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Research on multi-scale assessment and design of urban micro-landscape greening based on distributed computing frameworks

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ABSTRACT
Micro-landscape is a kind of green landscape designed to enhance the local landscape environment of the city along with the renewal of urban green space and the transformation of old city. The article adopts Hadoop technology and utilizes the Hadoop distributed computing framework to preprocess the data, constructs the urban micro-landscape greening evaluation system, and carries out research on four evaluation levels, namely, building façade landscape, multimedia landscape, water landscape, and landscape facilities. At the same time, based on the principal component analysis and factor analysis method for comprehensive evaluation, it is determined that the multimedia interaction factor is the most important factor affecting the effectiveness of micro-landscape greening. Then use SWMM model to design a city urban area, through SWMM model simulation to get the actual average annual runoff control rate of the demonstration area in 2023 is 59%, and the overall long-term goal of urban micro-landscape greening planning in 2020-2030 there is a gap, based on which put forward the urban micro-landscape greening design program.

Keywords: Hadoop, factor analysis, micro-landscape design, SWMM model

1. Introduction

In recent years, with the continuous improvement of people's living standards, the pursuit and aspiration for a better urban environment have become more and more urgent. Especially in the process of carrying out urban organic renewal and refined construction and management, cities have created bright and characteristic urban green landscapes by creating small and medium scales and small micro landscapes with distinctive themes [1-2].

Micro-landscape is a commonly used form in urban garden construction, mainly because micro-landscape can enrich the gardening elements, and can effectively enhance the artistry and ecological balance of the garden landscape. Because the garden itself is to have a variety of geomorphology,

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terrain heights and lows are interlaced, there are ups and downs, there are curved and straight in order to create an infinite artistic space, so the garden design needs to be combined with the characteristics of the landscape elements, simulation and design with the adaptability of the tiny terrain form, to meet the needs of local landscaping [3-6]. Micro-terrain according to the appearance of the shape is divided into linear and curvilinear, has an important role in landscape design, can change the limitations of a single terrain, through the simulation design can improve the terrain of the beauty and utilization. With the progress of society, micro-landscape design needs to be constantly innovated, combined with some new ideas, new technologies, to create a perfect landscape according to local conditions. These micro-landscapes increase the artistry of urban green space, enhance the image and quality of the city, and at the same time, allow the public to share urban public space to continuously improve the sense of access and happiness [7-10].

Literature [11] examined rural micro-landscapes in highly urbanized areas, pointing out that micro-landscapes can improve the living environment in rural areas, and that pressure relief and the number of tourists are important factors affecting the social benefits of micro-landscapes' performance, and proposing the adoption of spatial selection, path optimization and other strategies. Literature [12] examined the ideal form of rural micro-landscape creation, aiming to provide a theoretical basis for the future practice of high-quality and sustainable rural micro-landscape construction, and to measure the social benefits of micro-landscapes by establishing a structural equation model containing composite influence paths. Literature [13] analyzes urban architectural gardens with sustainable micro-landscapes with the aim of seeking methods with innovative planning and green design to find coping strategies to address the depletion of green spaces in Beirut. Literature [14] describes the significant impact of urban development on the railroad, and examines the space around a train station, through functional revitalization, landscape revitalization and other strategies, to reshape the activity space on both sides of the railroad, and to transform the grey zone of the city into a vibrant development zone of the city. Literature [15] outlines the classic cases of vertical greening, identifies the application schemes of traditional cultural elements in urban park design, and by combining vertical greening with cultural elements, modern urban parks can bring their cultural value into play, increasing the cultural function of urban park greening and the city's brand image. Literature [16] examined the environmental sustainability of landscape ecology based on analyzing the relationship between landscape ecology and land, such as the theory of landscape structure and function, the theory of ecological integrity and spatial heterogeneity, etc., and introduced macroscopic landscape ecology into the microscopic landscape design, in order to enrich the design concepts of modern landscape. Literature [17] introduced the concept of “micro-landscape tree communities” and classified them according to several characteristics, revealing that the optimization of the urban environment in the steppe industrial zone on the right bank of the Dnepr River was achieved by creating micro-landscape tree compositions using modern coniferous and deciduous plant species. Literature [18] highlights the inevitable politicization of urban nature and tries to understand if and how the places of the inhabitants related to public areas evolve, emphasizing a shift in the public policy approach to urban nature, involving the participation of citizens in urban greening projects. Literature [19] points out the shortcomings of landscape design and environmental art in China, emphasizing the fact that the requirements of this field are gradually increasing and that the application of more and more advanced technologies is driving the development of this field with the development and popularization of computer technology. Literature [20] analyzed the impact of high-rise buildings in Beijing on multiple visual morphological features of ornamental species in urban micro-landscapes, revealing that the planting position relative to the buildings affects the morphology of the trees, and proposing the planting of poplars and retention of angiosperms, such as the genus Ash, closer to the buildings. Literature [21] takes rural plant edibles as an example, analyzes the formation, characteristics and functions of edibles micro-landscapes, and analyzes the innovative design methods of rural micro-landscapes by drawing on traditional garden techniques, from the dimensions of main scenery and supporting scenery, real scenery and virtual scenery, with a view to providing innovative design ideas for the development of rural landscapes.

The study was based on Hadoop distributed computing framework to process the data, and then constructed the evaluation system of urban micro landscape greening, and derived four dimensions of building façade landscape, multi-media landscape, water body landscape, landscape facilities, and launched the study from these four dimensions. Based on the evaluation of principal component analysis and factor analysis, the landscape evaluation factors were derived, and the micro-landscape greening design of the urban demonstration area was carried out using the SWMM model, and the simulation measurements were carried out with the SWMM model to analyze the different areas, and the design scheme was determined based on the results of the study.

2. Urban micro-landscape greening assessment model based on a distributed computing framework

2.1. Hadoop Distributed Computing Framework

2.1.1. Hadoop Principles and Overview. Hadoop is an open source distributed computing system designed and developed by the Apache Software Foundation from 2002 to the present, after 20 years of application testing and continuous optimization and upgrading. Hadoop has developed into a huge closed ecological big data mining application technology system. The core idea of the Hadoop platform lies in "distributed storage" and "parallel computing". The core idea of Hadoop platform is "distributed storage" and "parallel computing". Hadoop platform core idea is "distributed storage" and "parallel computing", based on the distributed file system and parallel computing framework MapReduce is the core of the entire Hadoop ecosystem, together support the Hadoop platform robust and efficient, now Hadoop technology system in the field of big data in the storage and computing has played a pivotal role [22].

At the same time, after years of iterative upgrading, the Hadoop platform continues to improve and establish a number of excellent qualities, specifically as follows:

1) High reliability: Hadoop's storage and computation strategy is per-bit storage and computation, which endows the Hadoop platform with strong robustness and very strong disaster resistance.

2) High efficiency. Hadoop is able to carry out dynamic data migration among various computer nodes when dealing with computational big data, load the pressure of computing to each node of the cluster in a balanced way, and maintain the dynamic balance among the nodes of the cluster, so as to ensure that the cluster can run programs efficiently.

3) High scalability: Hadoop cluster nodes are assigned computing tasks by the cluster master node to each sub-node, which gives Hadoop cluster flexible expansion capabilities, and can easily and quickly expand the computing nodes.

4) Highly disaster-tolerant: Hadoop uses oversaturated backup of data in the cluster, and heartbeat detection of sub-nodes during computing tasks, and reassignment of failed tasks, which has strong disaster-tolerance capability.

2.1.2. The Hadoop Ecosystem. Hadoop after more than ten years of iterative upgrading, has a complete and comprehensive, functional self-consistent ecosystem, not only on its core products HDFS and MapReduce to strengthen the expansion, but also for its deficiencies in the complementary extension, and has introduced such as: Zookeeper, Hive, Pig, HBase, Common, Chukwa, and other products covering a variety of aspects of cloud computing, database, cluster management, data mining, etc. The Hadoop ecosystem is shown in Figure 1. Hadoop ecosystem is shown in Figure 1.

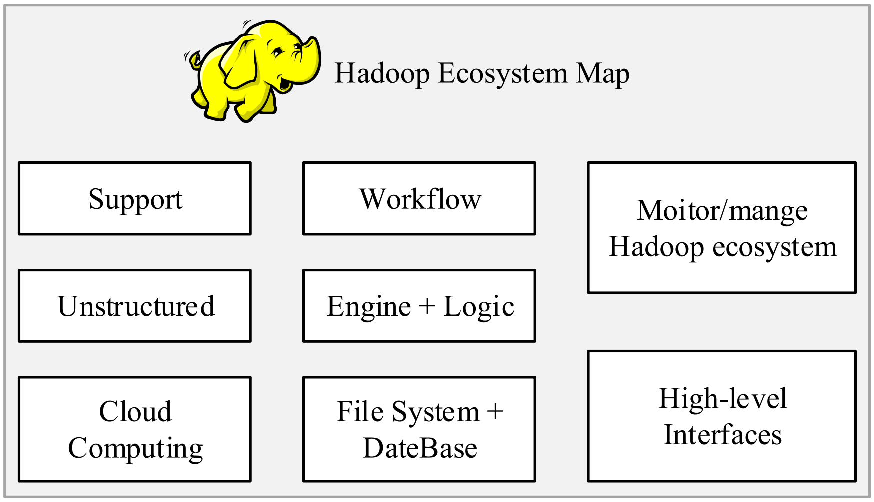

Fig. 1. Hadoop Ecosphere Map

2.1.3. Application of the Hadoop technology stack. The excellent performance of Hadoop platform makes it widely used in many fields, and in terms of spatio-temporal big data, there are some scholars based on the Hadoop technology stack to compute and analyze geospatial-based big data, from which the potential laws and information are mined to provide guidance for the research and technology application in the corresponding fields.

The Hadoop system studies the information storage and analysis of forest resources big data, which provides new research ideas for the investigation, planning and monitoring of forest resources.

2.2. Multi-scale assessment of urban micro-landscape greening based on Hadoop

2.2.1. Data pre-processing:

1) Data filtering. According to the pre-analysis of the target dataset, it may not be necessary to use all the data in the data processing. For example, if the data in the physical test data set has the label of exemption, or if the physical test data for boys and girls are modeled separately, it is necessary to use some data filtering means to filter and remove the data that do not need to be used for the time being.

When filtering data for a specified range, it is necessary to design and select some conditions in advance, according to which the conditions can be transformed into database operations (SQL statements). Data filtering commonly used roughly the following means: null matching, character matching, logical matching and so on.

2) KNN-based Missing Data Filling. KNN-based missing data filling method. The basic idea of its strategy is: take the missing data item as an object, with the help of its remaining attributes, search the complete data with its relatively close distance to find out k, and then with the help of the distance value that exists between it and the missing data, the corresponding attributes of the k missing data items are weighted average, and finally as a filler value to fill the data item. The traditional KNN based missing data filling is often done by calculating the categories of most of the classes among them and assigning them to the missing samples after finding k immediate neighbors, whereas in this paper, with the help of the property attributes present within the corpora data, a weighted average is taken of the attributes corresponding to the missing data items in the k nearest neighbors, and the average value acts as a predictive value for the missing items. In this, for data with more than 3 missing items, the operation of filtering will be performed due to too much missing information.

Where, KNN in this paper distance using Euclidean distance, calculated as (1):

$$\mathrm{dist}(X,Y)=\sqrt{\sum_{i=1}^{n}\left(x_i-y_i\right)^2} \tag{1}$$

According to the principle of Euclidean calculation, it can be seen that due to the large difference in the scale of the indicators of each test item, it is necessary to introduce the Z-Score method to carry out data standardization first, and its formula is shown in (2):

$$z = \frac{x - \mu}{\sigma} \tag{2}$$

After normalizing the data, the distance between the attribute data corresponding to the current remaining item in the complete data item and the data of the current remaining item is calculated using equation (1), after which the sorting operation is performed. Using the k items closest to the current data item after sorting, where each item corresponding to the remaining items is subjected to the operation of weighted mean and the obtained is filled into the missing items. This computational process can be represented by equation (3):

$$\hat{Y} = \frac{\sum_{i=l}^{k} x_i d_i}{\sum_{l=l}^{k} d_i} \tag{3}$$

In the above equation, the choice of k value is critical. If a lower value of k is chosen, it is equivalent to using smaller neighborhood data training to make predictions, and the accuracy of its prediction results is very dependent on the neighborhood value, which is very sensitive to the neighboring data and often results in great bias.

2.2.2. Selection of evaluation indicators for urban micro-landscape greening. The comprehensive evaluation system of this paper for urban micro-landscape greening is shown in Table 1.

Table 1. Urban microlandscape greening evaluation system

Primary indicator	Secondary indicator	Tertiary index
Urban landscape greening	Facade landscape	Night shine (X1)
		Visual effects (X2)
		Architectural features (X3)
		Human connotation (X4)
	Multimedia landscape	Visual effects (X5)
		Sensory experience (X6)
		Interactivity (X7)
		Human connotation (X8)
	Water landscape	Visual effects (X9)
		Sensory experience (X10)
		Interactivity (X11)
		Human connotation (X12)
	Landscape facilities	Art form (X13)
		Human design (X14)
		Intelligence (X15)
		Human connotation (X16)

2.2.3. Factor analysis assessment models:

1) Factor analysis model. The mathematical model of the factor analysis idea is:

$$X = AF + a\varepsilon(2-1) \tag{4}$$

In this mathematical model, F is the factor variables, implying m coordinate axes that are perpendicular to each other in the high-dimensional space; A is the factor loading matrix, a_i is the factor loadings, implying the loadings of the ith primitive variable on the j th factor variable, and ε is the special factor, which denotes the portion of the primitive variable that cannot be explained by the common factor.

Factor loading a_{ij} in model (4) is derived from the correlation coefficient of the ith original variable and the j th factor variable, which is calculated in equation (5) as follows:

$$S_j = \sum^{p} a_{ij}^2 \tag{5}$$

It can be seen that the variance contribution rate of factor variable F_j indicates the explanatory ability of factor F_j to the total variance of all original variables, and the higher its value, the higher the importance of the factor.

After obtaining the linear combination of the original variables expressed in terms of the factor, performance evaluation, at this time, each factor is the basis for evaluation, so it is also necessary to reverse the original variables expressed in terms of the public factors, the construction of the factor score function as shown in (6):

$$F_j = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \ldots\ldots + \beta_p x_p (j, p = 1, 2, 3, \ldots\ldots, m) \tag{6}$$

2) Evaluation steps of factor analysis:

(1) Indicator convergence and dimensionless processing. In this paper, the original data convergence processing is mainly used in the inverse inverse transformation method, that is, the inverse indicator normalization formula (7) is:

$$y_{ij} = -x_{ij} \tag{7}$$

Equation (8) is normalized for the fitness indicator as:

$$y_{ij} = -\left|x_{ij} - k\right| \tag{8}$$

Where y_{ij} is the value of the indicator after homogenization; x_{ij} is the value of the original indicator; k is the average value of the original indicators of each category.

The original sample data are dimensionless to eliminate the differences caused by different units. The original sample data is assumed to be factor analyzed with p indicator variables: $x_1, x_2, \ldots, x_p$, a total of n evaluation objects, and the value of the j th indicator of the ith evaluation object is x_{ij}. The value of each indicator is converted from x_{ij} to $\overline{x_{ij}}$, and the value of each indicator is converted to 10.

$$\overline{x_{ij}} = \frac{x_{ij} - \overline{x_j}}{s_j}, (i = 1, 2, \ldots, n; j = 1, 2, \ldots.p) \tag{9}$$

where $\overline{x_j} = \frac{1}{n}\sum_{i=1}^{n} x_{ij}, s_j = \frac{1}{n-1}\sum_{i=1}^{n}(x_{ij} - \overline{x_j})2, (j = 1, 2, \ldots, p)$, i.e. x_j, s_j is the sample mean and sample standard deviation of the j rd indicator. Correspondingly, $\overline{x_i} = \frac{x_i - \overline{x_i}}{s_i}, (i = 1, 2, \ldots, p)$ is said to be the standardized variable. In this paper, we directly use the default Z-score standardization in SPSS23.0 software to complete the dimensionless processing of each data.

(2) Factor analysis suitability test. The purpose of factor analysis is to synthesize a small number of representative factor variables from the original multiple variables, which means that there needs to be a strong correlation between the original multiple variables [23]. According to the research, KMO test and Bartlett's Sphericity test are suitable for testing whether the original data meets the correlation requirements for conducting factor analysis. The KMO test follows the following metrics: 0.9-1 is very appropriate, 0.8-0.9 is appropriate, 0.7-0.8 is average, 0.6-0.7 is not appropriate, and 0-0.5 is not appropriate. Corresponding to Sig<0.01 in the Bartlett's test of sphericity, it is considered that there is a significant correlation relationship between the variables suitable for factor analysis.

(3) Extraction of common factors. The estimation of factor loadings generally has the principal component method, maximum likelihood method, principal axis factor method, least squares method, etc. In this paper, we choose to use a wider range of SPSS default method principal component method. The principal component method is a method of converting a set of variables we observe into another variable, which can be expressed as:

$$\begin{gathered} y_1 = u_{11}x_1 + u_{21}x_2 + \ldots\ldots + u_{p1}x_p \\ y_2 = u_{12}x_1 + u_{22}x_2 + \ldots\ldots + u_{p2}x_p \\ \cdots \\ y_p = u_{1p}x_1 + u_{2p}x_2 + \ldots\ldots + u_{pp}x_p \end{gathered} \tag{10}$$

This system of equations requires:

$$u_{1k}^2 + u_{2k}^2 + \ldots\ldots + u_{pk}^2 = 1(k = 1, 2, 3, \ldots\ldots p) \tag{11}$$

The above equation requires that coefficient u_{ij} be determined according to two principles:

Principle I: Variables y_i and $y_j(i \neq j, i, j = 1, 2, 3, \ldots\ldots.p)$ are both uncorrelated.

Principle II: y_1 is the largest variance of all linear correlations of $x_1, x_2, x_3, \ldots, x_p$. y_2 is the largest variance of all linear combinations of $x_1, x_2, x_3, \ldots x_p$ that are uncorrelated with y_1. y_p is the largest variance of all linear combinations of $x_1, x_2, x_3, \ldots x_p$ that are uncorrelated with $y_1, y_2, y_3, \ldots, y_{p-1}$.

(4) Factor score model. Calculate the score of each common factor, the composite score. Factor score is the final result of the construction of factor variables reflected. The basic idea of calculating the

public factor score is to express the factor variable as a linear combination of the original variables, and the basic function (12) is as follows:

$$F_j = \beta_{j1}x_1 + \beta_{j2}x_2 + \beta_{j3}x_3 + \ldots + \beta_{jp}x_p (j, p = 1, 2, 3, \ldots, m) \tag{12}$$

This paper directly through the SPSS software selection regression method to obtain the score coefficients of each common factor, according to the formula to calculate the score of each common factor of the selected sample company, and then the weight determined by the variance contribution rate of each common factor to obtain the financial performance evaluation score of the sample company.

2.3. SVD-based parallelized distributed design for principal component analysis

Most of the time in the operation of principal component analysis is consumed in the solving part of the eigenvalue, if the solving speed of the eigenvalue is improved, then the time of the whole principal component analysis will be shortened dramatically, which shortens the time of the public factor extraction of the PCA method, and improves the efficiency of the analysis. In general, there are too many ways to perform matrix decomposition, but there are only two commonly used ones, one is orthogonal triangle (QR) decomposition, and the other is singular value decomposition. In this paper, we will use the idea of decomposition algorithm of SVD for the design implementation on MapReduce.

Either form of matrix can be introduced into the SVD algorithm for feature extraction, the core operation formula of SVD algorithm is (13):

$$A = U\Sigma V^T \tag{13}$$

A is any $a*b$ matrix, U is the orthogonal matrix of $a*b$, Σ is the diagonal matrix of $a*b$, and V^T is the orthogonal matrix of $a*b$ called the right singular matrix.

3. Urban micro-landscape greening assessment

The research scope of this paper is the square in the urban area of the city, including the cultural casino and boutique commercial street, the main balcony of the city and the landscape extension along the north side of the south side of the river. The research object is mainly tourists, including some scenic spot staff, the research method mainly adopts questionnaire research, supplemented by participatory research and free interviews and other forms of obtaining public feedback, the research time span is from October 2023 to September 2024, the total cumulative distribution of questionnaires 200 copies, recovered 200 valid questionnaires.

3.1. Extraction of evaluation metrics

3.1.1. Reliability test. The data obtained from the 200 research questionnaires were synthesized and analyzed for reliability and validity with the help of SPSS 25.0 software as shown in Tables 2 and 3. After Cronbach Alpha analysis, the value of 0.76>0.6, indicating that the data source is reliable and can be analyzed, after KMO and Bartlett sphericity test the value of 0.688>0.6, the significance value is less than 0.05, indicating that there is a correlation between the sample variables, and the sample is more suitable for doing factor analysis.

Table 2. Reliability statistics

Clonbach Alpha number	Term number
.755	17

Table 3. KMO and Bartlett test

KMO sampling availability number	0.071
Bartlett sphericity test approximation card square	687.571
Freedom	122
Significance	0

3.1.2. Common factor extraction and naming. After the sample reliability test, the factors with factor eigenvalues > 1 were extracted as shown in Table 4, from which it can be seen that a total of five male factors were extracted with a cumulative variance contribution of 61.573%.

Table 4. Total variance interpretation rate

	Initial eigenvalue			Extracting the load of the load			Rotational load squared		
Constituent	Total	Percentage of variance	Cumulation %	Total	Percentage of variance	Cumulation %	Total	Percentage of variance	Cumulation %
1	3.631	22.69	22.225	3.631	22.69	22.225	2.591	16.194	16.194
2	1.875	11.72	34.41	1.875	11.72	34.41	2.227	13.92	30.11
3	1.691	10.57	44.98	1.691	10.57	44.98	1.313	8.2	38.31
4	1.461	9.13	54.11	1.461	9.13	54.11	1.76	11.00	49.31
5	1.169	7.32	61.43	1.169	7.32	61.43	1.936	12.1	61.41
6	0.059	0.37	61.8						
7	0.619	3.87	65.67						
8	0.865	5.41	71.08						
9	0.815	5.09	76.17						
10	0.7	4.38	80.55						
11	0.644	4.03	84.58						
12	0.603	3.77	88.35						
13	0.546	3.41	91.76						
14	0.505	3.16	94.92						
15	0.434	2.71	97.63						
16	0.383	2.39	100						

According to the rotated component matrix, the index items included in the five male factors were determined as shown in Table 5, and the five male factors were named.

Among them, public factor 1 includes X9 water landscape visual effect factor, X7 multimedia landscape interactivity factor, X6 multimedia landscape perception factor, and X5 multimedia landscape visual factor, which is named F1 (multimedia interactivity factor).

Common factor 2 includes X12 water landscape humanistic connotation factor, X16 facility humanistic connotation factor, X8 multimedia landscape humanistic connotation factor, and X4 architectural culture connotation factor, which is named F2 (humanistic connotation factor).

Common factor 3 includes X11 Water Landscape Interactivity Factor, X10 Water Landscape Perception Experience Factor, X13 Facility Art Form Factor, and X1 Architectural Nightscape Lighting Factor, which is named as F1 (Landscape Perception Factor).

Common factor 4 includes X14 Facility humanization design factor and X15 Facility intelligence degree factor, which will be named F4 (Service facility factor).

Common factor 5 includes X3 architectural features factor and X2 building façade landscape factor, which will be named as F5 (architectural features factor). The variance contribution rates of these five public factors are 24.53%, 13.21%, 12.08%, 10.51%, and 8.47% in order.

Table 5. The component matrix after rotation

	Constituent				
	1	2	3	4	5
X9	0.863	0.092	0.129	0.086	-0.06
X7	0.759	0.262	-0.2	0.188	0.186
X6	0.712	0.072	0.166	0.136	0.397
X5	0.702	-0.078	0.431	0.06	-0.038
X12	0.171	0.84	0.316	0.276	0.112
X16	-0.059	0.814	-0.004	0.108	0.206
X8	0.227	0.673	0.393	0.091	-0.37
X4	0.133	0.637	-0.083	-0.164	0.383
X11	0.125	-0.007	0.786	0.111	-0.017
X10	0.068	0.144	0.704	0.089	0.228
X13	0.163	0.216	0.658	0.136	-0.034
X1	0.495	0.098	0.54	-0.075	0.316
X14	0.077	0.157	0.169	0.927	0.143
X15	0.18	-0.009	0.067	0.922	-0.061
X3	0.067	0.217	0.166	0.097	0.858
X2	0.415	0.114	0.144	0.054	0.566
Extraction method: main component analysis					
Rotation method: the maximum variance method of caesars					

3.2. Calculation of evaluation common factor score and comprehensive evaluation grade

The matrix of factor component score coefficients is shown in Table 6.

Table 6. Component score coefficient matrix

	Constituent				
	1	2	3	4	5
X1	0.118	-0.01	0.252	-0.121	0.164
X2	0.101	0.012	-0.025	-0.009	0.366
X3	-0.126	0.039	0.049	0.049	0.628
X4	0.01	0.363	-0.134	-0.149	0.185
X5	0.279	-0.038	0.161	-0.051	-0.121
X6	0.269	-0.006	-0.057	0.025	0.182
X7	0.351	0.091	-0.222	0.051	-0.024
X8	0.068	0.393	0.138	-0.044	-0.372
X9	0.415	0	-0.097	-0.026	-0.21
X10	-0.124	-0.055	0.393	-0.008	0.119
X11	-0.082	-0.096	0.455	-0.003	-0.034
X12	-0.017	0.392	0.064	0.084	-0.062
X13	-0.044	0.015	0.361	0. 007	-0.064

X14	-0.062	-0.022	0.019	0.544	0.089
X15	0.031	-0.07	-0.057	0.514	-0.035
X16	0.06	0.416	-0.085	-0.005	0.047
Extraction method: main component analysis					
Rotation method: the maximum variance method of caesars					

Based on the matrix of factor component score coefficients the expressions for each factor F1-F5 can be derived:

$$\begin{aligned} F_1 = {} & 0.118X_1 + 0.101X_2 - 0.126X_3 + 0.01X_4 + 0.279X_5 \\ & +0.269X_6 + 0.351X_7 + 0.068X_8 + 0.415X_9 - 0.124X_{10} \\ & -0.082X_{11} - 0.017X_{12} - 0.044X_{13} - 0.062X_{14} + 0.02431X_{15} \\ & +0.06X_{16} \end{aligned} \tag{14}$$

The same reasoning leads to the F_2, F_3, F_4, F_5 -factor expressions, respectively:

$$\begin{aligned} F_2 = {} & -0.01X_1 + 0.012X_2 + 0.039X_3 + 0.363X_4 - 0.038X_5 \\ & -0.006X_6 + 0.091X_7 + 0.393X_8 + 0.000X9 - 0.055X_{10} \\ & -0.096X_{11} + 0.392X_{12} + 0.015X_{13} - 0.022X_{14} - 0.07X_{15} \\ & +0.416X_{16} \end{aligned} \tag{15}$$

$$\begin{aligned} F_3 = {} & 0.225X_1 - 0.025X_2 + 0.049X_3 - 0.134X_4 + 0.161X_5 \\ & -0.057X_6 - 0.222X_7 + 0.138X_8 - 0.097X_9 + 0.393X_{10} \\ & +0.455X_{11} + 0.064X_{12} + 0.361X_{13} + 0.019X_{14} - 0.057X_{15} \\ & -0.085X_{16} \end{aligned} \tag{16}$$

$$\begin{aligned} F_4 = {} & -0.121X_1 - 0.009X_2 + 0.049X_3 - 0.149X_4 - 0.051X_5 \\ & +0.025X_6 + 0.051X_7 - 0.044X_8 - 0.026X9 - 0.008X_{10} \\ & -0.003X_{11} + 0.084X_{12} + 0.007X_{13} + 0.544X_{14} + 0.514X_{15} \\ & -0.005X_{16} \end{aligned} \tag{17}$$

$$\begin{aligned} F_5 = {} & 0.164X_1 + 0.366X_2 + 0.628X_3 + 0.185X_4 - 0.121X_5 \\ & +0.182X_6 - 0.024X_7 - 0.372X_8 - 0.21X_9 + 0.119X_{10} \\ & -0.034X_{11} - 0.062X_{12} - 0.064X_{13} + 0.089X_{14} - 0.035X_{15} \\ & +0.047X_{16} \end{aligned} \tag{18}$$

Taking the mean value of the above calculations results in F1 (multimedia interaction factor) = 5.181, F2 (humanistic connotation factor) = 3.762, F3 (landscape perception factor) = 4.871, F4 (service facilities factor) = 3.79, and F5 (architectural features factor) = 4.158.

The proportion of the variance contribution rate of each factor to the total variance contribution rate was used as the weight for calculation, thus arriving at the overall evaluation grade of the digital landscape, which was calculated by the following formula:

$$F = (0.251F_1 + 0.117F_2 + 0.4F3 + 0.091F4 + 0.072F5) / 0.591 \tag{19}$$

The calculation result shows that the overall evaluation of micro-landscape greening in the demonstration area is F=4.218, which is good according to the evaluation standard. In terms of evaluation factors, F1 (multimedia interaction factor) scored the highest among the five evaluation factors, 5.181, followed by F3 (landscape perception factor) 4.871, F5 (architectural features factor) 4.158, F2 (humanistic connotation factor) 3.762, and lastly F4 (service facilities factor) 3.79.

3.3. Determination of evaluation factor weights and application analysis

According to the rotated component score matrix, the factor loading of each indicator item on its common factor can be determined, and the weight value of each indicator item is obtained after standardization of the data, which makes it more obvious that the degree of influence of each evaluation indicator on the comprehensive evaluation grade is shown in Table 7.

The proportion of F1 (multimedia interaction factor) in the public factor is the highest, indicating that F1 (multimedia interaction factor) is the most important factor affecting the benefits of the urban demonstration area. Compared with the traditional physical landscape, the application of digital landscape in urban open space has advantages in terms of visual effect, landscape perception and landscape interactivity, etc., and the public is mostly curious about the digital landscape and participates in spontaneous behavior. Public curiosity about digital landscape and spontaneous behavioral participation are strong, and digital landscape with creativity and aesthetic sense of science and technology can often become the core attraction in urban open space.

Table 7. Evaluation factor weighting

Principal component	Weight value	Evaluation factor	Weight value
F1(Multimedia interaction factor)	38.48%	Visual effect of water view	14.00%
		Multimedia landscape interactivity	11.23%
		Multimedia landscape perception experience	8.56%
		Visual effects of multimedia landscape	9.00%
F2(Humanistic connotation factor)	19.67%	Water view humanistic connotation	6.14%
		Cultural connotation of facilities	6.71%
		Cultural connotation of multimedia landscape	5.51%
		Architectural culture connotation	5.17%
F3(Landscape perception factor)	18.11%	Water view interactivity	6.51%
		The water view is aware of the experience	5.84%
		Art form	5.25%
		The building night scene is bright	3.71%
F4(Service facility factor)	15.84%	Humanized design of facilities	8.49%
		Facility intelligence	8.40%
F5(Architectural characteristics factor)	12.61%	Architectural characteristics	8.58%
		Facade landscape	5.09%

4. Urban micro-landscape greening design based on SWMM modeling

4.1. SWMM model

The Stormwater Management Model SWMM model can be used to simulate stormwater runoff and pollutant loads in urban drainage systems, including catchment areas, pipe networks, and inspection wells to simulate hydrologic, water quality, and hydraulic processes [24].

Typical scenarios of the SWMM model are the technical implementation of detailed structure data in the drainage network system to control flooding caused by heavy rainfall, the ability to adjust the size of low-impact development (LID) flooding devices in response to the flow of nonpoint source pollutants from heavy rainfall, the drawing of maps of the extent of flooding of open nullahs for non-manual drainage and irrigation, and the development of guidelines for the minimization of surface runoff into drainage pipes, Analyze the effect of external catchments to the storm sewer network on outfall conduit discharge, determine the ratio of various nonpoint source pollutant constituents within the surface source pollutant load, analyze whether LID structures are reducing nonpoint source pollutant concentrations to the expected level, and analyze the results of rainfall runoff limitation by stormwater management measures.

4.2. Principles of SWMM model operation

4.2.1. Hydrological processes. SWMM model hydrological processes include the formation of surface produced catchment and the underground soil layer rainwater infiltration process and rainfall changes and other factors interact with each other in a complex process, in which the surface produced catchment area can be divided into a number of sub-catchment area, in the macro performance of the sub-basin narrowly expressed as a sub-catchment water surface, according to the structural properties of the surface sub-catchment area consists of three basic spatial units A1, A2, and A3, A1 refers to the impervious area with depressed storage depth, referred to as the impervious area with puddle storage, A2 refers to the impervious area without depressed storage depth, referred to as the impervious area without puddle storage, and A3 refers to the area that can be infiltrated in its entirety, referred to as the permeable area, and the rainfall is intercepted by the infiltration of rainwater into the soil subsurface through the A3 area.

4.2.2. Hydraulic processes. In a rainfall event, rainfall falls on the soil subsurface to form rainwater runoff after diffuse flow convergence into the rift valley shoulder side of the stormwater grates into the stormwater wells, rainwater flows into the drainage network system (which contains pumping facilities, water storage facilities, diversion facilities and other structures) are in accordance with the flow of non-uniform free-flowing, the water flow in the pipeline to produce a variety of hydraulic performance back to the water, overflow, accumulation of water, etc., and its processes If the pressure generated between the water flow and the pipe and canal is too large to damage the drainage facilities resulting in flooding events, the stormwater runoff in the pipe and canal are asymptotic non-constant flow of the principle of its movement through the SWMM model provided by the three methods in which two of the methods (kinematic and dynamic wave method) combined with the operation of the rainwater network of the convergence of the change in the process of the hydraulic process for the SWMM.

4.2.3. Water quality processes. The maximum value of the pollutant accumulation curve Bmax depends on the length of time that nonpoint source pollutants gather in sunny days, and the accumulation time index NB is generally less than or equal to 1 and kB (the rate of aggregation of the fixed parameter or semi-saturation parameter) to determine, or can be directly assigned to the initial cumulative mass of nonpoint source pollutants each in the hydrologic response unit, each pollutant in the SWMM simulation has its own appropriate accumulation model.

4.3. SWMM Simulation and Analysis

4.3.1. LID facilities. According to the different attributes of the site, four types of micro-landscaping facilities are set up in this SWMM simulation, which are permeable paving, undercroft green space (depth of 100mm), garden (depth of 250mm), and green roof. In the SWMM model, there are two ways to set up the micro-landscaping greening facilities, one is to create independent sub-catchment areas for each micro-landscaping greening facility, which can clearly reflect the water sources and runoff paths of each micro-landscaping greening facility, and is suitable for small-scale refinement of the simulation; and the other is to define part of the area in the sub-catchment zones as the micro-landscaping greening facilities, which is suitable for large-scale hydrological simulation, and is also the best method adopted in this study. This approach is suitable for large-scale hydrological simulation and is also the way of defining micro-landscape greening facilities adopted in this study. According to the SWMM user manual and similar areas, the parameter settings of micro-landscape greening facilities are shown in Table 8.

Table 8. The design of the initial facility parameters of microlandscape greening

	Landscape greening	Water float	Lower green space	Garden	Green roof
	Retention depth(mm)	100	100	252	52
Surface layer	Plant coverage	0	0.4	0.4	0.4
	Porosity	0.17	-	-	-
	Permeability(mm/h)	200	-	-	-
	Manning coefficient	0.016	0.17	0.17	0.26
	Grade(%)	2	3	26	3
Soil horizon	Thickness(mm)	-	800	800	550
	Porosity	-	0.4	0.4	0.4
	Water yield	-	0.1	0.1	0.17
	Wilting point	-	0.05	0.05	0.05
	Permeability(mm/h)	-	125	125	125
	Hydraulic gradient	-	12	12	12
	Water suction(mm)	-	93	93	93
Aquifer	Thickness(mm)	155	400	400	-
	Porosity	0.81	0.81	0.81	-
	Permeability(mm/h)	13.4	13.4	13.4	-
	Plugging factor	0	0	0	-
Canal	Flow coefficient	0	0	0	-
	Flow index	0.7	0.7	0.7	-
	Bottom lift(mm)	7	100	100	-
Drainage layer	Thickness(mm)	-	-	-	35
	Porosity	-	-	-	0.47
	Manning coefficient	-	-	-	0.5

4.3.2. Model parameterization. In addition to the above parameters, Manning's coefficient, puddle storage, infiltration rate, infiltration attenuation coefficient, and pipe roughness need to be set in the model for each sub-catchment to obtain empirical parameters as shown in Table 9.

Table 9. The urban demonstration area SWMM hydrological parameters

Serial number	Name	Value
1	The Manning coefficient in the impervious zone	0.014/0.027/0.017
2	Manning coefficient in the permeable zone	0.26
3	Storage depth of the impervious area(mm)	2.7
4	Storage depth in the permeable area(mm)	7
5	Imvious area no depression impervious area ratio	27
6	Maximum penetration rate(mm/h)	10.5.9
7	Minimum penetration rate(mm/h)	13.64
8	Fosmotic attenuation coefficient	10.51
9	Characteristic width	Sub-hui water area / Diffuse path length
10	Plumbing rough rate	0.014, 0.027, 0.017

4.3.3. SWMM model validation. The SWMM model analysis of the demonstration area was carried out using the measured rainfall data from the Y1 rainfall station, with a simulation step of 1 hour, to obtain the rainfall and surface runoff throughout the year as shown in Fig. 2, where the peak rainfall and the peak surface runoff within the site appeared at almost the same time, and the results were consistent with the rainfall and flooding patterns.

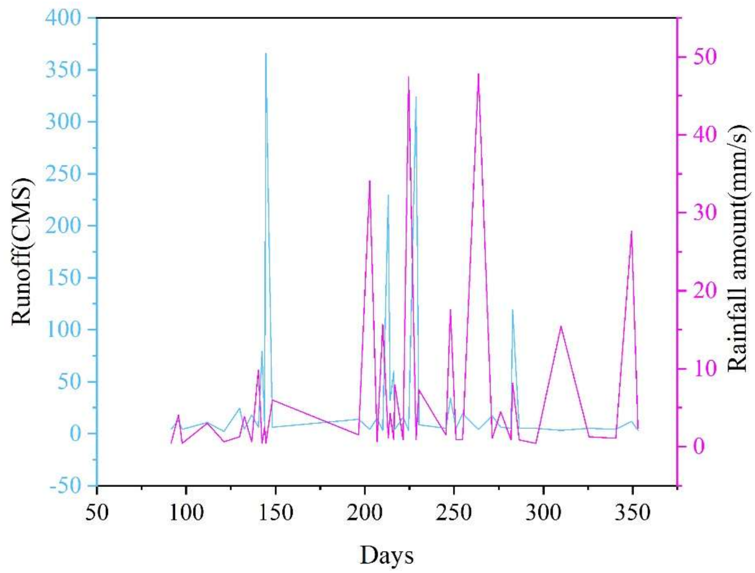

Fig. 2. Simulation results of rainfall and runoff of SWMM in the demonstration area

4.3.4. SWMM simulation results. The demonstration area modules are divided into H01-H10, and the total runoff volume of each drainage subdivision of H01-H10 is simulated by the SWMM model, and the actual annual runoff control rate of each block in 2023 is calculated as shown in Table 10.The results of the SWMM simulation show that, under the measured rainfall throughout the year in 2023, the actual annual runoff control rate of the urban demonstration area basically reaches more than 50%, and the average annual runoff control rate is 59%, which is a gap with the overall long-term target value of 70%.

Table 10. The total control rate of the actual annual runoff in the demonstration area 2023

Serial number	Partition number	Total precipitation /mm	Area /ha	The total control rate of the actual annual runoff in 2024
1	H01	2419	451	55%
2	H02	2419	151	61%
3	H03	2419	152	59%
4	H04	2419	89	68%
5	H05	2419	135	54%
6	H06	2419	23	56%
7	H07	2419	202	60%
8	H08	2419	99	60%
9	H09	2419	319	61%
10	H10	2419	213	61%
Population				59%

Among them, sub-area H04 is mainly the water body of Tianmu River, and the annual runoff control rate is basically the same as the planning value, and the remaining nine sub-areas have a gap of 8% to 21% with the planning value, of which sub-area H05 has the largest gap of 21% between the annual runoff control rate and the planning target.

In the process of urban micro-landscape greening construction and upgrading in 2020-2030, the annual runoff control rate can be improved and the target value can be realized by taking advantage of the mountains and waters in the demonstration area and combining with landscape design.

4.4. Urban micro-landscape greening design program

Taking into account the results of the field study, while planning and designing the various landscape nodes, emphasis should be placed on different urban engineering measures, such as “seepage, stagnation, storage, purification, utilization and drainage”, in accordance with local conditions. Should “restore the ecological function of facilities” as the first priority, as far as possible to restore the city's original rivers, reservoirs, ditches, protection of rivers, lakes, ponds and other natural water systems, development, transformation of urban community buildings, roads, green belts, plazas, parks and other public facilities to store rainwater ecological function. For the basic situation of each area, the development of targeted sponge city construction planning and technical programs.

Ancient City Area, Prickly Pine Area road traffic volume, the corresponding automobile exhaust pollution deposits more than the first rain pollution is serious; building density is high, the proportion of permeable area is not large; green space vegetation is rich and high coverage, the shortcomings of the distribution is more scattered. Suggestions in the ancient city, Prickly Pine area to carry out sponge city construction should pay attention to the green belt and the connection of the landscape nodes, specific engineering measures around the “stagnation, net, row” implementation.

East of the city area, the East China Sea area, Beifeng area road traffic is small, the corresponding automobile exhaust retention less, the old village building density is high, the proportion of permeable area is not large, green space vegetation coverage is low, but the region is distributed in a number of reservoirs, can play a role in water storage. It is suggested that when these three areas carry out sponge city construction, the engineering measures of their landscape nodes should be implemented around “seepage, storage, use and drainage”.

5. Conclusion

This paper uses Hadoop distributed computing to process the data and construct the urban micro-landscape greening evaluation system, based on the principal component analysis method and factor analysis evaluation method to determine the evaluation factors of which the multimedia interaction factor accounts for the highest proportion, which is the most important factor affecting the effectiveness of micro-landscape greening. Using the SWMM model to simulate the annual runoff control rate of the urban demonstration area in 2023, the results show that the average annual runoff control rate of the demonstration area in 2023 is 59%, which is a gap with the overall long-term goal of 70% of the planning in 2030, and there is a large space for improvement in the construction of urban micro-landscape greening. According to the results of the study, the urban micro-landscape greening design scheme is proposed to improve the urban micro-landscape greening construction.

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