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A Summary of Research Progress in Urban Green Infrastructure in China

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Abstract: *This paper clarifies the connotation of green infrastructure and its development, focusing on the current urban green infrastructure field: ecological research direction, green space system research direction, rain flood management research direction and greenway research direction, these research Although the direction is not the same, there is also a commonality: all reflect the connectivity of the green infrastructure. Finally, the progress of the green infrastructure research is preliminarily summarized, pointing out the lack of green infrastructure research in my country, and proposes future research prospects.*

Keywords: *green infrastructure; greenway; green space system; ecological pattern; rain flood management*

1. Introduction

Since the 18th National Congress of the Communist organization of China, the construction of ecological civilization has been included in the overall layout of national development. The 19th National Congress of the Communist organization of China has taken "adhering to the harmonious coexistence of man and nature" as the basic strategy of adhering to and developing socialism with Chinese characteristics in the new era, which provides a policy basis for promoting urban green infrastructure construction, improving people's well-being and building a high-quality living environment in the context of urban transformation.

The research and practice on urban green infrastructure construction in China is still in its infancy. This paper summarizes the connotation and development, research emphasis and analysis, problems and prospects of urban green infrastructure construction. Through research and sorting, the main problems and related research in the construction of green infrastructure in China are analyzed, and policy suggestions are provided for the future development of urban green infrastructure in China.

2. Connotation and development of green infrastructure

2.1 Connotation of green infrastructure

Urban green infrastructure (GI) refers to the natural or artificial green space network in and around the city[1], including not only forests, grasslands and farms, but also water areas, mines that can be restored or reclaimed, native land, etc. They are connected into a network space through corridors to provide natural landscape and ecosystem services for the city. The core of GI is that the natural environment determines the land use, Highlight the "life support" function of the natural environment, integrate community development into the nature, and establish a systematic ecological function network structure.

The new concept of green infrastructure comes from people's new understanding of sustainable land use and sustainable development. Green infrastructure construction is a major public investment. Reasonable layout can reduce the demand for gray infrastructure, save national public resource investment, reduce the sensitivity to natural disasters, and interconnected green infrastructure is beneficial to human health, wildlife breeding and social stability and development. The concept of green infrastructure was put forward to emphasize that green facilities are similar to roads and water and electricity pipe networks in nature, that is, a piece of green land can only be regarded as a water tank, and only on the basis of mutual connectivity can water tanks and pipes establish a water network

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from their own source, and can they really function as "infrastructure". A single green space without interconnection can only be regarded as a potential "part" or "part" of green infrastructure. Just like a water tank can not be called an infrastructure when it exists alone, many of its functions and values are suppressed and cannot be fully exerted. Only by truly completing the interconnection between natural areas within a certain scale, can a single "water tank" not be exhausted and the value of green infrastructure be fully exerted, These values are not only embodied in the scope of ecology and environment, but also have sociological, economic and aesthetic significance[2]. In a more micro specific context, it can refer to specific related engineering facilities or patches and corridors of green space, such as flood control system, water resource purification facilities, or a piece of secondary forest, or even a tree, green roof, which can be called green infrastructure.

2.2 Development of green infrastructure connotation

The United States has proposed the prototype of green infrastructure (GI) in its natural planning activities 150 years ago. Since 1960, with the continuous development of theories and methods of ecology, landscape ecology, landscape planning and other disciplines, scholars have further proposed the concepts of ecological network and ecological corridor, which has promoted the development of GI network structure research[3]. At the beginning of the 21st century, in order to improve urban biodiversity and other functions, some European countries promoted the practical application of green infrastructure in urban environmental planning[4]. International research on urban green infrastructure services focuses on cultural services, carbon fixation services, flood regulation, climate change and biodiversity protection.

In recent years, with the emphasis on urban ecological construction in China, a lot of research has been carried out on urban green infrastructure in China, mainly focusing on the identification and optimization of urban green infrastructure, ecological restoration design, ecological green belt delimitation, etc.

Urban green infrastructure is the main component of urban internal natural landscape and ecosystem, and also the main provider of urban ecosystem services. It plays a key "basic role" in urban ecology. However, research on urban green infrastructure and its ecosystem services is still relatively lacking at present[5].

3. Research focus and analysis of urban green infrastructure

The research focus of urban green infrastructure is mainly to coordinate the harmony between human beings and nature by using the comprehensive ecological network. There are different sub directions in its major research directions. At present, the more important sub directions are ecology, green space system, rain flood management and greenway. There are also corresponding studies in other non key directions, such as urbanization, regional scale, public participation, landscape services Urban rivers, etc.

3.1 Research on the ecological direction of urban green infrastructure

The theoretical research of GI in ecology is mainly based on landscape ecology to study how to apply the "patch", "ecological corridor", "matrix" and other theories in landscape ecology to green infrastructure research [6]. Generally, the "ecological performance" method in the field of ecology is used to build the minimum consumption distance model, plan the ecological buffer zone, and evaluate the ecological environment sensitivity of the region. At the same time, the minimum path is simulated according to GIS, and the human history ecological distribution is considered to build the network, then different factors are superimposed, and finally the GI based network ecological security pattern is built.

On the basis of theoretical research, scholars began to combine ecological theory with green infrastructure construction practice, adhere to the principle of ecological priority protection and sustainable development, solve the problem of habitat fragmentation in the process of rapid development, and build an ecological security pattern in rapid urbanization areas. However, there are also shortcomings. The research paper mainly focuses on qualitative analysis, and the quantitative analysis of ecological patches, green corridors and green space networks is insufficient[7-9].

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3.2 Research on urban green infrastructure in the direction of green space system

Urban green space system planning is one of the traditional areas of urban master planning. As a soft element of a city, green space system is of great significance for maintaining the urban ecological environment. In recent years, with the deepening of green infrastructure research, its theoretical and practical research in the field of green space system has become increasingly extensive. The main research content is to build an integrated green space system based on urban green infrastructure, and to study the method of applying green infrastructure to urban green space system planning[10].

Compared with gray infrastructure, green infrastructure has a variety of ecological functions, which can connect the urban fragmented green space network.[11]In recent years, the main research direction of scholars is to apply GI theory to green space system planning. In the construction of green space system, through calculating the landscape pattern index and viewing the patch connectivity, targeted green infrastructure construction can be carried out to form an overall green network model and form an ideal green space system structure. This integrated green space system based on GI is the development trend of green space system planning[12-13]. Because GI has environmental variability and biological connectivity, it can connect fragmented point green space into networked sheet green space, which is of great significance to the construction of urban and rural integrated green space system.

Scholars have made extensive exploration on how to apply GI to green space system planning, generally considering the following factors: the networking of green space connection, the connection between green spaces of different scales and the effective participation mechanism of green space planning.

3.3 Study on Urban Green Infrastructure in Rainwater and Flood Management

At present, urban rainwater and flood management facilities are mainly gray infrastructure, namely, reinforced cement pipes, hard roads, squares, etc. After a heavy rain or heavy rain, large cities often suffer from waterlogging. In recent years, more and more scholars have begun to pay attention to the role of urban green infrastructure in urban rainwater and flood management, mainly using its own dynamic regulation to conduct rainwater and flood management and transform the original gray infrastructure[14].

The GI based rainwater flood regulation mode generally starts with the construction of regional rainwater collection network nodes, mainly "green sponge", making full use of dynamic regulation, fully absorbing when there is more rainwater, and releasing and purifying stored rainwater when the rainfall is small.

It is also a cost saving and effective method to transform gray infrastructure into green infrastructure that can effectively regulate rainfall and flood. Generally, traditional drainage ditches and pipelines are planted ecologically in a low impact mode and connected with urban parks, residential green spaces, protective forests and other green infrastructures to form a rain flood regulation network, which is of great significance in the collection, release, regulation, storage, purification and comprehensive utilization of urban rainwater[16].

3.4 Research on urban green infrastructure in greenway direction

In China, attention has been paid to the practice of combining greenways with green infrastructure. Since the construction of greenways in the Pearl River Delta in 2010, a greenway network has been formed through community greenways, urban greenways and regional greenways to connect forests, farmland, wetlands with urban parks, rural parks, etc., thus forming a "dotted GI area - greenway connection system - regional GI core" model, an interconnected green infrastructure network, It is of great significance to improve the living standard of citizens[17-19].

4. Conclusion: Problems and prospects

4.1 Problems in current research

At present, domestic research on urban green infrastructure has made significant progress in theory and practice, but there are also some deficiencies.

(1) The concept of green infrastructure has not yet reached a general consensus, and it is often

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directly or indirectly referred to by the common definitions of Europe, America and other countries.

(2) The research on urban green infrastructure failed to better integrate the actual situation of domestic energy conservation and emission reduction, ecological civilization construction and other work, resulting in confusion in relevant research.

(3) The domestic understanding of the connotation and function of green infrastructure is not comprehensive enough, and the traditional model is still used in planning, design and implementation management. There is still a long way to go before green infrastructure can truly become the life support system of the city, drive urban renewal, and effectively guide the sustainable development of the city.

4.2 Prospect of urban green infrastructure research

Green infrastructure not only provides the concept of protection before development for non urbanized land resources, but also provides a set of operable methods for highly humanized urban built-up areas. As a green way to guide and drive urban renewal, green infrastructure construction is not only an active exploration based on urban problems and renewal demands, but also an important choice under the concept of green sustainable development in the 21st century.

In addition to ecology, green space system, rain and flood management, and greenways, the future research on urban green infrastructure will also become a trend in the combination of GI with current hot spots, such as rural urbanization, digital technology, and public participation.

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