

Retraction

Retracted: The Construction of Urban Park Green Infrastructure Network Based on Genetic Algorithm

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This article has been retracted by Hindawi, as publisher, following an investigation undertaken by the publisher [1]. This investigation has uncovered evidence of systematic manipulation of the publication and peer-review process. We cannot, therefore, vouch for the reliability or integrity of this article.

Please note that this notice is intended solely to alert readers that the peer-review process of this article has been compromised.

Wiley and Hindawi regret that the usual quality checks did not identify these issues before publication and have since put additional measures in place to safeguard research integrity.

We wish to credit our Research Integrity and Research Publishing teams and anonymous and named external researchers and research integrity experts for contributing to this investigation.

The corresponding author, as the representative of all authors, has been given the opportunity to register their agreement or disagreement to this retraction. We have kept a record of any response received.

References

- [1] H. Wang, W. Li, Y. Hou, M. Li, and S. Lee, "The Construction of Urban Park Green Infrastructure Network Based on Genetic Algorithm," *Wireless Communications and Mobile Computing*, vol. 2022, Article ID 9719633, 15 pages, 2022.

Research Article

The Construction of Urban Park Green Infrastructure Network Based on Genetic Algorithm

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In order to build a scientific and reasonable urban park green infrastructure network, Genetic Tabu hybrid algorithm is introduced into the field of urban park green infrastructure network construction, using ENVI5.5, ArcGIS10.2, Conefor2.6, and other software to construct the comprehensive green infrastructure network model and corresponding algorithm of a city park and improve and compare the genetic algorithm and Tabu search algorithm. Firstly, the ecological sensitivity of urban parks was evaluated, and 58 ecological source patches with high ecological value were selected. With the help of GIS platform, 71 potential corridors are simulated and generated by using the minimum cost path model. Then, select the index that can evaluate the importance of source patches in the ecological network to determine the importance ranking of source patches. Finally, according to the principles of clustering and network connectivity, select the ecological source with high patch importance, analyze the potential ecological corridor and current corridor, and combine and screen the factors of green infrastructure network. The results show that a city park green infrastructure network composed of 38 ecological source patches and 19 corridors is finally formed. Genetic algorithm has a potential application prospect in the construction of urban park green infrastructure network. By introducing genetic Tabu hybrid algorithm into the field of urban park green infrastructure network construction, it will change the mode of traditional urban park green infrastructure network construction.

1. Introduction

The rapid urbanization process has brought severe urban ecological problems. How to balance the contradiction between urban development and construction and ecological protection has become an important topic faced by major cities. With the impact of urban expansion, there have been many problems, such as large-scale occupation of ecological areas by built-up areas, degradation of urban ecological functions, continuous fragmentation of landscape, and reduction of habitat connectivity [1]. As a smart development strategy under the environment of rapid urbanization, green infrastructure (GI) is an overall method that takes into account the functions of nature protection and social services. It is of great significance to solve regional ecological problems and guide the healthy and sustainable development of urban land. Genetic algo-

rithm is an adaptive search and optimization algorithm based on the principles of natural genetics and natural selection. It can solve not only linear optimization problems, but also nonlinear optimization problems [2]. At present, genetic algorithm has been widely used in many fields and achieved good results, which fully shows the effectiveness of genetic algorithm. Compared with general algorithms, genetic algorithm is more suitable for optimizing complex nonlinear problems. The construction of green infrastructure in urban parks is a complex systematic project. The data it processes involves many fields and there are a large number of nonlinear problems [3]. Therefore, using genetic algorithm to solve these problems will get better results. Different from the green space system in current urban planning, green infrastructure puts more emphasis on the concept of network. Green infrastructure refers to the use of linear corridors to include

point and surface ecological patches such as urban parks, nature reserves, woodlands, and wetlands, so as to form a networked, flexible, efficient, and natural diversified green space ecosystem. Like other urban infrastructure, every part of it is interrelated. Green infrastructure is a facility network, which generally constitutes an ecological support system to ensure the sustainable development of environment, society, and economy. At present, the use of landscape connectivity index to delimit the regional green ecological network is the method adopted by most scholars, and it is mostly considered from the perspective of target species protection, but it does not include the ecological and social service functions of the corridor and people's needs for the ecological environment. In addition, the research type of corridor is relatively single, and the potential ecological corridor, green traffic corridor (greenway), and rainwater runoff channel in the region have not been studied.

Based on the analysis of green infrastructure system, taking a city park as the research area, the multiobjective green infrastructure network model of a city park is established, and the multiobjective green infrastructure network model is solved and analyzed by using a multiobjective genetic algorithm and genetic Tabu hybrid algorithm. The minimum cost path method is used to identify the elements of green infrastructure network, including the identification of source patches and the generation of potential corridors, so as to jointly build a green infrastructure network.

2. Literature Review

In recent years, urban construction has entered a new era with the main style of sustainable development and ecological civilization construction. The green infrastructure network with human settlements, ecological protection, and green technology as the context, as a form of space organization to control urban growth trend and protect natural environmental resources, has been widely studied and discussed at home and abroad. As the core technical means of green infrastructure planning, the core evaluation system of green infrastructure has been introduced into China from abroad and has been improved in continuous planning practice. In this context, the construction of urban green infrastructure based on the core evaluation system has a wider application prospect on the basis of scientific evaluation and quantitative analysis. Kranjcic and others used machine learning methods. Machine learning is divided into supervised classification and unsupervised classification. Each classification can be divided into several different methods. These methods are used to obtain the accuracy of satellite image information extraction. Using different satellite images, images with higher natural resolution lead to better classification. Reducing green urban infrastructure poses a great threat to urban sustainable development. Using machine learning method to monitor and track the health status of plants, effectively plan urban development, and maintain green urban infrastructure. Green infrastructure is a multibenefit solution for stormwater management, which may achieve

the total maximum daily load target [4]. Wu and others used the method of combining nondominated sorting genetic algorithm with rainwater management model to find the approximate optimal combination to minimize the load and minimize the overall relative cost on the watershed scale. According to the cost and effect, the selection and placement of three local most popular biological retention types, infiltration ditch type, and permeable pavement type are analyzed. The comparison of sensitivity analysis cost and estimation criteria shows that the assumptions made on these parameters greatly affect the optimal solution [5]. Due to its scattered distribution and large number, the original landscape pattern and land resources in the mining area have been seriously damaged, which hinders the development of the city. Yuan and others summarized the formation mechanism and temporal and spatial development characteristics of post-harvest landscape in Xuzhou, analyzed a series of contradictions and problems brought by post-harvest landscape, discussed the basic ideas of post-harvest landscape, put forward the objectives and methods of post-harvest landscape ecological restoration and reuse, and put forward the planning principles of post-harvest landscape reuse based on the concept of green infrastructure [6]. Green infrastructure (GI) has been increasingly seen as a nature based solution for climate change adaptation, mitigation, and other social goals of sustainable development. Choi and others provide a comprehensive overview of the links between climate benefits, CO₂ benefits and GI types, and classify them according to green gray continuum so that researchers/practitioners can find information according to the topics they are interested in. The trade-offs between various GI benefits are analyzed. The main common benefits and trade-offs of each climate benefit can be determined by strategic recommendations to maximize benefits and minimize trade-offs. In order to promote climate adaptation pathways through GI, policymakers must identify opportunities to provide a variety of ecosystem services and benefits while recognizing the hazards and trade-offs that need to be avoided or managed [7]. Liu and others investigated the contribution of using urban green space components as basic units in the strategic planning of green infrastructure for urban ecosystem conditions and services. Nine types of urban green space are selected and depicted from high-resolution data. Combined with the quantitative method and MAEs framework of six common urban ecosystem service functions based on urban green space. The results show that changing the composition and spatial layout of urban green space can easily promote the coordination or trade-off of various services. Small-scale urban green space components allow local detailed planning and potential comprehensive planning in other urban settlements [8]. GI planning has improved our ability to respond to climate change on an urban scale by providing a variety of ecosystem services and adopting a positive multifunctional and multidisciplinary approach in the planning. Ramyar and others proposed an interdisciplinary adaptive urban geographic information planning framework, which combines science with professional practice.

It includes adaptive strategies from climate change adaptation and ecological planning in a structured form to support different types of responses in planning at the same time and improve the convertibility and flexibility in planning and practice [9]. Green infrastructure (GI) planning was originally developed as an integrated approach to ecological and conservation planning. Then, it has been developed and applied in many disciplines such as urban and regional planning and landscape design.

3. Construction of Multiobjective Green Infrastructure Network Model

3.1. Setting Green Infrastructure Network Type Variables

3.1.1. Data Collection and Processing. The data used in this paper mainly includes all kinds of basic data and related graphic data. The graphic data includes landsat8 remote sensing satellite image (collected on October 9, 2017, with a resolution of 30m), DEM digital elevation data (derived from geospatial data cloud, with a resolution of 30m), urban terrain, and Road CAD map. The basic data include the municipal master plan (2010-2020), the municipal urban green space system plan (2013-2020), and the municipal ecological red line regional protection plan (2013) [10].

WGS 1984 coordinate system and Gaussian projection are adopted in this paper, and the data processing software is ENVI5.5, ArcGIS10.2, Conefor2.6, and Yaahp10.0, based on the municipal master plan (2010-2020) published by the Bureau of planning and natural resources [11, 12]. With the support of remote sensing software ENVI5.5, the combination of supervised classification and unsupervised classification is adopted to interpret the original remote sensing image. Obtain the land cover type map of the city (Figure 1 and Table 1).

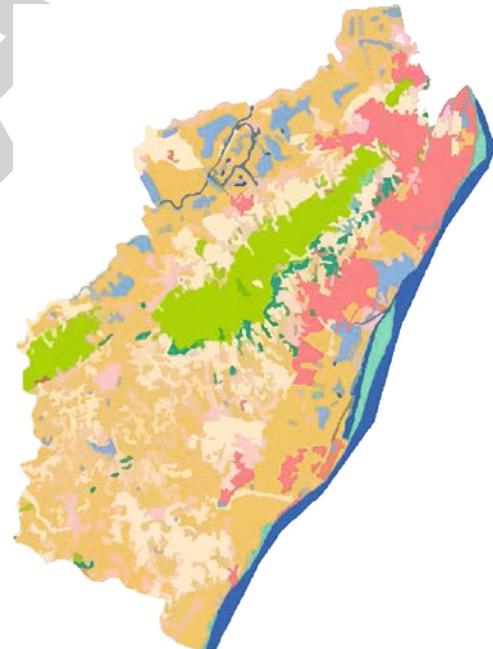
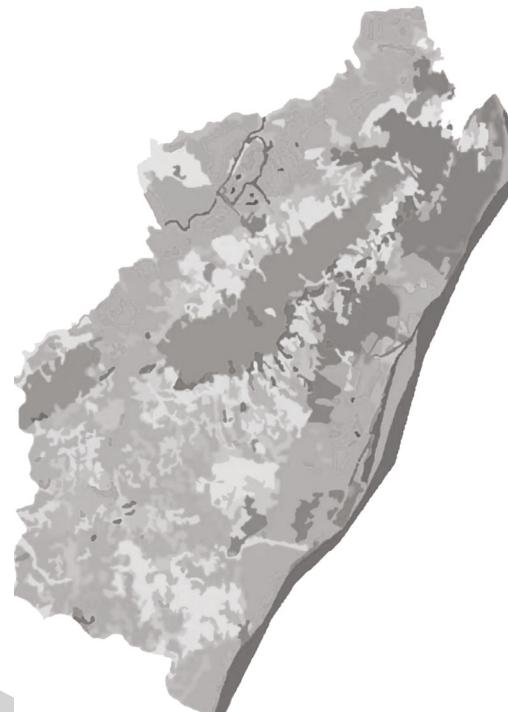
On this basis, the normalized vegetation index coverage map is calculated, and the land cover types are divided into six categories: forest land, grassland, farmland, water body, construction land, and unused land.

3.2. Determine Optimization Objectives and Constraints

3.2.1. Ecological Sensitivity Assessment of the City

(1) Selection of Ecological Factors. According to the classification of ecological factors in the ecological adaptability analysis method, this paper selects 9 factors that have a great impact on the ecological sensitivity of the city from the three aspects of biology, terrain, and human as the basic factors of this evaluation. They are normalized vegetation cover index (NDVI), land cover type, priority protection area, pollution source, traffic, elevation, slope, topographic relief, and water buffer zone (see Table 2).

(2) Construction of Evaluation System. The above nine single factors are used to construct the ecological sensitivity assessment system within the city. Target layer a of the evaluation system: ecological suitability evaluation index; Middle layer B: biological factors, topographic factors and human factors;



Rivers and lakes	Filling and woodland
Reservoir pits	Opening
On beaches	The grass
Paddy field	Construction land
Dry field	Unused
Forest land	

FIGURE 1: Satellite remote sensing image map and land cover type map of the city.

TABLE 1: Statistics of land cover types in the city.

Land cover type	Area (km ²)	Proportion (%)
Woodland	494.39	7.48
Grassland	248.68	3.77
Farmland	2822.76	42.79
Waters	586.65	8.9
Land used for building	2331.24	35.34
Unused land	113.34	1.72

Index layer C: nine factors including normalized vegetation index, land cover type, priority protection area, pollution source, traffic, elevation, slope, topographic relief and water buffer zone. The evaluation system starts with the index layer, from bottom to top, and finally obtains the overall goal of the target layer (Figure 2).

(3) *Determination of Factor Weight.* Taking the ecological sensitivity evaluation system as the target layer and biological, human, and topographic factors as the middle layer, the analytic hierarchy process model is established, as shown in Figure 3. According to the scaling method of 1-9 and its reciprocal, the importance of each two indicators is compared, and the weight value of each indicator is calculated. The process is shown in Tables 3 and 4.

(4) *Single Factor Evaluation Results.* Each factor is divided into different attribute value intervals according to certain standards. Each attribute interval can only correspond to one level, as shown in Table 5. The evaluation system adopts the five scores of 1, 2, 3, 4, and 5. The higher the score, the more sensitive it is. Each index factor is also divided into five grades according to different sensitivity characteristics, and its grade information is transformed into the score of land sensitivity. Based on this, a grid database for ecological sensitivity evaluation is established [13, 14].

(5) *Comprehensive Stacking Results.* The weighted summation tool of ArcGIS software is used to reclassify and obtain the final ecological sensitivity evaluation. According to the evaluation results, areas with high ecological sensitivity are generally distributed in large forest land, water area and waterfront area, ecological forest, important wetland, water source protection area, and other places [15].

Due to the need of building a network of green infrastructure, it is necessary to provide a basis for the identification of source patches. Therefore, the ecological sensitivity evaluation results are further analyzed by cluster analysis to facilitate the division of source patches. In this paper, the classification method of natural discontinuities is adopted to divide the sensitive area into five levels: extremely sensitive area, highly sensitive area, medium sensitive area, low sensitive area, and nonsensitive area, as shown in Figure 3 and Table 6.

3.3. Identification of Urban Green Infrastructure Network Elements

3.3.1. Identification of Source Plaque. Based on the ecological sensitivity zoning mentioned above, the areas with high ecological sensitivity are taken as the spatial scope of the green infrastructure planning [16, 17]. Combined with the current situation map of land cover types identified by remote sensing images, the areas highly used by human beings are removed; at the same time, due to the need of the meaning of this green infrastructure planning, the ecological areas dominated by large area water bodies such as the Yangtze River will be removed; then, sort the ecological areas by area, and select 50% of the large patches as the source patches of the green infrastructure network, a total of 55. The results are shown in Figure 4 and Table 7.

The source patches identified in this paper include not only the common types of park green space, ancillary green space, production, and protection green space in green space planning, but also the ecologically important areas within the city, such as nature reserves, important wetlands, water conservation reserves, and large-scale ecological public welfare forests [18].

3.3.2. Generation of Potential Corridors. The current urban ecological corridors include river corridors and transportation facilities corridors, while there are other potential ecological corridors between different homologous patches that can meet the needs of biological migration and reproduction. Potential ecological corridor is a banded green space connecting ecological source patches into a network. It undertakes the function of green infrastructure networking and is an effective means to guide the healthy and rational development of cities. The resistance of organisms moving in different land cover types is different, which affects the difficulty of moving between different landscape units [19, 20]. Therefore, the potential ecological corridor represents a continuous channel between patches connected by landscape units with low landscape resistance. When organisms move, they do not necessarily follow this path, but regarded it as the potential path with the lowest flow cost. Arranging the corridor at the path with the lowest cost can achieve the ecological goal and reduce the construction cost to the greatest extent.

This paper uses ArcGIS “minimum cost path method” to generate potential corridors. The resistance values are set for different landscape types between patches, the resistance surface is constructed by using GIS platform, and then the ecological corridor connected between source patches is simulated by using the minimum path tool.

(1) *Assignment of Various Landscape Resistance.* Vegetation cover, vegetation type, human disturbance, and other factors directly affect the landscape resistance. Determine the landscape resistance values of various landscape units in the city, as shown in Table 8.

(2) *Minimum Cost Path Generates Potential Corridors.* With the help of the cost distance tool of ArcGIS 10.2, take each source patch as the “source,” calculate the cost distance grid and cost backtracking link grid data from each “source” to each patch, use the “cost path” tool under the ArcGIS

TABLE 2: Basic factors of urban ecological sensitivity.

	Vegetation	Normalized vegetation index (NDVI)
Biology	Reserve Land use	Forest parks, nature reserves and drinking water source protection areas are preferred Land cover type of reserve
Terrain	Terrain	Altitude Topographic relief Slope
	Hydrology	Water buffer zone
Human beings	Human activity	Traffic pollution source

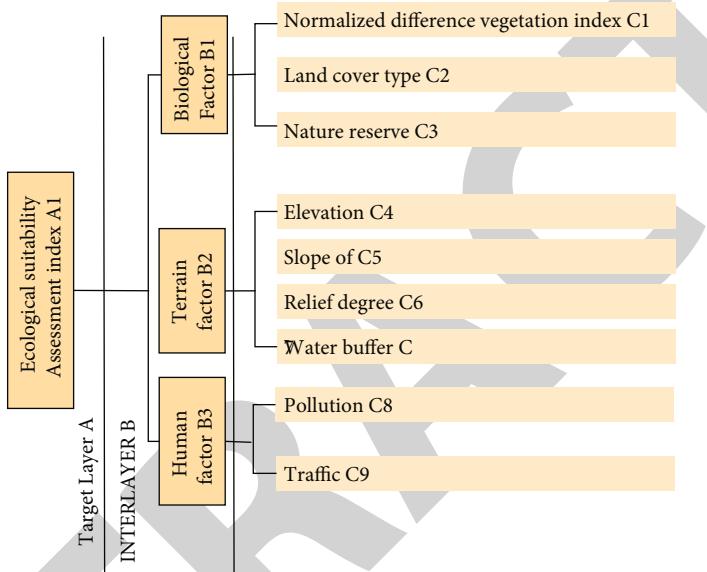


FIGURE 2: Evaluation system of urban ecological sensitivity.

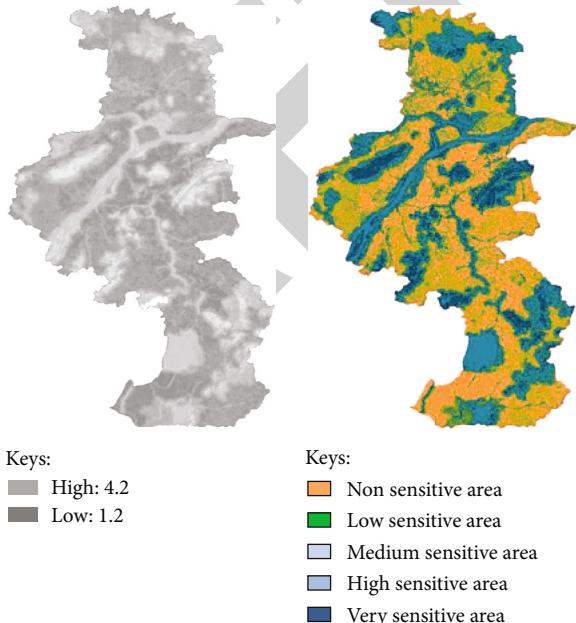


FIGURE 3: City sensitivity evaluation map and city sensitivity zoning map.

distance analysis module to calculate the minimum cost path between “source” and “destination,” and generate 71 potential ecological corridor paths [21].

3.4. Build a Multiobjective Optimization Model of Green Infrastructure Network

3.4.1. Genetic Algorithm. Genetic algorithm is an adaptive search and optimization algorithm based on the principles of natural genetics and natural selection. It can solve not only linear optimization problems, but also nonlinear optimization problems [22, 23]. At present, genetic algorithm has been widely used in many fields and achieved good results, which fully shows the effectiveness of genetic algorithm. Compared with general algorithms, genetic algorithm is more suitable for optimizing complex nonlinear problems. Urban green infrastructure network is a complex system engineering. The data it processes involves many fields and there are a lot of nonlinear problems. Therefore, using genetic algorithm to solve these problems will get better results.

3.4.2. Tabu Search Algorithm

TABLE 3: 1-9 scale method and its meaning.

1-9 scale	Degree of importance	Explain
1	Equally important	The same contribution to the goal
3	Slightly more important	Important
5	Basic importance	Confirm important
7	Really important	Obvious degree
9	Absolutely important	The degree is very obvious
2, 4, 6, 8		Indicates that the importance is between two of the above five scores
Reciprocal	Contrary to importance	Represents the reciprocal of the judgment scale obtained by comparing the factor and the result

TABLE 4: Total weight and ranking of index factors.

Target layer	Factor name	Criterion layer	Indicator name	Relative weight of indicators	Total weight	Sort
		Relative weight of factors				
Ecological suitability evaluation index	Biological factors	0.5584	Normalized vegetation cover index (NDVI)	0.4000	0.2234	2
			Land use type	0.2000	0.1117	4
			Priority protected areas	0.4000	0.2234	1
	Human factors	0.1220	Traffic	0.3333	0.0407	9
			Pollution source	0.6667	0.0813	5
			Slope	0.1682	0.0538	8
	Topographic factors	0.3196	Altitude	0.2390	0.0764	6
			Topographic relief	0.1976	0.0632	7
			Water buffer zone	0.3952	0.1263	3

(1) *Initial Solution*. In most cases, the initial solution is generated randomly. For a certain kind of problem, a specific algorithm can also be used to generate high-quality initial solution.

(2) *Fitness Function*. The fitness function is used to evaluate the search state and then combined with Tabu criterion and contempt criterion to select a new current state. Generally, the objective function is directly used as the adaptive value function, which is the most extensive and easiest way. Any deformation of the objective function or some eigenvalues reflecting the objective of the problem can also be used as the adaptive value function. Of course, the choice of the best fitness function depends on the specific problem.

(3) *Taboo Object*. Taboo objects are the elements placed in the taboo table. The purpose of taboo is to search more effective solution space in order to avoid circuitous search as far as possible. Generally speaking, there are three methods to select taboo objects:

- (1) Taking the state itself or its change as the taboo object is the simplest and easiest way to understand
- (2) Taking the change of state component as the taboo object can expand the scope of taboo and reduce the corresponding amount of calculation

(3) Taking the adaptation value or its change as the Tabu object, the latter two methods are generally used in function optimization. Although the amount of calculation can be reduced, the search is easy to fall into local minima due to the large Tabu range. How to avoid this problem should be considered in algorithm design [24]

(4) *Taboo Length*. Tabu length and candidate set size are two key parameters that affect the performance of Tabu search algorithm.

The selection of Tabu length is related to the characteristics of the problem and the experience of researchers, which determines the complexity of the algorithm sex. Generally speaking, there are two methods:

- (1) The taboo length is fixed. It can be set as a constant or fixed as a quantity related to the scale of the problem
- (2) Taboo length changes dynamically. It can be set to change in a certain interval, according to a certain principle or formula, or dynamically change with the change of search performance. A large number of studies show that the dynamic setting method of

TABLE 5: Classification criteria and evaluation values of various factors in ecological sensitivity assessment.

Ecologically sensitive factors	Index factor	Evaluation object	Grading standard	Ecological sensitivity	Evaluation value
Biological factors	Normalized vegetation index	NDVI	NDVI ≥ 0.3	Extremely high	5
			0.2 \leq ND VI < 0.3	High	4
			0.1 \leq ND VI < 0.2	Middle	3
			0 \leq ND VI < 0.1	Low	2
			NDVI < 0	Very low	1
	Land cover type	Surface landscape	Forest land and water body	Extremely high	5
			Grassland	High	4
			Farmland	Middle	3
			Unused land	Low	2
			Land used for building	Very low	1
Human factors	Priority protected areas	Drinking water source protection area, geological heritage protection area, forest park and other important ecological red line protection areas	Inside the protected area	Extremely high	5
			500 m buffer area	High	4
			500-800 m buffer area	Middle	3
			800-1000 m buffer area	Low	2
			Outside the buffer area	Very low	1
	Pollution source	Pollution source	Within 300 m buffer zone	Middle	4
			300-500 m buffer area	Low	3
			500-800 m buffer area	Very low	2
			Outside the buffer area	Extremely high	1
			40 m buffer area	High	5
Topographic factors	Altitude	Railway	40-100 m buffer area	Middle	3
			100-200 m buffer area	Low	2
			30 m buffer area	High	5
			30-80 m buffer area	Middle	3
			80-150 m buffer area	Low	2
	Traffic	Main road	Outside the buffer area	Very low	1
			≥ 200 m or < 8 m	Extremely high	5
			100-200 m	High	4
			50-100 m	Middle	3
			8-50 m	Low	2
Slope		Slope	$\geq 50\%$	Extremely high	5

TABLE 5: Continued.

Ecologically sensitive factors	Index factor	Evaluation object	Grading standard	Ecological sensitivity	Evaluation value
			25%-50%	High	4
			10%-25%	Middle	3
			3%-10%	Low	2
			0%-3%	Very low	1
			≥ 75	Extremely high	5
Topographic relief		Topographic relief	45-75	High	4
			25-45	Middle	3
			15-25	Low	2
			0-15	Very low	1
			<200 m	High	4
The coastline buffer zone of the Yangtze River, Gucheng River, Shiji lake, and other major waters			200-500 m	Middle	3
Water buffer zone			500-1000 m	Low	2
			>1000 m	Very low	1
		Shoreline buffer zone of other rivers, lakes, and other water bodies	<100 m	High	4
			100-200 m	Middle	3
			200-500 m	Low	2
			>500 m	Very low	1

TABLE 6: Division of ecologically sensitive areas.

Ecologically sensitive zoning	Area km ²	Proportion (%)
Extremely sensitive area	606. 91	9. 21
High sensitivity area	1191. 36	18. 09
Medium sensitive area	1277. 21	19. 39
Low sensitive area	1943. 38	29. 5
Non sensitive area	1568. 34	23. 81

Tabu length has better performance and robustness than the static method, and a more reasonable and efficient setting method needs to be further studied

(5) *Candidate Set.* Candidate sets are usually selected in the neighborhood of the current state. If the selection is too large, it will cause a large amount of calculation, while if the selection is too small, it is easy to cause premature convergence. The specific data size depends on the characteristics of the problem and the requirements for the algorithm [25].

(6) *Contempt for Norms.* The application of the code of contempt leads to the lifting of some states. The ways of the code are as follows:

- (1) Criteria based on fitness value
- (2) Criteria based on search direction
- (3) Based on the minimum error criterion

(4) Influence based guidelines

(7) *Termination Criteria.* Common termination methods include the following:

- (1) Given the maximum number of iteration steps
- (2) Sets the maximum Tabu frequency for an object
- (3) Set the deviation degree of the adaptation value

3.4.3. *Genetic Tabu Hybrid Algorithm.* Genetic algorithm and Tabu search algorithm are combined to develop strengths and avoid weaknesses, forming a new algorithm with good diversity and convergence. Tabu search is regarded as a genetic mutation operator to improve the mountain climbing ability of heredity, which integrates the characteristics of multi-starting points of heredity and strong mountain climbing ability of Tabu search, and overcomes the weakness of poor mountain climbing ability of heredity. At the same time, genetic algorithm also finds a better starting point for Tabu search, speeds up the convergence speed, and improves the quality of solution. The steps are as follows:

- (1) Generate initial population
- (2) Calculate the fitness, selection and crossover of individuals in the current generation
- (3) Call Tabu search for mutation operation



FIGURE 4: Distribution of ecological source patches.

- (4) Repeat the search process of 2 and 3 until the termination conditions of the algorithm are met

4. Application of Genetic Tabu Hybrid Algorithm in Greening Planning

4.1. Solution of Green Infrastructure Network Model by Genetic Algorithm. The general flow of genetic algorithm is as follows (see Figure 5).

The first step is chromosome coding, which randomly generates the initial population with a certain number of individuals, and each individual is expressed as the gene code of chromosome;

The second step is to calculate the individual fitness and judge whether it meets the optimization criteria. If so, output the best individual and its representative optimal solution; otherwise, turn to the third step.

The third step is to select regenerated individuals according to fitness. Individuals with high fitness have a high probability of being selected, and individuals with low fitness may be eliminated.

The fourth step is to generate new individuals according to a certain crossover probability and crossover method.

The fifth step is to generate new individuals according to a certain mutation probability and mutation method.

The sixth step is to generate a new generation of population by crossover and mutation, and return to the second step.

There are different ways to determine the general optimization criteria in genetic algorithm. For example, one of the following criteria can be used as the judgment condition:

- (1) The maximum fitness of individuals in the population exceeds the preset value

- (2) The average fitness of individuals in the population exceeds the preset value
- (3) The number of generations exceeds the preset value

- (1) Select operation

The selected probability is

$$P_c = f(X_i) / \sum f(X_i), \quad (1)$$

where X_i is the fitness value of chromosome i in the population and $\sum f(X_i)$ is the sum of the fitness values of all chromosomes in the population.

- (2) Exchange

- (3) Variation

Genetic algorithm needs a scalar fitness information to calculate, so it is natural to think of synthesizing all objective functions into a single objective by addition, multiplication, or other mathematical methods that may be thought out. However, this method has obvious problems. The first choice is to provide accurate information within the value range of the objective function, so as to avoid that one of the objective functions will be significantly better than other values. This requires that we can estimate the value of each objective function at least in some program, which is often a very expensive and unbearable process for practical problems [26]. However, if the method of integrating all objective functions is indeed feasible, it will not only be the simplest method, but also the most effective method, because there is no need for other interactive processes involving decision makers. Moreover, if the genetic algorithm successfully finds the point with the best fitness, then this point is at least one possible best advantage.

4.1.1. Weight Method. This method multiplies all objective functions by different weights and then adds them together as a single objective to be optimized. The function is

$$\max \sum_{i=1}^k \omega_i f_i(\bar{x}). \quad (2)$$

Different weights will get different results, and little is known about how to select weights, so one way to solve this weight method is to use different weights to get a set of solutions, but at this time, decision-makers still need to make the best choice according to their own requirements from these feasible solutions. It should be pointed out that although the weight coefficient can reflect the importance of each objective function value, it is not proportional. If we want the weights to be proportional to the objective function, we need to convert them into unified units.

TABLE 7: Statistical table of ecological source patches.

Source patch serial number	Area (HA)	Source patch serial number	Area (HA)	Source patch serial number	Area (HA)
1	5347. 1566	21	2185. 7049	41	6957. 0649
2	9784. 1056	22	443.6332	42	1605. 3048
3	5462. 9177	23	1027. 4332	43	824.8127
4	750. 0415	24	11162. 5363	44	4754. 9005
5	1000. 4171	25	13754. 8767	45	641 .8691
6	276. 4272	26	740.9969	46	160. 6894
7	1000. 7524	27	2939. 9361	47	1226. 0768
8	426. 6343	28	173.9455	48	234. 1933
9	637. 2303	29	1268. 6928	49	373. 1994
10	3351.2006	30	1535. 4861	50	9170. 4948
11	1102. 2585	31	3132. 8138	51	1733. 9468
12	289. 3481	32	437.2611	52	538. 2549
13	1489. 8974	33	175.6618	53	159. 0735
14	159. 4408	34	272.2380	54	154. 1064
15	845. 1284	35	1824. 0926	55	1906. 8279
16	822. 5513	36	627.0222	56	459. 5474
17	1671.3649	37	175.4612	57	210. 0424
18	16164. 5723	38	997.8814	58	188. 6114
19	200. 2173	39	487.1909		
20	241.2047	40	868.6341		

TABLE 8: Determination of landscape resistance value.

Land use type	Landscape resistance value
Woodland	1
Grassland	4
Farmland	30
Waters	500
Road	800
Unused land	120

4.1.2. Method Based on Pareto Noninferior Solution Concept. In Pareto, if X is a random variable, the probability distribution of X is shown in the following:

$$P(X > x) = \left(\frac{x}{x_{\min}} \right)^{-k} \quad (3)$$

where x is any number greater than x_{\min} , x_{\min} is the smallest possible value of X (positive number), and k is a positive parameter. The Pareto distribution curve family is parameterized by two quantities: x_{\min} and k . The distribution density is

$$p(x) = \begin{cases} 0, & \text{if } x < x_{\min}; \\ \frac{kx_{\min}^k}{x^{k+1}}, & \text{if } x > x_{\min}. \end{cases} \quad (4)$$

Pareto distribution belongs to continuous probability distribution.

In the optimization of multiobjective genetic algorithm, the fitness based on the concept of Pareto noninferior solution is introduced to sort the advantages and disadvantages of individuals, which can be divided into several sets, and then select the parent individuals to make the whole population move towards the forefront of Pareto solution under the guidance of the above information.

4.2. Tabu Algorithm for Solving Green Infrastructure Network Model. The flow diagram is intuitively described, as shown in Figure 6.

4.2.1. Initial Solution. In most cases, the initial solution is generated randomly. For a certain kind of problem, a specific algorithm can also be used to generate high-quality initial solution.

4.2.2. Fitness Function. The fitness function is used to evaluate the search state and then combined with Tabu criterion and contempt criterion to select a new current state. Generally, the objective function is directly used as the adaptive value function, which is the most extensive and easiest way. Any deformation of the objective function or some eigenvalues reflecting the objective of the problem can also be used as the adaptive value function. Of course, the choice of the best fitness function depends on the specific problem.

(1) Taboo Object. Taboo objects are the elements placed in the taboo table. The purpose of taboo is to search more

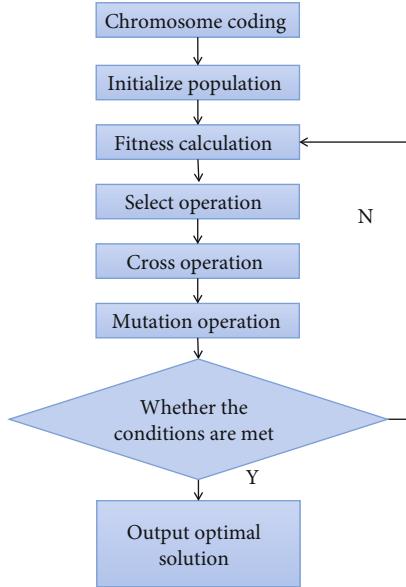


FIGURE 5: Flow chart of genetic algorithm.

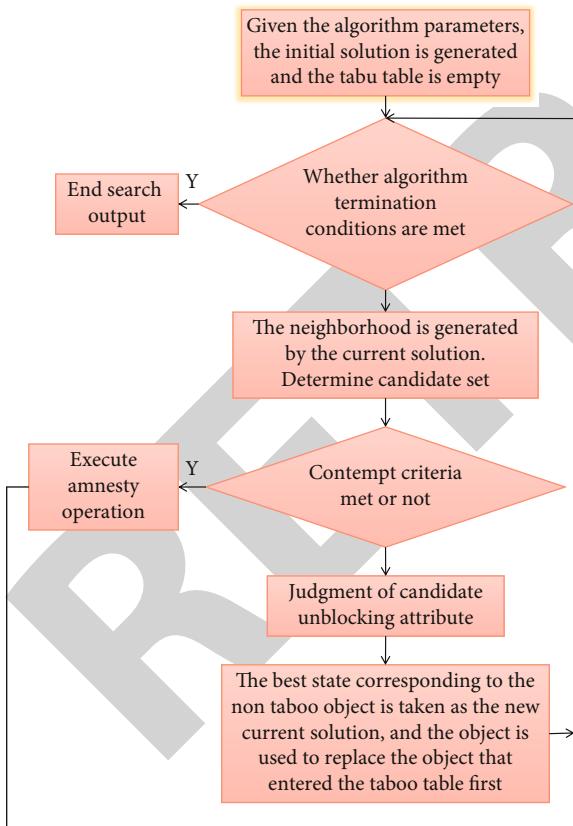


FIGURE 6: Tabu algorithm flow chart

effective solution space in order to avoid circuitous search as far as possible. Generally speaking, there are three methods to select taboo objects:

- (1) Taking the state itself or its change as the taboo object is the simplest and easiest way to understand
- (2) Taking the change of state component as the taboo object can expand the scope of taboo and reduce the corresponding amount of calculation
- (3) Taking the adaptation value or its change as the taboo object, it is generally used in function optimization [27]

Although the latter two methods can reduce the amount of calculation, because the Tabu range is too large, it is easy to make the search fall into local minima. How to avoid this problem should be considered in the algorithm design.

(2) *Taboo Length*. Tabu length and the size of candidate set are two key parameters affecting the performance of Tabu algorithm.

The selection of Tabu length is related to the characteristics of the problem and the experience of researchers, which determines the computational complexity of the algorithm. Generally speaking, there are two methods:

- (1) The taboo length is fixed. It can be set as a constant or fixed as a quantity related to the scale of the problem
- (2) Taboo length changes dynamically. It can be set to change in a certain interval, according to a certain principle or formula, or dynamically change with the change of search performance

A large number of studies show that the dynamic setting method of Tabu length has better performance and robustness than the static method, and a more reasonable and efficient setting method needs to be further studied.

(3) *Candidate Set*. Candidate sets are usually selected in the neighborhood of the current state. If the selection is too large, it will cause a large amount of calculation, while if the selection is too small, it is easy to cause premature convergence. The specific data size depends on the characteristics of the problem and the requirements for the algorithm.

(4) *Contempt for Norms*. The application of the contempt criterion allows some states to be lifted to achieve more efficient optimization performance. Common ways of flouting norms are as follows:

- (1) Criteria based on fitness value
- (2) Criteria based on search direction
- (3) Based on the minimum error criterion

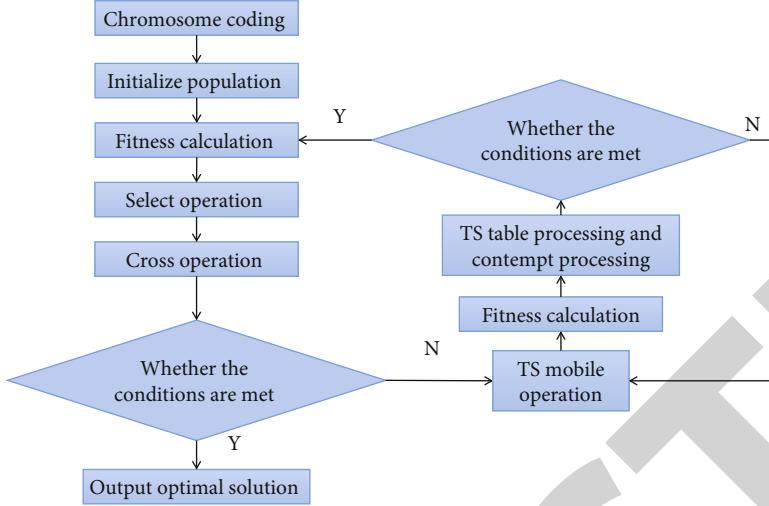


FIGURE 7: Hybrid algorithm steps.

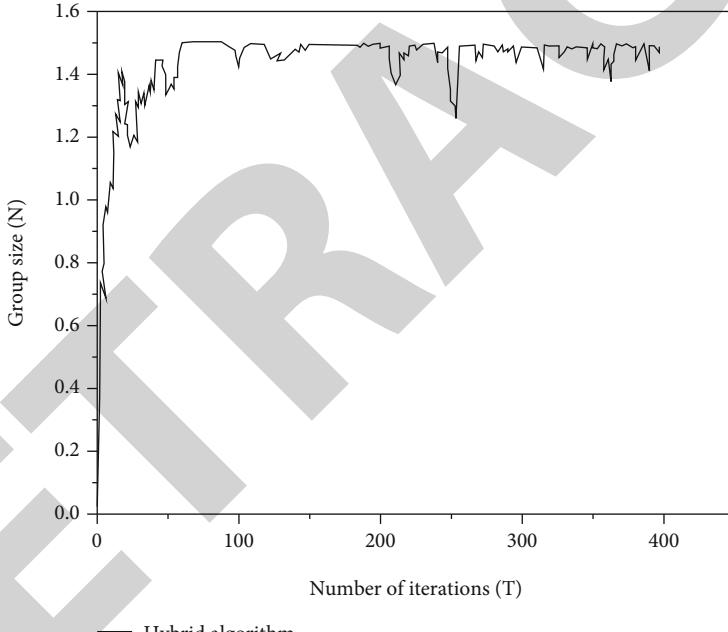


FIGURE 8: Search process of hybrid algorithm for model solution.

(4) Influence based guidelines

(5) *Termination Criteria.* Common termination methods include the following:

- (1) Given the maximum number of iteration steps
- (2) Sets the maximum Tabu frequency for an object
- (3) Set the deviation degree of the adaptation value

4.3. *Genetic Tabu Hybrid Algorithm for Solving Green Infrastructure Network Model.* Genetic algorithm and Tabu algorithm are combined to develop strengths and avoid

weaknesses, forming a new algorithm with good diversity and convergence. Tabu is used as genetic mutation operator to improve genetic mountain climbing ability, which integrates the characteristics of multiple starting points and strong Tabu mountain climbing ability, and overcomes the weakness of poor genetic mountain climbing ability. At the same time, genetic algorithm also finds a better initial point for Tabu, speeds up the convergence speed, and improves the quality of solution. The steps are as follows:

- (1) Generate initial population
- (2) Calculate the fitness, selection and crossover of individuals in the current generation

- (3) Call taboo for mutation operation
- (4) Repeat the search process of 2 and 3 until the termination conditions of the algorithm are met

The detailed steps are as follows (see Figure 7).

Step 1: Input the original data and required parameters. Input all attribute data of the greening planning problem. The operation parameters of the optimization algorithm are population size N , optimal preservation number m , crossover probability P_o , mutation probability P_m , Tabu table length K_{\max} , maximum iteration times T_{\max} of genetic main optimization and Tabu search sub-optimization process, convergence criterion ε , etc. At the same time, make the counter of genetic and Tabu search iteration $K_{GA} = K_{TS} = 0$

Step 2: Chromosome coding. The variables of greening resources are binary coded to form gene bonds

Step 3: Form an initialization group. N individuals were randomly generated

Step 4: Fitness calculation. The fitness of each individual in the group is calculated through the objective function and the weight of each objective

Step 5: Select the operation

Step 6: Cross-operation

Step 7: Judge whether the genetic termination conditions are met. If $K_{GA} \geq T_{\max}$ or $-\varepsilon < F'_{new} - F'_{old}/F'_{old} < \varepsilon$, jump out of the main genetic optimization process, and output the optimization results; otherwise, turn to Step 8 for Tabu search and moving operation, where F'_{new} and F'_{old} are the fitness of the new optimal solution and the previous optimal solution, respectively

Step 8: Tabu search mobile operation

Step 9: Fitness calculation. The fitness of each individual in the group is calculated through the objective function and the weight of each objective

Step 10: Tabu search table processing and contempt operation. If the best test neighbor solution generated by Tabu search optimization search is better than the current optimal solution S_{best} , ignore its Tabu attribute (execute contempt criterion), and update S_{best} and $S_{current}$ with the best test neighbor solution; if there is no above test neighbor solution, select the non-Tabu best solution as the new $S_{current}$ among all test neighbor solutions, regardless of its advantages and disadvantages with the current solution. At the same time, the change information of greening planning is stored in the Tabu table, the taboo length is set to K_{\max} , and the attributes of each taboo object in the Tabu table are modified

Step 11: Judge whether the taboo termination conditions are met. If $K_{TS} \geq T_{\max}$ or $-\varepsilon < F'_{new} - F'_{old}/F'_{old} < \varepsilon$, jump out of the TS mutation optimization process, and $K_{GA} = K_{GA} + 1$; return to Step 4 to continue the genetic optimization operation

Otherwise, $K_{TS} = K_{TS} + 1$, and turn to Step 8 to continue TS mutation operation.

The algorithm program is written in Matlab environment to obtain multiple approximate noninferior solutions of various green space area data. The value of its parameters

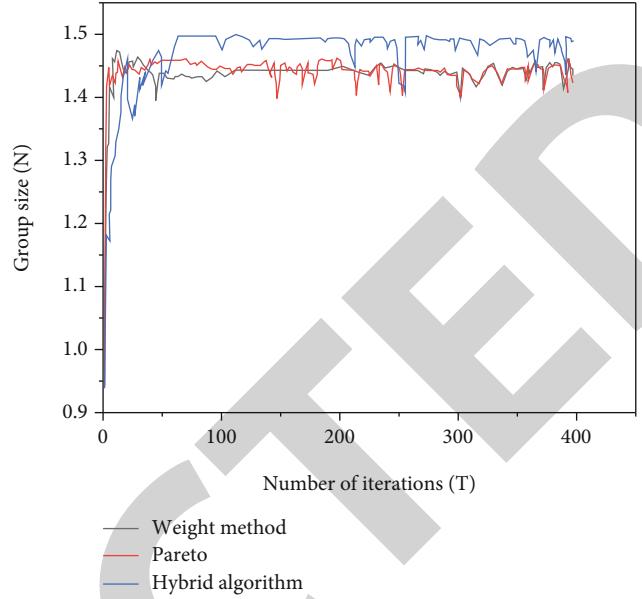


FIGURE 9: Comparison of three algorithms.

and the action mode of genetic operator are the same as those in the previous chapter, and three noninferior solutions are obtained. The results are shown in Figure 8, which shows the search process through genetic Tabu hybrid algorithm.

4.4. Comparison between Hybrid Algorithm and Genetic Algorithm. The hybrid strategy of genetic and taboo is used to avoid premature phenomenon and obtain multiple approximate non inferior solutions of multiobjective optimization problem. The hybrid strategy effectively combines the parallel large-scale search ability of genetic algorithm and the local search ability of Tabu, which has a great improvement in convergence performance and avoiding local minima. For heredity, once the individuals in the population are the same, the selection and cross-operation can hardly introduce new genes, but only make the population transfer through mutation and taboo operation. When the mutation probability is small, the algorithm will linger in the old state for a long time, the search efficiency is very low, and it is easy to converge in advance. Tabu accepts the nature of the inferior solution with a certain probability in local search, avoids the phenomenon of early convergence, and increases the probability of approaching the global optimal solution. In addition, the selection operator makes individuals with high fitness survive with a high probability, but too strong selection excessively attracts the search process to the local minimum, resulting in premature convergence [28]. Therefore, it is necessary to introduce Tabu algorithm. By solving the model, it can be seen that genetic taboo has the ability to find multiple approximate noninferior solutions of multiobjective optimization problems. Compared with simple heredity, the number of approximate noninferior solutions obtained by genetic Tabu hybrid strategy is greatly increased. Therefore, genetic taboo improves the “mountain climbing” ability

of heredity and avoids the occurrence of premature convergence. The solution results of hybrid algorithm and genetic algorithm are shown in Figure 9.

5. Conclusion

Rational planning and layout of green infrastructure and maximizing the ecological performance of space utilization are particularly important for urban scientific construction. By reasonably determining the areas that need priority protection, it is conducive to the key and phased implementation of the green infrastructure network, which is not only convenient for implementation and management, but also conducive to making full use of funds, coordinating the contradiction between protection and development, and guiding the smart growth and benign development of the city.

- (1) This paper takes the city as the scope, but does not involve the smaller scale of metropolitan area and central area. It is precisely the smaller scale of green infrastructure research, which has an important role and significance for the ecological protection and restoration of urban residential environment. In order to better realize the ecological service benefits of human settlements, it is of great significance to study green infrastructure from more scales
- (2) In this paper, the impact factors involved in the ecological sensitivity evaluation of urban land are complex. The evaluation standard system is based on previous experience and network analysis method, which has a certain subjectivity, and the evaluation system needs a lot of data to support the field evaluation. Due to the acquisition of some sensitive data, the sensitive factors and data selected in this paper have certain limitations. In the follow-up research, the scientific and objective index weight setting method needs to be further studied and discussed

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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