Study on Sustainable evaluation for Ecological Park Renewal

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Abstract. In the face of the spreading urban heat island effect in the city center, the design of urban pocket parks presents a viable solution. This study takes pocket parks in the central area of Shenyang City as an example and conducts quantitative sustainability analysis using the emergy method. Three parameters, namely, emergy yield ratio(EYR), environmental load ratio(ELR), and emergy sustainability index(ESI), are employed for the analysis. The research findings indicate that, using ESI as an example, the overall ecological sustainability effectiveness of the park improves with the passage of time. This provides urban managers with new ecological pathways to consider.

Keywords: Urban Pocket Park; Sustainability Analysis; Ecological emergy

1 Introduction

Urban pocket gardens refer to small gardens or green spaces created in limited urban areas. They are typically located in residential homes, apartments, office buildings, or corners of city streets, providing a designated area for planting flowers, plants, vegetables, or other vegetation. Urban pocket gardens can be open-air or established on balconies, rooftops, courtyards, as well as in public spaces like flower beds or gardens. These small gardens offer opportunities for people to connect with nature, relax, and enjoy a green environment. They have a positive impact on improving the quality of urban life and increasing biodiversity in urban ecosystems. Additionally, they can serve as social spaces within communities, fostering communication and cooperation among neighbors.

Ecological research on urban pocket gardens focuses on the following aspects: (1) Biodiversity: Studying the composition and quantity of different plant species in pocket gardens, as well as their influence on attracting and sustaining various animal species. By surveying and monitoring insects, birds, and other wildlife in the gardens, the contribution of pocket gardens to urban biodiversity can be evaluated. (2) Air quality and environmental benefits: Investigating the air quality within and around pocket gardens, such as measuring the filtering effect of plants on harmful substances in the air, and estimating their role in reducing urban air pollution. Additionally, research can

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explore the mitigation of the urban heat island effect and improvements in hydrological cycles as environmental benefits of plants in pocket gardens. (3) Community dynamics and social impacts: Researching the impact of pocket gardens on communities, including resident participation, community cohesion, and neighborhood interactions. By investigating and analyzing residents' attitudes, involvement, and usage of pocket gardens, the influence of these gardens on social connections and community identity can be understood. (4)Water resource management: Exploring how rainwater harvesting, irrigation, and water recycling techniques can be maximized to support the sustainability of pocket gardens. This research could involve the design and efficiency of rainwater collection systems, estimation of plant water requirements, and evaluation of water resource management strategies. (5) Sustainable urban development: Considering pocket gardens as part of urban greening initiatives and studying their role in urban planning and sustainable development. This type of research may involve assessing the contribution of gardens to urban ecosystem services such as soil conservation, water resource management, and air quality improvement, while also exploring ways to promote the widespread adoption and sustainable development of pocket gardens in urban design[1-10].

These research directions can help us better understand and promote the ecological value of urban pocket gardens, providing beneficial guidance for urban planning, community engagement, and sustainable development.

2 Methods and Case

2.1 Emergy method

The emergy theory is a comprehensive system analysis method used to evaluate and quantify the contribution and transformation of resources and energy in ecological systems. It proposes a globally unified measurement unit called "emergy" to compare and assess the relationships between different types of resources and energy[11-12].

The core concepts of emergy theory include:

1. Emergy: Emergy is defined as the total quantity of the quality and energy possessed by matter, energy, and information during their generation, transformation, and utilization processes. It reflects the cumulative and conversion history of resources and energy.

2. Emergy evaluation: Emergy theory evaluates and quantifies the energy and resource flows of the entire system by considering the emergy of various inputs, outputs, and interaction flows. This includes direct emergy (energy and material inputs), indirect emergy (economic input), and embodied emergy (environmental support), among others.

3. Emergy diagram: The emergy diagram is an important tool in the emergy theory, used to represent and analyze the flow and transformation of emergy. Through emergy diagrams, the sources and pathways of emergy inputs and outputs in the system can be identified, revealing the efficiency and sustainability of emergy conversion.

4. Sustainability assessment: Emergy theory provides a comprehensive approach to assessing the sustainability of systems by considering all emergy flows and transfor-

mations. This involves considerations such as emergy input-to-output ratios, cycling of emergy, system complexity, and stability.

The emergy theory finds wide applications in sustainable development, ecological economics, and systems ecology. It offers a systematic method to analyze resource utilization and energy conversion processes, facilitating a more holistic understanding of sustainability issues in resource management and decision-making. The emergy theory provides a powerful tool for comprehending and evaluating the interdependencies and environmental impacts among different resources and energy sources.

2.2 Sustainable indicators

In the context of emergy theory, several indicators are used to assess the sustainability and efficiency of systems.

1. Emergy Yield Rate (EYR): EYR is a measure of the efficiency or productivity of a system in terms of energy and resource utilization. It represents the ratio of emergy obtained as useful outputs to the total emergy invested as inputs in a system. A higher EYR indicates a more productive and efficient utilization of resources.

2. Environmental Load Rate (ELR): ELR quantifies the environmental impact or load associated with a system's operation. It measures the ratio of the total emergy support from the environment (e.g., solar energy and natural resources) to the total emergy utilized within the system. A lower ELR indicates a lesser environmental burden and suggests a more sustainable use of resources.

3. Emergy Sustainability Indicators (ESI): ESI combines multiple indicators to provide a comprehensive assessment of the ecological and economic sustainability of a system. It considers factors such as EYR, ELR, system complexity, resilience, and integration with the surrounding ecosystem. ESI offers a holistic view of the system's performance and helps evaluate its long-term sustainability and resilience.

These indicators are crucial for evaluating the efficiency, environmental impact, and overall sustainability of systems. They enable decision-makers to make informed choices regarding resource management, policy formulation, and sustainable development, considering the complex interdependencies between human activities and the environment.

2.3 Case introduction

Figure 1 presents the construction status of the Pocket Park next to Shenyang Center. Based on the construction data, an analysis of its sustainability emergy performance is conducted.

Fig. 1. Current status of the Pocket Park (Self-captured)

3 Results

3.1 Sustainable indicators

Figure 2 illustrates a sustainability analysis of pocket parks based on three categories of sustainable energy indicators.

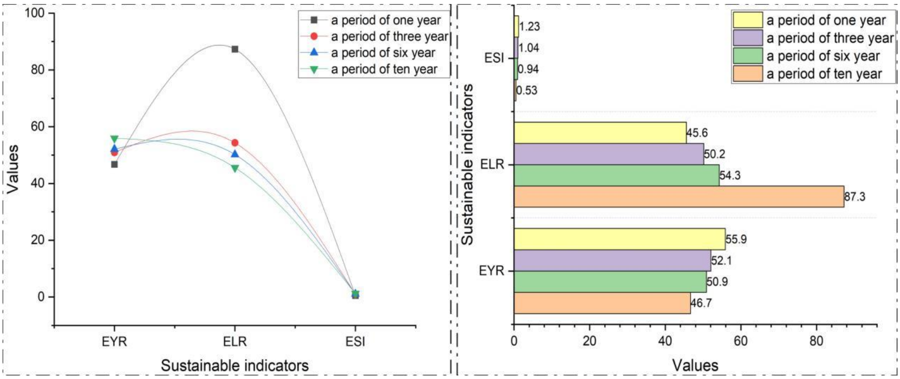

Fig. 2. The sustainability indicators trend(self-draw)

Through the evaluation of EYR/ELR/ESI indicators, it can be observed that the sustainability of the pocket park system undergoes continuous changes with the passage of time. Initially, the newly constructed park exhibits the highest environmental load rate, but as the park operates, it positively influences the surrounding environment, resulting in a decreasing trend. Taking ESI as an example from Figure 2, the ESI value increases from 0.53 to 0.94, and then further to 1.04 and 1.23 with the extension of time. This indicates an increasing level of sustainability within the entire park landscape system.

3.2 Sensitivity analysis

Performing sensitivity analysis on emergy data is necessary because it helps us evaluate and understand the extent to which data influences the results. Here are some important reasons for conducting sensitivity analysis on emergy data:

1. Validate model accuracy: Sensitivity analysis on different data values allows us to validate the accuracy and reliability of the model. If the model is highly sensitive to changes in input data, it may require a reevaluation and improvement of the model's structure and assumptions.

2. Identify key factors: Sensitivity analysis helps us determine which data factors have the greatest impact on the results. This aids in identifying and focusing on key factors and formulating corresponding management and decision-making strategies.

3. Assess decision risks: By understanding the influence of different data values on the results, we can assess the risks and uncertainties associated with decision-making. If the results are highly sensitive to specific data values, more data collection and accuracy are needed to support the decision-making process.

4. Support decision-making: Sensitivity analysis provides a range of results based on different data values, enabling decision-makers to assess the merits and feasibility of different options. This facilitates comprehensive decision-making and the selection of the most suitable approach.

Figure 3 illustrates the sensitivity trends of the three indicators.

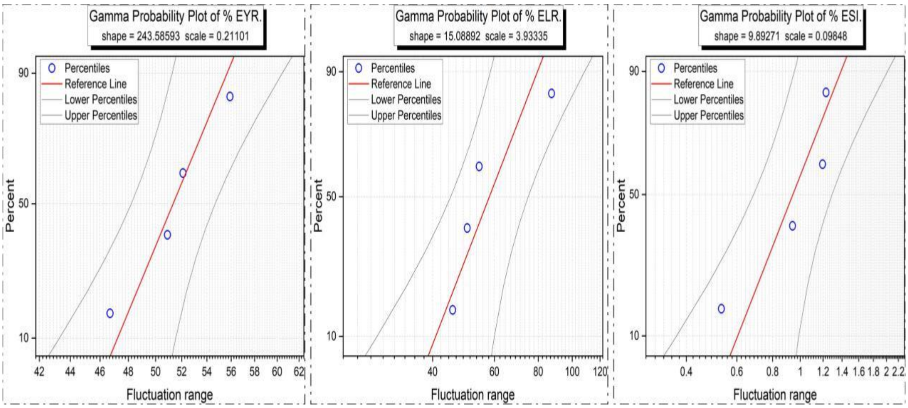

Fig. 3. the sensitivity analysis(self-draw)

Figure 3 represents the sensitivity analysis of the three indicators, with EYR showing a more linear trend in its changes, while ELR and ESI exhibit larger fluctuations. As ESI is calculated based on EYR and ELR, the variability in ELR directly influences the noticeable variations in ESI.

In conclusion, sensitivity analysis on emergy data is an important tool for evaluating model accuracy, identifying key factors, assessing decision risks, and supporting decision-making. It reveals the degree of data influence on the results, thereby enhancing the reliability and effectiveness of decision-making.

4 Conclusions

The design of pocket parks has played a positive role in mitigating the urban heat island effect in Shenyang City while enhancing recreational facilities for residents. From an ecological sustainability perspective, the longer the operational period of the pocket park, the higher its sustainable value. This study provides new insights for urban managers.

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