

# Evaluation and Optimization Model of Green Space Ecosystem Services in Urbanization Process

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**Abstract:** In the rapidly advancing wave of urbanization in China, a series of urban environmental problems have gradually surfaced, seriously threatening the quality of life of residents and the sustainable development of cities. In this context, the importance of urban green space ecosystems as the "lungs of the city" is increasingly prominent. Green spaces not only effectively absorb pollutants from the air, regulate urban microclimate, and alleviate the heat island effect, but also provide valuable leisure space and spiritual comfort for urban residents, playing an irreplaceable role in improving citizens' well-being and beautifying urban landscapes. This article explores in depth the evaluation methods of green space ecosystem services in the process of urbanization, aiming to comprehensively analyze the service functions and values of green space systems in various aspects such as air purification, climate regulation, biodiversity conservation, leisure and entertainment, and cultural education through scientific quantitative methods. At the same time, this article also constructs an optimization model for green space ecosystem services, aiming to guide urban planners and managers on how to scientifically layout green space systems, achieve maximum utilization and rational allocation of green space resources.

**Keywords:** Urbanization process, Green space ecosystem services, Evaluation and optimization.

## 1. Introduction

With the rapid development of local economies and the continuous improvement of people's living standards, the process of urbanization is advancing at an unprecedented speed [1]. During this process, a large amount of natural land is converted into construction land, and natural ecosystems such as forests and wetlands are constantly compressed, leading to serious degradation of ecological service functions. Environmental problems such as air pollution, water pollution, soil pollution, and noise pollution are becoming increasingly serious, which not only damages the physical health of urban residents, but also reduces the overall livability of cities [2]. In addition, urbanization exacerbates the heat island effect, alters local climate, and poses a serious threat to biodiversity [3]. In this context, how to balance economic development and ecological environment protection has become a difficult problem facing us. The urban green space ecosystem, as an important component of the urban ecosystem, has become the key to solving this problem with its unique ecological benefits, economic and social benefits, and landscape beautification benefits [4].

Urban green spaces, in short, are areas in a city that maintain or restore natural landscapes. They are like the green lungs of a city, providing valuable ecological services for the city [5]. The green space ecosystem can not only absorb pollutants from the air, purify air quality, but also regulate urban microclimate, alleviate the heat island effect, and improve urban thermal environment [6]. Meanwhile, green spaces are also important carriers of biodiversity, providing habitats and breeding grounds for numerous animals and plants, and maintaining the balance and stability of ecosystems [7]. More importantly, urban green spaces, as the "neighboring nature" in urban space, provide excellent places for urban residents to get close to nature, relax and socialize [8]. In the fast-paced urban life, people often bear enormous work and life pressures, and green spaces provide them with a space to relax and relieve stress. Strolling, resting,

exercising or engaging in cultural and recreational activities in green spaces can not only enhance people's physical health, but also promote mental health and enhance their sense of happiness in life.

In addition, green spaces are also an important carrier of urban culture. By hosting various cultural festivals, art exhibitions, etc., they enrich the spiritual and cultural life of citizens, enhance community cohesion and cultural identity. Given the important role of urban green space ecosystems in improving citizens' well-being, beautifying the urban environment, and promoting ecological civilization construction, the evaluation and optimization of their service functions are particularly important. However, current research on urban green space ecosystem services is still in its infancy, with incomplete evaluation methods and a lack of systematic optimization strategies. Therefore, this article aims to explore in depth the evaluation methods of green space ecosystem services in the process of urbanization, construct a scientific and reasonable evaluation system, and comprehensively analyze the service functions and values of green space systems in various aspects such as air purification, climate regulation, biodiversity protection, leisure and entertainment, and cultural education. At the same time, this article also constructs an optimization model for green space ecosystem services, providing scientific guidance for urban planners and managers, promoting the scientific layout and rational allocation of urban green space systems, and achieving the maximum utilization and sustainable development of green space resources.

## 2. Assessment of Green Space Ecosystem Services

### 2.1. Evaluation Content

The in-depth assessment of green space ecosystem services also covers multiple dimensions such as ecological landscape beautification, cultural education, and psychological health promotion [9]. In terms of ecological landscape beautification,

green spaces, as green patches in cities, not only enhance the visual beauty of the city, but also enhance its recognition and sense of belonging, which is crucial for shaping livable environments [10]. In terms of cultural and educational functions, green spaces are often display windows that combine urban history, culture, and natural ecology. By organizing various ecological education activities, they promote public awareness and respect for the natural environment, and cultivate environmental awareness. In addition, green space ecosystems play an undeniable role in promoting mental health.

Research has shown that exposure to natural environments can effectively alleviate stress, reduce anxiety and depression, and improve residents' mental health. Urban green spaces provide people with a peaceful space to escape the hustle and bustle and get close to nature, which helps to restore energy, promote mental health and social harmony. In summary, the assessment of green space ecosystem services is a multidimensional and comprehensive process that not only focuses on the direct improvement of the physical environment by green spaces, such as climate regulation and air purification, but also profoundly affects the spiritual and cultural life and mental health of urban residents. It is an important cornerstone for building ecological civilization and achieving sustainable development.

## 2.2. Evaluation Method

Habitat quality, as an important indicator of biodiversity maintenance capacity, profoundly reveals the key role played by ecosystems in conserving genetic diversity, species richness, and ecological complexity, which is a cornerstone of many ecosystem service functions. The habitat quality module in the InVEST model cleverly links land use data with various potential threat sources, comprehensively evaluates and maps the distribution status and degradation degree of habitats under different landscape configurations based on the sensitivity and resistance of different habitat types to specific threat sources. This process not only finely depicts the health status of regional habitats, but also intuitively reflects the richness and urgency of biodiversity conservation in the region through the quantified calculation of habitat quality indices and scarcity assessments.

$$D_{xj} = \sum_{r=1}^R \sum_{y=1}^{Y_r} \left( \frac{w_r}{\sum_{r=1}^R w_r} \right) r_y i_{rxy} \beta_x s_{jr} \quad (1)$$

$$i_{rxy} = 1 - \left( \frac{d_{xy}}{d_{r\max}} \right)$$

In the formula,  $D_{xj}$  represents the degree of habitat degradation,  $r$  is the threat source of the habitat,  $y$  is the grid in threat source  $r$ ,  $d_{xy}$  is the distance between grid  $x$  (habitat) and grid  $y$  (threat source), and  $d_{r\max}$  is the impact range of threat source  $r$ .

Urban green spaces play an indispensable and positive role in promoting the achievement of China's "dual carbon goals" (i.e. carbon peak and carbon neutrality). For the quantitative evaluation of its carbon sequestration function, we adopted a scientifically rigorous carbon sequestration rate method, which accurately calculates the carbon sequestration amount of urban green space ecosystems through specific formulas, as follows:

$$Q_{tCO_2} = \frac{M_{CO_2}}{M_{O_2}} \times FCS \quad (2)$$

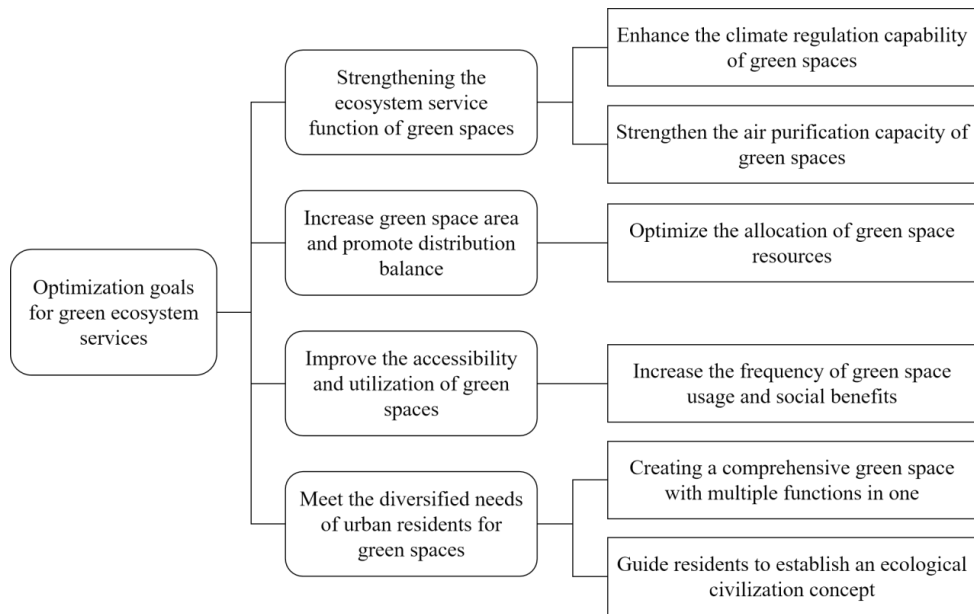
$$FCS = FCSR \times SF \times (1 + \beta) \quad (3)$$

In the formula,  $Q_{tCO_2}$  represents the total carbon sequestration of terrestrial ecosystems;  $FCS$  is the carbon sequestration capacity of forests and shrubs;  $M_{CO_2} / M_{O_2} = 44/12$ , The coefficient for converting  $C$  to  $CO_2$ ;  $FCSR$  is the carbon sequestration rate of forests and shrubs;  $SF$  represents the area of forests and shrubs;  $\beta$  is the carbon sequestration coefficient of forest and shrub soils.

## 3. Optimization Model for Green Space Ecosystem Services

### 3.1. Optimization Objectives

The goal of optimizing green space ecosystem services is to comprehensively improve the quality of urban ecological environment and build a more livable and sustainable urban space (as shown in Figure 1). Firstly, strengthening the ecosystem service function of green spaces is its core essence. Through scientific planning and rational layout, the aim is to significantly enhance the climate regulation capacity of green spaces, including mitigating the urban heat island effect, increasing air humidity, regulating microclimate, etc., to bring a more pleasant living environment to the city. At the same time, strengthening the air purification capacity of green spaces, utilizing the photosynthesis and adsorption of plants, effectively reducing the concentration of pollutants in the air, such as PM2.5, sulfur dioxide and other harmful substances, improving air quality, and ensuring the health of residents. Secondly, increasing green space area and promoting distribution balance are also key factors. This means that in the process of urban development, it is necessary to continuously optimize the allocation of green space resources, ensure a steady increase in green space area, and achieve a balanced distribution of green space in various regions of the city as much as possible. This can not only improve the overall greening level of the city, but also enable more residents to enjoy the convenience and benefits of green spaces, enhancing the ecological resilience and sustainable development capacity of the city.

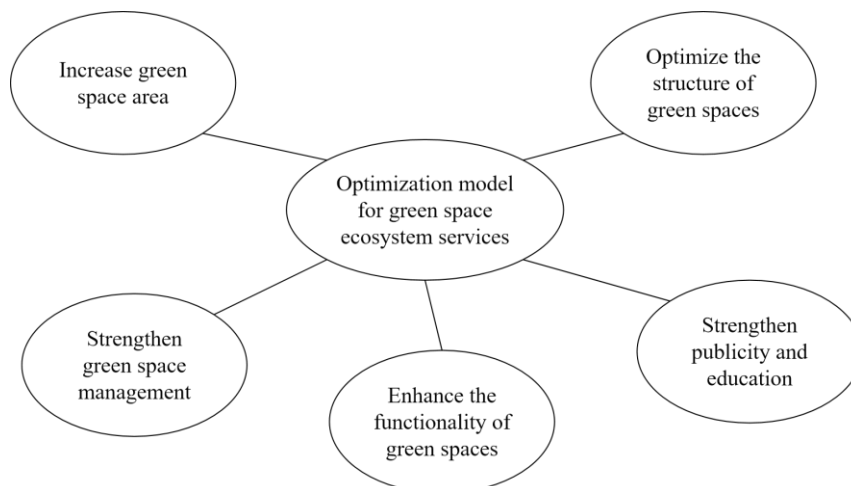


**Figure 1.** Objectives of green space ecosystem service optimization

Furthermore, improving the accessibility and utilization of green spaces is an important direction for optimizing services. By improving the transportation facilities around the green space, adding entrances and channels, etc., the time cost and spatial barriers for residents to reach the green space can be reduced, making the green space closer to people's lives. At the same time, encourage the multifunctional design of green spaces, such as incorporating elements of fitness facilities, children's play areas, cultural exhibitions, etc., to meet the diverse needs of different age groups and interest groups, and improve the frequency of green space use and social benefits. Finally, meeting the diverse needs of urban residents for green spaces is also an important component of optimization goals. This requires us to fully consider the actual needs and psychological expectations of residents when planning and designing green spaces, and create a comprehensive green space that integrates various functions such as leisure and entertainment, education and science popularization, and cultural inheritance. By organizing various activities, setting up promotional display boards, and conducting ecological education, we guide residents to establish an ecological civilization concept, enhance environmental awareness, and jointly safeguard the green home of the city.

### 3.2. Optimization Strategy

In practical applications, the optimization model of green space ecosystem services has become a key tool to guide urban green space planning and management. The model integrates the essence of optimization strategy and assessment results, aiming to achieve efficient allocation and sustainable use of green space resources (as shown in Figure 2). Firstly, the model emphasizes the effective increase of urban green space area through greening renovation, rational land reconstruction, and careful layout, in order to give the city more green coats. This not only expands the ecological space, but also provides more habitats for biodiversity and enhances the self-regulation ability of urban ecosystems. Secondly, optimizing the structure of green spaces is one of the core components of the model. By constructing a multi-level and multi type green ecosystem structure, such as forests, lawns, wetlands, etc., not only does it enrich the urban landscape, but it also significantly enhances the stability and resilience of the green ecosystem. This diversity helps to cope with extreme weather and natural disasters, ensuring the long-term health of urban ecological environments.



**Figure 2.** Optimization model for green space ecosystem services

At the same time, the model focuses on strengthening green space management. By increasing investment and optimizing

manpower allocation, ensure that every green space can be scientifically and finely managed and maintained. This

includes measures such as regular pruning, pest control, and soil improvement to maintain the good condition and ecological function of green spaces. In addition, enhancing the functionality of green spaces is also an important aspect of the model. By adding service facilities and opening up leisure activity areas such as fitness equipment, children's play areas, cultural exhibition areas, etc., green spaces can not only meet ecological needs but also fully satisfy residents' leisure, entertainment, and educational needs. Finally, the model emphasizes strengthening publicity and education. By organizing various activities, releasing promotional materials, and conducting ecological education, we aim to raise public awareness of the value of green space ecosystem services and stimulate everyone's consciousness and enthusiasm for protecting green spaces. Only when the whole society participates in green space protection can our city become greener and more livable.

#### 4. Conclusions

The urban green space ecosystem is not only the cornerstone of urban natural ecology, but also a key factor in improving residents' quality of life and promoting ecological and cultural prosperity. Through in-depth research in this article, we not only revealed the diversity and importance of ecosystem services in green spaces, but also conducted comprehensive and in-depth quantitative analysis using scientific evaluation methods, providing a solid theoretical basis for urban green development. More importantly, the green space ecosystem service optimization model proposed in this article provides direction for urban planning and management work. This model not only emphasizes the increase of green space area and the optimization of structure, but also pays attention to the improvement of green space management level and the expansion of functionality, aiming at achieving the efficient utilization and sustainable development of green space resources. Through the practical application of this model, we are expected to see a greener, more livable, and harmonious urban future, making green ecosystems truly the green engine of urban development and the source of people's happiness.

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