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Original Research

Quantifying the Impact of Geomorphic and Topographic Evolution on the Environmental Planning of Spring Water Resources

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Abstract

This paper studies the impact of geomorphic and topographic evolution on environmental planning so as to lay the foundation for future rural environmental planning in Jinan. This paper analyzes the impact of landform evolution on environmental planning and introduces the types of spring rural settlements in hilly landforms and intermountain plains, respectively. On this basis, an artificial neural network is used to reflect the dynamic change law of spring water and is combined with a fuzzy evaluation method to evaluate the impact of underground space development in Jinan on spring water and human activities. Through empirical analysis, it is known that artificial neural networks can accurately detect the dynamic change law of spring water, and on this basis, fuzzy evaluation methods are used to design the impact of spring water-rural settlement landscape planning. The impact of spatial development on spring water is divided into four levels: the stronger impact area, the strong impact area, the general impact area, and the small impact area of underground space development on spring water, which account for about 1.036%, 1.001%, 0.371%, and 97.591% of the total area of the study area, respectively.

Keywords: geomorphic and topographic evolution, environmental planning, settlement type, artificial neural network, dynamic change of spring water, fuzzy evaluation

Introduction

Landform evolution is mainly to study the coupling model of heat conduction law and landform movement law in the earth so as to obtain the landform distribution millions of years ago and the change law of landform in this region [1]. The problem of terrain reconstruction has attracted more and more geologists and mathematicians' attention abroad. From the existing studies, it can be seen that the study of landform involves the thermal structure inside the earth, river erosion, wind erosion, rainfall, and the impact of human factors (such as artificial canal excavation, increase and decrease of vegetation, large population influx, etc.) [2]. Jinan is rich in spring water resources, and is known as the "Spring City". Spring water plays an important role in people's

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lives and cultural activities. Since ancient times, the city has built around spring water resources and made great efforts to create a “riverside spring space environment” in which people and spring water complement each other [3]. The beautiful scenery of “every spring and every weeping poplar” has gradually become the city card of Jinan. In many villages and towns in the suburbs, the riverside spring space maintains a relatively primitive style and characteristics, and its form reflects the simple and harmonious symbiotic relationship between man and spring to a certain extent [4]. Although the status and value of the spring water have weakened or even disappeared, through the space fragments of the remains and the interviews and exchanges with the villagers, we can clearly understand the distinctive regional characteristics and profound historical heritage of the riverside spring space. The level of karst water in Jinan directly affects the state of spring gushing. It is of great significance to analyze and predict it effectively and scientifically. Although the research on the dynamic change of karst water in Jinan has attracted the attention of many scholars, due to the complexity of hydrogeological conditions in Jinan, it is difficult to select the structural form of the model and estimate the nonlinear parameters in numerical modeling, resulting in the failure of the model in describing the groundwater movement in fractured karst media [5].

The research on settlements abroad started earlier and has a relatively rich perspective, and the discussion on the essence of settlements is also relatively simple. Since the historical period when urbanization and traditional settlement forms were gradually opposed, research on the human settlement system in the industry has expanded rapidly [6]. The development of settlements showed different differentiation on the European continent and the American continent. The protection strategy of old European capital Yijia for traditional settlements is to retain its historical style and traditional gathering mechanism to the greatest extent, and inherit the context and settlement construction means as much as possible; the strategy system for intensive agriculture and nature conservation planning based on the application research of GIS and landscape ecology established by Reinhardt et al. has played an important role in the re planning of rural landscape and the coordination with urban land use [7]; Paraskevopoulou has put forward a landscape planning principle and landscape spatial planning model based on ecological space theory in recent years, with special emphasis on the integration of ecological value and cultural background in Rural Landscape [8]; under the impact of modern agricultural technology and foreign culture, the traditional settlement society in some developing countries is undergoing unprecedented changes. Faced with this situation, some domestic scholars have applied the cultural landscape theory of landscape ecology to study the settlement landscape undergoing drastic changes, emphasizing that in the construction of traditional settlements, we should protect not only traditional buildings but also other cultural landscape elements. Tian put forward the concept of “village ecosystem” and systematically discussed the characteristics and distribution mode of village ecosystem of different geomorphic types and the relationship between village farmland and land use [9]. Cao et al. carried out the “Research on Rural Development Model and Rural Urbanization in the Huang Huai Hai Plain”, summarized the economic problems of rural development since the reform and opening up, and discussed the regional model of rural development mechanisms [10], such as “Land Ecological Evaluation and Land Ecological Design” by Jing Guihe, and “Analysis of Landscape Pattern Change in the Western Suburbs of Shenyang” by Zeng et al. [11]. At present, research and practice on rural land consolidation or rural land use planning in some high-intensity land use areas mainly focus on optimizing the allocation of land use, adjusting unreasonable rural residential land and large-scale combined agricultural land, improving the landscape of villages, and fully tapping the potential of land resources. However, it does not go deep into more specific agricultural or rural landscape system analysis, landscape model research, or ecological planning [12].

This paper studies the impact of geomorphic and topographic evolution on environmental planning, establishes a nonlinear relationship model between spring water level and influencing factors by using an improved artificial neural network to simulate the dynamic change of spring water, and analyzes the impact of environmental planning design according to the dynamic change combined with a fuzzy evaluation method.

Impact Analysis of Landform Evolution on Environmental Planning

Overview of the Study Area

Jinan’s surface water and groundwater are closely related and interact with each other. The groundwater in the southern mountainous area is mainly recharged by atmospheric precipitation and the infiltration of rivers and reservoirs. The groundwater in the northern piedmont plain is mainly recharged by atmospheric precipitation, river infiltration, surface water irrigation, and seepage from irrigation canals. The groundwater in the urban area is mainly recharged by atmospheric precipitation, river infiltration, leakage of the municipal water supply network, and sewage pipe network [13].

The groundwater flow in the Jinan area is affected by topographic conditions, geological structures, and human activities. The groundwater in the southern mountainous area mainly flows from south to north, and the groundwater in the northern piedmont plain flows from west to east. The groundwater in the urban area flows from the high terrain areas to the low terrain areas, and the groundwater in the spring groups flows from the spring groups to the surrounding areas.

In conclusion, Jinan's hydrogeological environment is complex and dynamic. The groundwater resources in Jinan are rich, but they are facing problems of pollution and overexploitation. To sustainably manage the groundwater resources in Jinan, it is necessary to deepen the understanding of the hydrogeological environment, improve the groundwater monitoring and management system, implement effective measures to prevent and control groundwater pollution, and promote the rational use and conservation of groundwater resources [14].

Spatial Types of Spring Villages under Different Topographic and Geomorphic Evolution

Spatial Type of Spring Village under a Hilly Landform

In contrast to the foothill villages, those located in valleys are directly influenced by the flow of the spring water. These villages are typically clustered in the most fertile parts of the valley, where the spring water is most accessible. The houses are generally built along the riverbanks, and the pathways are usually arranged in a perpendicular or parallel manner to the water flow. The spring pool is usually located in the center of the village, serving as the main water source for the entire community. It is also used for irrigation purposes in the surrounding fields. The overflow water from the spring is carefully managed to prevent flooding and is directed towards the agricultural fields for irrigation. The villagers have adapted to the terrain and have learned to use the water flow to their advantage, integrating it into their daily lives and agricultural practices. The planning and layout of these villages demonstrate a harmonious coexistence between humans and nature, taking full advantage of the geographical features and spring resources [15, 16].

In both types of villages, the spring plays a crucial role in the spatial organization and daily lives of the villagers. The relationship between the spring and the village is not just a matter of practicality, but also reflects the cultural and social aspects of the community. The spring is not only a source of water, but also a symbol of life and prosperity, and its presence shapes the physical and social landscape of the village.

For example, in Yangjia village, Chishang Town, Boshan, the village is adjacent to a north-south mountain in the west and a large area of fields in the east. The village has two springs: Yangjia Spring and Daquan Spring. Among them, "Yangjia Spring" is located slightly above the foothill in the northeast of the village, and "Daquan" is located on the valley and river beach in the south central part of the village (Fig. 1a). The single buildings in the village still maintain the traditional characteristics of facing north and south. The whole settlement is back to the mountain and facing water and is evenly arranged on the hillside. The layout of the village is obviously restricted and affected by the gradually steep mountains, two valley rivers, and gradually rising hills in the east. The village conforms to the mountain situation, and the surrounding area of Shanyangjia Spring extends to the big spring on the West Beach. The whole village is arranged along the mountain contour. The "Daquan" quickly flows into the "Yangjiaquan", but because it is exposed on the West Bank of the river, the village buildings are far away from the river beach in order to avoid the flood caused by the river and seasonal mountain torrents, so the village form and function cannot be closely connected with the "Daquan". "Yangjiaquan" is more closely related to the morphology of the village. After the spring overflows and the villagers drink and wash paint, the remaining spring water needs to be discharged outside the village. Due to the limited amount of Yangjiaquan and the large east-west elevation difference of the village, it twists and turns to the west between the residential buildings through several simple open canals in the village and flows to the river valley in the west (Fig. 1b). For the convenience of drainage and water, the streets and residential buildings in the village are also restricted by the "Yangjia".

a) b)

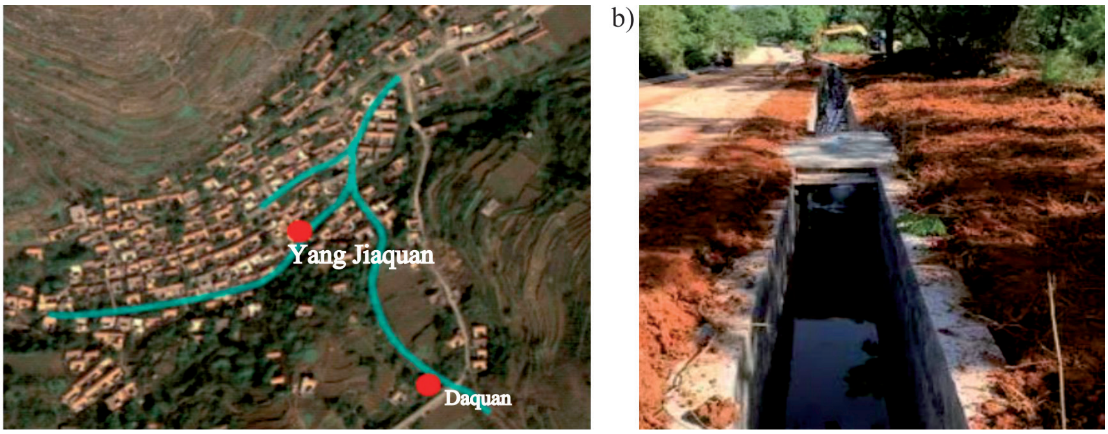

Fig. 1. Relationship between spring water at the foothills and the spatial form of villages. a) Village plan, b) Location of outlets and channels.

Mountain villages in China's Shanyu Valley are typically laid out in a band following the shape of the valley, with buildings distributed on one or both sides. The village structure is largely influenced by the shape of the valley and the location of spring water, which is crucial due to the region's common water shortage.

The spring is typically located upstream, in the middle, or downstream of the settlement. The village usually has one main road that follows the trend of the valley, with other roads branching off [17].

Taking Xiangquan village as an example, Xiangquan Valley is a mountain valley about kilometers long in the northwest and southeast. Xiangquan village is located in the middle of the mountain. The village is distributed in a zigzag belt along the foothills in the northeast of the valley. The main roads in the village are slightly inclined along the valley and the gentle slope of the contour line. The village buildings are arranged along both sides of the road. "Xiangquan" is located on the west side of the main road in the village, which is slightly higher. Spring overflow and seasonal mountain torrents are directly discharged through the road. In summer, when the water is prosperous, the spring water will overflow from the mouth of the cave, flow to the street in the village, and flow south along the street to the valley (Fig. 2a). The road section is in a "concave" state, and the buildings along the road are built with high pedestals and protective walls (Fig. 2b). The whole village is arranged along the main roads and in accordance with the terrain, and the spring is roughly located in the central part of the village. This way of discharging spring water shows the interest of the original utilization state. The Xiangquan spring in the summer, autumn, and rainy seasons has a large amount of water, and a small amount of mountain torrent passenger water is discharged after the rain. In this way, the main roads in the village are directly used as temporary drainage channels, which can give full play to the comprehensive utilization rate of the limited land in the mountain valley, and the short-term road borrowing will not bring too many obstacles to the villagers' lives. In order to strengthen the effective utilization of scarce water sources, a square pedicle pool is set at the lower elevation of the south end of the village to facilitate the villagers' daily washing and irrigation of fields in the South Valley.

Spatial Type of Spring Village under Local Plain Landform in the Mountains

There are complex landforms in Jinan and the surrounding villages and towns. The land for construction is tight, and the front and between mountains are flat.

Originally, it only accounted for 31.4% of the total area of the area, which can be said to be an ideal and precious geomorphic type for the development of villages in Jinan and surrounding mountainous areas. Compared with the mountainous environment, there are fewer constraints on the development of villages in flat areas, so the impact of springs and village spatial structure is more obvious. In local areas with flat terrain in mountainous areas, trees have more construction land, easy access to better water supply, and convenient transportation, but effective drainage systems have become the focus of spring village organizations [18]. The small number of people overflowing from the spring determines the use of spring water in the village, which jointly affects the characteristics of the spatial form of the village. In such a topographic environment, spring villages in Jinan and its surrounding mountainous areas can be divided into the above two types: A. take the spring pool as the residential community center; B. dual integration of residential community and rural land; The details of the two classifications are still shown in Table 1.

(1) Spatial form types of surrounding settlements with spring as the center.

The size of spring inflow determines the scale of spring wells or pools, and then determines the scale (number of households) of residential groups that can be supported by a single spring as a water source. As the public water source of the village, spring wells,

Fig. 2. Relationship between spring water and village spatial form in a mountain valley.

Table 1. Spatial types of spring villages with different geomorphic features.

Topography	Spring water village space type	Type traits
Hills	Mountain Spring Village	They are arranged in parallel with contour lines and run through them with roads and lanes parallel to contour lines and vertical lines
	Valley Spring Village	Settlements are generally banded and meandering in accordance with the valley, and the road follows the trend of the valley
Local plain	Spring as the center of the settlement around the type	The layout of the living area and farmland surrounding each other facilitates the villagers to use the spring water for life and production value
	Spring water as the center of the settlement and farmland around	Villages extend along one or both sides of the overflow system

or pools are often built manually in order to ensure the sanitation of drinking water and convenient access. If there is no overflow, a certain amount of public space is usually reserved around the spring to accommodate the water intake activities and induce villagers to stop and communicate [19]. The residential houses are arranged and alleys penetrating into the surrounding houses are reserved. It can not only facilitate the access of nearby residents, but also give consideration to the access of residents within a certain range. It ensures the fair utilization of spring water resources. Therefore, the spring village forms the natural structure mechanism of the surrounding layout of residential settlements centered on the spring.

When the number of service households in the spring approaches the upper limit or the reasonable access distance of the residential community exceeds a certain limit, the impact of the spring on the spatial form of the village will gradually decrease until it disappears. If a village has multiple similar springs, each spring will control the cluster elements within its scope, and the spatial form of the whole village will be formed by the combination of multiple combination centers. The center shape of each unit group is the most affected by the spring. With the outward divergence, the impact of the springs gradually decreases, and the fringe areas are intertwined. The detailed form is shown in Fig. 3.

(2) Spatial form types of residential settlements centered on spring water and farmland surrounding settlements.

When the spring water inflow is large, it can not only meet the requirements of residential water, but also meet the agricultural irrigation requirements of a certain area. The layout of spring villages is different from the previous type. Due to the increase of spring water inflow, for the consideration the residential community is often concentrated on the slightly higher side of the spring. On the other hand, the lower side is combined with the overflow channel to form economic crops such as vegetables with large water demand, to form a layout centered on the spring and surrounded by the duality of residential areas and agriculture. It not only maintains the convenience of domestic water in the village, but also does not have a negative impact on low waterlogging and humidity. The harmonious and effective utilization of spring water resources by settlement life and agricultural production has been realized.

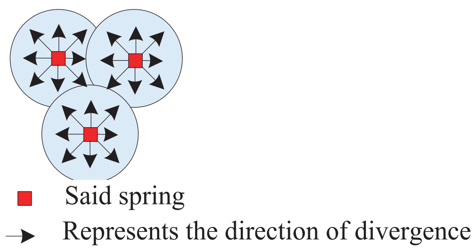

Fig. 3. Schematic diagram of spring water for village control.

Dynamic Change Model of Spring Water

Through the above research, we have understood the laws of the formation, distribution, and construction of springs and villages under the evolution of different landforms, introduced several types of villages, and, on this basis, constructed the spring dynamic change model based on an artificial neural network, so as to obtain a random model of spring dynamic change in Jinan and analyze the impact of landform evolution on environmental planning.

Artificial neural networks are a new research and application field based on the structure and function of the human brain. It has adaptive abilities and convenient updating. It can fully realize the function of approaching any nonlinear function on a bounded subset through the composition of neuron action functions. It can effectively solve the problems of structural form selection and nonlinear parameter estimation that cannot be overcome by conventional mathematical statistical methods. There are many kinds of neural networks, and the back-error propagation algorithm is the most widely used and effective method. Compared with other traditional models, it has better persistence and timely prediction.

The artificial network is composed of three basic layers: the input layer, the hidden layer, and the output layer. The learning process of its network is an information-alternating propagation process based on three basic layers: the forward propagation process of learning samples is to process the samples layer by layer from the input layer, through the hidden layer, to the output layer, and calculate the actual output value; the back-propagation process (the reverse modification process of error) is to continuously adjust the network weight and threshold by comparing the actual output and expected output of the network until the network converges to achieve the expected effect. The input and output of each node in the network have the following nonlinear relationship:

$$y_j = \left\{1 + \exp\left[-\sum w_{ij} y_i + \theta_j\right]\right\}^{-1} \tag{1}$$

Where y_i and y_j are the outputs of the learning samples to the network nodes i and j; w_{ij} represents the connection right from node i to j; and θ_j represents the threshold of node j.

The global error function of the network is:

$$E = \sum_{k=1}^{nk} E_k = \frac{\sum_{k=1}^{nk}\sum_{j=1}^{nj}\left(y_j - d_{kj}\right)^2}{2} \tag{2}$$

i and j represent neurons in the hidden layer and output layer respectively; k represents training times; d_{kj} represents the actual value; n is the number of bias layers.

The correction function of weight w_{ij} is:

$$\theta_j^{t+1} = \theta_j^t - \eta \frac{\partial E_k}{\partial \chi_j} + \alpha(\theta_j^t - \theta_j^{t-1}) \tag{3}$$

The threshold θ_j correction function is:

$$\theta_j^{t+1} = \theta_j^t - \eta \frac{\partial E_k}{\partial \chi_j} + \alpha(\theta_j^t - \theta_j^{t-1}) \tag{4}$$

Where t represents the number of corrections; η represents the learning rate; α represents the momentum term.

It can be seen from the above formula that the artificial neural network minimizes the error between the output value and the expected value by modifying the weight and threshold. When the global error is lower than the required error, we believe that the network can reflect the relationship between input and output to some extent. However, artificial neural network algorithms also haves many problems. For example, there is a lack of unified and complete theoretical guidance on the generalization ability of the network and many local minima in the network. This paper also deals with some problems in the modeling process of modeling.

In the learning process, in order to make the artificial neural network not unpredictable because of falling into the local minimum situation, this paper will use a simple evolutionary strategy to adjust the weight to achieve the purpose of rapid convergence. Firstly, the initial value is assigned to each connection weight. If the result error still fails to converge to the required result after multiple iterations and has been in a stable change state, it indicates that it is about to fall into the situation of local minimum situation. At this time, the network is adjusted by increasing or reducing the weight, and the generated value is used as the initial weight of the next step to adjust the weight of the two networks according to the following formula:

$$\Delta w_{ij}\left(n\right) = -\eta\left(n\right)\left(\partial E \div \partial w_{ij}\right) \div \left\|\nabla E\right\| \tag{5}$$

The selection of model learning samples and test samples determines the performance of the established artificial neural network. The learning sample data of this modeling covers a large range, and the corresponding learning and prediction ability of the network will be enhanced. At the same time, it can also make up for the weak generalization ability of the artificial neural network.

Impact of Underground Space Change on Spring Convergence

The evaluation index system for the impact of underground space development on spring water in Jinan involves three aspects: natural geographical conditions, hydrogeological conditions and engineering geological conditions. In order to reduce the fuzziness of the evaluation, the fuzzy comprehensive evaluation method is used to evaluate the impact of underground space change on spring convergence. According to the steps of the fuzzy comprehensive evaluation method, firstly, the corresponding evaluation factor se U–{C_1, C_2,..., C_{10}} for the impact of underground space development on spring water in Jinan is established, in which C_1, C_2,..., C_{10} is the index layer in the evaluation index system.

The evaluation result, that is, the impact of underground space development on spring water in Jinan is divided into four levels, namely, small impact, general impact, strong impact and stronger impact. The comment set is V = {*I*, *II*, *III*, *IV*}, where *I* is small, *II* is general, *III* is strong, and *IV* is stronger.

The degree of conformity of the evaluation index to the evaluation objective (the impact of underground space on spring water in Jinan) can be fuzzy divided by the mathematical concept of membership. The membership degree of the quantitative index can be quantified by constructing the membership function. The more mature methods include trapezoidal distribution curves and triangular distribution curves. Based on the analysis and statistics of previous data, this paper uses the method of combining expert scores and fuzzy statistics to determine the membership of each index. At the same time, in order to make athe smooth transition between evaluation grades, the fuzzy processing of decreasing membership values from the middle interval to both sides is adopted.

The study area is divided into 10 single factor indicators. Using MAPGIS software and according to the classification standards determined above, the zoning maps of each single factor indicator in the study area are drawn, respectively, and the corresponding vector map data structure is established. The data structure should include the membership vector and the comprehensive weight vector $A = W_i$ (i = 1~100) of the relative importance index in the impact of the underground space development on the spring in Jinan. Then, through the spatial analysis module in MAPGIS, the "area to area merging analysis" of each single factor map is carried out. After the superimposed comprehensive map is obtained, it is also necessary to conduct fuzzy comprehensive calculations on the attributes of all elements of the comprehensive map, that is, $B = A*R$, where $R=(R_1,R_2,R_3,R_4)=\begin{bmatrix}\alpha_{11},\alpha_{12},\alpha_{13},\alpha_{14}\\ \alpha_{21},\alpha_{22},\alpha_{23},\alpha_{24}\\ \alpha_{31},\alpha_{32},\alpha_{33},\alpha_{34}\\ \vdots\quad\vdots\quad\vdots\quad\vdots\\ \alpha_{101},\alpha_{102},\alpha_{103},\alpha_{104}\end{bmatrix}$, R represents the impact degree set, and the evaluation grade of all elements can be obtained according to the principle of maximum membership degree. Finally, the post-processing of the comprehensive map, including clustering, merging, and eliminating abnormal points, is carried out to obtain the zoning map of the impact of underground space change on spring water.

Results

Simulation Results of Spring Water Dynamic Change

Through the above methods, it can make an empirical analysis offor the research area. Under the impact of the landform, a village with abundant spring water resources is selected from the study area, and the spring water's dynamic change simulation model mentioned above is used to predict the spring water's dynamics. In this study, the data of 18 years from 1997 to 2015 isare selected as the learning sample, the data of 5 years from 2016 to 2020 isare selected as the test sample, and the data of 2021 is used as the prediction sample. According to the above modeling ideas, the learning samples are fitted, and the results are shown in Fig. 4.

It can be seen from Fig. 4 that the experimental results, the simulation results of the model, and the actual values fit well. Therefore, it is provend that the model has high accuracy in testing the dynamic changes of spring water. From Fig. 4, it can be observed that the fitted values are very close to the actual values in

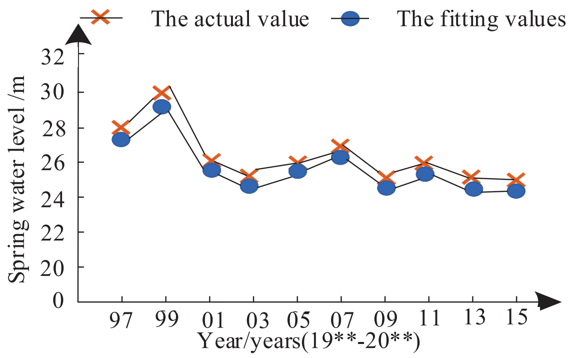

Fig. 4. Comparison between dynamic fitting value and actual value of spring water.

most years, indicating that the fitting model relatively accurately captures the trend of spring water level changes over time. However, in specific years (such as around 2001 and 2005), the difference between the actual value and the fitted value is larger than in other years.

The model is used to test the sample data to test whether the model can overcome the disadvantages of high fitting and low prediction in Jiangdu. The test results are shown in Table 2.

Table 2 lists the measured values, model calculated values, and relative errors between the spring water levels from 2016 to 2020. From the data fromof these five years, research can discover some interesting trends and patterns. Firstly, from the measurement of water level, the lowest water level was 24.89 meters in the spring of 2018, while the highest water level was 27.34 meters in the spring of 2016. Over the past five years, the range of water level changes has been approximately 2.45 meters. Although this change may seem small, in actual environments, this degree of water level change may have a significant impact on ecosystems. Secondly, let's take a look at the calculated values of the model. The predicted water level value of the model is very close to the actual measured value, with the largest difference occurring in 2018. The calculated value of the model is 25.14 meters, which is 0.25 meters higher than the actual measured value, and the relative error reaches 1.00%. In other years, the difference between the calculated values of the model and the actual measured

Table 2. Prediction results of spring water level change.

Year/ years	Measured water level /m	Model calculated value /m	The relative error/%
2016	27.34	27.16	-0.66
2017	26.83	26.94	-0.41
2018	24.89	25.14	0.10
2019	26.47	26.52	0.79
2020	26.89	26.85	-0.15

values is within 0.2 meters, with a relative error of less than 1%, indicating a very high prediction accuracy of the model. Then, focus on the relative error in the research. The prediction accuracy of the model reached its highest in 2016 and 2020, with relative errors of -0.66% and -0.15%, respectively, while the relative error was the highest in 2018, reaching 1.00%. Although these errors are relatively small, they may accumulate when making long-term predictions of spring water levels, leading to significant deviations in the final prediction results [20-21].

Spring- Impact on Landscape Planning in Rural Settlements

The model studied above is applied to analyze the impact ofn spring rural settlement landscape planning. The specific impact is as follows:

Impact of Street Planning

With the expansion of settlement scale and the improvement of residential concentration under the evolution of landforms, residents put forward requirements for more convenient transportation between each other. At this time, streets appear. Generally, one or several main traffic streets run through the whole settlement, closely connecting the living and communication spaces of the settlement residents. The village in the study area selected in this paper is a village with a small settlement model. Spring settlements are affected by topographic changes, and street planning is affected by spring settlements. The schematic diagram of street planning in the study area is shown in Fig. 5.

In Fig. 5, the red color indicates the street. The rural settlement is small in scale, and the main traffic space is the wide and straight street between the village entrance and the spring. This street is located in the middle of the village and runs through the whole village from west to east, extending to the main road outside the village. Due to functional differences, the widest part of the street is only 4m, and its main function is to provide residents with an area for walking or cycling. The street is close to the residential area. According to the spring trend, the overall trend of the street is planned with the planting ofin the residence and the surrounding natural growth vegetation.

Impact of Bridge Planning

A bridge is an indispensable transportation facility in water settlements, and its morphological characteristics also play an important role in the settlement landscape. In the spring settlements with an overflow water system, the water system will divide the settlements into several groups, and the traffic connection between these groups needs the connection of bridges. There is a bridge in the spring settlement of the overflow water system, which facilitates the passage of various means of transportation, such as carriages and cars. It is an important public transport facility in the spring settlement. The scale of the water system in the study area is large, and the location of the canal reaches 7m, so the characteristics of bridge planning are richer. Affected by historical factors, most of the existing bridges are simple Qingshi bridges. Due to the rich water system, in order to facilitate the villagers thinking, bridges need to be designed between the canals to realize the connection, which is also the impact of spring water on rural bridge planning. The schematic diagram of bridge planning and design is shown in Fig. 6.

The bridge design in Fig. 6 uses modern reinforced concrete technology. In this way, the arched position and shape of the built bridge can be set more freely, which makes the bridge shape more diversified and the construction process faster and firmer. The bluestone slab is still used as the main material of the stone bridge surface to ensure the consistency of rural style.

Fig. 5. Schematic diagram of street planning.

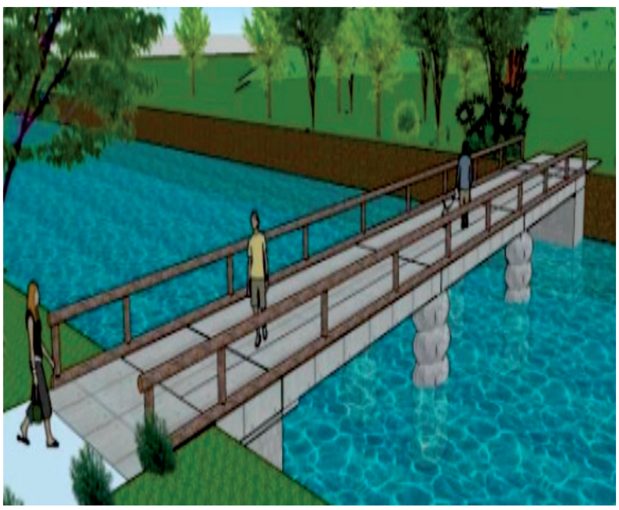

Fig. 6. Schematic diagram of bridge planning and design.

Impact of Square Planning

Square space is mainly a place for public communication activities in settlements. Due to the self-sufficient agricultural economy for a long time, residents pay more attention to their production and lives, and public communication activities are not paid attention to. In spring settlements in suburban counties, the location of the spring source has become the first choice for the location of the square. It is a place where residents often come to stay for their daily water intake. The morphological characteristics of the square are not only affected by the terrain, but also by the surrounding spring environment. The planning and design diagram of Country Square are shown in Fig. 7.

As can be seen from Fig. 7, one side of the square is an open water surface, another side is the main gate of folk houses, and the other two sides are planned to be close to the foot of the mountain. People can reach the square through the transition space everywhere. The scope of the square space is not very clear.

Impact of Underground Space Development on Spring Water

This part of the empirical analysis takes the whole of Jinan City as the research object. The impact of underground space development on spring settlements is shown in Fig. 8.

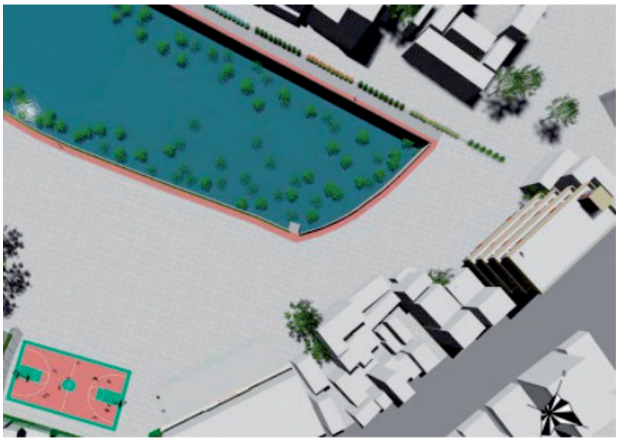

Fig. 7. Schematic diagram of rural square planning and design.

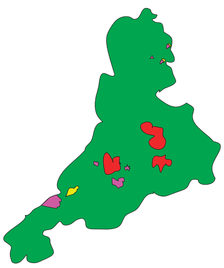

Fig. 8. Impact of underground space development on spring water settlement.

Stronger Impact Area

This area is mainly distributed from Wenhua Road to Jingshi Road in the middle of the study area, near Qianfo Mountain range, from Qixian town in the southwest to the West Campus of Jinan University, and sporadically near the eastern fault fracture zone. This area is located in the infiltration runoff area of Jinan Spring, with a topographic gradient of 2%~12%. The catchment conditions are good, which is conducive to the enrichment and migration of groundwater. The annual average precipitation infiltration of the front line from Qixian town in the southwest to the west. The campus of Jinan University is greater than 226 mm/a. The development of underground space makes itis easy to cause ground hardening and damage the precipitation infiltration conditions, which is not conducive to the supply of spring water. The development depth of this area is extremely rich in water, and the water inflow of a single well is greater than 3000 m^3/d. If a large amount of drainage is required for underground space development in this area, it is very easy to affect the recharge runoff of spring water, greatly affect the spring water level, and reduce the spring flow. The stratum structure of this area is mainly composed of Quaternary + magmatic rock + limestone or quaternary + limestone, which is close to the surface water area or fracture zone, and the minimum buried depth of groundwater is generally 10~15 m. If underground space development is carried out in this area, attention should be paid to the occurrence of water inrush accidents. Its construction technology is complex, the construction cost is high, and the mud and waste liquid during construction and domestic wastewater and flushing fluid during project operation are very easy to enter the karst aquifer and cause great pollution to the spring water quality with the migration of karst water. The development of underground space in this area has a strong impact on the spring water level and spring water quality, which is not conducive to the protection of spring water in Jinan.

Strong Impact Area

This area is mainly distributed in the area from Dayangzhuang to Wangfuzhuang in the west of the study area and on both sides of the strong impact area in the middle. The topographic gradient in this area is generally less than 6%, the catchment conditions are good, and the annual average precipitation infiltration is between 100 and 226 m/a. The development of underground space in this area has a strong impact on the recharge runoff of Jinan Sspring. The groundwater in the development depth of this area is rich in water, and the water inflow of a single well is between 1000~3000 m^3/d. The construction precipitation of underground space development is also large, which has caused a large disturbance to the regional groundwater flow field, which is not conducive to spring protection. The stratigraphic structure of this area is a quaternary system or combination of quaternary systems and limestone. The middle part is close to the strong impact area, and the areas on both sides are close to the surface water area or fracture zone. The minimum buried depth of groundwater is generally greater than 10 m. The development of underground space may reduce the supply runoff channel of spring water and have a great impact on the spring water level. The mud, waste liquid during construction, and domestic wastewater and flushing fluid during project operation are easy to enter the karst aquifer and cause great pollution to the spring water quality with the migration of karst water. The development of underground space in this area has a strong impact on the spring water level and spring water quality.

General Strong Impact Area

This area is mainly distributed around the Lashan mountains in the west of the study area. The topographic gradient of this area is 2%~6%, and the annual average precipitation infiltration is less than 196 mm/a. The development of underground space in this area has a general impact on the recharge runoff of Jinan Spring. At the development depth of this area, the water abundance of groundwater is medium and weak, the water inflow of a single well is less than 1000 m3/d, the construction precipitation is general, and the disturbance to the regional groundwater flow field is general. The stratigraphic structure of this area is composed of quaternary and limestone, which is far away from the fracture zone. There are branches of the Lashan River in the nearby surface waters. The minimum buried depth of groundwater is about 10~15 m. The development of underground space generally will not affect the spring supply channel and water flow section, and the probability of water inrush is low. As the area is far from the spring group, although the waste liquid during construction and project operation will pollute the regional groundwater, it will be diluted with the migration of groundwater, resulting in limited pollution of the spring water quality. The development of underground space in this area has a general impact on the spring water level and spring water quality.

Small Impact Area

This area has the widest distribution area and is widely distributed throughout the whole study area. It includes that the stratigraphic structure in the north of the study area is a quaternary area, which is located in the north of the spring collection and discharge area, and the topographic slope is less than 2%. According to observations, the development of underground space in this area will not occupy karst passages, thereby affecting spring water supply. The development of underground space will not occupy the karst channel and affect the supply of spring water. It includes that the stratum structure in the south of the study area is limestone. The underground space planning in this area is mainly a network layout combining points and lines, and most of it is located below the existing roads. The surface itself has hardened, and the impact of rainfall infiltration is limited. Because the layout of underground space is mostly a network layout combined with points and lines, it is generally below the existing roads, the ground itself has hardened, and the impact of precipitation infiltration is limited. As long as the layout avoids the strong leakage section, it can be regarded as having no impact. In addition, although the southern area is the main recharge and runoff area of spring water, although the development of underground space will occupy some karst channels, it will not reduce the water flow section. Because the buried depth of groundwater in this area is large, generally greater than 15 m, the karst water has no pressure, and the development of underground space will not touch the groundwater head. The abundance of groundwater in this area is generally weak, and the water abundance in some areas is medium. The water inflow of a single well is generally less than 100 m^3/d, and there is no need for engineering precipitation. There is basically no impact of surface water in the south of the area, and there will be no connection between surface water and underground karst water. If underground space development is carried out in the area, it will have little impact on the spring water level and spring water quality. According to our research, although the development of underground space in the area will occupy some karst passages, it will not reduce the water flow cross-section. This is because the burial depth of groundwater in the area is relatively deep, generally greater than 15m. Karst water has no pressure, and the development of underground space will not touch the groundwater head.

Discussion

South Spring Water Culture is an important component of Spring City Culture, and it has its own unique application in urban landscape construction, especially in the construction of spring cities. By studying the application of spring water culture in urban construction, it can provide a reference for Jinan and other cities with a large amount of spring water and have a significant impact on urban landscaping construction. Jinan Spring Village was formed and retained under the joint action of a special geographical environment, climate conditions, and long-term human activities. Combined with the rich, changeable, and distinctive spatial environment formed by different landforms, it belongs to a precious cultural heritage of human settlement type, condensing the survival wisdom of ancestors. The spring village in Jinan today is a form of human settlement formed by the continuous integration of new material and non-material elements after a long period of development and evolution and with the changes of the times. It has high research significance and protection value for the spatial form, material materials, inheritance and development of living habits, and cultural customs of traditional villages. On the basis of reviewing and summarizing the relevant research results at home and abroad, through literature review and field investigation, a large number of spring village cases located in Zhongshan District of Shandong Province are collected, and the research framework of spring village spatial form is constructed through typological research methods. From macro to micro, from concrete to abstract, the spring village is investigated and analyzed at different spatial levels, and the main research conclusions are as follows:

Firstly, in terms of the geomorphic environment of the village, the spring villages are divided into two categories: mountain and hilly spring villages and mountain local plain spring villages; there are five kinds: Piedmont spring village, valley spring village, surrounding village of residential settlement centered on spring, surrounding village of residential settlement and farmland centered on a spring, and belt village based on a spring overflow system. The level of the spring-exposed section is analyzed by the spatial form, and the spatial constituent elements and spatial form type characteristics of different levels are discussed. Secondly, on the level of village structure, the spring village space is divided into different spatial elements such as spring position, spring overflow system, residential area, production area, and so on. According to the spatial combination of different functions, spring villages are divided into three types: spring villages without an overflow system; a spring village with a main water system; and where overflow systems form a systematic spring village. Studying the spatial form, material materials, living habits, and cultural customs of traditional villages is of great significance for the protection, inheritance, and development of traditional villages. Based on the above analysis, we need to pay more attention to how spring water resources affect the connection and changes between village public activity areas and other functional areas, as well as how to guide each functional area to form spatial interweaving and functional composite spatial types.

Research can use neural network models to predict and manage the dynamic changes of spring water in order to ensure the rational utilization and effective protection of spring water resources and better serve the production and living needs of villages and the sustainable development of the village environment.

Conclusion

This study examined the impact of geomorphological and topographical evolution on environmental planning, conducting a detailed analysis of the spatial environment and landscape design of rural settlements in the spring. Further analysis was conducted on the spatial environment and landscape design of spring settlements in Jinan. By applying artificial neural networks and fuzzy evaluation methods, the study unveiled the influence of spring settlements on environmental planning. The model takes the precipitation amount of the current year, mining volume, and the groundwater levels of the previous and previous years as inputs, with the groundwater level of the current year as the output. The prediction results are accurate, and the algorithm is concise, avoiding intricate mechanism analysis and parameter identification. The model utilizes an evolutionary strategy to adjust the learning rate, allowing the network to automatically escape from local minima, accelerating network convergence, and enhancing its adaptability. A prediction example of the spring water gushing trend in Jinan verified the model's high simulation accuracy and real prediction results, providing a reference for macro-scale situation forecasting. The study divided the impact of Jinan's underground space development on spring water into four levels and drew a zoning map for the evaluation indicators for the underground space in the research area on the GIS platform. The limitation of the study is that the model's performance may vary due to different geological conditions and water level fluctuations. Future research should delve deeper into the impact of climate change on groundwater levels and incorporate it into the model. Faced with these limitations, future research should focus on improving the model to adapt to a wider range of geological conditions and consider the impact of climate change, thereby enhancing the model's predictive capability and improving groundwater management strategies.

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Conflict of Interest

The authors declare no conflict of interest.

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