Research on Landscape Performance Evaluation Technology Based on Big Data Multivariable Ornamental Plant Database

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Abstract: Contemporary planting design has posed higher requirements on the comprehensive utilization of plant morphology, ecology and other characteristics. On the basis of research foundation of ornamental plant database, the ornamental plant performance analysis and evaluation technology, established over the digital evaluation model and its test feedback technology, conducts technology exploration for landscape performance analysis and evaluation of planting design. This study is based on the parametric analysis and evaluation technology of VBA programming and function calculation. It is purported to improve the scientificity and objectivity of the planting design process. The technical framework of mathematical model is constructed to match engineering practice. And the weight variables at each level of the evaluation model are optimized and adjusted timely to meet design requirements of different design tendencies. Ornamental plant digital evaluation model and its test feedback mechanism are established to preliminarily form the ornamental plant analysis and evaluation system. It is added into the database as a new module.

Keywords: Big data, ornamental plant, landscape performance, digital model, evaluation

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1 Introduction

Contemporary planting design has posed higher requirements on the comprehensive utilization of plant morphology, ecology and other characteristics. Traditional design methods relying on perception and experience can no longer meet the requirements of discipline autonomy. Analysis and ecological evaluation methods of conventional plant advantage and disadvantage analysis includes the Delphi Approach, Comprehensive Evaluation and Grading of Plant Ecological Efficiency (LU MIN 2011); Analytical Hierarchy Process (AHP) explores replacing subjective evaluation with objective calculation through setting differently weighted influencing factors, quantitative evaluation criteria and evaluation factors for setting classification. The above methods require scoring and weight-setting by experts, both of which contains subjective evaluation factors and relatively high requirements for professional competence.

In this paper, scientific, objective and rational optimization technology is adopted to explore the parametric analysis and evaluation enabled through VBA programming and function computation. In this way, experience-depending conventional approach is changed. Analysis and judgement are conducted through data statistics and auxiliary parameters. From the perspective of biodiversity, focused study is conducted on ecological evaluation and landscape performance in plant selection. The paper also explores its important role and effect in the engineering practice, plant screening and later-stage management and protection.

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2 Establishment of Evaluation Indicator System

2.1 Underlying Theoretical Basis

With the development of eco-garden construction, plant landscape design is no longer confined to creating sensory and visual artistic effect. It also extends to landscape construction in various fields such as time, ecology and culture (ZOU KUANSHENG 2005). Time, space and resources are fully leveraged to facilitate effective use of land and plant resources for comprehensive consideration and evaluation, so as to promote the landscape performance of plant configuration design. Considerations shall be given to plants ecological habits determining the growth and maintenance inputs. Relevant indicators are accordingly considered, i. e., adverse environment tolerance, growth rate and others.

2.2 Determination of Evaluation Indicator Set

The selection of ornamental plants required considering generally continuing and improving the ecology, landscape and space efficiency of planting design, so as to maximize the landscape performance. The first-level indicators of plant performance evaluation are summarized as ecological feature, morphology and sustainability. The second-level indicator system is formed with reference to the ornamental plant design ideas and decomposed morphological and ecological factors, which are generated when constructing the predecessor digital platform (Figure 1).

First-level evaluation indicators	Second-level evaluation indicators
Ecology	native plants
	hardscrabble-tolerance
	cold-resistance
	Illuminance
	Shade-tolerance
	drought tolerance
	noise reduction
	soil type
	salt tolerance
	release of oxygen and carbon sequestration
	polluted gas absorption
	dust absorption
Morphology	plants life-forms
	oranmental characteristics
	branches
	leaf shape
	Leaf color during Autumn
	flower color
	Florescence
	fruit color
	fruit ornamental period
	Aromaticity
	canopy density of a plant
	branching height
	spatial distribution level
	pruning-tolerance
Sustainability	growth rate
	life cycles
	unit price

Fig. 1: Evaluation indicators collection

Reference is made to the classical plant growth habits description in abstracting plant ecological characteristics including: Cold-resistance, light adaptability, waterlogging-resistance, salt-alkali resistance, depth of root system, etc. According to the plant morphology described in *"Flora Reipublicae Popularis Sinicae"*, the key indicator elements includes visual ornamental characteristics such as branches & trunks, leaf shape, leaf colour and flower colour; olfactory ornamental characteristics such as aromaticity; space ornamental characteristics such as tree height, canopy density, branching height, etc. The sustainability of planting design is restricted by plant survival and maintenance easiness, replacement frequency at later stages, etc. The main relevant indicators include: Plant cultivation cost, growth rate, life cycles, etc.

3 Performance Evaluation Technology Research

In the technical logic and evaluation process of performance evaluation for practical application, four operational evaluation techniques were gradually summarized: Plant information parameterized association for information retrieval and quantitative information association; weighted matrix evaluation, real-time performance evaluation and analysis for real-time evaluation and analysis to planting solutions; model test feedback technology for continuous perfection and correction.

3.1 Plant Information Parametric Association Technology

Previous studies were based on Excel ornamental plant database and focused on plant morphology selection. The related findings were presented and exchanged at 2014 DLA Conference. In another paper, plant information such as morphological characteristics, ecological environment, geographical distribution, economic use, phenology and others was decomposed into volume information, morphological information, colour vision, phenological sequence, ecological adaptability, environmental information, planting specifications, etc. Such decomposition was done through analysing and quantifying the basic morphological information of ornamental plants based on the previous work in the database. Ornamental plant ecological evaluation and landscape performance evaluation were supplemented and strengthened. Ecological indicators including plant dust absorption, oxygen release and carbon sequestration, noise reduction and others were added. The corresponding plant data were also supplemented.

1) Information retrieval: According to the content of evaluation indicator set, VBA programming "Reference position" could be applied, i. e., Using "Worksheets ("Plant Information Storage").Rows(10).Font.Bold = true" to retrieve plant information in the Excel database, forming an evaluation application module based on database platform.

2) Information quantification and parametric association: In further application, the retrieved information was quantitatively processed. The conventional descriptive sentences universally recognized and accepted, such as "Shade-requiring, shade-tolerance and shade-intolerance", were analyzed. By the needs of digital research, they were preliminarily classified into three levels: Strong, middle and weak. And the indicator comment corresponding to each evaluation indicator was further refined.

At the same time, to avoid the subjective factors in the traditional evaluation and calculation, score assignment to each indicator comment was defined according to the consolidated evaluation indicator set, to construct the function relationship between the ornamental plant database retrieval information and evaluation scores. To facilitate the subsequent calculation, odd numbered series which were integral times between each other were mainly used for assignment. In the construction of evaluation model (Figure 2), the basic weight of judgment matrix at the scheme level was obtained through the score relationship of plants' own indicators, to ensure the objectivity of data and maintain the objectivity of the final total score.

	A	B	C	D
1	First-level evaluation indicators	Second-level evaluation indicators	Indicator comment	Evaluation assignment
20		noise reduction	strong	9
21			middle	3
22			weak	1
23		soil type	all kinds	9
24			Slightly acidic、neutral or slightly alkaline、neutral	3
25			neutral/Slightly acidic/slightly alkaline	1
26		salt tolerance	strong	9
27			middle	3
28			weak	1
29		release of oxygen and carbon	strong	9
30			middle	3
31			weak	1
32		polluted gas absorption	one more	9
33			one type	3
34			none	1

Plant Information Library | Rating of Evaluation Index | Hierarchy model | Criterion Layer Weight judgment | Progra

Example of character assignment by Excel: "strong" = 9; "middle" = 3; "weak" = 1

Fig. 2: Evaluation of the relationship between indicators and ratings scores

3) Module association: Combined the previous research results of ornamental plant data-base, the association between variable data is reorganized and constructed through VBA programming, function calculation and

other technical means. This includes forming a digital evaluation module based on the association between the module information and worksheet, the association between the data and image, and the association between data calculation and function and macro program. It can also provide the instant presentation of analysis graphics on plant evaluation and ornamental plant superiority comparison, etc. Plant evaluation and comparison is performed in an intuitive and convenient manner, to achieve the comprehensive evaluation and grading of ornamental plant landscape performance.

3.2 Weight Matrix Evaluation Technology

1) Weight matrix establishment: It draws on the structure concept of AHP proposed by Prof. T. L. Saaty, an American operational research scientist, in the early 1970s, referencing to the related results of previous ornamental plant database studies (YE CHEN & DAITING YUAN 2014). Hierarchical structure module was established in the evaluation model. Interconnected and orderly levels were formed according to the analysis of elements at each level. Hence, a series of judgment matrixes were established to construct a comparison judgment matrix of the first-level indicator relative to the target level, and establish the indicator weight set. Based on the previous ornamental plant database, the data module was corrected and updated, and new landscape performance function evaluation module was established. Normalized weight was calculated using "POWER", "PRODUCT" and other functions:

$$wi = \frac{\sqrt[n]{\prod_i^n}}{\sum_1^n \prod_i^n}$$

wi: normalized weight; *n:* number of data contained in the weight matrix

The Judgment Matrix of Noise Reduction

Noise Reduction	Sequoia sempervirens (Lamb.) Endl.	seashore paspalum	Amygdalus persica L. var. persica f. albo-plena Schneid	Arundo donax var. versicolor	Wisteria sinensis f. alba	Salix X aureo-pendula	Salix integra 'Hakuro Nishiki'	Gardenia jasminoides Ellis var. grandiflora Nakai	Pyrus betulifolia Bunge	Clerodendrum trichotomum	Swida alba Opiz	Melia azedarach Linn.	Michelia chapensis	Taxodium distichum Rich.	Nandina domestica	Series multiplicatio	N-th root	Normalized weight	AW	AW/W	CI	CR	
Sequoia sempervirens (Lamb.) Endl.	1	3	3	9	9	3	9	1	9	1	3	9	3	3	9	387420489	3.7372	0.17647	2.64706	15			
seashore paspalum	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15			
Amygdalus persica L. var. persica f. albo-plena Schneid.	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15	0	0	<0.1通过
Arundo donax var. versicolor	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			
Wisteria sinensis f. alba	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			
Salix X aureo-pendula	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15			
Salix integra 'Hakuro Nishiki'	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			
Gardenia jasminoides Ellis var.	1	3	3	9	9	3	9	1	9	1	3	9	3	3	9	387420489	3.7372	0.17647	2.64706	15			
Pyrus betulifolia Bunge	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			
Clerodendrum trichotomum	1	3	3	9	9	3	9	1	9	1	3	9	3	3	9	387420489	3.7372	0.17647	2.64706	15			
Swida alba Opiz	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15			
Melia azedarach Linn.	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			
Michelia chapensis	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15			
Taxodium distichum Rich.	0.33333	1	1	3	3	1	3	0.33333	3	0.33333	1	3	1	1	3	27	1.2457	0.05882	0.88235	15			
Nandina domestica	0.11111	0.3333	0.3333	1	1	0.33333	1	0.11111	1	0.11111	0.3333	1	0.3333	0.3333	1	1.8817E-06	0.4152	0.01961	0.29412	15			

Fig. 3: The Judgment Matrix of Noise Reduction

Matrix consistency test was also conducted:

CR = CI/RI (CR < 0.10 was regarded as consistent)

CR: Consistency Ratio; CI: Consistency Indicator; RI: Mean Random Consistency Indicator

By means of objective indicator assignment, the indicator factors of site requirements were assigned according to their importance to node planting design, to obtain the relative weights of factors as noise reduction, illuminance and cold-resistance, etc. Based on the previous ornamental plant database, the indicator factor score of the selected plant set was defined according to the functional relationship between the database and evaluation score, to obtain the relative weight of the plant set on a certain factor (e. g. noise reduction) could be produced for the plant set (Figure 3). The weight coefficient was calculated to ensure the objectivity of each step of formula calculation and the scientificity of the conclusion.

2) Convenient and controllable: Based on the flexibility of VBA programming technology, the relevant variables in the function formula could be adjusted at any time to control the result output. The weight coefficient in the matrix was adjusted quickly and conveniently by changing the evaluation scores of relevant indicator factors as per the different requirements for each indicator in the design.

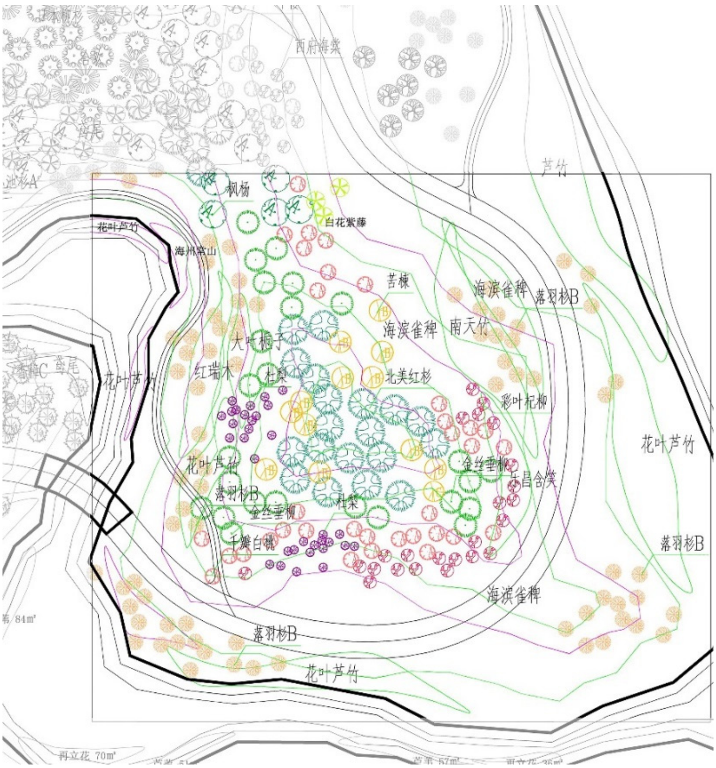

Fig. 4: Node plant configuration plane

3) Practical application: The plant selection and evaluation of Huanhuaxi node in a project in Yancheng was taken as an example (Figure 4). Firstly, the plant set was selected for the plot site. In the case of indicator factors with relatively great influence on the plot design, according to the digital platform, plant indicator factors were assigned by the function relations. The design requirements for the related index factors in the plot were preliminarily assigned.

And multilevel weight matrix was established including indicator level and solution level (Figure 3). The indicator weight of plant landscape evaluation was calculated through the case analysis of some plot design for Huanghuaxi node. The weight coefficient of the plant set evaluation was then obtained (Figure 5).

	Ecological	Morphology	Sustainability	Total score
Sequoia sempervirens (Lamb.) Endl.	0.49450549	0.42857143	3.857142857	1.90737834
seashore paspalum	0.69230769	0.42857143	3.065934066	1.59654631
Amygdalus persica L. var. persica f. albo-plena Schneid	0.49450549	0.42857143	1.483516484	0.89010989
Arundo donax var. versicolor	1.28571429	0.42857143	3.263736264	1.76609105
Wisteria sinensis f. alba	1.28571429	0.71428571	1.483516484	1.1255887
Salix X aureo-pendula	0.49450549	0.42857143	3.263736264	1.65306122
Salix integra 'Hakuro Nishiki'	1.28571429	1	1.483516484	1.24803768
Gardenia jasminoides Ellis var. grandiflora Nakai	0.49450549	1	1.483516484	1.13500785
Pyrus betulifolia Bunge	1.28571429	0.71428571	1.483516484	1.1255887
Clerodendrum trichotomum	0.69230769	0.71428571	1.483516484	1.04081633
Swida alba Opiz	1.28571429	1.85714286	3.263736264	2.37833595
Melia azedarach Linn.	0.69230769	1	1.483516484	1.16326531
Michelia chapensis	0.69230769	0.71428571	1.483516484	1.04081633
Taxodium distichum Rich.	1.28571429	1	3.857142857	2.26530612
Nandina domestica	1.08791209	1.85714286	1.483516484	1.58712716

Fig. 5: Plant collection evaluation score statistics
(Note: Use the Excel Function to highlight items above the average)

3.3 Instant Evaluation and Analysis Technology for Performance Evaluation

The plant related indicator assignment data obtained by the function relations, combined with the weight coefficient, works to generate the plant set score statistics table via the function analysis and calculations of Excel.

1) Result presentation: According to the first-level evaluation indicators, their scores were sorted by the function respectively to obtain evaluation ranking of the plant set in three different aspects of ecology, morphology and sustainability (Figure 5). In this way, evaluation was made on the advantages and disadvantages of the selected plants in all aspects.

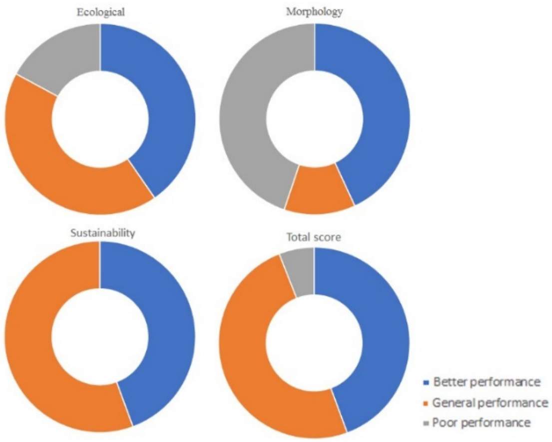

Fig. 6: Performance evaluation of plant configuration communities

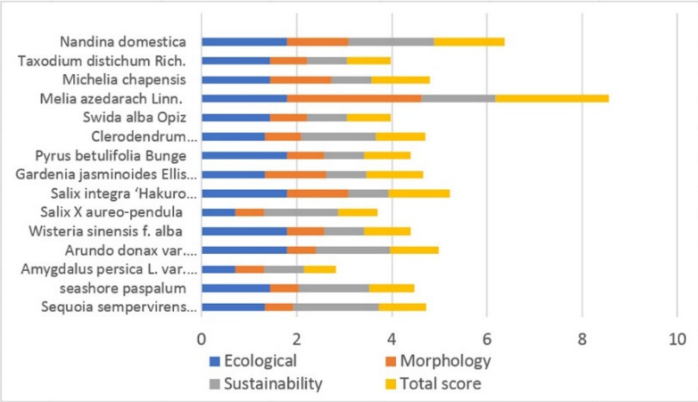

Fig. 7: Advantages of ornamental plants (Adjusted)

Through the function setting, the advantage comparison of ornamental plants was presented instantly in graphical form. And the advantages and disadvantages of plant application in the node planting design were analysed through total score ranking.

2) Related analysis:

1) Plant selection evaluation: Figure 5 showed that, *Arundo donax* var. *versicolor*, *Wisteria sinensis* f. *alba*, *Salix integra* 'Hakuro Nishilci', *Pyrus betulaefolia* Bunge, *Swida alba* Opiz, *Taxodium distichum* Rich. and *Nandina domestica* had relatively strong ecological advantages; *Salix integra* 'Hakuro Nishilci', *Gardenia jasminoides* var. *Grandiflora* Nakia, *Swida alba* Opiz, *Melia azedarach* Linn., *Taxodium distichum* Rich. and *Nandina domestica* had relatively strong ornamental advantages; *Sequoia sempervirens* (Lamb.) Endl., *seashore paspalum*, *Arundo donax* var. *versicolor*, *Salix xaureo-pendula*, *Swida alba* Opiz and *Taxodium distichum* Rich. had relatively strong sustainability. In the node plant configuration, *Sequoia sempervirens* (Lamb.) Endl., *seashore paspalum*, *Arundo donax* var. *versicolor*, *Salix xaureo-pendula*, *Swida alba* Opiz, *Taxodium distichum* Rich. and *Nandina domestica* had relatively strong comprehensive advantages.
2) Configuration solution evaluation: Through function calculation, in light of the plant score and the designed planting area, performance evaluation graph of site plant configuration community was formed (Figure 6) to obtain the objective evaluation of plant ecology, morphology and sustainability of site plant configuration.
3) Solution comparison: The weight variables at various levels of the evaluation model could be adjusted flexibly according to the design requirements in function construction, so as to adapt to different solutions of the design process and obtain objective analysis and evaluation results. When different requirements for the design are generated, the relative weight of each indicator factor could be feedback-adjusted through changing relevant variables in the evaluation model to achieve the purpose of instant analysis and feedback of the evaluation results. Taking the above results as an example, the importance of three first-level indicators and some second-level indicators were adjusted. The weight matrix could be changed instantly to the function relations through the association of evaluation model pages and variables. In this way, the weight coefficient of ornamental plant evaluation and the corresponding evaluation results could be obtained (Figure 7). The real-time analysis and evaluation could therefore be achieved.

3.4 Model Validation Feedback Technology

IBM SPSS Statistics was adopted to conduct model test using partial plant collection data from Huanghuaxi node.

Through KMP and spherical data test, it was considered that the next step of correlation analysis could be performed. Factor analysis was conducted on the data to obtain the correlation matrix and scree plot (Figure 8). Due to the absence of overall data distribution information, Kendall correlation was selected for correlation analysis (Figure 9).

		noise reduction	Illuminance	cold-resistance	Leaf color during Autumn	flower color	Aromaticity	growth rate	unit price	life cycles
Correlation	noise eduction	1								
	Illuminance	0.145	1							
	cold-resistance	0.041	0.03	1						
	Leaf color during Autumn	0.138	0.061	0.047	1					
	flower color	0.08	0.046	-0.04	-0.051	1				
	Aromaticity	0.003	0.054	-0.069	-0.106	0.072	1			
	growth rate	0.057	-0.039	0.079	-0.111	0.038	-0.165	1		
	unit price	0.003	0.052	-0.101	0.019	-0.2	0.08	-0.282	1	
	life cycles	-0.045	-0.008	0.032	-0.003	-0.189	0.093	-0.303	0.238	1

Fig. 8: Correlation matrix

			noise reduction	Illuminance	cold-resistance	Leaf color during Autumn	flower color	Aromaticity	growth rate	unit price	life cycles
Kendall's tau_b	noise eduction	Correlation coefficient	1	.132**	0.061	.151**	0.061	0.01	0.043	0.019	-0.026
		Significance (Two-tailed)	.	0.001	0.095	0	0.095	0.806	0.276	0.636	0.505
	Illuminance	Correlation coefficient	.132**	1	0.043	.099*	0.043	0.052	-0.019	.102*	-0.01
		Significance (Two-tailed)	0.001	.	0.256	0.014	0.256	0.204	0.645	0.012	0.812
	cold-resistance	Correlation coefficient	-0.011	-.083*	-.105**	-0.018	-.105**	-.098*	0.055	-.105**	0.012
		Significance (Two-tailed)	0.783	0.035	0.004	0.659	0.004	0.015	0.168	0.008	0.759
	Leaf color during Autumn	Correlation coefficient	.151**	.099*	-0.051	1	-0.051	-.091*	-0.05	.085*	0.007
		Significance (Two-tailed)	0	0.014	0.179	.	0.179	0.027	0.214	0.037	0.861
	flower color	Correlation coefficient	0.061	0.043	1	-0.051	1	0.074	0.046	-.212**	-.181**
		Significance (Two-tailed)	0.095	0.256	.	0.179	.	0.054	0.222	0	0
	Aromaticity	Correlation coefficient	0.01	0.052	0.074	-.091*	0.074	1	-.154**	.128**	.092*
		Significance (Two-tailed)	0.806	0.204	0.054	0.027	0.054	.	0	0.002	0.028
	growth rate	Correlation coefficient	0.043	-0.019	0.046	-0.05	0.046	-.154**	1	-.432**	-.282**
		Significance (Two-tailed)	0.276	0.645	0.222	0.214	0.222	0	.	0	0
	unit price	Correlation coefficient	0.019	.102*	-.212**	.085*	-.212**	.128**	-.432**	1	.368**
		Significance (Two-tailed)	0.636	0.012	0	0.037	0	0.002	0	.	0
	life cycles	Correlation coefficient	-0.026	-0.01	0.012	0.007	-.181**	.092*	-.282**	.368**	1
		Significance (Two-tailed)	0.505	0.812	0.759	0.861	0	0.028	0	0	.

**. The correlation is significant at 0.01 level (two-tailed).
*. The correlation is significant at 0.05 level (two-tailed).

Fig. 9: Kendall Correlation

Comparison showed that both the data factor correlation matrix and Kendall correlation-showed similar significance. The factors that showed significant correlations included: Cold-resistance − illuminance, cold-resistance − leaf colour in autumn, Waterlogging resistance − unit price, leaf colour in autumn − aromaticity − growth rate, flower colour − unit price − life cycles, unit price − growth rate − life cycles. The scree plot showed that the overall slope was relatively steep, hence all the factors had relatively great influence on the original data.

The correlation coefficient between various factors was further analysed, and statistics of the relative ratio between correlated factors was obtained. The statistical table obtained by IBM SPSS Statistics analysis was introduced as a part of the database evaluation module. And the above numerical values were substituted into the weight calculation through the function to improve the evaluation model and obtain a more objective and accurate plant evaluation conclusion.

4 Conclusion and Outlook

Based on the previous ornamental plant data platform, a digital evaluation model of ornamental plants and the validation feedback mechanism were established through the connected function relation. The ornamental plant analysis and evaluation system was preliminarily formed and added into the database as a new module. The weight variables at each level of the evaluation model could be flexibly adjusted by the design requirements to adapt to the changing needs in the design process to obtain the objective analysis and evaluation results.

Many aspects in this study can be further expanded and explored. The analysis and evaluation model can also be used to analyse and evaluate the plant research results in the built landscape environment. In accordance with the selected evaluation factors, the landscape performance of plant design in the landscape environment can be analysed and evaluated. At the same time, based on the existing classifications of strong, middle and weak levels, more detailed data can be introduced to further classify the indicators to improve its scientificity. IBM SPSS Statistics can be further incorporated to conduct deeper analysis of the plant evaluation results, securing closer linkage integration to the ornamental plant database through programming.

References

CHEN, Y. & YUAN, D. (2014), An Excel Based Digital Tool for Planting Design, Analysis and Evaluation. In: Proceedings DLA 2014, 283-290.

DELECTIS FLORAE REIPUBLICAE POPULARIS SINICAE (2014), Agendae Academiae Sinicae Edita. Flora Reipublicae Popularis Sinicae [M]. Science Press, Beijing.

KUANSHENG, Z. (2015), Elementary Introduction to the Application of Ornamental Plants to Modern Landscape Architectural Design [J]. Forest Inventory and Planning, 2005, 104-106.

MIN, L., KAI, G. & DONG-HE, L. (2011), Comprehensive evaluation and classification of Shandong wetland landscape architecture plants [J]. Journal of Shandong Jian Zhu University, 2011, 55-60.

OZIMEK, A. & LABEDZ, P., Quantitative and Qualitative Analyses of Landscape Views. Digital Landscape Architecture [J]. Anhalt University of Applied Sciences, 2013:93-101.