ECOLOGICAL PERFORMANCE EVALUATION METHODS IN URBAN EXISTING COMMUNITY REGENERATION: A COMPREHENSIVE REVIEW

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ABSTRACT

In recent years, due to existing communities consuming tremendous resources, achieving ecological regeneration in urban existing communities has become an important but challenging topic worldwide. Scientifically evaluating the ecological performance of existing communities can significantly enhance the efficiency of the regeneration and can help decision makers better formulate relevant policies. Although many evaluation methods for the ecological performance have been proposed in different countries, there is also no uniform method for ecological performance evaluation in urban existing community regeneration.

This paper comprehensively reviews literatures on the international frontier theories, methods and related practices of ecological performance evaluation, and highlights the most significant research works and results. This study also analyzes the adaptability and possible shortcomings of the existing ecological performance evaluation methods in the process of implementation. In addition, we takes the Chinese cities as an example and roughly suggests a new feasible ecological performance evaluation system in the conclusion. The results of this work can provide a good reference for ecological performance evaluation in urban existing community regeneration.

Keywords: existing communities, ecological performance, evaluation methods, regeneration, review.

INTRODUCTION

Eco-city was first defined by UNESCO in 1971 to study the urban environment with ecological theory and clarify the pursuit of a highly harmonious city between people and environment (UNESCO,1971). Nowadays, establishment of Eco-city has become an important issue worldwide. Previously, Howard's Garden City blueprint created a new form of urban planning beyond the original urban form and social organization (Howard, 1965). TND（traditional neighborhood development）and TOD (transit oriented development) proposed by the new urbanism movement advocate natural urban life. New urbanists believe that compact city, as a strategy to decrease urban sprawl, has a sustainable urban form (Calthorpe,1993; Duany & Plater-Zyberk,1991). It strengthens the functional space of central cities, with low energy consumption and low environment pollution, based on sustainable urban morphology. Recently, the increasing of global warming have promoted the practice of eco-city which fully embodies the concept of sustainable urban. In the past decades, the United States, Germany, Japan and other countries have carried out the practice of eco-city.

In particular, for China, the eco-city has been the prior mode of urban development due to the rapid urbanization. After more than 30 years of rapid urban development, ecological regeneration of existing communities is emergent. The performance evaluation systems play an important role in this process. Since the ecological performance was put forward in 1983, it has been widely used in

various fields, including economics, energy, environment, ecology et.al., which have all kinds of connections with urban morphology. Although many evaluation methods for the ecological performance have been proposed in different countries, there is also no uniform method for ecological performance evaluation in urban existing community regeneration. Through literature research, this paper studies different evaluation methods for the ecological performance and investigate the relationship between ecological performance and urban morphology. This paper also roughly proposes a feasible ecological performance evaluation system for Chinese existing community regeneration. The results can scientifically help decision-makers to formulate relevant policies and roadmap.

BACKGROUND

The establishment of ecological urban communities is significant in improving living environment, reducing energy consumption, and promoting global sustainable development of cities. In recent years, Chinese government actively carries out the green regeneration of existing communities the for construction of ecological cities. Chinese government also emphasizes the relationship between urban form and natural environment. It is clearly proposed that the resource-saving and environment-friendly city modes need to focus on energy conservation and emission reduction for high quality living environment. Particularly, Shanghai municipal government has put forward the overall objectives and requirements of the Shanghai master plan (2017-2035), which is vigorously promoting the development of green building, and striving to build a resource-saving, environment-friendly and ecological low-carbon city (MOHURD, 2017). Since 2018, Shanghai has begun to carry out ecological regeneration of existing communities.

Currently, many existing communities in Shanghai are in poor living quality. There are many problems in these communities, such as aging infrastructures, the disrepair of buildings, the deficiency of parking space, and low quality outdoor public spaces, which seriously affect people living quality. However, as an important component of urban fabric in Shanghai, the workers' new village has been built for more than 30 years. There is a huge contradiction between old physical spaces and the needs of residents. Thus, the new workers' village community model is selected as the research object to study the effect of ecological performance evaluation. New technologies are proposed to improve the ecological performance and realize the sustainable development of the existing community.

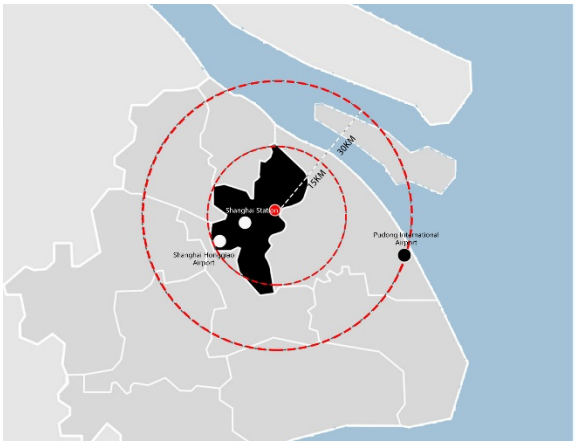


Figure 1. Macrolocational map of Workers' New Village, Shanghai

Figure 2. Real photos of Workers' New Village, Shanghai

In 1983, Professor Ferguson first proposed the concept of ecological performance. At present, the research on ecological performance mainly includes two parts: the construction of evaluation system and the implementation method. The term "performance" comes from management science, and its meaning includes "the process of implementing something and the realization of behavior", which can be used to evaluate the results of things. It often appears as compound words, such as performance evaluation, management performance, performance audit, etc. Urban morphology is an essential index for performance evaluation. And ecological performance evaluation system can guide the urban morphology in early stage.

1. Relationship between urban morphology and economic performance

Kevin Lynch (1981) focused on the relationship between economic performance and urban spatial structure in *Good City Form*. He selected performance indicators to evaluate urban form. Urban economics theory provides a conceptual framework for explaining the impact of urban form on economic output （Marshall,2013; Fischel and Mills,1985; Bogart,1998）. Good urban form and effective management contribute to the improvement of labor productivity. There are two main contributing factors: one is that the effective urban regional form enables enterprises to approach the larger labor market, so as to promote the employment opportunities of labor force; the other is that convenient transportation infrastructure and accessible conditions will improve the commuting efficiency between labor market and enterprises. It also helps to improve the employment and income of low-income people（Cervero,1998）. It is certain that the urban form has a great impact on the economic performance. For instance, sprawling and car-dependent urban forms, tend to have high infrastructure costs and energy consumption, which lead to low economic performance （Kenworthy and Laube, 1999）. Prud'homme et al. (1999) studied the influence of physical indicators such as labor accessibility and transportation network conditions on economic output. Cervero (2001) comprehensively studied the influence of city scale, urban form, accessibility, transportation network and other factors on economic performance from the macro to micro dimensions. In addition, another research perspective concerns the impact of immaterial forms, i.e. growth management policies on economic development.

2. Relationship between urban morphology and enegy performance

The concept of low-carbon urban design shows that energy performance and carbon efficiency can be improved by optimizing urban form. Currently, Energy performance at the building and city scales has been well researched, but at the community scale, it still needs further research. The geometric shape of buildings and urban forms are important parameters to determine the energy consumption of buildings. Some scholars have established the relationship between urban design parameters (such as building density, building type, layout, etc.) and energy consumption (building energy demand). Energy performance of communities are affected by many factors such as system efficiency, urban morphology, user behavior, etc. (Ratti et al., 2005; Steelers, 2003; Steinberger and Weisz, 2013)。

Urban form affects energy performance in two main ways: mutual shielding and microclimate. Steemers (2003) found a strong relationship between the shading angle of a building and energy performance in lighting, heating and cooling. Pisello (2012) demonstrates that the effect of mutual shading on the energy demand of a building must be considered. Microclimate change is largely determined by urban canyon effect. Studies have shown that the geometry of urban canyons can

increase energy consumption by 30% for buildings and 19% for residential buildings (Stromann-Andersen and Sattrup, 2011). This study demonstrates the importance of urban geometry in urban energy performance. Then, Taleghani compared six types of block patterns in the Netherlands. And he concluded that courtyard form is most energy-saving, rather than linear form and point form. The courtyard form provides better urban microclimate and comfortable outdoor thermal experience. Eicker et al. (2015) investigated the energy efficiency of buildings through simulation tools. He established standards according to the shape of blocks, and used data to evaluate energy demand and supply options. Iddrisu and Battacharyya (2015) proposed the SEDI (Sustainable Energy Development Index) to assess the sustainability level of different energy demand.

3. Relationship between urban morphology and environmental performance

Environmental performance should consider the small environment in different regions of the city and the large ecological environment under the global background, which is often associated with the urban morphological characteristics. Some ecological scholars have studied the mechanism of urbanization affecting ecological environment. In addition, some scholars in the field of planning and Architecture (Owens,1986) tried to associate different urban forms with diverse urban environment. For the quantitative expression of urban spatial structure, they mainly quantify the characteristics of it from the form, type and scale of urban elements. He quantified four indicators of urban form: centrality, density, texture and connectivity. The corresponding environmental performance factors are resources, ecological collection, supply system and occupant comfort (Alberti 1999). Martin and March provided a bottom-up approach to study the geometric properties of urban space, and constructed the relationship among density, spatial type and environmental performance (Leslie and Lionel, 1972). They used Fresnel diagrams to show how different types of cities with the same density create different environments. Using image processing techniques, Carlo Ratti et.al further studied the relationship between urban density, block type and different environmental performance (building energy consumption, solar radiation and wind energy distribution pattern), and proposed urban morphological parameters, such as street space aspect ratio and sky visibility (Ratti, et al, 2006; Carlo, et al. 2005）。Some scholars have studied an ecological conceptual model UEM (urban ecological model), which integrates social, economic, policy and environmental human activities into the comprehensive research and carries out environmental pressure simulation (Alberti 1999).

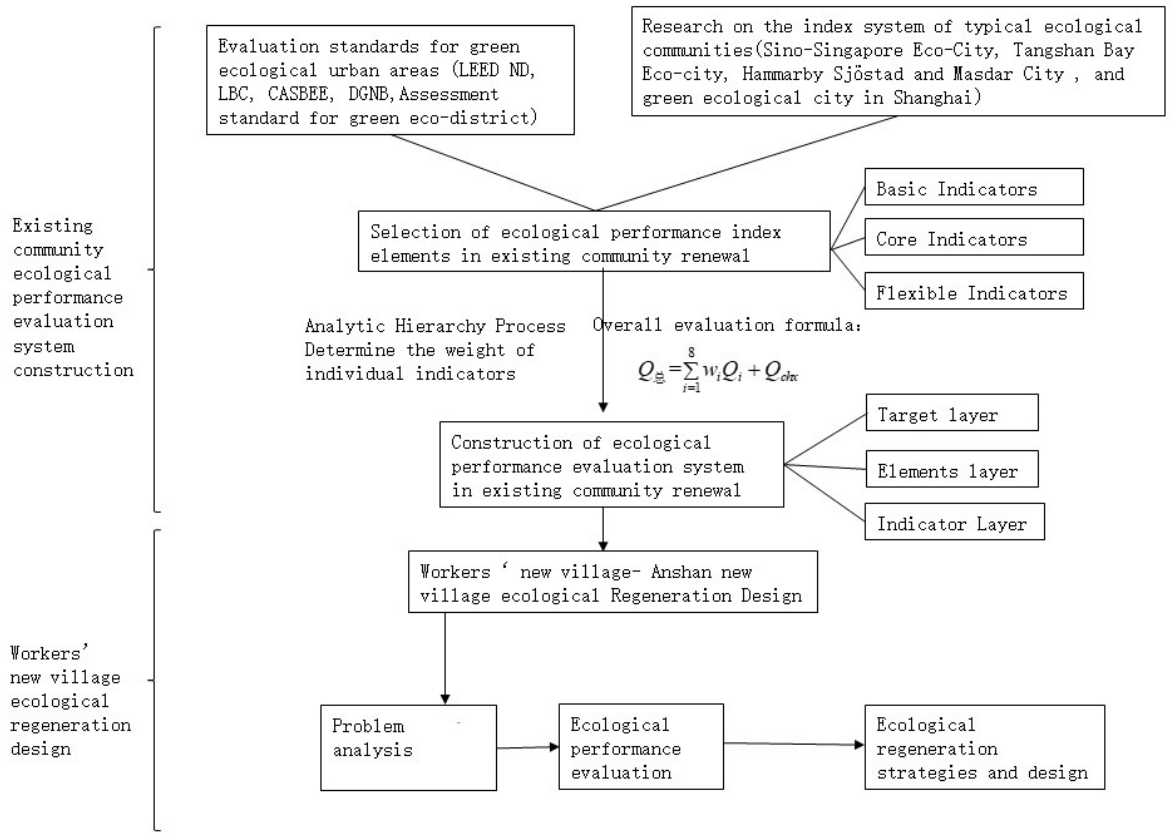
4. Relationship between urban morphology and spatial performance

Urban spatial performance refers to the overall effectiveness or outcome of the urban spatial structure, which is closely related to urban morphology. The performance of urban spaces has been the focus of urban economics, sociology and geography. Therefore, spatial structure basically determine the spatial performance, not only demographic, but also institutional, technological and ideological spatial characteristics. The spatial performance emphasizes the spatial distribution effect of economic output and welfare (Chen Rui, 2008). Wei Yaping (2006) firstly explicitly discussed the relationship between spatial structure and performance, including economic, social, environmental and other aspects. Some scholars proposed ecological area ratio (EAR) and green plot ratio (GPR) to guide urban spatial structure. The GPR studied by combining leaf area index (LAI), can be used as one of the evaluation indicators of ecological urban greening. Green plot ratio (GPR) was studied to standardize the green space and vegetation surface in communities(Ong, 2003). Compared with EAR, green GPR is more like a form based normative guide rather than a landscape or ecological performance standard.

5. Relationship between urban morphology and ecological performance

Different forms of urban structure have different impacts on ecosystem functions. Ecological patch structure is important for species survival. And urban development alters the ecological conditions of pre-existing areas through changes in physical properties. Urban form affects resources and services such as public transportation, energy and drinking water, thus indirectly affecting urban ecological performance. Whitford (2001), a British scholar, established the ecological performance evaluation system in four aspects of surface temperature, hydrology, carbon storage and biodiversity in Merseyside, UK. And he finally came to the conclusion that although compact cities have good regional performance, their performance will be weaker than other regions if they lack good green space system. Some scholars believe that dynamic indicators of several consecutive years can objectively reflect the change of local ecosystem and avoid deterioration. Swedish scholars Lisa Deutsch and Carl Folke proposed dynamic indicators of ecological performance, which can reflect the environmental pressure in human social activities. From the perspective of ecosystem resilience, soil phosphorus content, woody vegetation coverage and soil moisture content are taken as dynamic indicators of ecological performance. Monitoring the dynamic performance indicators of ecosystem elasticity is of great significance to avoid ecosystem deterioration. Indian scholar Sonak (2014) discussed the influencing factors of ecosystem resilience from natural, social and economic aspects. It is proposed that ecological performance indicators should have the characteristics of all stakeholders' attention, repeatable time period and integration of society and ecosystem. Additionally, it is proved that these ecological performance indicators are useful planning tools, which can guide the development of existing urban areas by quantifying the factors that affect urban planning.

Figure 3.Work flow of ecological performance evaluation establishment



CONCLUSIONS

In conclusion, urban morphology has closely related to ecological performance, as well as economic performance, energy performance, environmental performance and spatial performance. There are many studies on the selection of ecological performance evaluation indexes in the world, including the scope of the city or single building, as well as urban communities and different built environment. The selection principles is based on the criteria of reducing the impact of urbanization on ecosystem. The indexes are mostly selected from the perspective of landscape, urban ecosystem and land affordability. The performance potential of urban land use, the elasticity of ecosystem, the transformation of artificial landscape are considered. The research on ecological performance in China should include three indexes, namely, urban form compactness, fractal dimension and coastline length. Moreover, the evaluation system should also include urban form evaluation, regional ecosystem evaluation, urban ecosystem structure optimization, urban and rural space utilization and green infrastructure network construction.

However, currently, China has not yet formed a uniform evaluation standard, and the evaluation index system has the characteristic of discretization. Moreover, in the process of community regeneration, there is still a lack of guidance of ecological performance evaluation system. The ecological performance evaluation system mentioned in this paper can provide a conceptual model of ecological assessment for the existing community. The evaluation of ecological performance in the renewal of existing communities is a complex process, including the analysis of economic, social, environmental and other comprehensive elements. Thus, the method of combining comprehensive indicator evaluation and single indicator evaluation can be adopted and the weight of key indicators should be studied in the future.

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