development of eco-district. LEED-ND is primarily intended to address the typical urban sprawl in postwar urban development in the United States (Barrington-Leigh and Millard-Ballb, 2015). Its index system focuses on curbing low-density sprawl, reducing car dependence, and promoting green buildings. There are clear, logical relationships among its three main categories. In fact, LEED-ND is a United States-based evaluation tool (Sharifi and Murayama, 2014) that provides a systematic, targeted strategy for urban planning and development in the United States. LEED for Cities/Communities is inextricably linked to the continuous urban renewal, stainability and the development of data storage and analysis technology.

A strategy-based assessment tool is closely related to its construction background, and its validity depends on the response of its rating system to the main challenges in urban development. This study's findings raise the question: Is the overseas strategy-based SAS very suitable for China? LEED-ND established a process that identified six Regional Priority credits to address geographically specific environmental considerations (USGBC, 2014); however, this process would only increase the *availability* of the rating system. Chinese projects can be LEED-ND certified and improve energy and land-use efficiency through the certification process, but cannot make targeted improvements based on core issues in China's urban development. Therefore, we think that it is necessary and important for developing countries to establish their own strategy-based standards that address their individual national context.

5.4. Indicators weights: Standard orientation

In previous studies, more emphasis was placed on the comparison of individual indicator's weight. In this study, we explored the weight distribution characteristics of the second-level indicators of LEED-ND and ASGE. The allocation of weights will affect the guiding role of assessment standards in urban construction.

LEED-ND puts forward a good idea for the assignment of indicator weights: increase the guiding role of standards in urban construction by motivating projects to seek to earn points on high-weight indicators. The resultant strengths are: (a) it not only limits the certification scores, but in essence, guarantees the implementation of basic strategies or capital construction goals, and (b) it provides flexibility for the project development while meeting requirements. Besides scoring on the high-weight indicators as much as possible, applicants can flexibly select the indicators to increase their scores, according to different regions and project types.

Also, the indicator quantity deserves more discussion. The number of known city-level SASs is mainly between 30 and 50 (Kaur and Garg, 2019; Sharifi and Murayama, 2013). ASGE has 103 indicators, which significantly dilutes the weight of a single indicator, resulting in a lack of critical indexes. The effect of weight assignment and the number of indexes on the validity of the rating system is easily overlooked. Reasonable determination of the weight allocation, indicator quantity, and index system should be an integrated decision-making process.

6. Conclusion and recommendations

Throughout the history of SASs, it has been a process from a single building to the community to the city. The growth of the LEED family of certifications reproduces this process. From LEED-BD to LEED-ND to LEED-city, it reflects the continuous updating of human cognition and practice and data analysis and storage technologies. LEED-ND and city/community LEED provide ASGE with a reference in both spatial and temporal dimensions. Comparative research not only can help us examine the individual standards, but also trigger our thinking about the future direction of such tools. We summarized the conclusions and recommendations of our study from the following two aspects.

6.1. ASGE: Strengths and weakness

The ASGE system was born from the urgent need for sustainable development in China. The development of a Chinese standard was based on international experience and cutting-edge research results of similar rating systems. Its index system covers all aspects of sustainable urban development and responds to China's current urban development issues. ASGE fits into China's urban and rural planning system and can be used as a basis for urban control planning and detailed planning. Therefore, it has the possibility to guide the sustainable development of the city effectively. In addition to new technology strategies, it also emphasizes the importance of non-technical factors such as management and human behavior for energy saving and sustainable development. For example, the index system breaks through the traditional water-saving technology and treatment methods for wastewater and wastes; realizes the importance of non-hard technologies such as management and human behaviors on energy-saving and sustainable development; emphasizes information management methods of the future; and advocates for a green lifestyle and energy-saving education. These aspects all are forward-looking.

However, by comparative study, ASGE also presents some challenges: (a) the index system focuses on the macro-level of sustainable urban development, and does not consider residents' employment, education level, and social equity enough; (b) it pays attention to land utilization efficiency but ignores the problem of urban expansion encroaching on cultivated land and natural habitat; (c) indicator weights are homogeneous, and there are no key indicators that play a leading role; (d) too many indicators would make the assessment process complicated and increase weight homogenization, which may decrease the evaluation criteria's effectiveness.

6.2. Recommendations on sustainability assessment standards in developing countries

Based on the review of Chinese and U.S. eco-district/city rating standards, the following recommendations are drawn.

First, developing countries should pay more attention to the strategies-based standards encouraging measurable outcomes, and establish an index system that consciously responds to the nation's strategic targets and urban development issues. As developing countries are still at the urbanization stage, the risks to the environment far outweigh those of developed countries. Specific strategies, methods, and implementation steps—and formulation of quantized assessment standards—are required to realize sustainable city development. The strategy-based index system connected to performance should not concentrate on universality but respond effectively to the critical problems to be resolved in urban development within the limits of background factors.

Second, construct a set of well-established rating systems, which need systematic thinking from the perspective of national strategy and local individuals. This requires standards to include (a) both strategy-based and performance-based types of assessment standards. Urban development requires the guidance of strategies-based standards, but at the same time, outcome-oriented tools have the advantage of measuring the actual performance of existing communities or cities; (b) a set of rating systems referring to different urban levels, from an individual building up to the entire city. Mutual-based assessment standards can enhance their overall impact and guiding roles, and offer the possibility of simplifying the index system of a single standard to increase its validity.

Third, standards should attach importance to weight assignment, especially weights of the index system's second-level indicators. One example is to use the analytic hierarchy process (AHP) or a fuzzy analysis method (Ameen, 2018) to determine the indicators' weights according to the order of urgency of the urban crisis. It should be emphasized that the assignment of indicator weights is not a simple process of distinguishing the importance of indicators, but a consideration of the standard's overall target. It should set the critical indicators with high weights and make the distribution of indicators weights a gradient, to ensure the standard's essential construction goals and development strategies can be implemented.

Finally, implementation of standards should focus on a two-way sustainable development path: from top-down and bottom-up, and encourage the development and application of market-driven standards, while presenting national evaluation standards and keeping in mind the local priorities involved in the holistic, sustainable development of a people-centered city.

Acknowledgement

The U.S. authors recognize Lawrence Berkeley National Laboratory's support from the U.S. Department of Energy under Contract No. DE-AC02-05CH11231 and support from the Energy Foundation. This research is also supported by Chinese Academy of Sciences, K.C.Wong Education Foundation: GJTD-2018-05; Ministry of Science and Technology of the People's Republic of China, National Key R&D Program: 2018YFC0704800; National Natural Science Foundation of China, Project Number: 51741808; China Scholarship Council, Grant numbers: No. 20170628512.

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