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Standardized Management Model for Urban Landscape Engineering

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Abstract: In recent years, the Chinese government has recognized the important role of urban green space, and each province has formulated corresponding policies to increase the area of green space. However, China's urban land development faces problems such as insufficient preliminary research, disorganized construction management, and chaotic organization and management. These problems are also reflected in urban garden projects. Compared with developed countries, China's urban garden engineering technology and management in the modern sense are relatively backward. The study takes the garden engineering project management as a comprehensive research subject, and elaborates on it from two perspectives, which are project management content and quota design method. First, based on the Plan-Do-Check-Act (PDCA) cycle, a standardized management system with cost management, progress management, quality management and safety management as the main content is constructed. Then, the limit design method is developed utilizing multiple linear regression analysis. Finally, the limit design method is tested. The test results show that the limit design scheme proposed in the study can optimize the traditional limit design scheme by 53.34%. The quota design methods were evaluated, and the 10 sample items received a score range of 38.22 to 86.09 points, with an average score of 62.36 points. There are six projects with scores above 60 and 4 projects with scores below 60. This verifies that the quota design is reasonable. In terms of theory, the research combines the current laws and regulations and the administrative management system to construct a complete urban landscape engineering management system, which can provide a reference for solving the existing problems in the current urban landscape engineering management. In practice, although the proposed limit design method has a prediction error of 7.84%, it is still less than 10% of the legal ceiling. In engineering practice, it can effectively strengthen construction management and organizational management. Overall, the study proposes to build a standardized management system based on the PDCA cycle, with cost management, schedule management, quality management, and safety management as the main contents. The limited design method constructed using multiple linear regression analysis has effectiveness and practicality.

Keywords: Normalization, garden engineering, PDCA cycle, sustainable landscape engineering, theoretical system, progress management, management model, project management.

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1. Introduction

The construction of urban landscape engineering projects refers to the entire process of forming a landscape entity from the design, planning, construction, and maintenance of a landscape product by a landscape construction enterprise with relevant qualifications. Its basic task is to comprehensively coordinate the site according to the specific requirements of the customer and the drawings and plans reviewed by relevant departments, scientifically allocate manpower and resources, and ensure that the construction project can be completed on time and with high quality (Nian et al., 2021). As an important form of architecture, landscape architecture plays an undeniable role in building various environments that people need. Urban landscaping and landscape construction management can have a positive promoting and promoting effect on the socio-economic development and urbanization progress of the region (Guérineau et al., 2022). Therefore, ensuring the quality management and control of landscape engineering has become particularly important. However, although foreign research on this aspect has been relatively complete, the technical management of urban landscaping engineering in Chinese cities is relatively backward due to insufficient research in the early stages of land development and chaotic construction and organizational management (Chiarini and Kumar, 2022). In addition, the PDCA cycle method can effectively improve the level of construction quality management through the entire process of engineering quality management before and after construction. It can also play a timely role in inspection and correction (Rajagopalan, 2021). However, it cannot be denied that there is currently relatively little research on the use of PDCA circulation valves for landscape engineering management. Based on this, the study constructs a standardized management system based on the PDCA cycle. Additionally, multi-source linear regression analysis is employed to create a limit design approach. Its purpose is to solve the current problem of chaotic management in landscape engineering and provide theoretical guidance for the construction of urban landscape engineering.

2. Literature Review

With the rise of the concepts of "ecological city "and "green city, "many scholars have carried out research on the management of urban landscape engineering. Men J. (2022)combined BIM technology with the PDCA cycle and proposed a more complete construction safety management implementation method. This method optimized the current engineering safety management method from four perspectives: safety plan formulation, risk control, safety hazard investigation, and safety summary (Men, 2022). Tsukada S. et al. (2020) evaluated open garden projects using the PDCA cycle, and (Andenæs et al., 2021)used the PDCA cycle theory to solve the technical risks of ecological roofs. At present, the PDCA cycle theory has been applied to engineering project management in many fields, providing an effective theoretical framework for engineering management.

Proposed an urban landscape design method based on nonlinear theory and life cycle theory for the problem of large differences in urban landscape design. The simulation results show that the average regression standard deviation of this method is 0.567, the standard value is 0.753, and the F-value is 0.655, which has better visual feature expression ability (Liu et al., 2022). Considering the limitations of standard support vector machines, used least squares support vector machines to optimize the linear regression equation, therefore improving project cost prediction accuracy. The experimental results show that the error of the predictable result of this method is within 7% (Fanand Sharma,2021) proposed a beach design scheme based on landscape engineering analysis. They believed that the overall planning of the landscape should be paid attention to in the design stage, and a complete coastal landscape design method should be formed by combining theories of site planning and image cutting (Ramadhan and Nuryanti, 2021).

Conducted a risk assessment of the current sustainable construction projects in the UAE, and listed risk management factors including management technology risk, green construction risk, regulatory risk, cost control risk and personnel risk. More than 30 specific risks were ranked, of which lack of funds by the client, design and planning errors, temporary changes in design schemes, delays in the construction period, and errors in defining the construction scope were the most important risks (El-Sayegh et al., 2021) used earned value management to quantitatively evaluate engineering projects. In this framework, all work is planned, budgeted and scheduled according to the earned value of the time period (Sone et al., 2022). proposed a project cost control method integrating project delivery combined with BIM technology, which can effectively solve the problem of project cost accounting confusion (Elghaishand Abrishami, 2021) proposed a sustainable development rating system based on existing landscape analysis to address the issue of sustainable development of urban landscape architecture to promote data support for promoting the development of urban landscape architecture in the era of big data(Yoffe et al., 2022).

From the research of scholars at home and abroad, it can be seen that, at present, scholars have conducted in-depth research on engineering project management, but there are few special studies on urban landscape engineering management. The proposed management plan or system is relatively complicated and unsuitable for overseeing small urban landscape engineering projects. Therefore, the research on the management system of urban landscaping projects based on the PDCA cycle theory and the quota design model using multi-source linear regression, which is based on previous studies, are innovative, and provide theoretical guidance for current garden landscape engineering management.

3. Construction of Standardized Urban Landscape Engineering Management System

3.1. Construction of Theoretical System of Urban Landscape Engineering and Division of Management Subjects based on PDCA Cycle

The Chinese government issued new quality system requirements and standards in 2016, but the practice in the urban landscape engineering industry has not been effective. The performance is that the expected effect cannot be achieved after the completion of the urban landscape engineering project, resulting in insufficient ornamental, ecological, and practical values (Żychowska et al., 2022). There are two main reasons: First, the construction party often fails to do a good job in the quota design, resulting in a large amount of budget for the early stage of the project, and cutting corners and materials for the later stage of the project. The second is that the construction party regards the urban landscape project as a commercial project rather than an ecological project, and the design and planning are often for commercial services. According to the quality management system adopted by China's urban landscape industry at the present stage, combined with the PDCA cycle theory, most urban landscape construction enterprises are urged to change the extensive management mode and exclude factors that affect project quality. Table 1 displays the utilization of the PDCA cycle approach in project management (Connelly, 2021).

Table 1. Application of PDCA cycle in engineering management

Content	Cost	Schedule	Quality	Safe
Plan	CP	SP	QP	SP
Do	CD	SD	QD	SD
Check	CC	SC	QC	SC
Action	CA	SA	QA	SA

From Table 1, the application of the PDCA cycle method in engineering management mainly includes four parts: planning, execution, inspection, and summary. Each part includes four major aspects: cost control, progress control, quality control, and safety control. Modern urban landscape engineering management needs to combine architectural engineering, organizational behavior, social management and landscape ecology. It needs to be reclassified according to its functions in social development (Benkhaled et al., 2022). After referring to relevant research, a theoretical system of sustainable urban landscape engineering management model is constructed, as shown in Fig.1(Pamukcu-Albers et al., 2021).

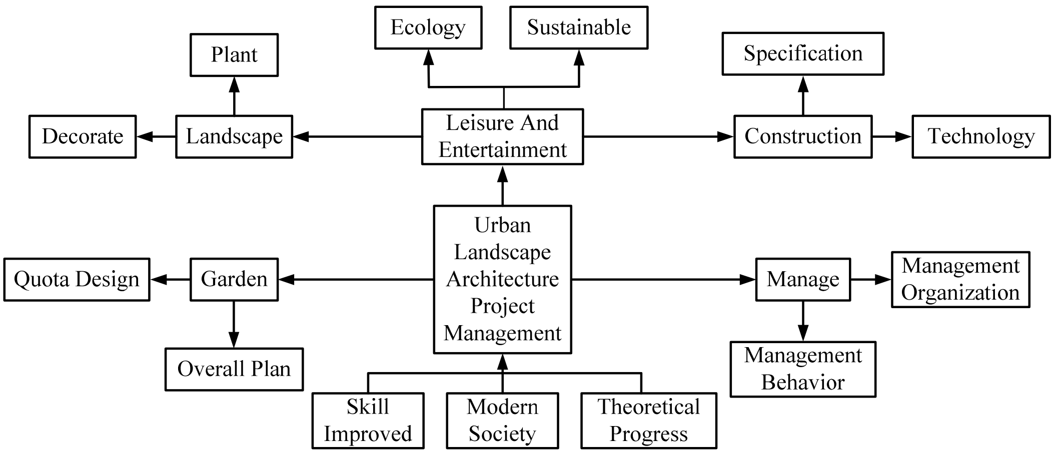

Fig.1. Theoretical system of sustainable urban landscape engineering management system

The management of urban landscape engineering is an organizational form in which multiple subjects intersect, and a management method that organically combines management and technology through scientific management theory (Martinsuoand Ahola, 2022). From atechnical point of view, urban landscape engineering covers various engineering forms such as earthwork engineering, municipal engineering, water supply and drainage engineering, and greening engineering, and the participants are complex, including design and planning personnel, construction personnel, supervisors and owners, thus forming the stage division of the main body of urban landscape engineering management, as shown in Fig. 2 (Sadowski, 2021).

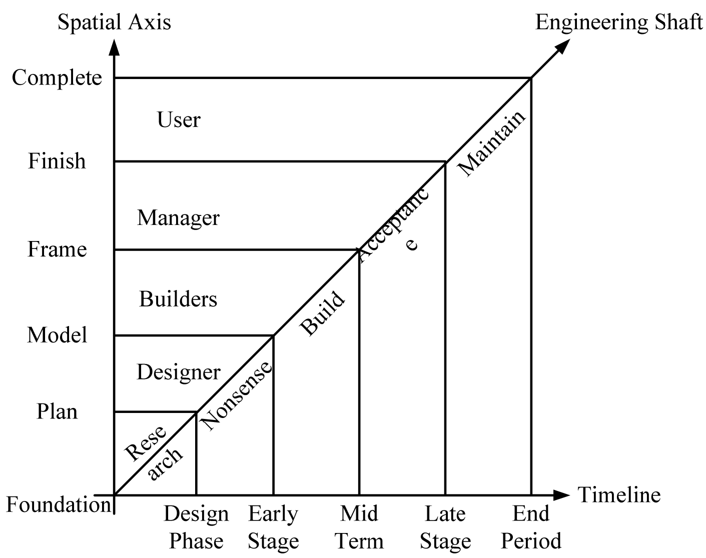

Fig.2. Stage division of the management subject of modern urban landscape engineering

In addition to the above issues, since the construction sites of urban landscape engineering projects are mostly urban built-up areas, it will inevitably involve communication with government departments and accept the supervision of relevant administrative departments. For large-scale urban greening projects, the Chinese central government will guide and supervise through the National Greening Committee established by the State Council. The administrative management system andthe industry management system of urban landscape engineering areshown in Fig. 3 (Barzegar et al., 2021).

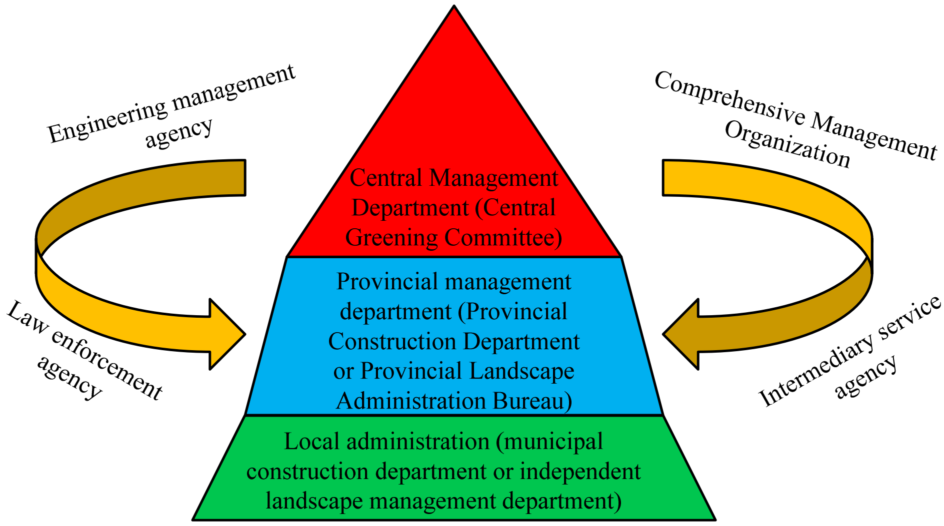

Fig. 3. Urban landscape engineering administrative and industry management entities

In Fig. 3, the engineering management organization includes the engineering construction project transaction department, the engineering project management department, the engineering quality safety department and the engineering quality supervision department. The law enforcement management agencies include the Policy and Regulation Division, Legal Affairs Division, Urban Management Administrative Law Enforcement Bureau and Landscaping Supervision Agency. Comprehensive management institutions include urban landscaping management technical guidance institutions, urban landscaping scientific research institutions, and park management departments. Intermediary service organizations consist of the Landscape Architecture Society, the Landscaping Industry Association and the Park Industry Association.

3.2.Contents of Urban Landscape Engineering Management based on PDCA Cycle

As a process of implementing planning content and design intentions, urban landscape engineering management is as shown in Table 2 for the content and purpose of actual construction management in accordance with the requirements of design and construction drawings (Temeljotov and Lindkvist, 2021)

Table 2. Contents and purposes of urban landscape engineering management

PDCA cycle stage	Specific contents	Purpose
Plan	Guarantee project execution budget cost	Reduce waste of manpower and material resources and reduce costs
Do	Coordinate the construction progress of the department	Find out the problems existing in the construction process and take corresponding measures
Check	Guarantee the quality of construction management	Ensure that systems and norms are implemented and implemented
Action	Ensure the safety of construction projects	Ensure the safety and integrity of construction personnel and construction materials

According to Table 2, urban landscape engineering management can be divided into four parts: cost management, progress management, quality management and safety management. Relevant studies have shown that optimizing cost control during the preparation and design phases has a probability of more than 90% maximizing investment benefits, while the probability of maximizing investment benefits in the formal construction phase is only 10% (Tian et al., 2022). Project quota design is an important means to maximize the interests of landscape construction enterprises, and can directly reflect the level of project management.

Project progress management mainly involves creating and implementing project plans (including daily plans, weekly plans and monthly plans) and is expressed by “duration” in the construction management process to ensure that the project can achieve the expected tasks step by step. Usually, the work decomposition method is used to analyze the structure of different stages of process and project management, and divide them into units that are easy to operate and manage (Petroutsatou, 2022). Fig. 4 outlines the stage division for progress management in urban landscape engineering (Kamal et al., 2022).

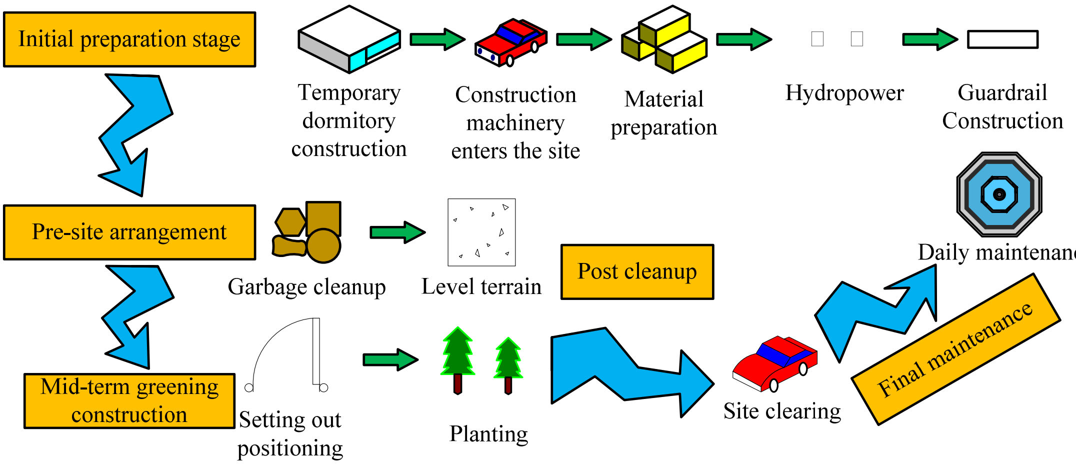

Fig. 4. Progress management stages of urban landscape projects

The phase arrangement in Fig. 4 is not absolute. In real-world engineering,the sequence of construction progress should be arranged according to the objective technical specification requirements of the project construction combined with the sequence of the entire construction activities and subjective organizational behavior management. Some procedures that are not logically managed, such as piling positioning, removal of excess earthwork, etc., can be flexibly adapted.

The problems existing in the quality management of China's current urban landscape projects are mainly insufficient design quality management in the planning stage (including overall planning and quota design), lax construction quality control during the construction stage (including unqualified material replacement and substandard construction techniques), insufficient investment in maintenance quality after completion. According to relevant research, there are mainly six factors that affect the quality of engineering projects, as shown in Table 3 (Liu et al., 2022).

Table 3. Quality management factors of urban landscape engineering

Influencing factors		Main content
	Men	Cognition and proficiency
	Machine	Equipment Performance and Maintenance
5M	Material	Material procurement, transportation, quality inspection and storage
	Method	Process and technology selection, operating specifications and acceptance criteria
	Measurement	Fixed-point pay-off accuracy
1E	Environment	Construction site temperature and humidity, lighting, soil and vegetation, etc.

From Table3, the factors that affectengineering project quality include primarily human factors, machinery, materials, methods, measurement, and environmental factors. For example, environmental factors mainly include on-site temperature, lighting, etc. Safety management is the basis for ensuring the smooth construction of urban garden projects. China's existing laws and regulations pertaining to garden construction safety are the "Urban Greening Regulations" promulgated by the State Council of China in 1992, which only stipulates compensation plans for losses caused during the construction of urban garden projects, and lacks targeted safety management methods. According to relevant current laws: "Sinochem People's Republic of China Urban and Rural Planning Law," "People's Republic of China Construction Law," "People's Republic of China Land Administration Law," "Plant Quarantine Regulations," "Construction Project Safety Production Management Regulations," etc., combined with Fig. 2 and Fig. 3. The role of different entities in different stages of the market is divided, and a strict supervision system is established,as shown in Fig. 5 (Song, 2022).

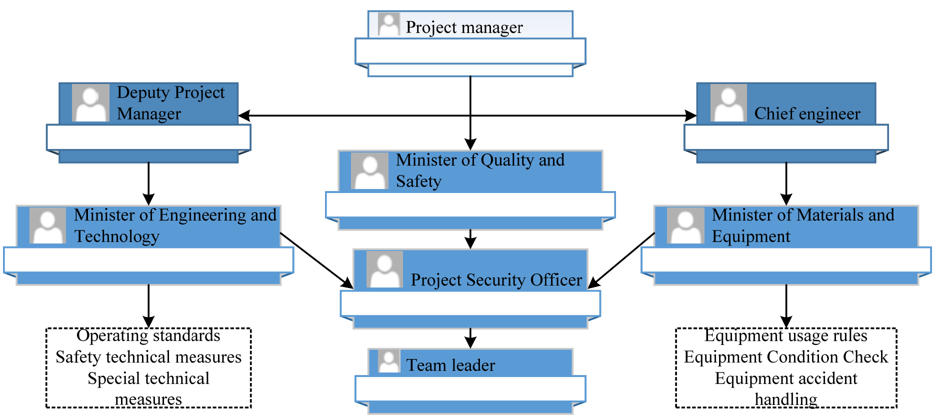

Fig. 5. Safety management system of urban landscape engineering

The study develops the concept of urban landscape engineering management in theory and creates a corresponding system to remedy existing deficiencies. It can be found that in the management of urban landscape projects, no matter what step, capital planning is inseparable. The management of personnel and materials needs budget support, and the design of engineering quotas is the most important part of engineering management.

4. DesignMethod of Urban Landscape Engineering Quota based on MultipleLinearRegression Analysis

4.1. Multiple Regression Linear Model Construction and Optimization

The study selects ten urban landscape projects completed in Chengdu, Sichuan Province, from 2020 to 2022 as examples, and constructs a design model of urban landscape engineering quotas through factor analysis(The selection of projects is based on relevance, and the selection criteria are based on the degree of relevance. Due to the large content and sufficient diversity of the tenurban landscape engineering, they are representative). According to relevant research, urban landscape engineering includes construction engineering, greening engineering, and water, electricity, and Heating Ventilating and Air Conditioning engineering. Each project has labor costs, main material costs, auxiliary material costs, mechanical costs, water, electricity labor costs, water, electricity material costs, and water, electricity and machinery costs (Yu et al., 2021). All costs are numbered as C1, C2, C3, G1, G2, G3, H1, H2, H3. The engineering data are processed according to the standards of the Chengdu Engineering Cost Association, and the selected sample project costs are shown in Table 4 (Karabulut et al., 2022).

Table 4. Cost per square meter of sample projects

-	Construction work			Landscape engineering			Water, electricity, HVAC engineering		
No	C1	C2	C3	G1	G2	G3	H1	H2	H3
1	375.27	141.52	292.90	40.41	155.94	78.98	7.46	12.04	31.36
2	719.82	158.97	227.22	5.44	284.41	59.16	4.39	32.57	17.80
3	416.68	166.15	225.55	37.21	201.32	30.74	12.85	44.97	25.56
4	732.61	145.99	272.65	16.79	233.42	38.34	13.61	28.50	21.15
5	611.04	238.99	258.66	8.17	471.72	53.30	12.93	33.75	25.10
6	581.37	242.42	375.58	10.05	361.83	71.04	5.61	35.59	29.87
7	690.47	212.99	375.07	35.35	143.97	56.65	12.82	28.63	29.68
8	992.16	188.92	281.72	21.35	173.44	27.96	6.94	27.92	27.76
9	700.78	292.69	235.79	28.01	185.46	58.81	6.82	18.98	12.82
10	495.35	190.97	283.32	14.70	228.30	57.26	19.72	26.55	27.16

From Table 4, the overall cost value of the relevant samples remains between 7 yuan/m2 and 1000 yuan/m2. Due to the widespread use and maturity of SPSS software, the research SPSS 26.0 data statistics software to conduct factor analysis on the nine factors in Table 4, and use the KMO test and Bartlett test to verify the correlation and validity analysis of factors(KOM test statistics are indicators used to compare simple correlation coefficients and partial correlation coefficients between variables, mainly used in factor analysis of multivariate statistics; The Bartlett's spherical test is a test method that tests the degree of correlation between various variables. Based on the actual analysis of the research, the selection of the two can accurately determine the correlation of factors), as shown in Table 5 (Rönkkö and Cho, 2022).

Table 5. Factor correlation and validity analysis

Kmo test statistic							0.813		
Bartlett's test of sphericity				Approximate chi-square			452.286		
				Degrees of freedom			37.000		
				Sig.			0.000		
Project	C1	C2	C3	G1	G2	G3	H1	H2	H3
Initial value	1	1	1	1	1	1	1	1	1
Extract value	0.950	0.895	0.924	0.854	0.872	0.795	0.952	0.953	0.932

In Table 5, the KMO test statistic is 0.813, indicating a significant difference between the sum of the squares of the correlation coefficients and the sum of the squares of the partial correlation coefficients of the nine factors, suitable forfactor analysis. The spherical test result indicates that Sig. is 0.000, which is less than 0.05, indicating that there is a correlation among the nine factors. The principal component analysis extraction values of all the factors are greater than 0.7, indicating that the variables can be expressed by all factors. Fig. 6 shows the explanation of the total variance for each factor.

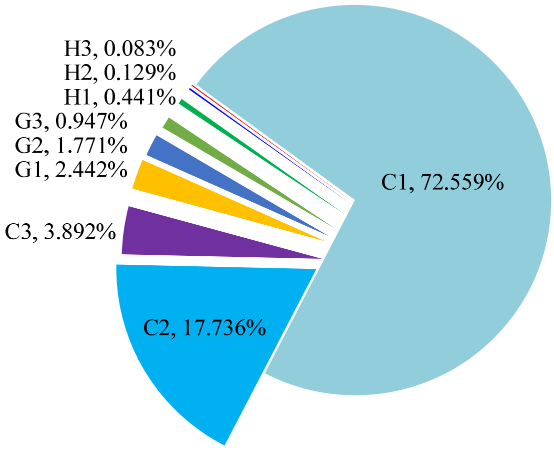

Fig. 6. Explanations of the total variance of each factor

In Fig. 6, the initial eigenvalue expressions of the two factors C1 and C2 are 72.559% and 17.736%, respectively. The variable expression of the two factors was 90.30%, and the total expression of the first six factors was 99.35%. All factors were used as variables for multiple regression analysis since the extracted values of all factors were greater than 0.7, ensuring the precision and dependability of the model. According to the results in Fig. 6, the 95% confidence intervals are calculated for each factor in different unit area cost intervals. Eq. (1) shows the calculation method.

$$\left[\mu-1.96*\frac{\sigma}{\sqrt{n}},\mu+1.96*\frac{\sigma}{\sqrt{n}}\right] \tag{1}$$

In Eq. (1), μ is the average value of all samples; σ is the standard deviation of all samples; n is the number of samples in an experiment, and 1.96 is a coefficient that conforms to the normal distribution of the 95% confidence interval. The calculation results are shown in Fig. 7, Fig. 8 and Fig. 9.

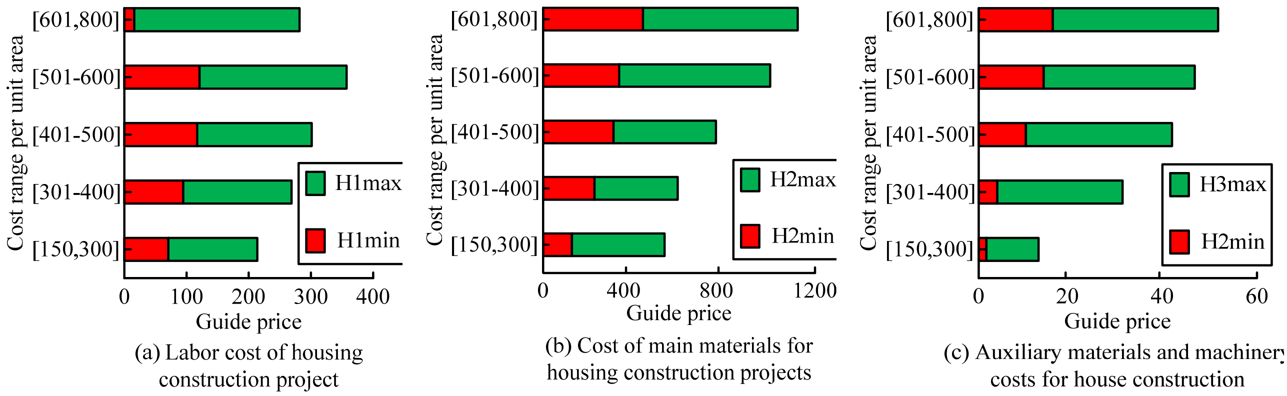

Fig. 7. Guidance price of construction work

From Fig. 7 (a), the labor cost of garden construction projects shows an increasing trend in the range of [150-600] square meters. The minimum labor cost remains around 100 yuan/m2, but it will decrease after exceeding 600 square meters, with the minimum value below 25 yuan/m2. Fig. 7 (b) and 7 (c) reflect that the material and mechanical costs for garden construction projects increase proportionally with the building area. The greater the building area, the more the material and mechanical costs of the construction project. The most notable variations were observed in the 150-400 and 500-800 ranges, while the range of 400-600 showed relatively small changes.

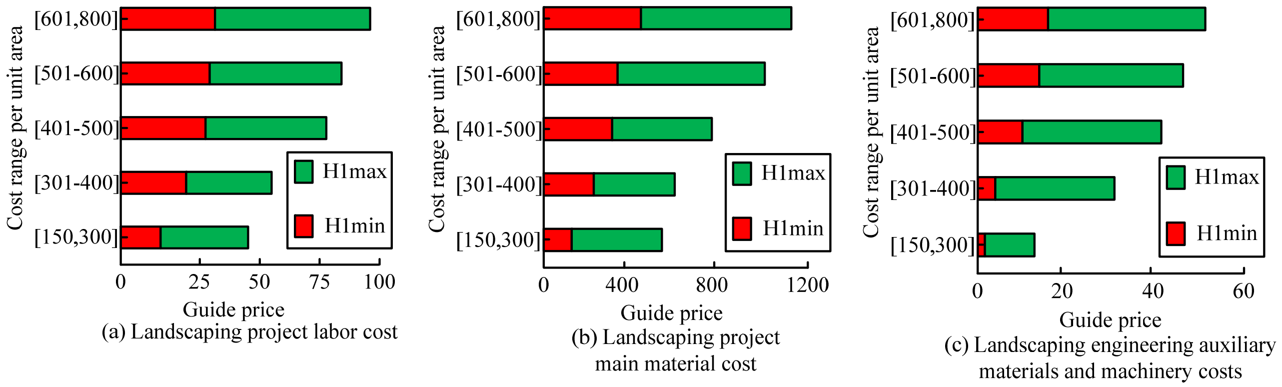

Fig. 8. Green project guide price

As shown in Fig. 8, all guidance costs for landscaping projects are positively correlated with the greening area. Fig. 8(a) indicates that the labor cost of landscape engineering changes the fastest between 150 and 400, increasing by about 12 yuan/m2, while the increase during the other time periods is relatively minor. Fig. 8 (b) demonstrates that the main material costs of landscape engineering have increased significantly between 150 to 400 and 500 to 800, with increases of approximately 170 yuan/m2 and 120 yuan/m2, respectively. Fig. 8 (c) indicates that the cost of auxiliary materials and machinery for landscaping projects has significantly increased in various intervals with the increase of green area. In addition, compared to garden construction projects, the labor cost of garden greening projects is only about a quarter. This is because the technical proficiency needed for greening projects is relatively low.

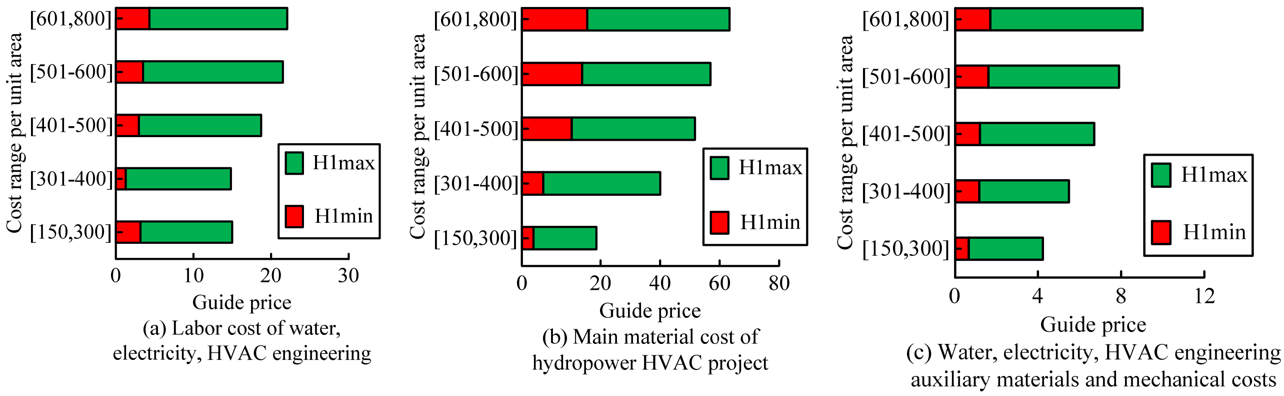

Fig. 9. Guidance price of hydropower HVAC engineering

From Fig. 9, the cost of garden water, electricity, and HVAC engineering is relatively cheap, maintaining an overall price range of 0-80 yuan/m2, and is positively correlated with the construction area. It is noteworthy thatin Fig. 9 (a), there is a decrease in labor costs for water, electricity, and HVAC projects when they are in the range of 301 to 400, while other expenses show an increasing trend between them. From Fig.s 7, 8, and 9, there is a significant difference between the maximum and minimum prices for garden construction. Scientific and reasonable quota design can save a lot of budget. Establish a multiple linear regression model using SPSS 26.0 and extract the factors that are well expressed in factor analysis, as shown in Eq.(2).

$$f(x) = aC_1 + bC_2 + cC_3 + dG_1 + eG_2 + fG_3 + eH_1 + hH_2 + iH_3 + \alpha \tag{2}$$

In Eq. (2), a , b , c , d , e , f , e , h and i are all factor coefficients, and α is a constant. The model was statistically tested, and the results are shown in Table 6.

Table 6. Statistical test of multiple linear regression model

R	R 2	Adjusted R 2	Estimated standard error	Durbin Watson test	
0.983	0.959	0.981	62.53217	1.698	
/	Sum of square	Degrees of freedom	Military	f	Significant
Return	13131224.586	8	1451355.744	352.781	0.000
Residual	93761.273	21	4234.281	/	/
Total	1.3224985859×107	29	/	/	/

R2 of the model before adjustment is greater than 0.9, indicating that the fitting effect of the model is good. The Durbin Watson value of the model is 1.698, which indicates that there is no autocorrelation among the variables. The significance Sig. of the model is 0.000 and less than 0.05, indicating that there is a significant linear relationship between the cost per square meter of urban landscape engineering and the variables. The standard and non-standard coefficients of each factor were further analyzed, and the results are shown in Table 7.

Table 7. Standard coefficients and non-standard coefficients of each factor

Test	Non-standard coefficient		Standard Coefficient	t	Significant
	B	Standard error	Beta		
Constant	-41.538	48.014	/	-0.874	0.375
C1	-0.452	0.427	-0.072	-0.682	0.482
C2	0.629	0.119	0.462	5.129	0.000
C3	3.214	1.292	0.139	2.415	0.020
G1	2.528	1.285	0.051	2.137	0.051
G2	0.254	0.191	0.046	1.299	0.081
G3	1.202	1.113	0.041	1.163	0.284
H1	2.686	3.299	0.158	0.792	0.371
H2	1.791	0.586	0.327	3.220	0.002
H3	-0.462	6.432	-0.011	-0.062	0.032

In Table 7, the significance values of C1, G3, and H3 are all greater than 0.1. In order to construct a more effective and reliable model, the indicators with lower significance should be eliminated. The optimized model is shown in Eq. (3).

$$f\left(x\right)=aC_2+bC_3+cG_1+dG_2+eH_1+fH_2+\beta \quad (3)$$

In Eq. (3), a, b, c, d, e, and f are all factor coefficients, and β is a constant. The optimized model was statistically tested, and the results are shown in Table 8.

Table 8. Statistical test of optimization model

R	R 2	Adjusted R 2	Estimated standard error	Durbin watson test	
0.997	0.994	0.992	64.14728	1.725	
/	Sum of square	Degrees of freedom	Military	f	Significant
Return	1.4125139451×107	6	2258124.617	571.194	0.000
Residual	105424.296	24	4241.892	/	/
Total	14230563.747	30	/	/	/

In Table 8, the R-square of the optimized model is greater than 0.99, which shows that the fitting effect of the optimized model is very good. The Durbin Watson test value is 1.725, which indicates that there is no autocorrelation phenomenon among the variables. The significance is 0.000 and less than 0.05, indicating that in the optimized model, there is a significant linear relationship between the cost of urban gardening projects and these sixvariables. The optimized model was analyzed with standard coefficients and non-standard coefficients, and the results are shown in Table 9.

In Table 9, the significance values of all indicators are less than 0.05, indicating that the optimized model has good significance. The equation of the optimized model is shown in Eq. (4).

$$f\left(x\right)=0.513C2+2.174C3+2.778G1+0.324G2+2.416H1+1.893H2 \quad (4)$$

In Eq. (4), the coefficients before the independent variable are all taken from the B value.

4.2.Evaluation of Quota Design Method

To verify the rationality of the quota design method, the evaluation system is divided into a criterion layer, a target layer, and an indicator layer based on the Analytic Hierarchy Process (AHP), with the division principle being the cost of the project. And invite experts from relevant fields for analysis. The criterion layer is “Chengdu urban landscape engineering quota design effect evaluation” (denoted as S), and the target layer is “unit price benefit per square meter of landscape construction project” (denoted as T1), “unit price benefit per square meter of landscaping project” (denoted as T2), “unit price benefit per square meter of garden hydropower HVAC project" (denoted as T3). The indicator layer is "labor cost benefit," "main material cost benefit," and "auxiliary material and machinery cost benefit," which are respectively recorded as I11, I12, I13, I21, I22, I23, I31, I32, and I33. Each indicator's weight is determined by the average unit price per square meter of the 10 currently completed urban garden projects in Chengdu, and the results are shown in Fig. 10.

Table 9. Standard coefficients and non-standard coefficients of optimization model

Significance test	Non-standard coefficient		Standard coefficient	t	Significant
	B	Standard error	Beta		
Constant	-42.517	36.902	/	-1.061	0.241
C2	0.513	0.051	0.397	9.642	0.000
C3	2.174	1.041	0.098	2.002	0.048
G1	2.778	1.082	0.059	2.376	0.021
G2	0.324	0.148	0.077	2.189	0.027
H1	2.416	1.284	0.107	1.688	0.043
H2	1.893	0.402	0.317	4.715	0.000

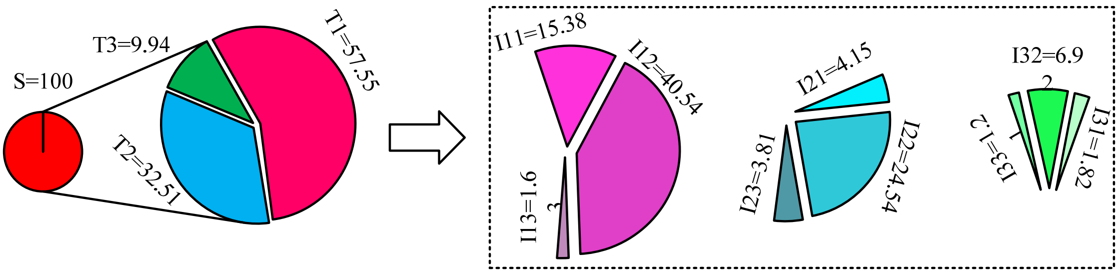

Fig. 10. Index weights of each layer of quota design for urban gardening projects

In Fig. 10, the weights of each index in the target layer are listed, as the numerical values of the indices differ significantly. The data requires standardization, and Eq. (5) presents the standardized equation.

$$x_0^* = x_0 \div \bar{x} \quad (5)$$

In Eq. (5), is the standardized index value, the initial value of the urban landscape engineering project index, and the average value of the urban landscape engineering garden project index. Eq. (5) is only applicable when, at that time, the standardized formula is shown in Eq. (6).

$$x_0^* = \left(x_0 - n\bar{x} \div \bar{x}\right) \quad (6)$$

In Eq. (6), $n = 1, 2, 3, \cdots$, the comprehensive scoring formula is shown in Eq. (7).

$$S = 15.38C1 + 40.54C2 + 1.63C3 + 4.15G1 + 24.54G2 + 3.81G3 + 1.82H1 + 6.92H2 + 1.21H3 \quad (7)$$

Substituting the relevant data of the selected 10 sample urban landscape engineering projects into Eq. (4), (5), and (6), the results are shown in Fig. 11.

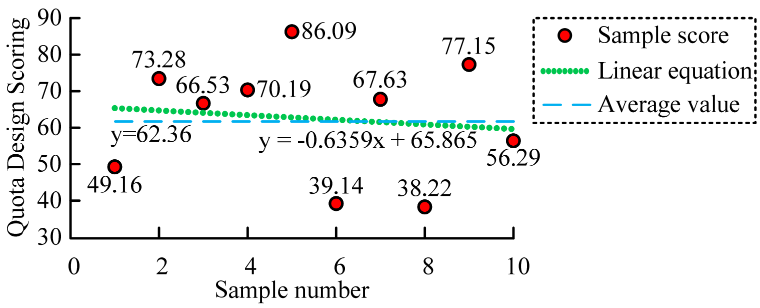

Fig.11. Scoring of sample limit design

In Fig. 11, the sample items scored a range from 38.22 to 86.09, with an average score of 62.36. There are 6 item scores above 60 points and 4 item scores below 60 points. It shows that the quota design of more than half of the sample items isreasonable, and the proposed method is effective.

4.3.Practical Application of Quota Design Method

In order to verify the effect of the limit design method proposed in the study on actual engineering projects, a large-scale urban landscape engineering project that has not yet been developed in Chengdu is selected as a case. The project has a long side of 160 meters and a short side of 80 meters, with fourtowers and a commercial building. The four towers form a square with a side length of 40 meters to form an atrium (that is, the distance between the towers is 40 meters). Table 10 displays the initial cost scheme for the project.

Table 10. Initial cost scheme of case engineering project

Project name		Quantity (unit)	Cost per square meter (yuan/m 2)	Total cost (yuan)
Garden house construction project	Asphalt fire lane	2000(m 2)	350	700000
	Granite pavement	1500(m 2)	400	600000
	Sintered brick pavement	400(m 2)	200	80000
	Gym	200(m 2)	400	80000
	Fitness Equipment	10	3000	30000
	Aerobic runway	400(m 2)	250	100000
	Granite fence	300(m 2)	2000	600000
	Composite landscape corridor	2	100000	200000
	Garage roof hydrophobic layer	300(m 2)	200	60000
	Entrance large musical fountain	20(m 2)	1500	30000
	Reserve project fee	1	/	500000
	Labor costs	5120(m 2)	200	1024000
	Auxiliary materials and machinery costs	5120(m 2)	20	102400
	Garden Architecture Fees	5120(m 2)	/	4106400
	Cost per square meter of landscape architecture	Yuan(m2)	/	802.03
Landscaping project	Precious trees and shrubs	50(m 2)	10000	500000
	Ground cover	2000(m 2)	150	300000
	Lawn with flowers	1000(m 2)	20	20000
	Labor costs	3000(m 2)	180	540000
	Auxiliary materials and machinery costs	3000(m 2)	120	360000
	Landscaping costs	3000(m 2)	/	1720000
	Landscaping cost per square meter	Yuan(m2)	/	573.33
Garden hydropower HVAC project	Main material cost	8120(m 2)	12	97440
	Labor costs	8120(m 2)	10	81200
	Auxiliary materials and machinery costs	8120(m 2)	5	40600
	Garden water and electricity HVAC costs	8120(m 2)	/	219240
	Garden water, electricity, heating and ventilation costs per square meter	Yuan(m2)	/	27

Table 10 illustrates that the original plan of the urban landscape engineering project is 6,045,640 yuan, 744.54 yuan per square meter. Forecasting the project through Eq. (2), we can get 753.18 yuan per square meter, the total forecast cost is 6115821.60 yuan, the error is 70181.6 yuan, and the error range is 1.16%, which is in line with the limit forecast error range stipulated by China. It scores the original scheme through Eqs (4), (5) and (6). The original scheme is 57.14 points, indicating that there is still a lot of room for improvement in the quota design.

Assuming that the developer has insufficient funds to bear the cost, under the condition that the total area of the project remains unchanged, it adjusts according to the guiding prices in Fig. 7, Fig. 8, and Fig. 9, and replaces some materials or contents in Table 10; Then it modifies the corresponding area and quantity. The optimized scheme is shown in Table 11.

Table 11. Optimized limit design scheme

Project name		Quantity (unit)	Cost per square meter (yuan/m 2)	Total cost (yuan)
Garden house construction project	Concrete fire lane	2000(m 2)	150	300000
	Imitation granite brick pavement	500(m 2)	200	100000
	Cement brick pavement	400(m 2)	80	32000
	Gym	200(m 2)	400	80000
	Fitness Equipment	10	3000	30000
	Rubber track	400(m 2)	180	72000
	Aluminum square passes fence	300(m 2)	800	240000
	Bamboo landscape corridor	2(m 2)	50000	100000
	Garage roof hydrophobic layer	300(m 2)	200	60000
	Entrance fountain	20(m 2)	1200	24000
	Reserve project fee	1(m 2)	/	300000
	Labor costs	4120(m 2)	180	741600
	Auxiliary materials and machinery costs	4120(m 2)	18	74160
	Garden Architecture Fees	4120(m 2)	/	2153760
	Cost per square meter of landscape architecture	Yuan(m 2)	/	522.76
Landscaping project	Common trees and shrubs	100	5000	500000
	Better ground cover	2000(m 2)	180	360000
	Better lawn	2000(m 2)	40	80000
	Labor costs	4000(m 2)	160	640000
	Auxiliary materials and machinery costs	4000(m 2)	100	400000
	Landscaping costs	4000(m 2)	/	1980000
	Landscaping cost per square meter	Yuan(m 2)	/	495
Garden hydropower HVAC project	Main material cost	8120(m 2)	15	121800
	Labor costs	8120(m 2)	10	81200
	Auxiliary materials and machinery costs	8120(m 2)	5	40600
	Garden water and electricity HVAC costs	8120(m 2)	/	243600
	Garden water, electricity, heating and ventilation costs per square meter	Yuan(m 2)	/	30

It can be seen from Table 11 that the optimized urban garden project plan is 4,377,360 yuan, 539.08 yuan per square meter. The predicted cost is calculated by the corresponding formula. The predicted cost of the optimized scheme is 4034020.4 yuan, the predicted cost per square meter is 496.80 yuan, the error is 343339.6, and the error range is 7.84%. Although the error is larger than the original plan, it is still within the specified range. According to the scoring formula, the score of the optimized scheme is 87.62 points, which is 53.34% higher than the original scheme.

From Table 10 and Table 11, the substantial reduction in the investment budget is mainly due to the replacement of some materials with materials with similar functions but lower prices while also providing better turf quality. The replacement of the three materials of the fire lane, road surface, and corridor resulted in significant cost savings. It compares the price per square meter and standard value of each index of the two schemes, as shown in Fig. 12.

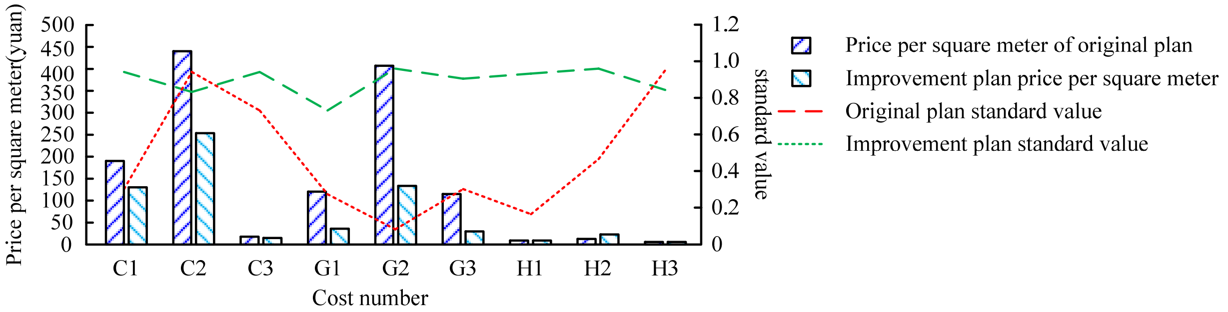

Fig. 12. The price and standard value of each index per square meter of the two schemes

It can be seen from Fig. 12 that the optimized scheme has significantly reduced the main material cost of the landscape construction project, the labor cost of the landscaping project and the total cost of the landscaping project, and the corresponding standard value also reflects the good optimization effect. In terms of garden hydropower HVAC optimization, the proposed quota design model is generally effective and has little impact on cost control. It can effectively prevent the closure of landscape engineering projects caused by fund chain disruptions from developers.

5. Discuss

Overall, the initial eigenvalue expressions for factors C1 and C2 are 72.559% and 17.736%, respectively. The variable expression of the two factors is 90.30%, and the total expression of the first six factors is 99.35%. The minimum labor cost of garden construction projects is maintained at about 100 yuan/square meter, and its guidance cost is positively correlated with the actual green area. In the statistical test of the multiple linear regression model, the Durbin Watson value is greater than 0.9, indicating that the actual fitting effect of the model is good, while the R2 value of the optimized model is greater than 0.999, indicating that the fitting effect of the optimized model is good, which is basically consistent with the research of others (Mourato et al., 2021). In evaluating quota design methods, the recorded scores for the 10 sample items range from 38.22 to 86.09, with an average score of 62.36. There are sixprojects with scores above 60 and 4 projects with scores below 60. This verifies that the quota design is reasonable. Meanwhile, in practical applications, the prediction error range of the optimized scheme is 7.84%, which outperforms other researched solutions (Zhang, 2022). Overall, the study proposes to build a standardized management system based on the PDCA cycle, with cost management, schedule management, quality management, and safety management as the main contents. The limit design method constructed using multiple linear regression analysis has effectiveness and practicality.

6. Conclusion

Landscape engineering management combines science and technology with management methods in the development process, but there is a lack of scientific theoretical guidance in the practice of urban landscape engineering in China. The study summarizes the relevant theories of urban landscape engineering, and summarizes the standardized urban landscape engineering management system at the theoretical level. It mainly includes the content of urban landscape engineering management, technical specifications of urban landscape engineering management, and the main body of urban landscape engineering management. The study also explores the application of urban landscape engineering management in different life cycles according to the PDCA cycle theory. Finally, the study proposes a quota design model for urban landscape engineering based on the multiple linear regression method. The AHP method was employed to evaluate cost management, schedule management, quality management, and safety management of the quota model. The research results show that the prediction error of the model limit is 7.84%, and the cost saving is 53.34%. Compared with the methods in literature (Men, 2022) and literature (El-Sayegh et al., 2021), it has better comprehensive performance. Compared with the method in the literature (Tsukada et al., 2020), the calculation is simpler, and it is more suitable for urban landscape engineering projects with less engineering volume. Overall, this study constructed a standardized management system based on the PDCA cycle and utilized multi-source linear regression analysis to construct an extreme design method, providing ideas for the expansion of landscape engineering management methods. The research has some limitations, as the proposed management model lacks practical verification, and the proposed quota design model has no significant effect on the cost optimization for garden hydropower HVAC projects. Future research can verify the proposed management model and further optimize the limit design model.

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Institutional Review Board Statement

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