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IMPROVED VARIABLE SCALE OPTIMISATION ALGORITHM IN WATER SAVING LANDSCAPE DESIGN AND ITS APPLICATION

Abstract: With the acceleration of urbanisation, the problem of water resource shortage is becoming increasingly serious. Currently, the water use situation in Chinese cities is severe and the contradiction between the supply and demand of water resources is prominent, which has become one of the main factors restricting sustainable development of cities. Traditional research on water-saving landscape design focuses mainly on the analysis of the efficiency of water resource utilisation within a single area or city. The scope of the research is limited and the research methods are individual, which cannot fully meet the current needs of sustainable urban water-saving landscape design. The improved variable scale optimisation algorithm has become an indispensable tool in modern landscape design and would play a more important role in landscape design and ecological environment protection in the future. In response to the shortcomings of traditional variable-scale optimisation algorithms in solving the optimisation problem of water-saving landscape design for ecological sustainable development, this article would use an improved variable-scale optimisation algorithm to study the water-saving landscape design for ecological sustainable development in Community X, City B, Province A. The research results indicated that there were three experts who rated the effect of the water saving landscape design of the first group of designers as good or above, accounting for 37.5 %. The number of people who rated the effectiveness of water-saving landscape design in the second group as good or higher was 8, representing 100 %. The improved variable-scale optimisation algorithm could effectively improve the application of water-saving landscape design in ecological sustainable development.

Keywords: water-saving landscape design, variable scale optimisation algorithm, ecological sustainable development, water resource

Introduction

Water scarcity is a global problem. There is a shortage of water resources in many countries. To achieve sustainable economic and environmental development, optimising urban landscapes through planning, management, and design is an effective way to promote sustainable urban landscape development.

In recent years, many new concepts have been proposed in the field of landscape design, such as ecological design, water-saving design, etc. Landscape design refers to the planning and design of landscape and gardens. Its elements include natural landscape elements and artificial landscape elements; It is integrated with various disciplines such as planning, ecology, and geography, and has different meanings in different disciplines.

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These new concepts are the result of continuous practice and exploration by landscape designers. Landscape designers recognise that while improving human quality of life and meeting human environmental needs, they must consider both natural and economic factors. For landscape designers, water-saving design is one of their key considerations. In practical applications, water-saving design often involves multiple parameters, such as water quantity, water quality, etc. Therefore, how to reasonably incorporate these parameters into landscape design is an important issue.

This article improved the variable-scale optimisation algorithm and applied it to the design of water-saving landscapes for ecological sustainable development. The results showed that the improved variable scale optimisation algorithm was easier to solve problems and had better design performance compared to traditional algorithms. This method provided a reference for selecting water-saving solutions in actual landscape design, and also provided an effective and practical solution. The innovation of this article lied in the fact that ecological sustainable development and water-saving landscape design became an important development direction in the field of landscape design. In the future, more designers would join this field and make greater contributions to the sustainable development of cities.

Related work

With the gradual popularisation of the concept of sustainable development, improving the utilisation rate of water resources is a continuous research and practice topic in the urban planning and landscape design industry. Among them, Marin and de Meulder [1] took the transformation of the Limburg region in central Belgium to a circular economy as a design practice, and proposed that the constructivist approach to urban landscape design might embed social and economic dimensions when applying urban metabolism; urban landscape design operated within its intervention field, potentially promoting interdisciplinary dialogue in urban metabolic design research. Through the importance of visual expression of communication between stakeholders in the landscape planning and design process, Raaphorst et al. [2] developed an analytical framework based on semiotics and iconology theory, which made it possible to analyse the visual content of landscape design expression and interpret it in iconology. How to use the advantages of technological development to deal with the overall planning and design of urban spaces, and carry out an effective evaluation, so as to formulate appropriate strategies for the overall development of the city was necessary. Therefore, Xie [3] conducted a questionnaire analysis on Shandong province residents. The research results indicated that, in terms of secondary evaluation, the most important aspect was the "ecological principle", followed by the "consideration principle", the "application principle" and the "economic principle". Among the 15 evaluation indicators, the five most valued were: reducing impact, improving the environment, characteristics, environmental trends, and supporting greening. Based on the research results, suggestions were proposed to achieve environmental planning and overall design through reasonable planning, and improve the overall quality of the environment, to achieve sustainable development. However, the above studies were all theoretical studies on landscape design and lacked a scientific algorithm for verification.

The variable-scale optimisation algorithm is a computational model that simulates the evolution process of natural rivers, thus achieving the goal of controlling changes in river morphology by changing the water and sediment conditions of the river. Since its inception, this algorithm has attracted the attention of scholars around the world and has been widely applied in areas such as hydrology and water resources. Among them, the distribution of non-convex cost functions is crucial for better understanding optimisation algorithms widely used in signal processing, statistics, and machine learning. The famous Kuramoto model has become an important mathematical model for studying the synchronisation phenomenon of coupled oscillators on various network topologies. Ling et al. [4] combined these two seemingly unrelated objects by studying the optimisation landscape of a nonlinear function. Due to the commonly used fixed coordinate system and not suitable for different functional scenarios, naturally inspired optimisation algorithms might not be able to effectively search. To overcome this drawback, Liu et al. [5] proposed a framework called ACoS (Advertising Cost of Sales) to adaptively adjust the coordinate system in natural inspired optimisation algorithms. In ACoS, feature coordinate systems were established using cumulative population distribution information, which could be obtained based on adaptive strategies of the covariance matrix and additional archiving mechanisms. Due to the fact that population distribution information to some extent reflects the characteristics of functional landscapes, natural-inspired optimisation algorithms in the feature coordinate system had the ability to recognise the morphology of functional landscapes. These studies demonstrated the applicability of some optimisation algorithms in the field of landscapes, thus providing a foundation for applying variable-scale optimisation algorithms to the design of water-saving landscapes for sustainable ecological development.

Construction of ecological sustainable development and landscape design

Introduction to relevant technologies

(1) *Introduction to sustainable ecological development*

Ecological sustainable development refers to protecting and improving the ecological environment, maintaining ecological balance, and providing sustainable resources and environment for future generations while meeting the economic, social and cultural needs of modern people. Ecological sustainable development is one of the common global goals, involving economic, social and environmental aspects, thus aiming to achieve sustainable economic growth, social justice and harmony, and environmental health and stability. The core of the concept of ecological sustainable development is to adhere to people-oriented principles and promote coordinated development of economy, society, and environment. It emphasises prioritising the interests of current and future generations and focusing on protecting the natural environment, thus improving resource utilisation efficiency and promoting green and low-carbon development, thereby promoting sustainable consumption and production methods and ensuring the stability and resilience of ecosystems. To achieve the goal of sustainable ecological development, the international community has formulated a series of global, regional, and national policies and measures, such as the United Nations Sustainable Development Agenda, the Paris Climate Agreement, the Convention on Biological Diversity, the Convention to Combat Desertification, etc. At the same time, various countries actively promote the practice and exploration of sustainable ecological development through legislation, policies, technology, and markets.

(2) *Water-saving landscape design*

Water-saving landscape design is a landscape design technique that minimises water consumption and improves the efficiency of water resource utilisation, to reduce water costs while ensuring the aesthetics of the landscape. Teng and Conqui [6], Toy and Neslihan [7]. The purpose is to achieve water conservation by controlling water consumption from the source and scientifically utilising irrigation technology.

The design of water saving landscapes must be optimised and improved from multiple perspectives, such as site planning, plant configuration, and irrigation systems Maki and Tomoko [8], Bilous et al. [9]. An irrigation system refers to the complete set of facilities in an irrigation project, which includes three parts: water sources (rivers, reservoirs, wells, etc.) and channel buildings; the water supply system that takes water from the water source and transports it to the irrigation area, including channels or pipelines and their tunnels, aqueducts, culverts, and inverted siphons; the water distribution system for distributing water in irrigation areas, including various levels of channels within the irrigation area, as well as control gates, diversion gates, and sluice gates for controlling and distributing water volume; temporary channels in the field. Usually, starting from site planning, different types of vegetation can be classified, combined, and arranged according to water demand and planting methods. From the perspective of plant configuration, it is necessary to choose plants that are drought resistant, disease resistant, pest resistant, rapidly growing, and have strong ornamental properties. In terms of irrigation systems, advanced technologies such as drip irrigation, sprinkler irrigation, and micro irrigation can be used to control the amount of water and irrigation time, so that plants can obtain sufficient water.

Through water-saving landscape design, not only can water consumption be reduced, waste avoided, and water costs reduced, but the ecological value of the landscape can also be increased and people’s awareness of environmental protection can be raised. Ecological value refers to a special manifestation of “average value” in philosophy. It makes economic judgments in meeting the needs and development process of ecological environment objects, ethical judgments by humans in dealing with the relationship between the subject and object of the ecological environment, and functional judgments of natural ecosystems as independent systems that exist independently of human subjects. Therefore, water-saving landscape design is increasingly valued in modern urban construction and environmental protection Zhao et al. [10], Long and Cheng [11].

In this context, more and more landscape designers are paying attention to water conservation design and exploring how to achieve goals such as water conservation, environmental protection, and sustainable development in landscape design. At present, the current situation of water-saving landscape design for ecological sustainable development is manifested mainly in the following aspects.

Emphasis on water conservation in landscape design: More and more landscape designers are paying attention to water conservation design and reducing water consumption by adopting water-saving irrigation systems and selecting plants suitable for arid areas.

The application of environmentally friendly materials: In landscape design, more and more environmentally friendly materials are being used, such as biodegradable materials, recycled materials, etc., to reduce their impact on the environment. Environmentally friendly materials refer to a type of material that, under the action of light, water, or other conditions, degradable materials would experience a decrease in molecular weight, physical properties, and gradually be absorbed by the environment. They can also be called degradable materials.

Construction of green infrastructure: Green infrastructure refers to infrastructure that provides services to the urban ecosystem through natural systems, such as rainwater gardens, ecological roofs, etc. In landscape design, the construction of green infrastructure has also become a trend.

Integration of landscape design and urban planning: The integration of sustainable ecological development, water-saving landscape design and urban planning is becoming more and more close. Through landscape design, the urban environment is improved. The quality and stability of the urban ecosystem is improved and the sustainable development of the city is realised.

Construction of variable-scale optimisation algorithms

(1) *Variable scale optimisation algorithm*

Water resources refer to water sources that can be utilised or are likely to be utilised, which should have sufficient quantity and appropriate quality and meet the specific utilisation needs of a certain place over a period of time. China is a country with a shortage of water resources. With the acceleration of urbanisation, the issue of water resources has become more prominent. How to adapt urban landscape design to the concept of ecological sustainable development has become an important research topic in the contemporary urban planning and landscape design industry [12, 13]. Since the birth of humanity, water has been closely related to human life, such as agricultural irrigation, industrial production, and the use of living water. In the contemporary Chinese urban planning and landscape design industry, water has become one of the focuses of attention, and water conservation is an important component of China’s sustainable development strategy. Therefore, how to make water resources more reasonable and efficient is of great significance for China’s urbanisation process.

The variable-scale optimisation algorithm is an optimisation method based on "scale transformation", which transforms the original problem into several optimisation sub-problems through scale transformation. This effectively avoids the "premature convergence" and "local minima" phenomena that traditional variable weight coefficient algorithms are prone to while solving multi-objective optimisation problems, and has high optimisation efficiency.

(2) *Model and algorithm flow of variable scale optimisation algorithm*

With global climate change and population growth, the shortage of water resources is becoming increasingly prominent and water saving has become one of the important directions for sustainable ecological development. In landscape design, how to reasonably utilise water resources and reduce water consumption has become an important issue. The variable-scale optimisation algorithm is an optimisation algorithm based on natural phenomena, with global search ability and efficiency, which can be applied to the design of water-saving landscapes for sustainable ecological development.

The variable-scale optimisation algorithm is an improved global optimisation algorithm that can be used to achieve comprehensive optimisation of multiple indicators such as water and soil in ecological landscape design. The basic idea of variable scale optimisation algorithm is to simulate the evolution process of species in nature, and gradually optimise the objective function through continuous mutation, crossover, and selection. Water-saving landscape design is a design method that achieves water-saving goals by reducing water consumption and improving water utilisation efficiency while ensuring the aesthetics of the landscape. The relationship between variable-scale optimisation algorithms and water-saving landscape design is that the former can achieve precise optimisation of ecological landscape design by analysing and simulating environmental element information distributed in different scale spaces, thus effectively controlling various factors in the design process, which has the characteristics of high efficiency, accuracy, and reliability. The latter is based on the overall planning of the garden landscape according to the actual situation by adjusting the structure of the vegetation, the irrigation methods and other means to achieve maximum water conservation. The combination of the two can make landscape design more scientific and sustainable, while also contributing to urban construction and ecological environment protection. The basic idea of variable scale optimisation algorithm is to simulate the evolution process of species in nature and gradually optimise the objective function through continuous mutation, crossover, and selection. In the design of ecologically sustainable water-saving landscapes, the objective function can be set to minimise water consumption, maximise landscape benefits, etc. By using variable-scale optimisation algorithms, the optimal design scheme can be obtained, thus achieving the goals of water conservation and ecological sustainable development. Specifically, the variable-scale optimisation algorithm can be applied to the following aspects:

1) Optimising plant configuration in landscape design: By using variable-scale optimisation algorithms, the optimal plant configuration scheme can be obtained, thus maximising landscape benefits [14, 15].
2) Optimisation of irrigation system in landscape design: Through variable-scale optimisation algorithms, the optimal irrigation system scheme can be obtained, thus minimising water consumption while ensuring the growth needs of plants.

In summary, the variable scale optimisation algorithm has broad application prospects in ecological sustainable water-saving landscape design, and can provide effective design tools and decision-making support for landscape designers. The process is shown in Figure 1.

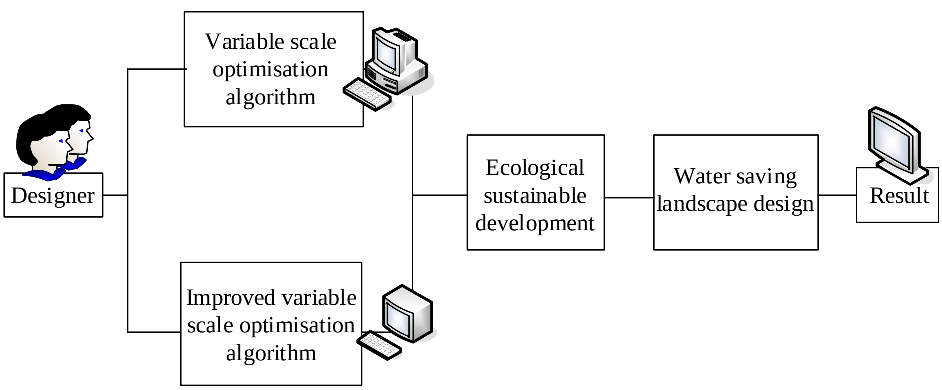

Fig. 1. Process of ecological sustainable development water-saving landscape design

The solving model of the variable-scale optimisation algorithm is analysed. In the variable-scale optimisation algorithm, the individual fitness function is based on the global optimal solution. Therefore, when the individual fitness function exceeds the local optimal solution, the algorithm would fall into the local optimal solution; at the same time, the selection operator, crossover operator, and termination condition in the variable scale optimisation algorithm have a greater impact on the individual fitness function. The selection of the fitness function directly affects the convergence speed of the genetic algorithm and whether it can find the optimal solution, because the genetic algorithm basically does not use external information in the evolutionary search and only uses the fitness of each individual of the population to search based on the fitness function. Therefore, in response to the shortcomings of traditional variable scale optimisation algorithms in solving optimisation problems, this article improved and optimised the variable scale optimisation algorithm [16, 17].

Improved variable scale optimisation algorithm for water-saving landscape design optimisation

(1) *Vision of the spatial environment of the water-saving landscape*

The formula can be obtained as follows:

$$\varphi = max\left[\frac{\alpha_1^2 - \alpha_\mu^2}{\alpha_1^2}, 0\right] \tag{1}$$

where α_1^2 is the local variation of the set of images for water-saving landscape design, and $\alpha_\mathrm{\mu}^2$ is the optimal coefficient for images of water-saving landscape design. This article adopted the gradient descent method to reconstruct the visual environment of the water-saving landscape space through regional segmentation, so that the sparse feature values of the environmental design images of the water-saving landscape space environmental design images met $V \in D$. Based on the results of a sparse prior expression, the optimal visual reconstruction threshold at frame (a, b) of the water-saving landscape spatial environment design image $G_\mathrm{n}(\mathrm{a}, \mathrm{b})$ was obtained. Template matching was performed on the design images and the matching coefficients were obtained as follows:

$$h_o^* = \begin{cases} Td_k, c \leq o \leq a - b \\ h_o, otherwise \end{cases} \tag{2}$$

where T is a standardised constant, which is combined with the segmented region template matching method to design and detect the spatial environment of the landscape with less water, d_k… h_o… The maximum gray value is as follows:

$$m_{qh} = \frac{\vartheta_{qy}}{(\vartheta_{00})^\delta} \tag{3}$$

The visual reconstruction of the spatial environment of the water-saving landscape was carried out and a variable-scale optimisation algorithm was used to achieve perception of the fusion of water-saving landscape information. The information reconstruction model was obtained and its expression form is as follows:

$$h(a, b) = g(a, b) + \theta(a, b) \tag{4}$$

where $g(a, b)$ represents the original water-saving landscape spatial environment image; $h(a, b)$ - reconstructed images; $\theta(a, b)$ - a grayscale image. Based on the above analysis, a variable scale optimisation algorithm can be designed for water-saving landscape design [18, 19].

(2) *Improved variable-scale optimisation algorithm*

The improved variable-scale optimisation algorithm has extensive and important applications in water-saving landscape design for ecological sustainable development. Firstly, this algorithm can optimise the water saving effect by analysing, modelling, and optimising environmental factor information at different spatial scales. Specifically, it can provide designers with an accurate and efficient tool to explore green gardens and low water consumption methods to achieve design goals. For example, it can optimise landscape design schemes by combining factors such as water resources, land use, vegetation type, and structure, thereby improving water resource utilisation efficiency. Second, the improved variable-scale optimisation algorithm can comprehensively optimise multiple factors based on the specific characteristics and needs of landscape design, including water, land use, vegetation structure, and ecological security. This aligns landscape design more with the principles of ecological sustainable development, which can better protect water resources and ecosystems, and improve the economic, social and ecological value of the landscape. Finally, the visualisation technology of this algorithm can also improve the transparency and participation of landscape design. Designers can intuitively understand the weights and optimisation results of each factor through visualisation technology, thereby better understanding design decisions and adjustment plans [20, 21]. At the same time, visualisation technology can also improve the efficiency of landscape design and communication with society and the public, which is of great significance for protecting water resources and achieving sustainable ecological development. Therefore, this article would optimise the water saving landscape design for ecological sustainable development based on an improved variable-scale optimisation algorithm. The specific steps are as follows: Firstly, combined with the segmented region template matching method, the feature visual reconstruction of water-saving landscape spatial environment design images is carried out. Based on the method of local feature adaptive feature matching, an information fusion model for water saving landscape spatial environment vision is constructed. Finally, a water-saving landscape spatial environment artistic feature expression model is constructed. Under the improved variable-scale optimisation algorithm, the information fusion expression is obtained as follows:

$$h = l \otimes g + m \tag{5}$$

among them, $\otimes$ represents a convolution operator. By combining the vector set of collected images of the spatial environmental design of the water saving landscape, a decomposition model for the visual characteristics of the spatial landscape was established. The optimal resolution feature values for water-saving landscape spatial environmental vision were obtained as follows:

$$d_{QQN}(u) = \sum_{o=-\infty}^{\infty} \sum_{k=0}^{M_q - 1} q\left(u - oU_d - kU_q - v_k U_v - x_o \theta\right) \tag{6}$$

$$d_{QQN}(u) = \sum_{k=-\infty}^{\infty} f_k q(u - kU_d) \tag{7}$$

In the formula, U_d is the optimisation iteration width of the genetic evolution. The segmented model for the design of the spatial environment of the landscape with water savings is obtained.

The image pixel decomposition model is expressed as follows:

$$a(u) = \sum_{n=1}^{N} \sum_{l=1}^{L(n)} \sigma_{ml} d(u - U_n - \varepsilon_{nl}) + w(u) \tag{8}$$

σ_{ml} is the fuzzy feature component of the visual environment of water-saving landscape space. The output of landscape optimisation design is obtained as follows:

$$\begin{cases} a = P\sin\mu\cos\gamma & 0 \leq \gamma \leq 2\pi \\ b = P\sin\mu\sin\gamma & 0 \leq \mu \leq \pi \\ c = P\cos\mu & P = F/2 \end{cases} \tag{9}$$

where μ and γ are the visual reconstruction function and the angle function of the water-saving landscape space, respectively, and P is the template matching coefficient.

Application experiments and evaluation in water-saving landscape design for ecological sustainable development

Overview of City B in Province A

(1) *Geographical location*

City B is located in the center of Province A on a valley plain between two major mountain ranges. The entire terrain of the city is high in the north and low in the south, thus forming a dustpan shape. The highest point above sea level is 3124 meters. The lowest point is 769 meters and the average elevation is about 900 meters.

(2) *Climatic conditions*

Province A has a temperate continental monsoon climate. Spring is characterised by rapid warming, large temperature differences, dryness, and windy and sandy weather; winter is dry and cold, with mostly sunny weather; summer is hot with concentrated rainfall; the number of sunny days increases in autumn and the weather is stable. The precipitation situation in Province A from 2020 to 2022 is shown in Figure 2.

As shown in the figure, the precipitation situation in province A was very uneven, with the main precipitation concentrated in June, July and August. The precipitation in late winter and early spring was very low, thus leading to a shortage of water resources in the province and making it one of China’s water-deficient provinces. Therefore, the sustainable ecological development of water-saving landscape design was of great significance in Province A [22, 23].

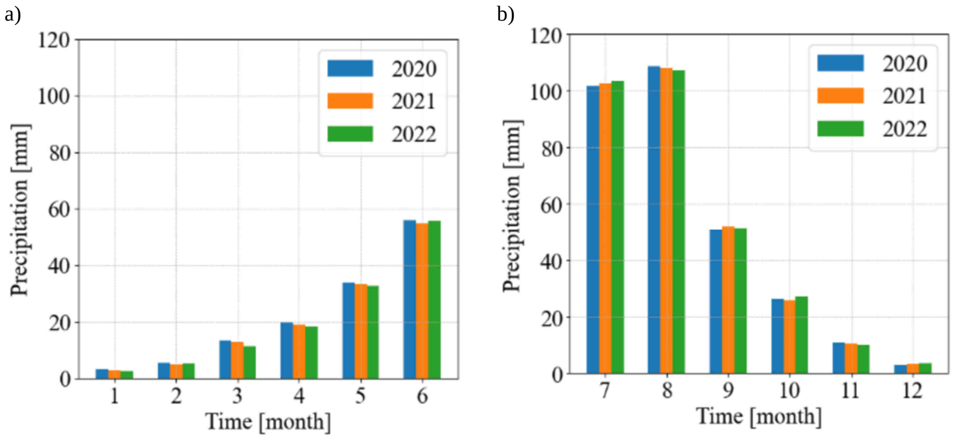

Fig. 2. Precipitation for 2020, 2021, 2022: a) months 1-6, b) months 7-12

Water saving landscape in the Community X, City B, Province A

In the layout of modern urban landscape planning, the water-saving landscape plays a vital role, which also determines that the urban water-saving landscape plays an indispensable role in the city. Rainwater collection and use technology to maintain urban water landscape is very important. However, the awareness of ecological sustainable landscape design for water saving in daily life is not high, especially for cities deficient in water that are developing urban landscapes for water conservation [24, 25].

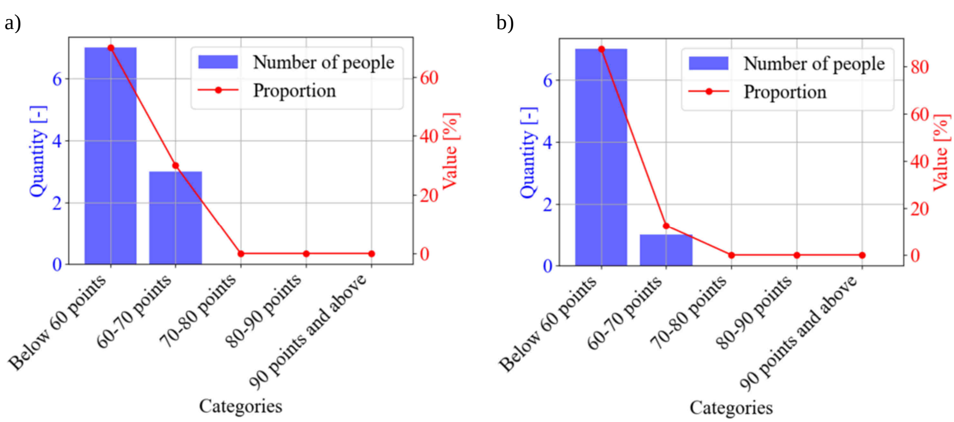

Fig. 3. Water-saving landscape design in Community X: a) designer's evaluation, b) expert evaluation

As the Community X is the first ecological community in the City B, in the Province A, it covers an area of approximately 0.75 km^2. Among them, the construction land is approximately 200 acres, and the green land is approximately 421 acres. The area of pedestrian roads, squares, etc. is approximately 300 acres. The motor vehicle lane covers an area of approximately 172 acres, while the non-motor vehicle lane covers an area of approximately 48 acres. The greening rate is about 37 % and the number of households is over 5200. Therefore, by taking the Community X as an example, this article invited 10 water-saving landscape designers and 8 experts in the field of water-saving landscape design to evaluate their water-saving landscape design. The rating level was divided into 4 levels. Among them, scores below 60 represented failure and scores between 60 and 70 represented just passing. A score of 70-80 was good. A score of 80-90 represented fine and a score of 90 or above represented excellence. The results are shown in Figure 3.

From the figure, it could be seen that the number of designers and experts who believed that the water-saving landscape design of Community X was unqualified 7, accounting for 70 % and 87.5 %, respectively. This indicated that the water-saving landscape design of Community X urgently needed improvement.

Comparative experiments

To conclude whether the effect of the application of the improved variable scale optimisation algorithm in ecological sustainable development water saving landscape design was better than the design method of the variable scale optimisation algorithm, this article selected the area Y of the Community X as the experimental object, which was a water saving landscape design area with a certain scale. Ten designers were divided into two groups, with five members in each group. The first group was designed using traditional algorithms, while the second group was designed using an improved variable-scale optimisation algorithm. During the design process, two groups of designers divided the Y area into two equally sized areas for sustainable ecological water-saving landscape design. They could freely play within their respective areas, but they needed to follow the same design requirements and constraints. The design process and results of two groups of designers were recorded and the design time and design effect were compared [26, 27].

(1) *Design time*

The comparison of design time between two groups of designers is shown in Figure 4.

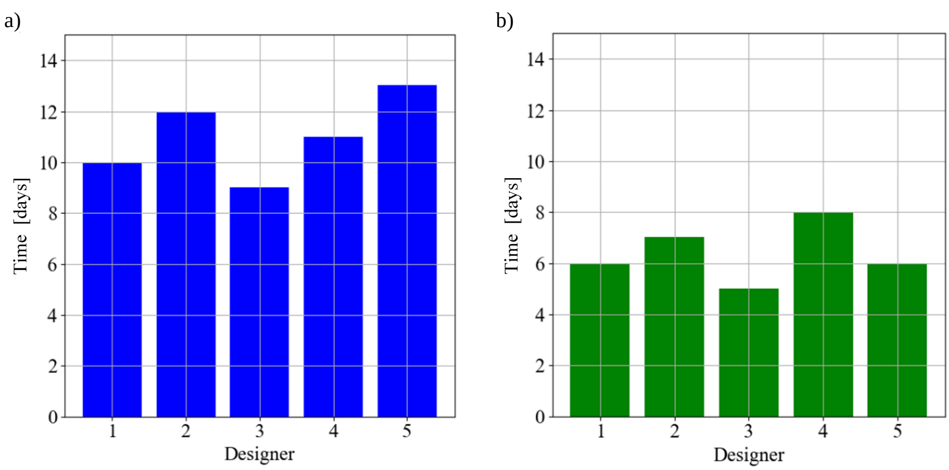

Fig. 4. The time required for designers to design: a) the first group of designers, b) the second group of designers

From Figure 4a, it was seen that the time required for the first group of 1-5 designers was 10 days, 12 days, 9 days, 11 days, and 13 days, respectively; in Figure 4 b, the time required for the second group of 1-5 designers was 6 days, 7 days, 5 days, 8 days, and 6 days, respectively; from the figure, it was seen that the time required by the second group of designers was significantly shorter than that of the first group, indicating that the improved variable scale optimisation algorithm had a better application effect in ecological sustainable development water saving landscape design than traditional variable scale optimisation algorithms [27].

(2) *Design effect*

By comparing the design time data of two groups of designers, it can be preliminarily evaluated that the improved variable scale optimisation algorithm is more efficient in ecological sustainable water-saving landscape design. However, it should be noted that the design time may not fully reflect the level of design quality, and other factors must be considered in a comprehensive way. Therefore, this article once again invited eight experts who rated the water-saving landscape design of Community X to rate the effects of the water-saving landscape design of the ecological sustainable development of two groups of designers. The rating level remained unchanged, as shown in Figure 5.

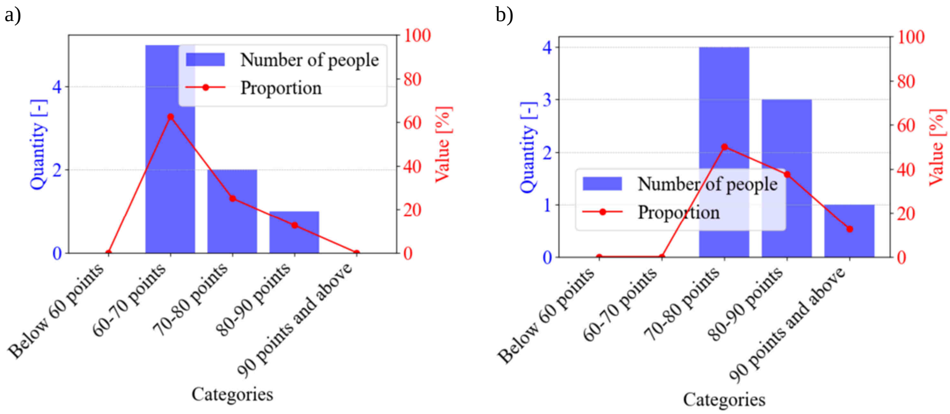

Fig. 5. Expert evaluation of the water-saving landscape design effect a) the first group of designers, b) the second group of designers

From Figure 5a, it could be seen that there are five people, representing 62.5 %, who scored 60-70 points on the effectiveness of water-saving landscape design of the first group of designers by experts. There were 2 people with a score of 70-80, which represents 25 %. There was one person with a score of 80-96, which was 12.5 %. There were no excellent or failed scores. According to Figure 5b, it could be seen that there were 4 people, representing 50 %, who scored 70-80 points on the effect of water-saving landscape design of the second group of designers by experts. There were 3 people with a score of 80-90, which is 37.5 %. There was one person with a score of 90 or higher, which was 12.5 %. There were no scores for failing or just passing. From the figure, it could be seen that the number of experts who rated the effect of water conservation landscape design of the first group of designers as good or better was 3, representing 37.5 %. The number of people who rated the effectiveness of water-saving landscape design in the second group as good or higher was 8, representing 100 %. This indicated that the landscape design effect of the second group of designers was much better than that of the first group of designers, and further validated the application effect of the improved variable-scale optimisation algorithm in the water-saving landscape design of ecological sustainable development, thus providing reference for designers in related fields.

Conclusion

With the increasing scarcity of global water resources and the increasingly serious environmental problems, the design of water-saving landscapes for ecological sustainable development has become a hot topic in the current landscape design field. This article would study the application of improved variable-scale optimisation algorithm in water-saving landscape design for ecological sustainable development, and designed a comparative experiment. Compared with traditional algorithms, the improved variable scale optimisation algorithm could reduce the time required for design and had higher design effectiveness. It had more advantages in achieving complete optimisation of multiple indicators in the design of ecological landscapes. At the same time, the application of the improved variable scale optimisation algorithm could also improve the efficiency of landscape design and reduce human and material costs, so as to make positive contributions to ecological sustainable development. Therefore, the application prospects of improved variable-scale optimisation algorithms in ecological sustainable water-saving landscape design are very broad, and it is one of the important research directions for future landscape design and ecological environment protection. Due to insufficient knowledge reserves, although ideal results were achieved in the design of water-saving landscapes for ecological sustainable development, there were still doubts. This was mainly because this article took Community X in City B, Province A as the experimental object. Although it had a certain representativeness, whether it was applicable to other places still needed to be verified, so as to make the experiment more rigorous. It is hoped that in future research, researchers can expand the experimental subjects as much as possible, and reduce the impact of accidental events, so as to draw more accurate conclusions.

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