Beijing City Lab

Zhang Y, Zhang J, 2015, A review of existing labels for evaluating sustainable cities. Beijing City Lab. Working paper #70

A comparative study of existing labels for evaluating sustainable cities

Zhang Yongping[1,2], Zhang Jingyuan[3]
1. Nijmegen School of Management, Radboud University Nijmegen, the Netherlands
2. School of Planning and Geography, Cardiff University, the UK
Email: zhangyongping2112@gmail.com
3. School of Design and Environment, National University of Singapore, Singapore
Email: xunklose@foxmail.com

Abstract: In this study, we presented a conceptual model of the city and explained how it could be sustainable, then comparatively evaluated three labels, namely BREEM Communities, LEED-ND and CASBEE City, based on our explanation. The three labels were compared from three aspects: dimension coverage, process coverage, and weighting and scoring. CASBEE City is concluded to be a relative better label to evaluate the sustainable performance for cities; this is reasonable since it's a city-level label, while other twos are actually neighborhood-level labels. In the next stage of our study, a new sustainability assessment label at the city level would be developed, aiming to build socioeconomic, input- and output-related indicators so as to evaluate urban sustainability more comprehensively.

Keywords: evaluation labels, urban sustainability, comparative study

1. Introduction

A city can be defined as a relatively large and permanent human settlement (Goodall, 1987; Kuper, 2013). Generally speaking, cities are complex systems, physically consisting of buildings, green space, and various public facilities (e.g., transport systems). Cities can be spatially divided into districts or neighbourhoods (Rohe, 2009), which are usually made up of buildings and surrounding open spaces, and several cities together aggregate to a comparatively larger region. Cities are incredibly vibrant springs of education, employment and commerce, social encounter and recreation, and nerve centres of modern global economy. More and more migrants are attracted by urban areas to seek a better quality of life; In Europe, approximately 75% of population is living in urban areas, and by 2020 this number will increase up to 80% (Uhel, 2006). On the other hand, because most of human activities take place in urban areas, cities also elicit the vast majority of social and economic problems, and have exerted enormous impacts on environment at local, regional and even global levels.

In general, presently sustainable development, which is frequently defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Burton, 1987), has become a consensus to guide social, economic, and environmental activities of human beings. Specifically, when it comes to the development of cities, a balance between social, economic, and environmental dimensions should be achieved in urban areas so as to develop harmoniously and efficiently, and limiting, as much as possible, negative impacts on the natural environment simultaneously. As the increased awareness of sustainable development, more and more cities have adopted sustainability as a future goal, and proposed various plans, regulations, and actions to improve current ways of development, and to support the achievement of sustainability in urban areas. Understanding the progress towards sustainability, and formulating calculation methods for quantitatively measuring the sustainable performance of urban development is necessary to pursuing this goal.

The initial focus of assessment labels that measures sustainable development was at the building level (Sharifi & Murayama, 2014). Since the introduction of the UK Building Research Establishment Environmental Assessment Method (BREEAM) in 1990, numerous labels have been developed for the building sector to assist decision making and improve the environmental performance of buildings and building stocks (Haapio, 2012). Among them, Leadership in Energy and Environmental Design (LEED), Comprehensive Assessment System for Building Environmental Efficiency (CASBEE), and also BREEAM have been used for more than two decades, and applied a multi-criteria approach to evaluate by considering different criteria like energy use, indoor air quality, thermal comfort, and various costs (Soebarto & Williamson, 2001). Although these labels can measure the sustainable performance of buildings, they more emphasize the environmental dimension and cannot reflect the whole level of an urban habitat as an integrated unit.

The general trend these days appears to be that assessment methods and tools are developed for a broader context and larger scale, after experiences were gained in assessing individual buildings (Cole, Brown, & McKay, 2010). A move towards the assessment of the intermediate level of neighborhood started in the second half of the last decade when CASBEE expanded its family of assessment labels to include CASBEE for Urban Development (CASBEE-UD) as a label for assessment at the neighborhood level (Sharifi & Murayama, 2014), followed by other labels such as LEED for Neighborhood Development (LEED-ND) and BREEAM Communities. These labels can only measure the sustainable performance at the community or neighborhood level, rather than reflecting city's performance. However, compared with building labels, neighborhood labels could have a better reference to develop labels at the city level.

When it comes to sustainable assessment labels at the city level, to the best of our knowledge, there are only two labels. The first one is European Energy Award (EEA), which specifically supports municipalities willing to contribute to sustainable energy policy and urban development through the rational use of energy and increased use of renewable energies. Over 1200 municipalities have been presented the EEA, and EEA has successfully established itself as the energy policy and climate protection label in Europe (Forum European Energy Award, 2014). However, this label assesses the sustainable performance of cities only considering energy aspect; this greatly limits its ability to evaluate sustainability comprehensively. The second one is CASBEE for Cities (hereinafter referred to as CASBEE City), which was first published in 2011, is a system for comprehensively evaluating the performance at the city level, using a triple bottom line approach of environment, society and economy. The further introduction and analysis about CASBEE City will be shown in section 3.

There are some studies to evaluate sustainable assessment labels from a comparative perspective. A previous study compared existing building environmental assessment tools, and concluded that the comparison of the tools and respective results was difficult, and there was a trend transforming the existing green building assessment tools into sustainable building assessment tools (Haapio & Viitaniemi, 2008). Nguyen and Altan (2011) compared five well-known rating systems, and claimed BREEAM and LEED both scored the highest with 75 points under their evaluation criteria. CASBEE, Green Star and HK-BEAM made up the lower group, but they were the upcoming ones that were trying to have more influence across the field (Nguyen & Altan, 2011). Wallhagen et al (2013) presented a framework for comparing building environmental assessments tools and tested it by comparing distinctly different tools (LEED-NC v3, Code for Sustainable Homes (CSH), and EcoEffect). Results showed that these tools measured “environmental” building differently and push “environmental” design in different directions (Wallhagen, Glaumann, Eriksson, & Westerberg, 2013). For comparing labels at the neighborhood or community level, Haapio (2012) analyzed three well-known tools: BREEAM Communities, CASBEE-UD and LEED-ND. As the conclusion shown, the interest towards certification systems is increasing amongst the authorities, especially amongst the global investors and property developers. Authorities, city planners, and designers would benefit most from the use of the tools during the decision making process. Among these three labels, criteria and indicators are sometimes interlinked; achieving one may contribute to achieving others. They strongly emphasized the characteristics of their state of the region, depending on corresponding national standards, regulations, building codes, cultural heritage, way of living, and building culture. Sharifi and Murayama (2013) reviewed seven neighborhood tools from Australia, Europe, Japan, and the United States using seven criteria: the issues of sustainability coverage, pre-requisites, local adaptability, scoring and weighting, participation, reporting, and applicability. Results showed that most of the tools were not doing well regarding the coverage of social, economic, and institutional aspects of sustainability; there were ambiguities and shortcomings in the weighting, scoring, and rating; in most cases, there was no mechanism for local adaptability and participation; and only those tools which were embedded within the broader planning framework were doing well with regard to applicability. This article provided an in-depth discussion about existing tools at the neighbourhood level (Sharifi & Murayama, 2013). Sharifi and Murayama (2014) examined three cases from the US, the UK, and Japan that have been highly ranked under LEED-ND, BREEAM Communities, and CASBEE-UD, respectively, to explore the uptake of sustainability criteria in projects certified under neighborhood sustainability assessment tools. This examination was done through investigating the compliance of each case with sustainability principles, followed by a comparison by evaluating each case using assessment tools other than the ones that have been used for certifying the selected developments. Main results showed that social, economic, and institutional aspects are not adequately accounted for bothin theory and practice, which are in consistent with the results indicated by Sharifi and Murayama (2013); practice of neighborhood sustainability assessment is market-driven and characterized by the dominance of the environmental aspects of sustainability to a large extent; and assessment tools can co-evolve through learning from their successes and failures. When it comes to city labels or tools, comparative study has yet been conducted. However, the results of comparative studies at the building and neighborhood levels could be provided as reference for evaluating city labels and the performance of urban sustainability.

From the literature review above, we found there are numerous labels or tools developed to evaluate building sector, but these labels are not suitable to assess the sustainability of urban habitats; some labels at the neighbourhood level have been proposed to evaluate communities and neighbourhoods, but relevant studies are relatively scant; to the best of our knowledge, EEA and CASBEE City are the only two sustainable labels at the city level. On the other hand, there are already some studies to evaluate building and neighborhood labels from a comparative perspective, which provided a good reference for evaluating city labels and the urban sustainability.

In this paper, we at first develop a conceptual model of the city and explain how it could be sustainable, followed by comparatively evaluating several labels based on our explanation. In section 2, the model and the explanation was presented, followed by an evaluation in section 3. Finally a conclusion was given in section 4.

2. Understanding the city and its sustainability

2.1 The conceptual model of the city

To understand which type of development in cities can be regarded as sustainable, some researchers have adopted thermodynamic principles to understand urban development. Learning about ecosystems and the (fundamentally thermodynamic) laws of their evolution can help us to understand cities and draw analogies in terms of sustainability between urban and natural habitats (Wilson, 2006). Newman (1999) proposed a metabolism model of human settlements. There are mainly three concepts in this model: resource inputs, dynamics of the settlement, and waste outputs. The terms of 'resource inputs' and 'waste outputs' are pure physical attributes of the urban system and are thus quantifiable. Newman identified 'land', 'water', 'food', 'energy', 'building material', and 'other resources' as the relevant components of resource inputs. Components of waste outputs are solid waste, liquid waste, toxics, sewage, air pollutants, greenhouse gases, waste heat, and noise. Dynamics of the settlement is a more complex concept, which basically covers the entire inner workings of the urban environment. As such, the concept covers multiple disciplines such as economics, politics and policy making, as well as social structure, population behavior and basic production and consumption patterns. Robinson (2012) analyzed how cities behave physically by considering the thermodynamic concept of entropy: cities are open systems, and they import relatively low entropy energy and materials while export high entropy wastes. To be sustainable, the exchanges of non-renewable energy and matter across the city boundaries should be minimised, by increasing the import of renewables (e.g. sun, wind and local organic materials) and by minimising net internal entropy production through synergetic energy and matter exchanges between processes and actors within a city. Damen (2014) extended the interactions within the model proposed by Newman (1999) to gain a better understanding of the entire urban process, and further constructed a framework that can evaluate sustainability using various indicators at neighborhood scale.

Based on existing understanding and explanation, in this section, we proposed a conceptual model of the city, shown in Figure 1.

Figure 1. A conceptual model of the city; the remote sensing image, obtained from Google map, shows a small city Dexing (main urban areas) in China.

Figure 1 shows a city, which is enclosed by a hypothetical boundary (a rectangle in this figure, and could be the same as the administrative boundary in reality) and a conceptual model of city's function or metabolism. The city's metabolism, defined as a biological systems way of looking at the resource inputs and waste outputs of settlements by Newman (1999), can be understood from three parts as mentioned before: inputs, internal dynamics, and outputs.

The city inputs various resources, which will be used to support the internal dynamics functioning inside the city boundary. In reality, these resources can be divided into non-renewable type (e.g., petroleum and coal) and renewable type (e.g., light and wood), as well as can be categorized as resources from nature (e.g., light and water) and those produced and transited from elsewhere (e.g., clothes and books), and also be divided into social, economic, and environmental resources (e.g., workers, money investment, and wood, respectively).

Various dynamic processes exist inside the city boundary. The physical and biological processes of converting resources into other useful resources (products) to maintain city's function and wastes are similar with "the human body's metabolic processes or that of an ecosystem" (Newman & Kenworthy, 1999). These useful resources can be used to improve quality of human life or livability, and specifically can be divided into environmental, social, and economic resources. Correspondingly, it is helpful to investigate city's internal dynamics from environmental, social, and economic perspectives.

The city outputs contain wastes, wasted resources, and output resources. After the internal dynamics process within the city, materials that eventually cannot be used are outputted as wastes. Wasted resources are those can be used but actually not because of limited technologies or human subjective ignorance. Output resources are those products produced in the city or materials which are conveyed to other places and became parts of resources input of other cities.

The understanding above is based on existing studies, but there exists some essential differences. First, it can be regarded as an extension of the metabolism model proposed by Newman (1999); both of them considered three processes: input, output, and internal dynamics. However, the city in Newman's model didn't have a hypothetical boundary, which makes the content of these three processes greatly different. For example, building material is defined as input, but in our model it could be an inputted resource from the outside the city boundary or be a resource inside the city boundary; in the latter scenario, it cannot be regarded as part of input resources. Second, in tandem with the understanding of Robinson (2012), our model treats a city with a hypothetical boundary, and approaches from the thermodynamic concept of entropy. However, our model more emphasizes the city's connection to or communication with other cities, treating it as an important node in the whole city network. For example, we consider city inputs various resources (e.g., human resources and clothes) from other places, and outputs resources produced in the city (e.g., computers and skilled workers) to other places.

2.2 How to be sustainable

To achieve sustainability, the input, internal dynamics, and output of the city should be processed in a sustainable way. At first, let us think about the input of resources for a city. Basically, it is impossible for a city to be self-organized without the resources from outside the city, even ignoring the input of some basic natural resources such as light. The actual situation is, with the increase of communication between cities and the decrease of transport cost, the exchange of resources between cities even will be rapidly increased. Therefore, to minimize the resources input in general is not a wise choice. To support sustainable development, two aspects should be considered simultaneously. On one hand, to try to minimize the input amount of non-renewable resources (or resources produced by non-renewable resources) and to minimize the transport cost (covering economic and environmental costs) used to convey resources. One the other hand, to ensure the minimization does not reduce the efficiency of urban dynamics.

All these inputted resources, together with existing resources in the city, will be used to support urban internal dynamics, which can convert these resources to other useful resources (products) that cities need. To maintain city's function, various environmental, social and economic resources are needed. To be sustainable, it's crucial to realize reasonable distribution of resources (produced by urban dynamic process or directly obtained from nature and other places). The reasonable resource distribution includes three levels of meanings. At first, the efficiency of urban dynamics should be enhanced so as to produce reasonable amount of necessary resources. Then, the proportions of any type of resources should be reasonable. Assuming the whole amount of resources that can be utilized by people are limited at a certain period (because of limited efficiency at a certain period), if there are more environmental resources, comparatively there would be less socio-economic resources, which usually are transferred from some environmental resources (e.g., changing a natural land into a residential land). The unreasonable distribution of resources will elicit serious problems, for example, more economic resources exist and less social resources exist, which might mean some social issues (e.g., education and medical care) have been ignored. Finally, the proportions of any sub-type of each resource should also be reasonable. Taking social resources as an example, typical social resources include education resources, medical resources, and pension resources. Assuming the total amount of social resources is limited at a certain period, its distribution for each sub-type of social resources should be reasonable according to city's requirements.

When it comes to the output, to become sustainable, the amount of wasted resources and wastes should be as small as possible. Ideally, if a city is sustainable, there would be no resources wasted and no wastes (because all wastes could be used in the city as the resources for other products). For the output of resources which are conveyed to other places, to minimize the output amount of non-renewable resources and to minimize the transport cost which is not only beneficial to the city's but also other places' sustainability.

3. Evaluating selected labels

In this section, an evaluation is conducted by comparing selected labels. At present, there are only two city labels, namely EEA and CASBEE City. Although EEA has been widely applied in real world, but almost no research pay attention to evaluating this label; only (Kern & Bulkeley, 2009) mentioned EEA in their study. In addition, we cannot obtain the detailed information about EEA, like the indicators this label adopts. For CASBEE City, there are some relevant studies, although pretty limited, about it, for example, Shuzo Murakami et al (2011) introduced its development. More importantly, it's free to get access to its technical manual, after registering on the website. Therefore, CASBEE City has been selected. On the other hand, BREEAM Communities, LEED-ND, and CASBEE-UD are the three most widely compared neighborhood labels. Considering the basic concept of CASBEE-UD is similar with that of CASBEE City, to avoid repetition, only BREEAM Communities and LEED-ND are selected to be compared with CASBEE City. In this study, the 2012 version of BREEAM Communities, the 2009 version of LEED-ND, and the 2012 version of CASBEE City have been used for analysis.

In section 3.1, the basic information of these three labels is compared. Then, based on our understanding of the city and its sustainability, labels are compared from three aspects: dimension coverage, process coverage, and weighting and scoring. Specifically, dimension coverage is to assess what the major dimensions are considered in the labels and how successful they are in comprehensively evaluating sustainable performance of the city. Dimensions considered here cover environmental, social, and economic dimensions. Process coverage is to assess whether the labels consider and evaluate the three processes: resources input, internal dynamics, and resources output. Additionally, weighting and scoring is to investigate the main methodolgy adopted in the labels to weight and score the importance of different themes and criteria, which actually mainly reflect the reasonable distributions of various resources in cities.

3.1 Basic information

BREEAM, first developed by the Building Research Establishment (BRE) in 1990, is the world's earliest established and most widely used method of evaluating building sustainability. BREEAM Communities was initially launched in 2008, and is an independent, third party assessment and certification standard based on the established BREEAM methodology. It can improve, measure and certify the social, economic, and environmental sustainability of large-scale development plans by integrating sustainable design into the master planning process (BRE, 2013). In BREEAM Communities, the environmental assessment method is expanded to more holistically approach sustainability with consideration of the social and economic impacts of development. BREEAM Communities can be applied internationally through a simple bespoke international process, where the flexibility of the scheme allows the assessment process to be adapted to local specific context. BREEAM Communities consists of six categories, including governance, social and economic wellbeing, resources and energy, land use and ecology, transport and movement, and innovation, and 40 assessment issues.

LEED-ND, which was launched in 2007, is the latest series of the U.S. Green Building Council's (USGBC) assessment tools which was developed in partnership with Congress for the New Urbanism (CNU) and the Natural Resources Defense Council (NRDC) (Hurley & Horne, 2006). Unlike other LEED rating systems, which focus primarily on green building practices and offer only a few credits for site selection and design, LEED-ND places emphasis on the site selection, design, and construction elements that bring buildings and infrastructure together into a neighborhood and relate the neighborhood to its landscape as well as its local and regional context. LEED-ND creates a label, as well as guidelines for both decision making and development, to provide an incentive for better location, design, and construction of new residential, commercial, and mixed-use developments. Assessment criteria of LEED-ND include five categories: smart growth and linkages, neighborhood pattern and design, green infrastructure and buildings, innovation and design process, and regional priority credit, and 41 assessment credits and 12 prerequisites.

CASBEE, first released in 2002, is the first building environmental assessment method developed in Japan for the promotion of sustainable building practices in the country (Wong & Abe, 2014). CASBEE-UD was developed in 2006 to assess the environmental efficiency of planned projects consisting of multiple buildings and public areas (S. Murakami et al., 2007). CASBEE City, first published in 2011, is a system for comprehensively evaluating the performance at the city level, using a triple bottom line approach of environment, society and economy. It can objectively assess the effectiveness of the city's policies and environmental measures. CASBEE City implements the concept of environmental efficiency and allows evaluation of a city from two aspects: the aspect of decreasing negative environmental load (L) emitted outside the city, and the aspect of the city (Blanch Verges, 2009). When evaluating a city, CASBEE City sets a hypothetical boundary to enclose the city. In doing so, it can evaluate the Built-Environment Efficiency (BEE) of the city. Improvement in environmental quality and activities (referred to as "Quality," or "Q") within the enclosed space and reduction in negative environmental impact (referred to as "Load," or"L") on the area beyond the boundary would lead to higher BEE values, thus a better rating. Detailed description are shown in Figure 2. Since CASBEE City calculates Load and Quality separately, for Quality aspect, there are environmental, social, and economic main categories, including ten minor categories, and twenty sub-categories; for Load aspect, there are two main categories: CO^2 emissions from energy sources and CO^2 emissions from non-energy sources, which are divided into four minor categories and one minor category, respectively.

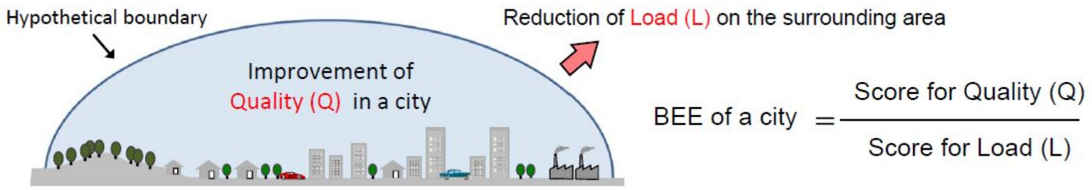

Figure 2. The conceptual model of the city and the calculation of BEE from the CASBEE official website (source: http://www.ibec.or.jp/CASBEE/english/index.htm).

3.2 Dimension coverage

Table 1 shows the dimensions covered by the three labels, and the number and weighting percentage of indicators (or items, credits) under each dimension are also presented. According to its main impact to improving sustainability, all indicators adopted by each label were classified into environmental, social, and economic dimensions. For example, the main impact of the indicator "adequate quality of housing" in CASBEE City is to improve social sustainability; therefore this indicator was grouped into social dimension. However, some indicators have more than one type of impact or it is difficult to identify their main impacts, for example, the indicator "street network" in LEED-ND is a basic indicator to describe the neighborhood pattern and it affects comprehensively the sustainability; in this situation, it will be grouped into mixed dimension. It should be mentioned that 12 prerequisites in LEED-ND are mandatory in the evaluation system, but they are not allocated points (or scores); therefore, they are not shown in Table 1. In addition, the indicators in the category of "innovation and design process" and "regional priority credit" in LEED-ND are also not shown in Table 1, which are not included in 100 base points (up to 10 bonus points for these indicators). This is the same for the indicators in the category of "innovation" in BREEM Communities.

As Table 1 indicates, different labels have different emphases. For BREEM Communities, there are 19 indicators covering environmental dimension; these indicators account for 45 weighting percentage, showing their great importance to measuring overall sustainability. 13 indicators (26.3 weighting percentage) cover social dimension, showing social dimension is the second important issue. Only two of total 40 indicators cover economic dimension, and they are "economic impact" and "labour and skills". However, although the number of economic indicators is extremely small, the weighting percentages of "economic impact" and "labour and skills" are 8.9% and 5.9%, respectively, much higher than average weighting of other indicators. 6 indicators are grouped as covering mixed dimension, and is relatively a small proportion.

For LEED-ND, there are 20 environmental indicators, accounting for 32% weighting, which shows environmental dimension is dominant, in line with BREEM Communities. There are 8 social indicators (16% weighting) and only 2 economic indicators (5% weighting); the total weighting of socioeconomic dimension is just 21%. The number of indicators covering mixed dimension in LEED-ND is 11, greatly larger than that in BREEM Communities, implying that the classification of LEED-ND does not match with the measurement of city sustainability well if approaching urban sustainable development from environmental, social, and economic perspectives.

When it comes to CASBEE City, situation greatly changes. Because, at first, the indicators in CASBEE City are classified into these three dimensions directly; therefore, the main impact of each indicator can be identified clearly and no indicator will be in mixed group. In addition, to label the performance of the city, the Quality and Load should be calculated separately in CASBEE City, and thereby the number and weighting percentage of indicators should also be observed separately. For quality calculation, there are 5, 11, and 4 indicators covering environmental, social, and economic dimensions, respectively, and equally accounting for approximately 33 weighting percentage. In CASBEE City, each dimension is weighted equally, which is different from LEED-ND and BREEM Communities, but the number of social indicators are larger than the total number of environmental and economic indicators, which shows this label addresses social dimension more detailed. For Load calculation, all five indicators clearly cover environmental dimension; all of them consider CO2 emission from energy or non-energy sources, which greatly simplified the calculation process.

Among these three labels, CASBEE City considers the importance of social, economic, and environmental dimensions equally when calculating Quality, while the others emphasize more on the evaluation of environmental dimension. In addition, there are many indicators covering mixed dimension in LEED-ND and BREEM Communities, especially for the latter one, which makes it difficult to evaluate the performance of three dimensions separately and clearly; this situation does not exist for CASBEE City, because this label just categorizes its indicators according to these dimensions.

Table 1. The number and weighting percentage of indicators for each dimension

Dimension	Exampled indicators	The number and weighting percentage of indicators							
		BREEM Communities		LEED-ND		CASBEE City			
						Quality calculation		Load calculation	
Environmental	Heat Island Reduction, adapting to climate change	19	45%	20	32%	5	1/3	5	100%
Social	Mixed-Income Communities, adequacy of childcare service	13	26.4%	8	16%	11	1/3	0	0
Economic	tax revenues	2	14.8%	2	5%	4	1/3	0	0
Mixed	street network, compact development	6	13.8%	11	47%	0	0	0	0

3.3 Process coverage

Table 2 presents the input and output covered by the three labels, including the number and weighting percentage of indicators in the process of input and output. For BREEM Communities and LEED-ND, their concepts and methods don't have clear consideration of the resources exchange across the boundary of neighborhoods or communities, thereby it is very hard to identify specific indicators reflecting the exchange process. Specifically, only four indicators, accounting for 6.5% weighting, namely "noise pollution", " light pollution", " transport carbon emissions", and " water pollution", can be identified as the output indicators, and none can be identified as input indicator in BREEM Communities. None of them can be identified as input or output indicator in LEED-ND, although several indicators, like "wastewater management", "light pollution reduction", "solid waste management infrastructure" indirectly reflect the resources exchange or wastes output. For the Quality calculation process in CASBEE City, there are two indicators, namely "CO^2 absorption by forests" and "contribution in CO^2 reduction in other regions", can be identified as the input and output indicators. Although the number is very limited, their total weighting is as high as 19.4%. For the Load calculation in CASBEE City, all of existing five indicators can be treated as the output indicators. This is reasonable considering the conceptual model of the city in CASBEE City adopts a hypothetical boundary, and the calculated Quality is that within the hypothetical enclosed urban space and the calculated Load is that on the external environment of the space.

From the above analysis, we can find that both of BREEM Communities and LEED-ND rarely consider the input or output indicators, while CASBEE City consider much more. This fact reflects that CASBEE City performs much better than the other twos in terms of the process coverage.

Table 2. The number and weighting percentage of indicators for each process

Process	Exampled indicators	The number and weighting percentage of indicators							
		BREEM Communities		LEED-ND		CASBEE City			
						Quality calculation		Load calculation	
Input	CO^2 absorption by forests, and contribution in CO^2 reduction in other regions	0	0	0	0	2	19.4%	0	0
Output	light pollution, and noise pollution	4	6.5%	0	0	0	0	5	100.0%

3.4 Scoring and weighting

Weighting is one of the most theoretically controversial aspects within the sustainable assessment systems (AlWaer, Sibley, & Lewis, 2008; Retzlaff, 2009). It implies the significance and importance of different criteria, although it is extremely difficult to compare and rank different elements (Retzlaff, 2009).

Each of the forty assessment indicators in BREEM Communities has an individual weighting and a variable number of credits. For example, the weighting coefficient of the indicator "noise pollution" is 1.8%, and its available credits are 3; in this respect, the weighting value of each credit is 0.6%. To calculate a comprehensive score, at first, the number of credits awarded to each indicator should be determined by the assessor in accordance with the criteria; second, the credits achieved in each assessment issue are then multiplied by the corresponding individual weighting, which gives the indicator weighted score; third, in order to determine the category score, the individual assessment indicator weighted scores for all indicators in any category are added together; finally, an additional 1% can be added to the final score of the relevant category for each 'innovation credit' achieved (up to a maximum of 7%). BREEM Communities certifications are awarded Outstanding (≥ 85 points), Excellent (≥70 points), Very good (≥55 points), Good (≥45), Pass (≥30), and Unclassified (<30 points).

The LEED 2009 indicator (named credit in the LEED system) weightings process is based on the following parameters: All indicators are worth a minimum of 1 point; all indicators are positive and whole numbers; there are no fractions or negative values; All indicators receive a single, static weight in each rating system; there are no individualized scorecards based on project location; the rating systems has 100 base points, and "Innovation and Design Process" and "Regional Priority" indicators provide opportunities for up to 10 bonus points. The LEED 2009 indicator weightings process involves three steps for LEED-ND: first, a reference neighborhood is used to estimate the environmental impacts in 15 categories associated with a typical neighborhood development pursuing LEED certification; second, the relative importance of neighborhood impacts in each category is set to reflect values based on the NIST (National Institute of Standards and Technology) weightings. Third, data that quantify neighborhood impacts on environmental and human health are used to assign points to individual indicators. Each credit is allocated points based on the relative importance of the neighborhood-related impacts that it addresses. The result is a weighted average that combines neighborhood impacts and the relative value of the impact categories. Credits that most directly address the most important impacts are given the greatest weight. LEED-ND certifications are awarded Certified (40–49 points), Silver (50–59 points), Gold (60–79 points), and Platinum (80 points and above).

Weighting coefficients in CASBEE City for major assessment domains (e.g. environment, society and economy) are equally set, because this label is based on the universal concept that any city seeks a balanced tripled bottom line sustainability. If multiple mid-level/minor criteria or indicators exist, weighting coefficients within each group are equally set. However, weighting coefficients may be adjusted to meet specific context of different cities. Indicators are evaluated on a scale of 1.0 to 5.0 using an assessment index established for each indicator based on data such as statistics. The score scale, either in ascending or descending order, is set based on indicator-specific assessment results from all municipalities. After calculating total scores for Q and L, both of which are given on a 100-point scale, BEE value can be calculated for comprehensive assessment using equation, and it can be shown in a 2D graph, called a BEE chart, which plots a Q value on the vertical axis and an L value on the horizontal axis. CASBEE City classifies the results in five ranks: S (Excellent), A (Very Good), B+ (Good), B- (Fairy Poor) and C (Poor) based on the BEE value.

There are some differences among the methods adopted in BREEM Communities and LEED-ND and that in CASBEE City: first, weighting are allocated by comparing the performance level against a target level of performance for the former, while for the latter each criterion has 5 score levels from 1 to 5, and level 3 is a level of the normal situation, which is an accepted level of performance in Japan and will be used as a reference level. Second, BREEM Communities and LEED-ND consider the importance of innovation, and allocate some extra points to this category, while CASBEE City does not. Third, CASBEE City calculates Quality and Load separately, which represent positive and negative impacts, respectively, then the final comprehensive performance is determined by BEE (equal to Quality/Load). For other twos, they consider positive and negative indicators at the same time. And finally, the results for BREEM Communities and LEED-ND are classified more clearly while for CASBEE City the results are more visualized because of the adoption of the BEE chart. However, these methods have disadvantages or advantages compared with each other; it's unreasonable to say which would be better than the others.

4. Conclusion

In this paper, we presented a conceptual model of the city and explained how it could be sustainable, then comparatively evaluated three labels, namely BREEM Communities, LEED-ND and CASBEE City, based on our explanation. In the conceptual model, a city is enclosed by a hypothetical boundary, and can be understood from three components: inputs, internal dynamics, and outputs. The city inputs various resources, which will be used to support the internal dynamics happened inside the city boundary. Various dynamic processes exist inside the city boundary. The physical and biological processes convert resources into other useful resources (products) to support city's function and wastes production. These useful resources can be used to improve quality of human life or livability, and specifically can be divided into environmental, social, and economic resources. The outputs contain wastes, wasted resources, and output resources. After the internal dynamics process of the city, materials that eventually cannot be used were outputted as wastes. Wasted resources are those can be used but actually cannot because of limited technologies or human subjective ignorance. Output resources are those products produced in the city or materials which are conveyed to other places and became parts of input resources of other cities.

To support sustainable development, for the process of resources input, two aspects should be considered simultaneously. On one hand, to try to minimize the input amount of non-renewable resources (or resources produced by non-renewable resources) and to minimize the transport cost (covering economic and environmental costs) use to convey resources. On the other hand, to ensure the minimization does not reduce the efficiency of urban dynamics. For internal dynamics, it's crucial to achieve reasonable distribution of resources (produced by urban dynamic process or directly get from nature and other places). When it comes to the output, the amount of wasted resources and wastes should be as small as possible. For the output of resources which are conveyed to other places, to minimize the output amount of non-renewable resources and to minimize the transport cost is not only beneficial to the city's but also other places' sustainability.

Then, BREEM Communities, LEED-ND, and CASBEE City were compared from three aspects: dimension coverage, process coverage, and weighting and scoring. Although BREEM Communities and LEED-ND actually are two labels at neighborhood level, because only two city labels can be identified and the technical manual of one of them (European Energy Award) is not available, these two neighborhood labels were selected for comparison. For dimension coverage, among three labels, CASBEE City considers the importance of social, economic, and environmental dimensions equally when calculating Quality, while the others emphasize more the evaluation of environmental dimension. In addition, there are many mixed indicators in LEED-ND and BREEM Communities, especially for the latter one, which make it hard to evaluate the performance of three dimensions separately and clearly; this situation does not exist for CASBEE City, because this label just categorizes its indicators according to these dimensions. For process coverage, we found both of BREEM Communities and LEED-ND rarely consider the input or output indicators, while CASBEE City considers much more. This fact reflects that CASBEE City performs much better than the other twos in terms of the process coverage. When it comes to weighting and scoring, the methodology adopted by each label has different features and it's hard to say which one would be better. From the comparison above, we conclude that CASBEE City is relatively a better label to evaluate the sustainable performance for cities; this is reasonable because it's a city-level label, while other twos are actually neighborhood-level labels.

Next step, we plan to develop a new sustainability assessment label at the city level. To do this, at first, we would further investigate the detailed mechanism of each process related to city functions, to improve our conceptual model of the city. Second, we would build our rating system by referencing to existing labels, especially CASBEE City. Considering substantial existing labels donot perform well in terms of social and economic evaluation and the input and output processes are ignored to a great extent, in our study, we will pay particular attention to building socioeconomic indicators and input-related and output-related indicators so as to evaluate urban sustainability more comprehensively.

References

AlWaer, H., Sibley, M., & Lewis, J. (2008). Different stakeholder perceptions of sustainability assessment. *Architectural Science Review, 51*(1), 48-59.

Blanch Verges, A. (2009). Environmental Efficiency Assessment on Spanish Urban Settings applying CASBEE methodology.

BRE. (2013). BREEAM Communities: Integrating sustainable design into masterplanning. In BRE (Ed.). UK.

Burton, I. (1987). Report on reports: Our common future: The world commission on environment and development. *Environment: Science and Policy for Sustainable Development, 29*(5), 25-29.

Cole, R. J., Brown, Z., & McKay, S. (2010). Building human agency: a timely manifesto. *Building Research & Information, 38*(3), 339-350.

Dame, R. G. (2014) Evaluating urban quality and sustainability. Master thesis, University of Twente.

Forum European Energy Award. (2014). European Energy Award. Zurich.

Goodall, B. (1987). *The Penguin dictionary of human geography*: Puffin.

Haapio, A. (2012). Towards sustainable urban communities. *Environmental Impact Assessment Review, 32*(1), 165-169.

Haapio, A., & Viitaniemi, P. (2008). A critical review of building environmental assessment tools. *Environmental Impact Assessment Review, 28*(7), 469-482.

Hurley, J., & Horne, R. (2006). Review and analysis of tools for the implementation and assessment of sustainable urban development. *future, 7*, 6.

Kern, K., & Bulkeley, H. (2009). Cities, Europeanization and Multi‐level Governance: Governing Climate Change through Transnational Municipal Networks*. *JCMS: Journal of Common Market Studies, 47*(2), 309-332.

Kuper, A. (2013). *The social science encyclopedia*: Routledge.

Murakami, S., Kawakubo, S., Asami, Y., Ikaga, T., Yamaguchi, N., & Kaburagi, S. (2011). Development of a comprehensive city assessment tool: CASBEE-City. *Building Research & Information, 39*(3), 195-210.

Murakami, S., Yamaguchi, N., Asami, Y., Ikaga, T., Kaburagi, S., Matsukuma, A., . . . Hashimoto, T. (2007). Outline of CASBEE for Urban Development (CASBEE-UD). *AIJ Journal of Technology and Design, 13*(25), 191-196.

Newman, P., & Kenworthy, J. (1999). *Sustainability and cities: overcoming automobile dependence*: Island Press.

Nguyen, B. K., & Altan, H. (2011). Comparative review of five sustainable rating systems. *Procedia Engineering, 21*, 376-386.

Retzlaff, R. C. (2009). Green Buildings and Building Assessment Systems A New Area of Interest for Planners. *Journal of Planning Literature, 24*(1), 3-21.

Robinson, D. (2012). *Computer modelling for sustainable urban design: Physical principles, methods and applications*: Routledge.

Rohe, W. M. (2009). From local to global: One hundred years of neighborhood planning. *Journal of the American Planning Association, 75*(2), 209-230.

Sharifi, A., & Murayama, A. (2013). A critical review of seven selected neighborhood sustainability assessment tools. *Environmental Impact Assessment Review, 38*, 73-87.

Sharifi, A., & Murayama, A. (2014). Neighborhood sustainability assessment in action: Cross-evaluation of three assessment systems and their cases from the US, the UK, and Japan. *Building and Environment, 72*, 243-258.

Soebarto, V. I., & Williamson, T. J. (2001). Multi-criteria assessment of building performance: theory and implementation. *Building and Environment, 36*(6), 681-690.

Uhel, R. (2006). Urban sprawl in Europe: the ignored challenge. *EAA Report, 10*(2), 2006.

Wallhagen, M., Glaumann, M., Eriksson, O., & Westerberg, U. (2013). Framework for Detailed Comparison of Building Environmental Assessment Tools. *Buildings, 3*(1), 39-60.

Wilson, A. G. (2006). Ecological and urban systems models: some explorations of similarities in the context of complexity theory. *Environment and Planning A, 38*(4), 633.

Wong, S.-C., & Abe, N. (2014). Stakeholders' perspectives of a building environmental assessment method: The case of CASBEE. *Building and Environment, 82*, 502-516.