

Establishment and Improvement of Urban Green Space Management System -----Taking Wuxi City as an Example

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Abstract: Taking the establishment and improvement of Wuxi urban green space management system as an example, this paper conducts informatization management of greening basic data based on actual situation, introduces the architecture, development goals, functions, maintenance and update, of urban green space management system, as well as its continuous improvement by daily work, and describes the new direction of urban greening industry management. Based on the conclusion of urban green space management system and the expectation, characteristics of urban green space management system are formed to finally meet the new requirements of digital real-time management of greening industry.

1. Introduction

In recent years, the urban landscaping in China develops rapidly, which is the only living infrastructure. Its management more important than its formation, and its management is specially dynamic. Traditional management of green space could not adapt to the current fine management requirement. Firstly, the information such as urban greening, ancient and famous trees, shade trees, and park green land is hard to be accurate; secondly, the data cannot be update in real time along with the increasing urban greening and higher density; thirdly, the establishment of new green land is more complex. Facilities of earthquake prevention and disaster reduction and ecological cleaning are required in the establishment and renovation of urban greening, which causes higher difficulty in its management. Traditional ledger cannot realize effective management because of the large data, updates and complexity, resulting the problems in data real-time update, accuracy of green land blocks and width of management.

People generally carry out information management of green land management systems on the basis of existing ledgers. There are two major problems in its establishment: one is the new green land patches are increasing along with the continuous advancement of urban construction; second is the increasing infrastructure and dynamically changing urban green space patches; third is the complex situation of urban green management from the institution to the management objects, the different management depth at all levels and the incomplete coverage. To establish the green space management system on the basis of improving the basic ledger will cause the long development time, the large investment, and the effect is often not ideal.

Geographic Information System (GIS) belongs to the category of spatial information system. It is a spatial information system that collects, stores, manages, and analyzes the regionally geographical distribution data. It is an emerging discipline along with the development of computer science, space science, earth science, mapping and remote sensing, information science and management science and other disciplines [1]. With the continuous development of GIS system, it has been applied to all aspects of urban management and people's lives. Urban green space management and GIS are integrated to establish a GIS green space management system integrating data storage, professional management and administrative management system, to achieve an all-round digital management of industry. It is currently at the exploration stage in China, however, it is a new direction for the management of the greening industry and a new breakthrough from planning,

design, construction to management in the urban greening industry.

Since the Ministry of Construction issued the Urban Garden Greening Evaluation Standard GB / T50563-2010 in 2010, various cities have successively researched and established urban green space management systems in accordance with the standard. Research on Digital Information Management System of Road Green Land in Jinan City by Du Xin and Wang Weixia introduces the digital information management system of road green land in Jinan City, including the query, statistics and analysis functions of road green space related information, which implements a more flexible and mobile dynamic management of the daily maintenance management of road green land [2]; Management Information System of Green Space Attached Urban Road in Kunming by Lu Renxing taking the main road of Kunming as the subject of investigation, makes use of modern digital photography technology to collect the relevant information and configuration models of road green space plants, and beautifies these by text and image processing software [3]; Xi'an Digitized Landscaping Management System Patterns by Wang Yiqun, Gan Laili and Wang Jie proposes a Xi'an digital gardening management system construction model with 3S technology as a platform, to provide first-class environmental management service system [4]; Design of Chongqing Urban Green Space Management System by Niu Qian and Zhou Tinggang designs the overall structure of Chongqing urban green space management system by ArcGIS Server, .Net 2005 and SQL Server2000, and adopts the digital green space concept to realize the green space query, green space management and green space statistics functions of Chongqing green land management system [5]; Software Developing Based on GeoServer of Garden Green Management Information System in Beijing City by Xia Zhenping, Zhao Xiuli and Zhou Yangyang is to develop corresponding functions based on WebGIS platform, using GeoServer technology to publish maps, and MySQL's spatial database technology, thus building a landscape information sharing platform [6].

Due to the complex types and large areas of urban green space, the management systems of Jinan and Kunming, starting from road green space, is the digital management of key green areas, focusing on the in-depth and demand of maintenance management. Whereas, the coverage of green space management is not comprehensive, and urban green planning, the construction and management process cannot be fully reflected; The green space management systems of Chongqing and Beijing cover all kinds of green spaces comprehensively, and have strong statistical and analytical capabilities for data. However, the management depth is insufficient and cannot fully cover and reflect the work of the landscaping department; The green space management system of Xi'an is comprehensive in terms of depth and breadth, but the research depth on the management authority setting is insufficient, and its integration with the management system is poor.

Combining the research characteristics of each city, the establishment of urban green space system should start from three aspects: first, the comprehensive coverage of various types of green land, convenient and flexible green land statistics, query, and analysis; second, combining urban green planning, construction, and management processes to cover the work of greening management department and improve the actual application function of the system; third, scientific design of the management authority according to the management system. Through the guidance of the urban green space management system, the garden landscape management enterprises and institutions at all levels of the city and all sectors of the society shall be regulated to carry out "horizontally wide and vertically deep" fine management, and become a management system with leadership decision-making, professional application, and public participation. Taking Wuxi City green space management system as an example, this paper analyzes its establishment and improvement process.

2. Purposes And Application Functions of Establishing Information System

According to the national garden city standard, combining with the actual situation of Wuxi landscape management, Wuxi green space management system aims to establish an interoperable, efficient and integrated landscape greening information management platform based on basic geographic information resources and information services, integrate data resources, speed up the informationization process of urban landscaping management and service work, improve

management capabilities, reduce management costs, enhance information utilization and update speed, and gradually make informationization, digitization, and networking the basic operation of landscaping management.

The system breaks the previous concept of complete basic ledger management, and establishes a dynamic management system that constantly improves the basic ledger via daily management work. It solves the three major problems in the establishment of urban green space management system. Firstly, rely on the satellite remote sensing images published by the planning bureau, and share its dynamic changes to urban green space patches to solve the problem of real-time data update; second, refine the basic ledger in the system by daily urban greening management, that is, guide the refinement of urban green space data from depth to breadth (depth refers to the refinement of the attributes of green land patches and breadth refers to the full coverage management of various urban green spaces) through the setting of the target requirements of urban greening management, and solve the accuracy of basic ledger green land patches and the breadth of management coverage. Wuxi green space management system continuously covers many aspects of urban landscaping, and accurately reflects all aspects of urban landscaping. It provides a scientific and objective basis for guiding urban landscaping work and for the future planning and development of urban landscaping.

At present, the green space in Wuxi City established has achieved the following functions and objectives: (1) use the secondary development of GIS, remote sensing mapping and other technologies to form a database that meets the requirements of urban landscaping management, and conduct management and maintenance; (2) manage and grasp the current status data to realize the dynamic update and maintenance of the green space data of the system; (3) realize the functions of querying, retrieving, and statistics of the current status of urban green space, corresponding to various types of green space indicators; (4) separate columns of ancient and famous trees, shade trees, etc. to optimize the visibility of this function; (5) provide the auxiliary decision-making function of special work on the creation of various basic data and indicators.

3. Architecture of Wuxi Green Space Management

Wuxi landscaping management system comprehensively manages multi-source, heterogeneous, multi-scale, multi-temporal basic terrain spatial data and remote sensing image data. It is data management and publishing platform with computer network as carrier and geographic information system (GIS) technology as platform. The system adopts C/S, B/S mode, with GIS and web-service technology as the core, combining ArcGIS RIA technology, to optimize the current information system management to achieve the system goals. The system is characterized by compatibility, expandability, practicality, safety and easy maintenance.

3.1. The Overall Operating Architecture

3.1.1. Operating Environment

Table 1 Operating environment.

No.	Categories	Name	Operating environment
1	Database server	Database platform	Oracle 11g
2		Spatial data engine	ArcSDE 10sp1
3	Application server	Spatial data publishing platform	ArcGIS Server 10 sp1
4		.NET framework	.NET FrameWork 3.5 sp1
5	WEB server	WEB server	IIS 7.5
6		.NET framework	.NET FrameWork 3.5 sp1
7	B/S client	Browser	IE7.0 and above/Firefox3.0 above

3.2. Operating Interface

3.2.1. B/S



Figure 1. Login interface.

The system provides two kinds of login users: administrator users and ordinary users. The administrator login can perform city-wide and district-wide data query statistics and modification, and set permissions and functions for the statistics, improvement, and reporting of urban green space data at two levels in the urban area; the ordinary users can only query the data in this area but cannot conduct statistics, which effectively matches the management scope of the city, district, street, and social units with the query data.



Figure 2. Main interface of system.

When log in as an administrator, the system modules include five modules: Green Land Coverage Area, Green Land Coverage Rate, Park Service Radius, Positioning Query, and Layer Control. The top is the shortcut menu. The functions of each part mainly include map display and simple map operations, such as zoom in, zoom out, pan, full map, previous view, next view, measuring distance, area and other map operations. The left side of page is each function module, and the right side is the map display form.

3.2.2. C/S

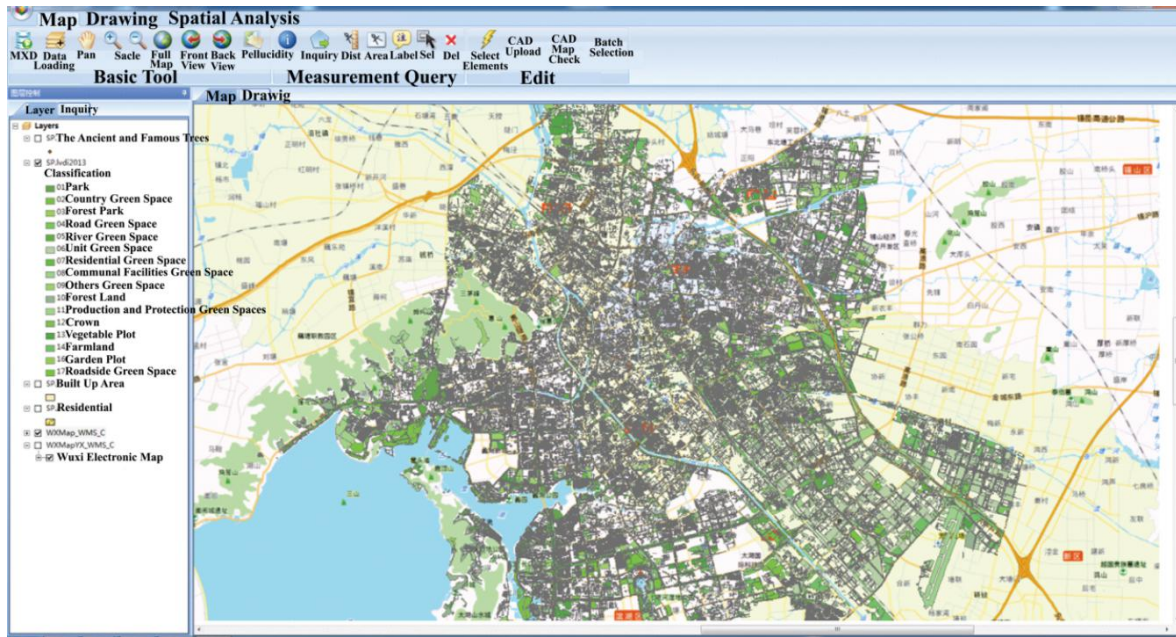


Figure 3. Main interface of system

The system includes Map Browsing, Map Drawing and Spatial Analysis modules. The top of the system is each functional module. Map Browsing includes zoom in, zoom out, pan, full picture, previous view, next view, measuring distance, area and other map operations; Map Drawing includes operations such as inserting a north arrow, scale, and exporting pictures; Spatial Analysis includes statistics of green space area, statistics of green space coverage, analysis of park service radius, and display of ancient and famous trees. The left side of the system is the layer control interface, and the right side is the map display form.

4. Data Management

4.1. Data of Green Land Patches

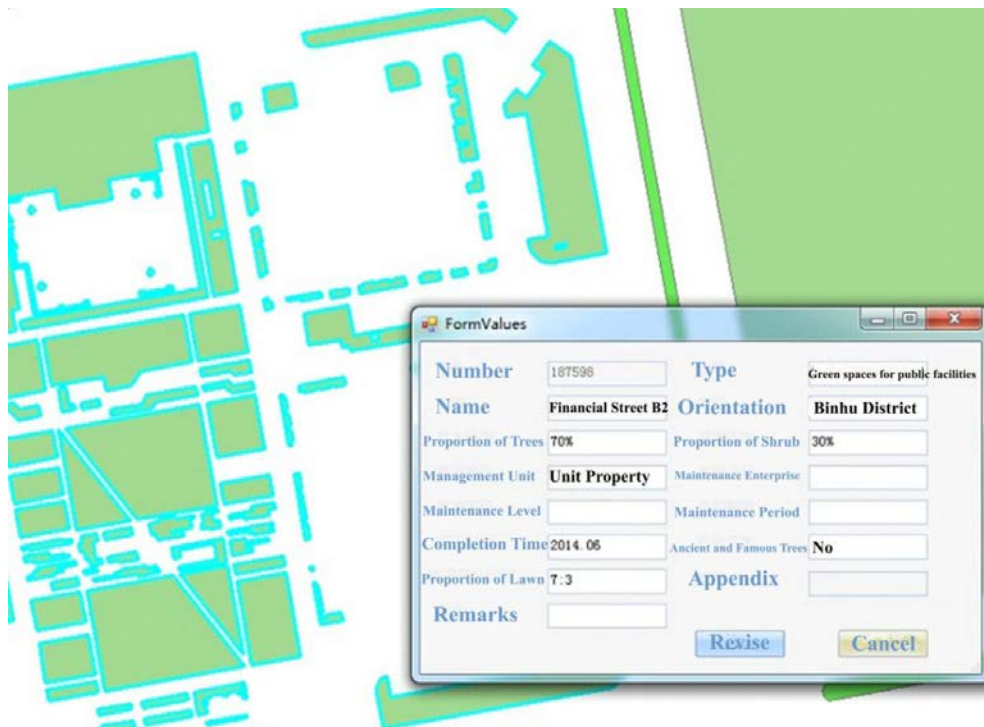


Figure 4. Data of Green Land Patches

The most important and core data source in the green space management system is the green land patches. Green land patches are digitally converted into GIS format data by remote sensing maps or green land census data. At present, the green land patches first rely on the layers published by the planning bureau to share their dynamic changes to the urban green land patches; secondly, the green land patches in the area are updated during the acceptance process of the urban greening construction project; thirdly, part of data are improved in daily management. Each green space patch is designed with corresponding attributes according to management needs. It is an independent image in urban green space management, including green space name, category, area, etc. These data are generated after inspection, and the data in GIS format is incorporated into the urban green space management system. These basic data constitute the Wuxi Green land database. The established green land database can be easily searched, and all data or related data can be statistically and analyzed to achieve qualitative or quantitative analysis of the data, providing basic information for scientific and accurate planning of green land.

4.2. Status (Planning) Land Use Vector Layer Data

According to the national garden city indicator requirements, the system can calculate the park green space service radius coverage rate, green land compliance rate of urban public facility and other indicators. It needs to use the current residential area land, public facility land, urban road land and other data. GIS overlay analysis of the green space data and these terrain data is conducted by spatial analysis model of the system to obtain the desired results. Further, overlay analysis of green space data and planned land use data can assist urban construction in a more scientific and reasonable direction.

4.3. Map

The map contains remote sensing map and section map with different image functions. With the increase of resolution, the remote sensing map can clearly distinguish the geographical environment we are familiar with, while ordinary section map can distinguish areas for easy search. These two maps have been combined to add road names and more important facilities on the remote sensing map. And the geographic location search system is added to query the required geographic information more efficiently.

4.4. Detailed Data of Themes



Figure 5. The ancient and famous trees management module.

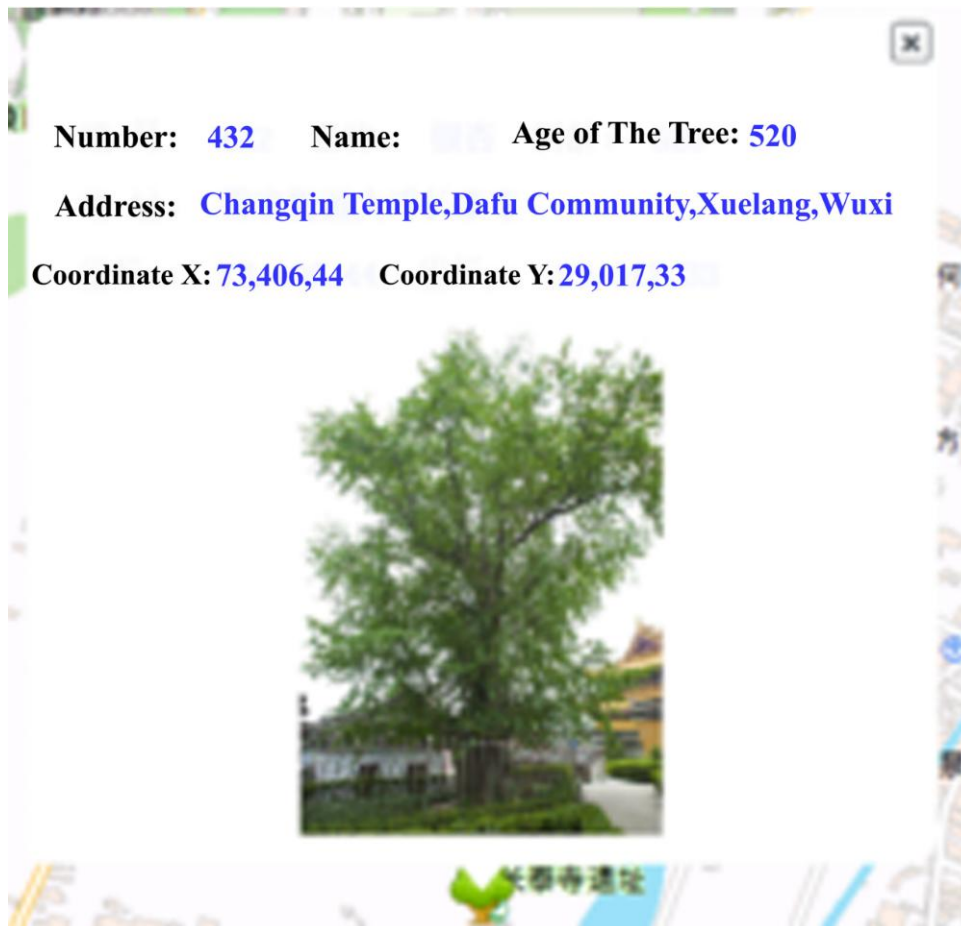


Figure 6. Every ancient and famous tree has its own image.

In urban greening management, some greening elements need to add some thematic modules according to demand. For example, the shade tree management module can display the shade tree type of a certain road with certain visual signs; the ancient and famous trees management module adopts certain beautiful icons (including certain audio and video, pictures and other data added to the attributes) by inputting the data and interfaces of the ancient and famous trees. Every ancient and famous tree has its own image, including number, name, age, address, coordinates, etc., and each ancient tree falls on the map in the form of an icon, which can reflect the distribution of ancient trees, making the interface more intuitive; the theme of city-managed green space maintenance, indicating the scope of city-managed green space, adding the unit, type, maintenance level, etc. of the green space maintenance as the attributes, which can intuitively show the city-managed green space maintenance; the theme of park green space, indicating the attributes such as the scope, area, and name of park green space, can facilitate the calculation of indicators and the construction of scientific decision-making. These themes can be added in time according to demand, ensuring the open and friendly data.

4.5. Data Updates

Due to the different sources of database data, the time nodes of each data are not necessarily the same, which shall be subdivided according to management. Remote sensing maps, topographic maps, etc., can be updated as needed on a periodic basis of 2-5 years due to the cost of updating or complicated updating. The status (planning) land vector layer data with relatively small changes can be updated as needed every 1 year or 2 years. The green patch attributes, detailed data of themes, etc., need to be updated in real time during management. According to the user characteristics of the landscape management system, the urban landscape management department is the administrative competent department that completes the work related to landscape, and its main responsibility is to conduct the construction, maintenance and management of various green areas, woodlands, parks,

scenic spots and nurseries in the city according to law relying on the coordination with other departments and social participation. Therefore, the attribute data of the green land patches can be dynamically updated in the management system to standardize the management according to the above management characteristics and the power of related departments.

5. Functions of System

5.1. Overview of Functions

The green land management system includes five functions.

5.1.1. Map Browsing

It includes zooming in, zooming out, measuring distance, measuring area, saving pictures, remote sensing map switching of topographic maps, etc. This function provides the greening management departments, maintenance units, and citizens at all levels with an instant and accurate browsing of the current status of the green land to understand the greening of various regions.

5.1.2. Information Query

Users can search for its specific attribute data, thematic data, map location query, etc. through green patch. This function provides the greening management departments and maintenance units at all levels with specific information on green land, reduce on-site survey work during greening management, administrative approval, etc., improve work efficiency and save a lot of time by querying information.

5.1.3. Management of Patches

The attributes of each green patch are designed and modified according to management needs (including thematic data), the CAD drawings of the new projects needed are uploaded to the green map layer, and the planning vector topographic maps and remote sensing maps, etc are updated.

Specifically, the attributes of patches provide the convenience for data maintenance and modification, to mainly realize the adding, editing and deleting function annotated by GIS attribute data to ensure the reality and accuracy of the database. One function is to add attribute data in the field and provide options according to the actual situation, including name, orientation (specific location), green coverage area (the actual area attribute of the patch), green area, green area nature, urban area, proportion of trees/shrub/lawn, management unit, maintenance enterprise, maintenance level, maintenance period, completion time, whether there are ancient and famous trees, ratio of evergreen/deciduous; the second function is to upload relevant documents, including completion drawings and materials, nursery stock lists, facility quantity lists, maintenance worksheets, administrative approval materials for greening changes, etc. This function not only satisfies the materials required for bidding, daily operations, and hierarchical management of green space maintenance, but also provides comprehensive drawings and data of current green space facilities and plants for administrative licensing.

In terms of fine management of patches, vectorized data in multiple formats can be accepted and converted. For example, CAD electronic completion drawings can be seamlessly input after simple processing, the original patches are refined, and the data particles are reduced through management to ensure the update and maintenance of electronic map data, and the more accurate statistics.

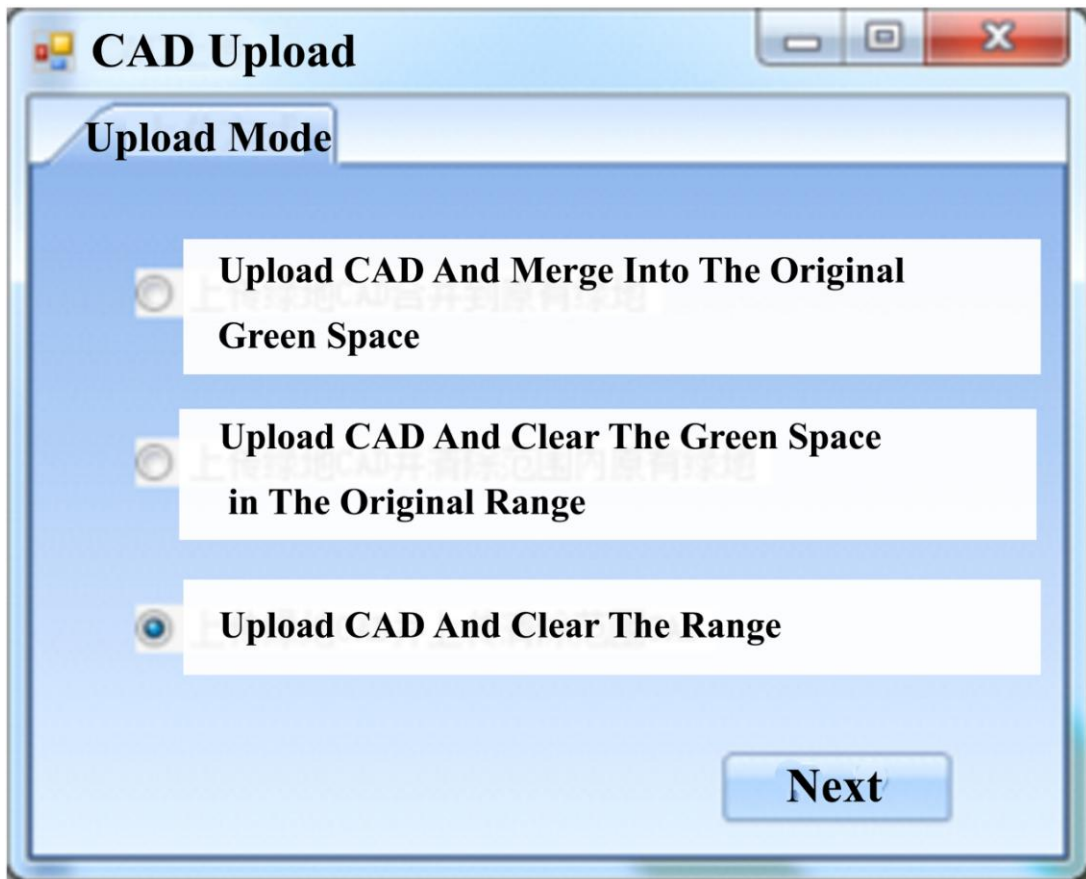


Figure 7. Uploading CAD files.

By uploading CAD files, CAD elements are added to the green map layer to update the changes in the green space construction process in a timely manner. It includes 3 uploading methods like “upload CAD and merge into the original green space”, “upload CAD and clear the green space in the original range” and “upload CAD and clear the range”. Operation steps: click “CAD Upload”, the form pops up, and set the upload attributes as needed. The main difference is that users need to check the original green space and new green space in the area. New green space is directly merged and uploaded. If it is a renovation project, users need to clear the green space in the range or upload a certain area and then clear it. This function provides survey drawings for the planning and design of urban greening, provides decision-making and design basis for greening changes, green land renovation and expansion projects, and is of great help to greening management departments, design and supervision departments.

5.1.4. Statistic Analysis of Data

It includes green space statistics, green area coverage statistics, park green space service radius coverage rate statistics, etc., including statistics by district, category, and custom field. This function directly replaces the urban greening census. By uploading materials for the completion and acceptance of greening project in the daily work of greening management departments at all levels, the statistical data in the patch attributes are updated in real time to keep the system data up to date. It plays an important role in urban greening statistical analysis, landscape city creation, urban greening planning, etc., and provides scientific decision-making basis for leaders and managers.

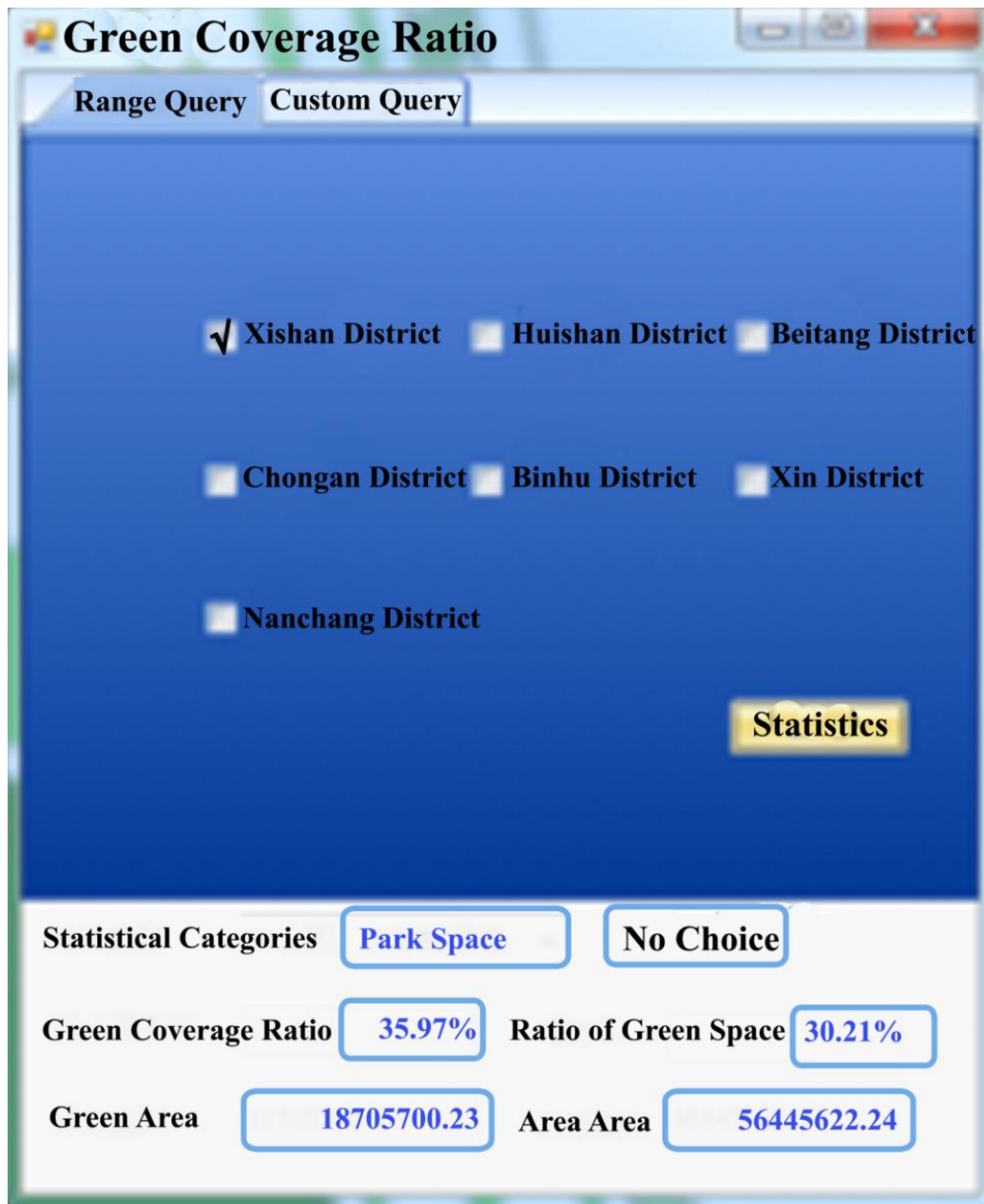


Figure 8. The green coverage statistics.

On the one hand, the green coverage statistics can query the green coverage of each area (or custom field). Operation steps: click the area to be counted (multiple options are supported), select the green space category to be included in statistics, and click Statistics to get the statistical results. In the "Custom Query Panel", click "Custom Field Query", and then draw the polygon range on the map as needed, double-click to finish, and obtain the green coverage within the polygon; users can also click "Input Range Query" in the "Custom Query Panel" to upload the CAD file of the statistical range. The main page will highlight the area range to obtain the green coverage in the CAD range.



Figure 9. Park service radius analysis.

On the other hand, park service radius analysis can query park radius service radius coverage within the range. Operation steps: click “Select Residential Patch”, and then click a residential land section to obtain the coverage of the park green space service radius in the selected section; click “Custom Field Query” to draw a polygon on the map. After drawing, the coverage of the park green space service radius of the residential land within the drawing range is obtained. Click “Input Range Query” to upload the CAD file in the statistical range to obtain the coverage of the park green space service radius of the residential land within the CAD range.

5.1.5. Map Out

It includes adding scale, frame, north arrow, text description, etc. This function provides data and basis for research on greening work, conference sketch, survey and design, and administrative approval. These five functions are the basic functions of the system. Through continuous improvement of evaluation standards and continuous refinement of functional design, the module functions of flat management can be added or optimized according to management requirements.

5.2. The Difference Between Two Modes in Functions

The main difference between the system design B/S and C/S modes is: the nature of B/S is display, where data cannot be modified, and the browser is used as a platform for easy viewing; C/S is a full-featured management mode, which requires the installation of GIS and other software for specific operations. The B/S terminal has some functions of the C/S terminal. Users can view and obtain statistic data via the browser, so that the system can be applied more efficiently.

6. Future Development Goals of System

6.1. Network Topology Management And Data Nodes Optimized As Required

An element of the designing Wuxi green space management system is the basic ledger in the daily urban greening refinement management system. At present, the login mode has been listed as the administrator user and super administrator user in the B/S system, which is the most simple authority management mode. At present, the administrative management model is basically tree management, which is managed from the city, district, and street level by level, and green space management is no exception. The basic functions that have been opened are for the city and district to jointly manage and consult.

Considering that the basic data of green space needs to be continuously improved in its daily work, and the Internet model is used, more nodes are needed to enter the system. The author temporarily divides nodes into fixed nodes and non-fixed nodes. First, fixed nodes, that is, the above-mentioned cities, districts, streets, etc., need to be put in place in accordance with green space management responsibilities (data management should be fully covered). Each node is managed and verified by superior nodes, and green land management database should be improved according to management objectives, which is a continuation of the current management model. In

addition, each node can add certain data functions according to its own needs. For example, a certain street releases a news that has a certain timeliness such as greening the community. When the data is input, select each node to be visible. After the district management node agrees, the rest of nodes can consult this information at the same time. Another example is that after a node modifies the data, it will leave a modification record, which is convenient for the superior node to verify or check the modification reason in the future; secondly, non-fixed nodes, such as communities, greening enterprises, enthusiastic citizens, etc. can upload the green space status photos and green space situation to the related green space database after verification. After verification by the node management unit or superior node unit, confirm or deal with the corresponding situation in time. Non-fixed nodes may participate in the improvement of some green space data according to management requirements, which is allowed, and only requires strict control of superior node units.

With the refined network topology management model, under the background of the data that requires to be perfected, each node will have a certain differentiated data development direction when combing the industry assessment or actual task, which will be more conducive to improving the green space database and enhancing the management efficiency.

6.2. Green Land Visualized Operations And More Intelligent Decision-making

With the continuous improvement of the green space management system, the object-oriented visualized operation will provide a more efficient and intuitive experience. For instance, the current green space data is relatively independent. When users need to select a certain attribute range of green space in a certain range, they need to set the calculation method in the system. If users need to search or modify green land data in multiple ranges, multiple attributes, and multiple standards, it is impossible to set all the calculation methods. This requires the system to realize the intelligent visualized operation, not only in the calculation method that can be set by the program, but also in a framework within the scope, and users can choose the data they need without using the programming language. Another example is that the current Wuxi green space management system basically displays pictures and data reports in terms of green space data. Combined with the above node optimization, green space attributes, current status photos, microviews, plane graphs, text introductions, etc. will be associated with related green spaces. When the specific attributes of a certain green area need to be obtained, these visualized data will provide a better intuitive impression according to users' needs.

In terms of scientific decision-making of green space management, based on the landscape management system database and evaluation model system, a comparative analysis of monitoring data in different regions and different requirements is conducted, problems in management work are found in time, and decision-making plans are proposed for the management department to make a scientific decision and achieve dynamic management.

7. Conclusion

The establishment of Wuxi green space management system will greatly reduce the workload and complexity of the planning, design, construction and maintenance management of the greening of Wuxi, while also improving the efficiency of the greening management work and optimizing the organizational structure and workflow of the urban greening cause. It can reasonably make use of human, financial and material resources investment, to improve the quality of planning and design of greening, construction and maintenance management, and achieve scientific management. In addition, it can also strengthen the macro management, comprehensive management and target management of the urban greening department, strengthen the supervision and guidance of urban greening work, and thus play a role in improving the urban ecological environment and enhancing the quality of work, leisure and life of citizens. The technical mechanism of data statistics, information release and transmission provided by Wuxi green land management system has greatly improved work efficiency and data accuracy. It has realized the digitization of decision-making, organization of planning and construction, standardization of internal management, and

diversification of construction results. The Wuxi green land management system will alleviate unfavorable management factors such as the lagging green land data, and standardize the management behaviors of green management departments at all levels, which is the new direction of green industry management.

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