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The Influence of Blue-green Space Design on Carbon Cycle and Climate Regulation of Urban Public Space

Peiyun Bie[1], Hanhan Zhou[1,2]*

[1]College of Tourism and Landscape Architecture, Guilin University of Technology, Guilin 541004, Guangxi, China

[2]Institute of Guangxi Tourism Industry, Guilin 541004, Guangxi, China

ABSTRACT

The rapid development of urbanization intensifies the climate change. As an ecological unit in urban public areas, blue-green space has unique value for carbon cycle and climate regulation. In this paper, the effects of blue-green space on carbon fixation and emission reduction, heat island effect mitigation and carbon sink function enhancement are analyzed, and the main mechanism of its climate regulation efficiency is discussed. This paper proposes the methods of optimizing the functional layout, enriching the ecological diversity and applying the intelligent monitoring technology to enhance the comprehensive ecological benefits of blue-green space. The results show that the scientific design of blue-green space can significantly reduce carbon dioxide concentration, improve the resilience of urban ecology, and provide support for low-carbon development.

KEYWORDS

blue-green space; carbon cycle; climate regulation; urban ecology

Urban expansion has promoted the social and economic development, but the accompanying high carbon emissions and climate imbalance also pose serious threats to the ecosystem. As an important part of urban ecology, blue-green space not only has the function of carbon sink, but also can effectively alleviate the thermal environment by adjusting local climate conditions. Studying the mechanisms and optimization strategies of blue-green space for carbon cycle and climate regulation can effectively deal with the problems of urbanization and climate change.

1 The Influence of Blue-green Space Design on Carbon Cycle and Climate Regulation of Urban Public Space

1.1 Reduce Carbon Dioxide Concentration in the Atmosphere through the Carbon Fixation Function of Vegetation in Blue-green Space

The blue-green space design can significantly reduce the carbon content in the air by capturing carbon dioxide from the atmosphere and fixing it in the organic matter in the plants through the photosynthesis of vegetation. In this process, the types, densities and distribution patterns of plants directly determine the efficiency of carbon fixation. Trees play a key role in carbon storage because of their large canopies and long life cycles. Shrubs and grasslands are characterized by rapid carbon absorption and soil stability, and form a multilevel cooperative vegetation ecosystem. The diversified combination and layout improves the carbon fixation capacity of blue-green space and strengthens the regulation function of urban microclimate.

In terms of spatial structure, the innovative design of blue-green space further expands the carbon absorption capacity of vegetation. The vertical greening system realizes the three-dimensional utilization of urban space by covering the vegetation on building facades and roofs, and makes up for the shortage of plane green space resources. Because of the relatively continuous ecosystem, the continuous large areas of green space constitute the stable core of carbon cycle [1]. This diversified layout distributes the carbon pressure caused by anthropogenic emissions and also structurally promotes the efficient operation of the carbon cycle among the atmosphere, soil and organisms.

1.2 Alleviate the Urban Heat Island Effect through the Evaporation Cooling of Water Bodies in Blue-green Space

The water bodies in the blue-green space rapidly absorbs the heat in the environment through evaporation to form a local cooling effect. It alleviates the heat island phenomenon caused by the dense buildings and the heat storage on road surfaces, and creates a relatively cool micro-environment in urban public space. The distribution breadth and the form diversity of water bodies determine the influence range in local cooling. Various forms of water body design, such as fountains, small wetlands and artificial lakes, create distinct levels of climate regulation functions through different degrees of evaporation.

The moisture released in the evaporation process increases the water vapor content in the air and changes the dynamic balance of the local microclimate. This moist environment improves the moisture retention of soils and provides favorable conditions for plant growth. Especially in the blue-green space where vegetation and water are closely intertwined, the moisture further enhances photosynthesis in plants and stabilizes the regional carbon cycle. In conclusion, in urban areas with high carbon emissions, the synergistic effect of water bodies and vegetation provides important support for alleviating the contradiction between carbon accumulation and high temperature.

1.3 Improve the Carbon Sink Capacity and Climate Regulation Efficiency of Cities through the Scientific Planning and Scale Control of Blue-green Space

Through the fine allocation of vegetation and water resources in blue-green space, a multi-functional collaborative ecosystem can be built to enhance the carbon sink potential of urban public space. Reasonable spatial layout pays attention to the ecological connection between vegetation and water bodies to avoid the repetition of a single function or the imbalance of resource distribution [2]. Through the analysis of carbon emission intensity and environmental carrying capacity of a region, the allocation of vegetation and water bodies is accurately matched to the most needed areas, thus optimizing the ecological efficiency of blue-green space. The types and distributions of vegetation, as well as the shapes and scales of water bodies, are taken into account in the form of dynamic parameters in the planning, so that the carbon cycle efficiency is systematically improved.

2 Strategies to Enhance the Impact of Blue-green Space Design on Carbon Cycle and Climate Regulation in Urban Public Space

2.1 Optimize the Functional Layout of Blue-green Space to Give Full Play to its Role in Carbon Cycle and Climate Regulation

The functional layout of blue-green space can be optimized through scientific planning. And taking the precise allocation of different ecological units as the breakthrough point, the role of blue-green space in urban carbon cycle and climate regulation can be improved. In the planning process, it is necessary to comprehensively consider the population density, carbon emission level and microclimate characteristics of the region, and prioritize the areas with the high emission and severe heat island effect into the core scope of blue-green space layout. Based on the systematic analysis of air flow passages and heat distributions, it is found that the rational allocation of green space and water bodies is the key step, and the synergistic effect of the two should be integrated into the design to realize the effective connection of carbon absorption and heat regulation functions.

Function partitioning is a practical strategy to optimize the layout of blue-green space. According to the different requirements of carbon cycle and climate regulation, a region can be divided into the carbon sink core area, climate buffer area and biodiversity support area. In the carbon sink core area, tree species with high-efficient carbon fixation are the main body, and the carbon absorption capacity can be optimized through the intensive planting of them. The climate buffer area focuses on integrating water and wetland elements to alleviate the local thermal stress through evaporation cooling and humidity regulation [3]. The dynamic adjustment of function partitioning should be combined with the actual situation of urban land resources to ensure the efficient use of space, thus flexibly responding to new demands brought by environmental changes.

The layout of blue-green space also needs to fully consider the integration with the surrounding buildings and infrastructure. Vertical greening covers the building facade with vegetation, the green roof expands the contact surface of the green ecosystem, and rain gardens give the blue-green space new ecological functions by regulating runoff. These design patterns extend the blue-green space from the ground surface to the three-dimensional space, so as to significantly expand the coverage of carbon absorption and climate regulation.

2.2 Introduce Diverse Vegetation and Water Elements to Enhance the Resilience of the Ecosystem

The blue-green space design emphasizes the diversified allocation of vegetation and water bodies to enhance the functional coordination and environmental adaptability of the ecosystem. Vegetation selection should give priority to local tree species and species with strong weather resistance, which can not only conform to regional ecological characteristics, but also reduce the need for manual intervention. Through the mixed planting of trees, shrubs and grasslands, multifunctional vegetation communities can be formed. Trees have the high carbon storage potential and are suitable for long-term carbon fixation. Shrubs and grasslands can enhance the dynamic balance of short-term carbon cycle through rapid growth and efficient absorption. Wetland plants, floating plants and emergent plants can be introduced into water body design to further optimize water purification and heat absorption functions and enrich biodiversity.

The vegetation structure should be multi-level designed to build a vertical distributed ecosystem, through low ground cover plants, mid-level shrubs and tall trees. This three-dimensional design maximizes the carbon absorption capacity of vegetation and reduces the heat island effect by reducing exposed surface areas. For the treatment of water elements, ecological buffer zones, such as wetlands or ecological embankments, can be designed in combination with the specific functional positioning of blue -green space to further improve the efficiency of water bodies in the carbon cycle [4].

In the implementation process of design, it is necessary to pay attention to the synergistic effect of vegetation and water bodies. For example, planting wetland-friendly trees and shrubs around water bodies can not only contribute to carbon fixation, but also optimize local humidity and temperature through evapotranspiration. In addition, the combination of water bodies and vegetation can form a natural ecological buffer zone, which can make the carbon cycle system more efficient and stable. In order to adapt to the change of environmental conditions, it is necessary to continuously monitor the design of blue-green space and dynamically adjust the configuration strategy to maintain the stable operation of the ecosystem and efficiently play the regulatory function of blue-green space.

2.3 Apply Intelligent Monitoring Technology to Dynamically Evaluate the Comprehensive Benefits of Blue-green Space

The blue-green space design introduces intelligent monitoring technology to provide a systematic tool for the dynamic assessment of carbon cycle and climate regulation. IoT sensor networks should be installed to collect multi-dimensional environmental parameters such as carbon dioxide concentration, air temperature and humidity, and soil quality in real time. The distribution density and type of sensors should be customized according to spatial characteristics. For example, it focuses on collecting carbon absorption data in areas with high vegetation cover, and the changes in evaporation and humidity around water bodies. This high frequency and high precision data acquisition method provides solid data information support for the scientific evaluation.

The combination of geographic information system (GIS) and remote sensing technology makes the spatial visualization of monitoring data possible. In the process of 3D ecological modeling of blue-green space, the real-time data input and simulation algorithm work together to build a complete model covering vegetation growth dynamics and water heat exchanges. Based on this model, the artificial intelligence algorithm can accurately analyze the future carbon absorption efficiency and climate regulation potential, and find the weak links in the layout [5].

In addition to data collection and analysis, intelligent monitoring technology also needs to be deeply integrated with the management system to form a closed-loop feedback mechanism. For example, when the monitoring data shows that the evaporation of the water body is too high, the operation mode of the water spraying equipment can be adjusted immediately to balance the humidity. And when the carbon absorption capacity of vegetation decreases, a replanting plan should be initiated and efficient species should be preferentially selected.

3 Conclusion

The fine and multi-functional design of blue-green space has far-reaching significance for carbon cycle and climate regulation. The integration of scientific and reasonable layout and various ecological elements can effectively enhance the ecological service efficiency of blue-green space, and the introduction of intelligent monitoring technology can help blue-green space maintain ecological advantages in dynamic changes. The research reveals that the optimization of blue-green space design is not only related to the stable operation of urban ecosystem, but also directly affects the construction of low-carbon cities and the practical path of sustainable development in the future. Promoting the comprehensive and systematic design of blue-green space will become an important direction to cope with the urbanization and climate challenges.

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About the Author

Peiyun Bie (2004.04-), Female, Han, Shijiazhuang, Hebei, Undergraduate Student, College of Tourism and Landscape Architecture, Guilin

University of Technology, Research Fields: Landscape Architecture Planning and Design.
*Corresponding Author: Hanhan Zhou (1990.06-), Female, Han, Guilin, Guangxi Zhuang Autonomous Region, Master, Lecturer, College of Tourism and Landscape Architecture, Institute of Guangxi Tourism Industry, Guilin University of Technology, Research Fields: Landscape Architecture Design and Theory.

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