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Research on the Application of Landscape Greening Maintenance Technology in Modern Urban Landscape

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Abstract: This paper discusses multiple aspects of modern landscape greening maintenance technology, including core elements such as smart irrigation, plant physiological monitoring, and ecological restoration, along with their synergistic effects. It also introduces the evolution characteristics, key maintenance points in different scenarios, intelligent management methods, and relevant case studies and benefit assessments. Additionally, it analyzes the challenges faced in technology promotion and proposes solutions

Keywords: Garden greening maintenance; Technology application; Intelligence

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1. Introduction

With the acceleration of urbanization, the importance of landscaping and maintenance technology is becoming increasingly prominent. The “Opinions on Promoting Green Development of Urban and Rural Construction” released in 2022 emphasizes the importance of ecological environment protection and sustainable development, which provides policy guidance for the development of landscaping and maintenance technology. Modern landscaping and maintenance technology has shifted from traditional extensive methods to intelligent and refined methods, covering core elements such as intelligent irrigation systems, plant physiological monitoring technology, and ecological restoration processes. At the same time, it also has its application characteristics in different scenarios, such as three-dimensional greening maintenance and road landscape belt maintenance. However, in the process of promoting this technology, it faces problems such as contradictions in institutional adaptability and obstacles to technological implementation. Measures such as establishing standardized regulations, improving talent training systems, and strengthening collaborative innovation between government, enterprises, and research institutions need to be taken to achieve harmonious development of urban ecology and landscape.

2. Composition of landscape greening maintenance technology system

2.1. Core elements of modern maintenance technology

Intelligent irrigation system is one of the key technologies for modern landscaping and maintenance. It can provide precise water supply according to the water demand of plants, improve water resource utilization efficiency, and reduce waste. Plant physiological monitoring technology can real-time understand the growth status of plants, including key physiological indicators such as nutrient absorption and photosynthesis, providing scientific basis for adjusting maintenance measures. The ecological restoration process targets the damaged ecological environment and restores its ecological functions through a series of technical means. These core elements work together, and the intelligent irrigation system provides suitable water conditions for plant growth, ensuring normal physiological activities of plants. The feedback from plant physiological monitoring technology can further optimize irrigation and other maintenance measures. At the same time, ecological restoration techniques improve the overall ecological environment, promote the long-term healthy growth of plants, and together constitute the core system of modern landscaping and maintenance technology.

2.2. Characteristics of technological system evolution

Traditional landscaping and maintenance techniques are often crude, relying mainly on manual experience and simple tools, lacking systematicity and precision. With the development of technology and the updating of concepts, modern landscaping and maintenance techniques have shown significant evolutionary characteristics [1]. On the one hand, the degree of mechanization continues to increase, and the application of various professional mechanical equipment greatly improves the efficiency and quality of maintenance work, such as automated pruning equipment, efficient irrigation systems, etc. On the other hand, information technology is gradually integrating into real-time monitoring of plant growth environment and status through sensors, the Internet of Things, and other means, providing data support for precise maintenance. At the same time, the concept of ecologicalization is increasingly prominent, emphasizing the adherence to ecological laws, the adoption of eco-friendly maintenance methods, and the promotion of harmonious coexistence between plants and the environment. These evolutionary features collectively drive the development of landscaping maintenance technology towards a more efficient, scientific, and sustainable direction [2].

3. Application scenarios of technology in urban landscape

3.1. Maintenance of public green space system

The maintenance of public green space systems, particularly three-dimensional greening in open areas like parks and squares, is of utmost importance for enhancing urban aesthetics and ecological balance. To ensure the healthy growth of diverse plants, irrigation schedules must be meticulously planned based on each plant's water requirements, while fertilization should be tailored to their specific nutrient needs. Pruning activities also need to be timed appropriately to align with the growth cycles of different species [3]. For climbing plants, regular inspections of their support structures are essential to prevent potential hazards. In the management of ground cover plants, maintaining soil fertility and moisture levels is crucial, as is the prompt removal of weeds to prevent them from competing with the ground cover for vital nutrients. When it comes to ornamental vegetation, pruning should not only follow aesthetic principles to create visually appealing shapes but also adhere to the natural growth patterns of the plants to foster robust health. Modern technology plays a significant role in this process. Soil moisture sensors and light intensity detectors are employed to continuously monitor the plants' growth environment. This real-time data allows for timely adjustments to maintenance practices, thereby significantly improving the efficiency and quality of maintenance efforts.

3.2. Maintenance of road landscape belt

The maintenance of road landscape belts is a multifaceted challenge that requires careful consideration of plant selection, irrigation management, and pollution control. Selecting stress-resistant plants is fundamental, as these species must withstand the harsh conditions of road environments, including extreme temperatures, drought, and high levels of pollutants. By choosing plants that are well-adapted to local conditions, we can significantly enhance their survival rate and overall growth quality, thereby ensuring the stability and longevity of the landscape. Optimizing irrigation in isolation zones is equally critical. A well-designed irrigation system that precisely controls the amount and frequency of water delivery based on the specific needs of different plants and seasonal variations not only ensures that plants receive adequate hydration but also minimizes water waste. Additionally, addressing traffic pollution is essential for maintaining the health and aesthetic appeal of road landscapes. Implementing measures such as installing dust nets and selecting plants with strong pollution-absorbing capabilities can effectively mitigate the impact of traffic exhaust and dust on plants [4]. These integrated strategies not only protect the ecological functions of the landscape but also enhance its visual appeal, contributing to a more sustainable and pleasant urban environment.

4. Intelligent maintenance management measures

4.1. Refined management mode

4.1.1. Data-driven decision-making system

In the realm of intelligent maintenance management, the data-driven decision-making system has become a cornerstone. Building a plant growth database based on the Internet of Things is fundamental to this approach. By strategically installing sensors on garden plants, real-time data on temperature, humidity, light intensity, and other environmental variables can be gathered [5]. These sensors continuously feed information into a centralized plant growth database, creating a comprehensive and dynamic record of each plant's growth conditions. Advanced data analysis techniques are then employed to explore and quantify the complex relationships between plant growth patterns and these environmental factors. This analytical process provides maintenance personnel with a robust scientific basis for making informed decisions. Furthermore, the system establishes a sophisticated pest and disease warning model. By integrating historical pest and disease data with real-time environmental data from the database, the model can predict the probability and potential trend of pest outbreaks. This enables early warnings and proactive measures to prevent or mitigate potential threats. Additionally, the maintenance demand prediction algorithm leverages data on plant growth stages and environmental conditions to forecast specific maintenance needs such as watering, fertilization, and pruning. This level of predictive capability allows for precise and timely maintenance activities, ultimately improving the overall efficiency and quality of the maintenance process.

4.1.2. Resource optimization and allocation plan

In intelligent maintenance management, a refined resource optimization and allocation plan is essential. A precise water and fertilizer supply model can be designed, which calculates and supplies water and fertilizer accurately by considering factors like plant species, growth stages, and soil fertility. This model helps to enhance the efficiency of resource utilization. Meanwhile, it's crucial to develop differentiated maintenance cycles and work intensity standards. These should take into account the growth characteristics of various plants, seasonal variations, and the significance of different landscape areas [6]. More refined maintenance should be given to key areas and special plants. Human and material resources should be arranged sensibly to prevent both excessive and insufficient maintenance. Through these approaches, scientific and efficient maintenance management can be realized, thereby improving the overall quality and landscape effect of urban landscaping.

4.2. Intelligent service platform

4.2.1. Mobile operation and maintenance management system

In the context of modern landscape and greening maintenance, developing a comprehensive mobile operation and maintenance management system is of paramount importance. This system, equipped with advanced GIS positioning capabilities, allows for the precise determination of each area's location within the garden [7]. This feature is crucial as it enables maintenance personnel to swiftly navigate to the designated spots, thereby significantly reducing response times and enhancing operational efficiency. The work order distribution function is another key component of this platform. It intelligently allocates tasks based on the urgency of maintenance needs and the availability of personnel, ensuring that resources are utilized optimally and that work is carried out in a timely manner. Additionally, the quality monitoring function plays a vital role in maintaining high standards. By enabling real-time monitoring of maintenance activities, it allows for the prompt identification of any issues and facilitates immediate corrective actions. This multifunctional platform not only integrates various essential features but also transforms the way landscaping maintenance is conducted. It makes the process more scientific, efficient, and precise, ultimately providing robust technical support for the upkeep of modern urban landscapes.

4.2.2. Public participation and interaction mechanism

Creating a citizen green supervision app and establishing a maintenance quality evaluation feedback system are important measures for public participation and interaction mechanisms. The Citizen Greening Supervision APP allows the public to easily participate in garden greening maintenance supervision. Users can upload discovered problems and related image information at any time, enabling maintenance management departments to obtain feedback and take measures in a timely manner. The maintenance quality evaluation feedback system evaluates maintenance work from multiple dimensions, including plant growth status, environmental hygiene, facility maintenance, and other aspects. The public can score and evaluate the maintenance quality through this system, and provide improvement suggestions. These measures not only increase public participation, but also promote the continuous optimization and improvement of maintenance management work, achieving the intelligence and efficiency of urban landscape maintenance [8].

5. Empirical study on technology application

5.1.Typical city case analysis

5.1.1. Beijing Olympic Park project

The study of Beijing Olympic Park, as a typical case of large-scale public green space, is of great significance. The park has integrated intelligent irrigation and ecological monitoring systems, achieving significant results. The intelligent irrigation system can provide precise water supply based on soil moisture, plant water demand characteristics, etc., which not only meets the growth needs of plants but also avoids water resource waste [9]. The ecological monitoring system can monitor indicators such as air quality, soil quality, and biodiversity in real time, providing scientific basis for the ecological management of the park. Through the integrated application of these technologies, Beijing Olympic Park has achieved efficient landscaping maintenance, improved landscape quality, and provided reference experience for the construction and management of large-scale public green spaces in other cities.

5.1.2. Shanghai century avenue renovation project

The economic benefits of the combination of anti-pollution plant configuration and mechanized maintenance equipment in the landscaping and greening maintenance of Shanghai Century Avenue renovation project were

evaluated. The reasonable allocation of anti-pollution plants in this project not only improves the landscape effect, but also reduces the impact of pollution on the environment to a certain extent [10]. At the same time, the introduction of advanced mechanized maintenance equipment has improved maintenance efficiency and reduced labor costs. Through comprehensive analysis, it is found that this combination application mode saves a lot of capital investment in the long run, and over time, the ecological benefits of plants gradually emerge, further improving the environmental quality and economic benefits of cities, providing useful references for the landscape renovation of other cities.

5.2. Comprehensive benefit evaluation system

5.2.1. Ecological benefit indicators

Carbon sequestration measurement is one of the important indicators for evaluating ecological benefits. By measuring the amount of carbon dioxide absorbed by photosynthesis in garden plants, their contribution to carbon reduction can be measured. The biodiversity index reflects the richness and stability of garden ecosystems. Considering various factors such as plant species and animal habitats, higher biodiversity means a healthier ecological environment. The degree of alleviation of the heat island effect reflects the improvement effect of landscaping on the urban thermal environment. By comparing the temperature differences between garden areas and surrounding non-garden areas, and analyzing their ability to regulate urban climate, the benefits of mitigating the heat island effect can be determined. These evaluation models comprehensively measure the ecological benefits brought by the application of landscaping maintenance technology from different perspectives.

5.2.2. Operation and maintenance cost model

Building a full lifecycle cost analysis framework requires comprehensive consideration of multiple aspects. Including initial technology investment costs, including the procurement of green plants, advanced maintenance equipment, etc. The operating cost of equipment is also an important part, such as water and electricity fees, equipment maintenance fees, etc. Personnel costs cannot be ignored, including maintenance personnel salaries, training expenses, etc. At the same time, material costs such as fertilizers, pesticides, and other supplies should also be considered. When quantifying the relationship between technology investment and maintenance benefits, it is necessary to compare the costs and benefits generated under different maintenance technologies. The benefits can be derived from ecological benefits, such as air purification, climate regulation, etc. Assess social benefits, such as improving urban aesthetics and resident satisfaction. By accurately quantifying these relationships, a basis can be provided for the rational selection and optimization of landscaping and maintenance technologies.

5.3. Analysis of obstacles to technology promotion

5.3.1. Institutional constraints

There is an adaptive contradiction between the existing municipal management system and the requirements of new technology applications. The municipal management system often has a certain degree of stability and conservatism, and its decision-making and implementation processes are relatively complex and slow. In terms of promoting landscaping and maintenance technologies, this system may not be able to respond promptly to the needs of new technology applications. For example, new technologies may require specific funding and equipment procurement, but the budget approval and resource allocation processes under the current system may hinder the fulfillment of these needs. At the same time, the personnel structure and professional competence within the system may also affect the application of new technologies. Some managers and staff may lack sufficient understanding and mastery of new technologies, making it difficult to effectively promote their application in practical maintenance work, thereby restricting the promotion and application effect of landscaping and

maintenance technologies in modern urban landscapes.

5.3.2. Technological transformation bottleneck

There are many obstacles and bottlenecks in the application of landscaping maintenance technology. In terms of equipment compatibility, maintenance equipment produced by different manufacturers may have differences in specifications, interfaces, etc., which may result in the inability to work together and affect maintenance efficiency. For example, some automated irrigation systems cannot be effectively integrated with fertilization equipment to achieve precise maintenance. The skill gap of personnel is also a key issue. Modern landscaping maintenance technology involves many advanced concepts and complex operations, such as data analysis of intelligent monitoring systems and scientific use of plant growth regulators. However, some maintenance personnel lack relevant knowledge and skill training, making it difficult for them to proficiently master and apply these technologies, thereby restricting the effective promotion and transformation of the technology and hindering its better role in modern urban landscapes.

6. Conclusion

In modern urban landscape construction, the maintenance technology of garden greening is crucial. It not only improves the quality of the landscape, but also relates to the improvement of the ecological environment and the sustainable development of the city. However, the current promotion of this technology faces issues such as regional differences and insufficient system integration. To address these issues, it is necessary to establish standardized technical regulations to ensure the scientific and standardized nature of maintenance work; Improve the talent cultivation system and provide professional talent support for the industry; Strengthen collaborative innovation between government and enterprises, integrate resources from all parties to promote technological progress. Meanwhile, looking ahead to the future, cutting-edge technologies such as digital twins and AI decision-making will bring new opportunities for landscaping and maintenance. Through the implementation of these measures, it is expected to improve the level of maintenance technology, promote its better application in urban landscapes, and achieve the harmonious development of urban ecology and landscape.

Disclosure statement

The author declares no conflict of interest.

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