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Optimization of the scheme for natural ecology planning of urban rivers based on ANP (analytic network process) model

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Abstract

Rivers serve as a highly valued component in ecosystem and urban infrastructures. River planning should follow basic principles of maintaining or reconstructing the natural landscape and ecological functions of rivers. Optimization of planning scheme is a prerequisite for successful construction of urban rivers. Therefore, relevant studies on optimization of scheme for natural ecology planning of rivers is crucial. In the present study, four planning schemes for Zhaodingpai River in Xinxiang City, Henan Province were included as the objects for optimization. Fourteen factors that influenced the natural ecology planning of urban rivers were selected from five aspects so as to establish the ANP model. The data processing was done using Super Decisions software. The results showed that important degree of scheme 3 was highest. A scientific, reasonable and accurate evaluation of schemes could be made by ANP method on natural ecology planning of urban rivers. This method could be used to provide references for sustainable development and construction of urban rivers. ANP method is also suitable for optimization of schemes for urban green space planning and design.

Key words

ANP, Ecology planning, Optimization, Urban rivers

Introduction

Urban rivers are an important component of urban ecological infrastructure, performing indispensable services to ecosystem (Xia *et al.,* 2014). They also play an irreplaceable role in public health (Baschak and Brown, 1995). General speaking, due to restrictions laid down by Blue Line, land on the two banks of rivers are forbidden to be exploited for commercial purpose. These lands mainly serve as a public open space for urban public. In many cities, rivers are found in the form of belt parks or urban green corridors (Mugavin, 2004). Because of its scarcity as an urban landscape, rivers are gaining attention from the government and public. In recent years, construction and development of urban river landscape is proceeding at a fast speed. The debate over river protection and development have been going on for years. Urban rivers are important in two ways: first, rivers are vulnerable ecosystem that require careful maintenance to ensure its normal functioning; second, public usually prefer riverside area for recreation (Lay *et al.*, 2013). However, the normal ecological functions of urban rivers are frequently impaired in actual practice, which makes it unsuitable to serve public need. The natural morphology of rivers usually gives way to artificial morphology, thus altering the flow rate and water level of rivers and hence the aquatic community and ecological environment of water. Large area of hard section or lawn is planned to meet the needs of public activities. But this leads to deterioration of soil and water conservation capacities.

Use of hard revetment and riverbed lining has influenced the hydrological exchange process, resulting in water quality deterioration. Moreover, the garbage and wastewater produced by recreational activities, further affects water quality (Wagner *et al.,* 2009); construction of large amount of infrastructures at the cost of natural landscape of rivers and reduces the value of natural landscape (Åberg and Tapsell, 2013). While landscape and recreational functions of urban rivers are highlighted, the ecosystem services and values inherent to urban rivers are overlooked. So far, public and designers have reached consensus that the basic principle of maintaining or reconstructing natural morphology and ecological functions of urban rivers should be strictly adhered to.

For a reasonable river development and construction, an appropriate planning is important. Currently, the reasonability of river development and construction project is only evaluated after the completion of project. For example, POE method (Sherman *et al.,* 2005) has been widely applied in the post-use survey of landscape, building and planning projects, based on which the reference is provided for decision-making in improvement of the status quo. Given that destruction of natural morphology and ecosystem of urban rivers is an irreversible process, the pre-construction optimization of planning schemes has to be performed. Currently, most planning schemes are screened, based on subjective evaluation of experts, who differ greatly in knowledge and experience. This is the reason for considerable arbitrariness of planning schemes selected. Thus, it is necessary to study the quantitative method for making a reasonable evaluation.

Scheme optimization constitutes major subject of study in the field of decision-making. AHP (Qiao *et al.,* 2012) is the most commonly used method of scheme optimization available. This method quantifies qualitative data to improve the accuracy of evaluation. For decision-making case featured by multi-objective, multi-criterion, multi-judge and large number of available schemes, AHP method can well address the issues of quantification, non-quantification, rationality and irrationality (Qiao *et al*., 2008). The limitation of AHP model is that only unidirectional hierarchical relationship between decision-making layers is considered (Aragonés-Beltrán *et al.,* 2014). There is no consideration of mutual influence between different decision-making layers or in same layer. When general objective layer is decomposed layer by layer, interaction between different factors cannot be avoided. The factors in each layer should be considered in light of the fact that factors of lower layer have a controlling effect on those of the upper layer. This is known as feedback. ANP method is superior over AHP method as it can solve these problems (Zaim *et al.,* 2014). The ecological environment construction of urban rivers has gained increasing attention from public. The planning scheme after being implemented will have significant effect on the ecological environment and recreation environment of urban riverfront area, so it must be taken seriously. The evaluation factors of planning scheme need to consider many aspects of demands, while these factors are also interactive, and there exist mutual dependence and feedback between them. The ANP method exactly provides right channel to solve such problems. In the present study, ANP method was adopted for evaluation and optimization of schemes for natural ecology planning of urban rivers.

Materials and Methods

The four design schemes for Zhaodingpai River in Xinxiang City, Henan Province are included as objects of optimization. Every scheme includes a series of planning drawings and planning notes. Zhaodingpai River is a river with functions of flood control and drainage. But due to lack of protection and planning, Zhaodingapi River has been seriously damaged. The government of Xinxiang City has launched plans to reconstruct Zhaodingpai River. Besides overall planning map, the four schemes are provided with detailed explanation, analysis, economic and technical indexes (Fig. 1).

Methods : ANP method is widely applied in planning decision fields such as industrial planning, supply chain planning, but it is rarely applied in optimization of ecological environment planning scheme. In the construction project of landscape and environment, suitable optimization decision methods have a fundamental effect on the rationality of construction. In the present study, an attempt was made to solve thee optimization

Fig. 1 : Schemes of the natural ecology planning of Zhaodingpai River

problem of natural ecology planning of urban rivers with ANP.

ANP divides the system factors into two major parts: the first part is known as controlling layer, which consists of objectives and decision criteria. All decision criteria were considered as mutually independent and were only controlled by objective factor. The second part was network layer, which consisted of all clusters controlled by controlling layer. The factors showed mutual reliance and control; both the factors and layers showed dependence between themselves. Each criterion in hierarchical structure controled not a simple independent factor, but a network structure with mutual reliance and feedback. A typical hierarchical structure of ANP is shown in Fig. 2. The calculation procedure of ANP was divided into six steps (Yeh and Huang, 2014):

Selection of criteria, factors and alternatives; Based on the in-depth analysis of decision-making problem, the factors and clusters were formed according to controlling relationship between the objects; An analysis was performed over whether the factors within each cluster were mutually independent and whether there existed reliance and feedback relationship. The hierarchical structure of ANP was then constructed; Pairwise comparison was performed between the associated factors and clusters; then pairwise comparison judgment matrix was constructed; Each super matrix was calculated; The dominance degrees and importance degrees were analyzed and calculated.

Calculation of ANP is complex without software, which restricts popularization of ANP. Super decision software developed by Prof. Saaty is designed to handle analytic network process. In the present study, calculation was done with SD 2.2 software (Xu and Chan, 2013).

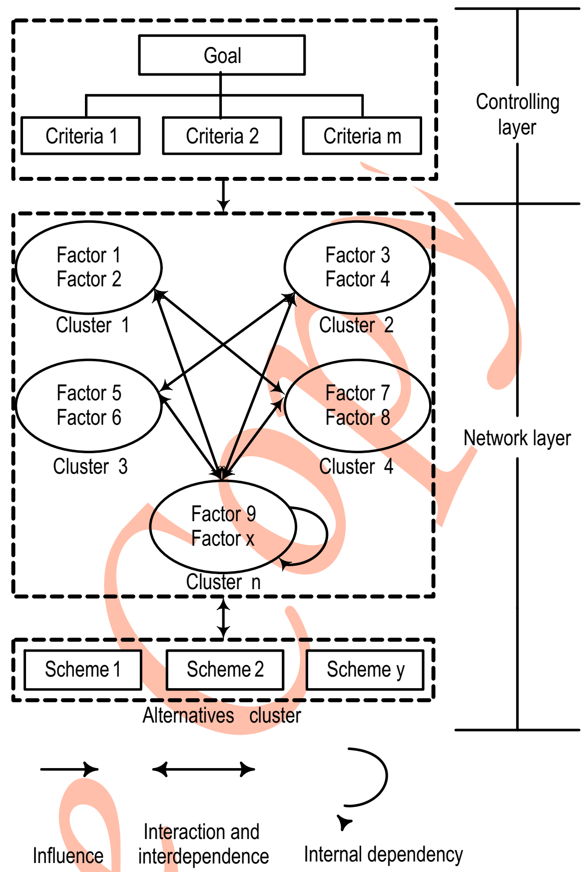

Fig. 2 : Typical hierarchical structure of ANP

Table 1: Hierarchy model of natural ecology planning of urban rivers

Objective	Criteria	Factor	Meaning of the factor
Goal	River morphology (C1)	Riverbank morphology (F1)	River should have a meandering morphology.
		Revetment morphology (F2)	Close-to-nature or ecological revetment should be adopted.
		Riparian zone morphology (F3)	Forest belt of riverbank should have significant natural characteristics.
	Morphology of artificial works (C2)	Road morphology (F4)	Roads should have smooth, curved morphology.
		Building morphology (F5)	Buildings should merge with natural environment in terms of shape, color and texture.
	Eco-environment (C3)	Pollution control (F6)	Pollutants produced on riverbanks because of recreational activities should be strictly controlled.
		Hydrological exchange (F7)	Ecological engineering practice should be adopted at the river bottom to ensure the hydrological exchange.
		Plant species diversity (F8)	More plant species should be used to increase plant species diversity.
		Plant community diversity (F9)	A stable diversified plant community should be formed.
		Forest coverage (F10)	Coverage of riverbank forest belt should be increased.
	Landscape aesthetics (C4)	Seasonal species richness (F11)	Landscape with rich seasonal variation should be formed.
		Spatial diversity (F12)	Diversified space that meets various public demands should be formed.
	Activity site (C5)	Diversity of activity site (F13)	Sites meeting various public needs for activities should be set up.
		Suitability of proportion of hard sites (F14)	Proportion of area occupied by hard sites should not exceed 30%.

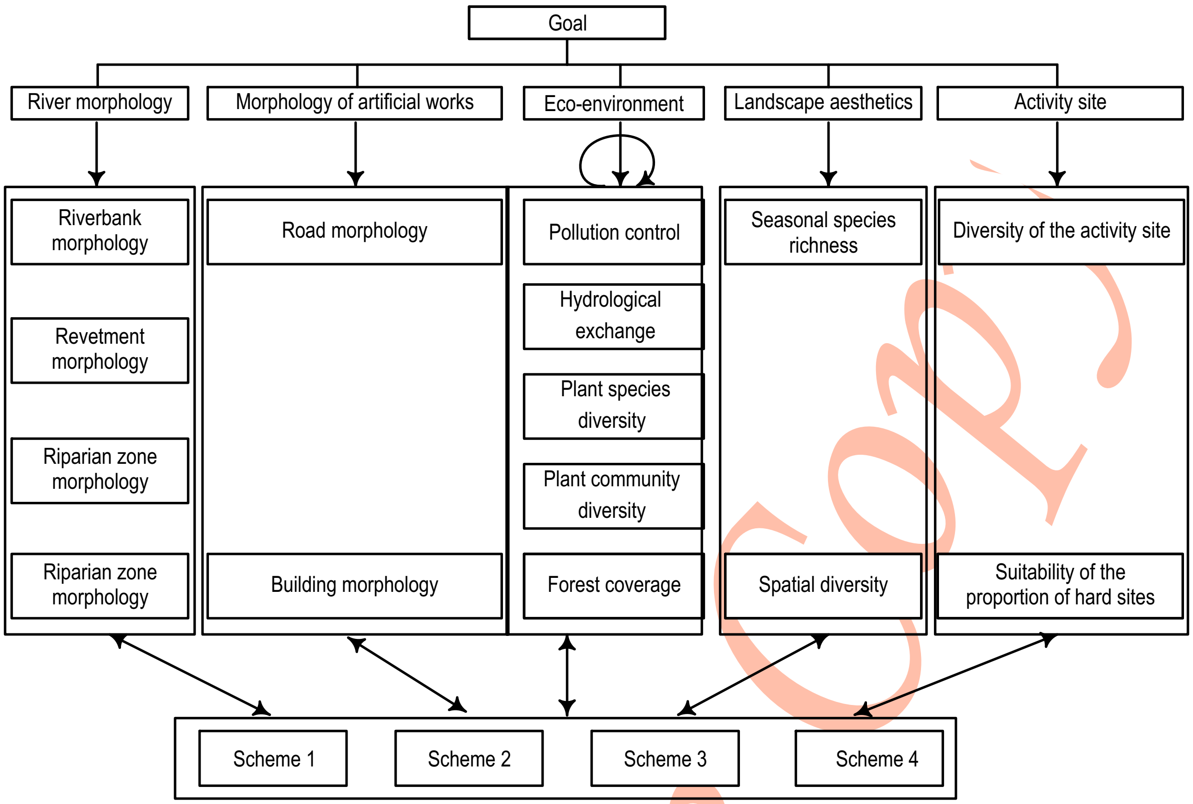

Fig. 3 : ANP model in SD software

Results and Discussion

The ecological environmental construction of rivers belongs to social and public welfare undertakings. Under normal conditions, the investor of river ecological environment construction is the government departments, while the reviewer are expert and the user is public. Therefore, decision on the planning scheme should consider the demands of government, experts and public comprehensively. Combining the results of literature (Mooney and Tan, 2012; McCormick *et al*., 2014; Francis and Hoggart, 2009; Trammell and Bassett, 2012), and government, expert and public interview, the river morphology, morphology of artificial works, eco-environment, landscape aesthetics and activity sites were selected as criteria consisting of 14 factors (Table 1).

The groups and nodes were input in SD software to establish ANP model (Fig. 3). Firstly, a cluster was established according to factor and scheme classification; secondly, elements were added to this cluster to form nodes, and the nodes were connected according to the relations among elements to form a complete network model; thirdly, elements were compared according to cluster comparison and node comparison respectively. 1-9 scale was adopted for pairwise comparison, and the software could work out *C.R.*, so as to examine the consistency in judging the matrix. After pairwise comparisons of all the elements which had dependence or feed-back relationship, the software could calculate the unweighted supermatrix, weighted supermatrix and limit supermatrix directly. The final ranking result of the scheme were obtained according to the limit supermatrix.

The calculations enabled by SD software included, comparison matrix calculation, unweighted supermatrix calculation, weighted supermatrix calculation and limit supermatrix calculation (Qiao and Feng, 2013; Horenbeek and Pintelon, 2014).

Comparison matrix is the judgment matrix consisting of factors. Through data analysis and expert judgment, correlation of each factor in cluster to other factors was determined. Thus, the comparison judgment matrix for factor was constructed. The judgment is based on 1-9 scale, and for each judgment *C.R.*<0.1, thus satisfying the consistency requirement.

The unweighted supermatrix refers to the judgment matrix for the clusters (Table 2). Weighted supermatrix was the matrix obtained by multiplying the factors in the unweighted supermatrix by the corresponding global dominance degree (Table 3).

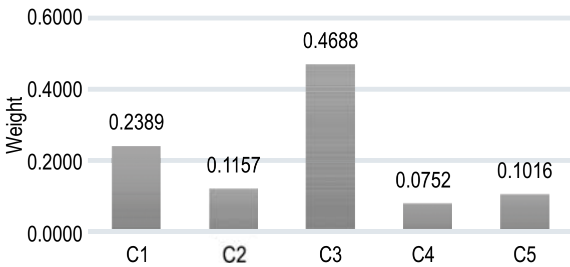

Fig. 4 : Weights of the factors in criteria layer

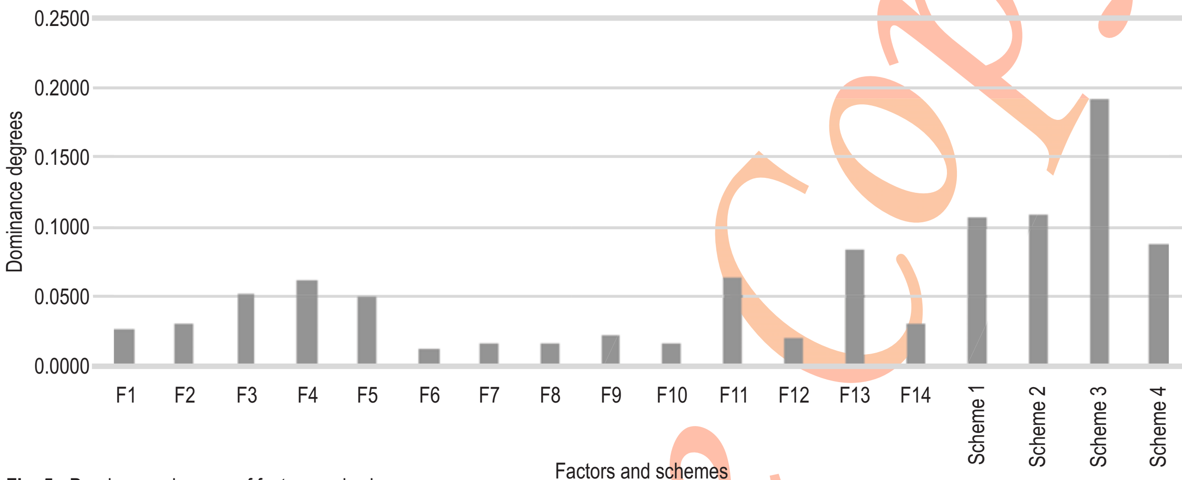

Fig. 5 : Dominance degrees of factors and schemes

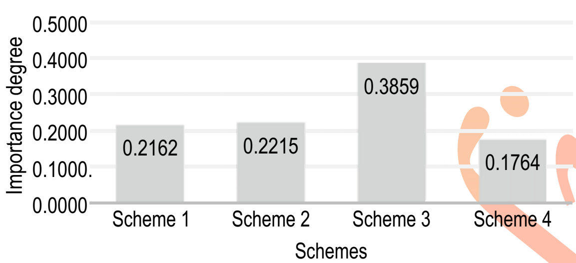

Fig. 6 : Importance degrees of schemes

The limit supermatrix was obtained by the power of weighted supermatrix until the corresponding factors in each column were identical. The factors in each column of the limit supermatrix represented the dominance degree of each factor to general objective, the important degree of each factor in the cluster to general objective (Table 4).

According to calculation, C3 and C1 among all criteria showed highest weights, while weights of C2, C5 and C4 were lower (Fig. 4). This indicated that in landscape planning of rivers, the ecological environment construction should be top priority. Diversity of river morphology is basis for the diversity of biological community. Planning that deviates from natural morphology of rivers will reduce the diversity of biological community and impair the health of river ecosystem services. The weights of C2, C5 and C4 were lower, indicating that the artificial construction was at a less important position as compared with natural landscape and ecological functions. But the artificial construction is needed for satisfaction of public needs.

The weight of F13, F11 and F4 was highest among the factors, followed by those of F3, F5 and F14 (Fig. 5). In landscape planning of rivers, the biggest difficulty was how to deal with the relationship between artificial construction and natural ecology. In terms of satisfying recreational functions, construction of activity site, seasonal species richness, road morphology, enjoy higher priorities. If these factors are planned properly, the natural landscape and ecological functions can be maintained.

Finally, scores of four schemes were normalized, and important degrees of four schemes were obtained. Fig. 6 shows that scheme 3 was superior over scheme 1, scheme 2 and scheme 4. Results indicated that ANP is an effective tool to provide an accurate solution for interdependencies that are able to affect the decision to be made for network like models.

To conclude, natural ecological planning is a key link in the development and construction of urban rivers. It is a complicated process to scientifically and reasonably evaluate the planning scheme. The existing methods can't meet the requirements of scientific accuracy. As a quantitative method which can deal with complex decision-making problems with dependent and feedback relationship, ANP provides a solution to difficult problem. In the present study ANP structure model was constructed which consisted of control layer and network layer.

Table 2 : Unweighted super matrix in super decision software

		Alt				C1			C2		C3					C4		C5		Goal				
		S 1	**S 2**	**S 3**	**S 4**	**F1**	**F2**	**F3**	**F4**	**F5**	**F6**	**F7**	**F8**	**F9**	**F10**	**F11**	**F12**	**F13**	**F14**	**C1**	**C2**	**C3**	**C4**	**C5**
Alt	S1	0	0	0	0	0.2322	0.0938	0.25	0.2998	0.1288	0.1279	0.1469	0.1239	0.4016	0.1082	0.2222	0.25	0.2045	0.25	0	0	0	0	0
	S 2	0	0	0	0	0.2322	0.2654	0.25	0.2920	0.2586	0.2284	0.1583	0.1566	0.1509	0.1624	0.2222	0.25	0.1388	0.25	0	0	0	0	0
	S 3	0	0	0	0	0.3952	0.2654	0.25	0.2377	0.3864	0.4725	0.5480	0.5435	0.2981	0.6011	0.4444	0.25	0.5902	0.25	0	0	0	0	0
	S 4	0	0	0	0	0.1404	0.3753	0.25	0.1706	0.2262	0.1713	0.1469	0.1759	0.1494	0.1283	0.1111	0.25	0.6655	0.25	0	0	0	0	0
C1	F1	0.2599	0.2599	0.2627	0.1692	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5396	0	0	0	0
	F2	0.3275	0.3275	0.1591	0.3875	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1634	0	0	0	0
	F3	0.4126	0.4126	0.5782	0.4433	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2970	0	0	0	0
C2	F4	0.3333	0.6667	0.7500	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0
	F5	0.6667	0.3333	0.2500	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0
C3	F6	0.1708	0.1706	0.1956	0.1456	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1769	0	0
	F7	0.1901	0.2495	0.1894	0.2546	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2888	0	0
	F8	0.2294	0.2495	0.2326	0.2029	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0.0809	0	0
	F9	0.2029	0.1731	0.2335	0.1697	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1241	0	0
	F10	0.2068	0.1575	0.1489	0.2271	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3293	0	0
C4	F11	0.8333	0.6667	0.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
	F12	0.1667	0.3333	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0
C5	F13	0.6667	0.75	0.75	0.75	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	F14	0.3333	0.25	0.25	0.25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2

Alt-Alternative; S 1-Scheme 1; S 2-Scheme 2; S 3-Scheme 3; S 4-Scheme 4

Table 3 : Weighted super matrix in super decision software

		Alt				C1			C2		C3					C4		C5		Goal				
		S 1	S 2	S 3	S 4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	C1	C2	C3	C4	C5
Alt	S1	0	0	0	0	0.2322	0.0938	0.25	0.3	0.1288	0.1279	0.1469	0.1239	0.4016	0.0541	0.2222	0.25	0.2045	0.25	0	0	0	0	0
	S 2	0	0	0	0	0.2322	0.2654	0.25	0.2920	0.2586	0.2284	0.1583	0.1566	0.1509	0.0812	0.2222	0.25	0.1388	0.25	0	0	0	0	0
	S 3	0	0	0	0	0.3952	0.2654	0.25	0.2377	0.3864	0.4725	0.5480	0.5435	0.2981	0.3006	0.4444	0.25	0.5902	0.25	0	0	0	0	0
	S 4	0	0	0	0	0.1404	0.3753	0.25	0.1706	0.2262	0.1713	0.1469	0.1759	0.1494	0.0641	0.1111	0.25	0.0666	0.25	0	0	0	0	0
C1	F1	0.5712	0.0572	0.0578	0.0372	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.5396	0	0	0	0
	F2	0.0720	0.0720	0.0350	0.0852	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1634	0	0	0	0
	F3	0.0908	0.0908	0.1272	0.0975	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2970	0	0	0	0
C2	F4	0.0755	0.0510	0.1699	0.0566	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.75	0	0	0
	F5	0.1510	0.0755	0.0566	0.1699	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.25	0	0	0
C3	F6	0.0256	0.0256	0.0293	0.0218	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1769	0	0
	F7	0.0285	0.0374	0.0284	0.0382	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2888	0	0
	F8	0.0344	0.0374	0.0349	0.0304	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0809	0	0
	F9	0.0304	0.0259	0.0350	0.0254	0	0	0	0	0	0	0	0	0	0.5	0	0	0	0	0	0	0.1241	0	0
	F10	0.0310	0.0236	0.0223	0.0341	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3293	0	0
C4	F11	0.1417	0.1158	0.1303	0.1303	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2	0
	F12	0.0289	0.0579	0.0434	0.0434	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8	0
C5	F13	0.1533	0.1724	0.1724	0.1724	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.8
	F14	0.0766	0.0575	0.0575	0.0574	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.2

Alt-Alternative; S 1-Scheme 1; S 2-Scheme 2; S 3-Scheme 3; S 4-Scheme 4

Table 4 : Limit super matrix in super decision software

		Alt				C1			C2		C3					C4		C5		Goal				
		S 1	S 2	S 3	S 4	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	C1	C2	C3	C4	C5
Alt	S1	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074	0.1074
	S 2	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
	S 3	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917	0.1917
	S 4	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876
C1	F1	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268	0.0268
	F2	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298	0.0298
	F3	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527	0.0527
C2	F4	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226	0.6226
	F5	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503	0.0503
C3	F6	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131	0.0131
	F7	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160	0.0160
	F8	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172	0.0172
	F9	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210	0.0210
	F10	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132	0.0132
C4	F11	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647	0.0647
	F12	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216	0.0216
C5	F13	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836	0.0836
	F14	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306	0.0306

Alt-Alternative; S 1-Scheme 1; S 2-Scheme 2; S 3-Scheme 3; S 4-Scheme 4

The control layer is made up of the objective layer and the criteria layer, while the control layer is made up of the factor set and the scheme set. The operation is performed by using SD software. After the weighted matrix and limit hypermatrix calculations of the evaluation system are respectively performed, the index weight of the criteria layer and the factor weight of the factor layer are gained. After normalization of the importance degree of the schemes, the sequencing of the importance degree of each scheme is obtained, and the final scheme to be implemented is optimized.

River is a crucial component of ecological infrastructure of modern cities. The city river planning demands multiple functions to satisfy the needs for ecological environment protection, leisure and entertainment, landscape aesthetics and biodiversity etc., and it is of great significance for the sustainable development of river to well select the final planning proposal. Evaluation of the planning proposals is based on multiple goals and principles, with fairly complicated relations between different factors of evaluation: these factors depend, influence and feedback on each other; and there are factors of qualitative description and quantitative description. The study adopts the method of ANP to evaluate objectively the level of urban river planning schemes, ensuring that high-quality and competitive planning schemes can be implemented so as to improve the environmental serving functions and value of rivers and promote sustainable development of river's integrated environment.

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