Landscape spatial accessibility analysis of urban water system planning: A case study of Xixian New Area

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Abstract. Urban water system planning is the special planning of urban master planning, and focuses on ensuring flood control and ecological security. Therefore, it is based on water conservancy disciplines, ignoring its coupling with urban planning and territorial spatial planning to some extent. The composition, structure, distribution pattern, scale and other factors of urban water system affect its security, ecological and landscape functions, and its spatial layout is extremely important. Paper analyses the layout of water system, chooses the landscape accessibility of water system space as the research object, establishes the model and analysis framework, takes the different scale cities as the research scope, chooses three water system planning of Xixian New Area as the case, concretely analyses and demonstrates the spatial accessibility of water system planning, and holds that water system and urban safety should be guaranteed at the macro level, and scientific water system planning should be hold at the medium level, and landscape design is in micro-level. The accessibility of water system landscape is an important aspect of water system planning, which provides scientific basis for rational layout and planning design, creating a good urban space environment.

1. Landscape spatial accessibility of urban water system

With the continuous progress of society and the increase of urban public open space, experts and scholars at home and abroad have carried out continuous research on accessibility, and the society has further deepened its understanding of accessibility. Reachability actually reflects the landscape resistance of landscape to a certain horizontal movement process. Landscape reachability refers to the relative or absolute difficulty of overcoming all kinds of resistance from the origination to the destination, and Its comparative indicators include distance, time, cost and so on [1]. Accessibility is a spatial concept, which is closely related to the concepts of location, spatial interaction and spatial scale, and expresses the dense relationship between spatial entities [2]. It reflects the accessibility and fairness of resource enjoyment, and it is an important indicator of the sustainability of urban environment and urban construction, and also an important indicator of the quality of living environment of residents. At present, there are two kinds of knowledge about accessibility in academia: broad-sense accessibility and narrow-sense accessibility. Broad-sense accessibility focuses on highlighting people's potential to reach urban public space, including viewing willingness, traffic cost, spatial characteristics, etc. Narrow-sense accessibility emphasizes the time cost, economic cost, etc.
and transportation cost that people pay to overcome space obstacles. The analysis of landscape space accessibility mainly focuses on urban landscape green space, urban public resources, road traffic, parks, etc. Paper mainly discusses the accessibility of urban water system space. The nature of urban water system determines that it has strong continuity and can form a good strip landscape. It can connect dispersed urban water, green spaces and parks in series into a whole with complex ecological and landscape functions, and has important significance for the surrounding urban land use.

2. Model analysis of spatial accessibility evaluation for water system planning

2.1. Theoretical model
Scientific and reasonable spatial distribution of water system is the key point of urban water system planning, which is helpful to promote the coordinated development of the region and improve the happiness index of urban residents. The main methods of reachability research can be divided into qualitative and quantitative methods. Qualitative methods mainly describe the content of research, and generally unavailable to get quantitative indicators; Quantitative research is divided into statistical analysis and GIS analysis. The methods for evaluating spatial accessibility of river systems include physical model method and empirical model method, in which mechanism model method emphasizes spatial accessibility and is mainly applicable to macro and medium-level analysis, while empirical model method emphasizes psychological accessibility and is mainly applicable to medium-and micro-level analysis. In the paper, the mechanism model method and empirical model method are organically combined to achieve the integration of rational cognition and perceptual experience. Based on the analysis of accessibility research results, the accessibility evaluation methods of mechanism model method and empirical model method are compared as following table 1.

| Evaluate method | Research emphasis | Method characteristics | Evaluating indicator | Influence factors | Category factors | performance |
|-----------------|-------------------|------------------------|----------------------|------------------|-----------------|-------------|
| Mechanism model method | Implicit accessibility/ Physical accessibility | Mainly applicable to macro and medium-level analysis: 1. Comprehensive and systematic; 2. An objective perspective based on spatial morphology and structural characteristics; 3. The evaluation results are mainly based on spatial distribution map, rational and intuitive. | Total water system, Per capita area Time cost, economic cost, Transportation cost, ... | √√√ Travel cost factors | Distance/time cost, path |
| | | | | | Citizen demand factors | Population |
| | | | | | Water system area, Water system volume |
| | | | | | Area perception, Quantitative perception, Landscape feeling, Distance perception, ... | √√ Travel cost factors | Distance/time cost, Distance/time cost, path |
| | | | | | Citizen demand factors | Different Classes and ages demand |
| | | | | | Water system quality factors | Ecological breath cultural atmosphere Management and maintenance |

Note: Consideration of influencing factors: higher√√√, general√√, lower√.
2.2. Research frame design

In view of the particularity and complexity of urban water system planning process, a scientific and reasonable evaluation method is constructed by combining mechanism model method and empirical model method, integrating their advantages and making up for their disadvantages. As shown in figure 1 is analytical framework of comprehensive evaluation method for urban water system, which includes one research purpose, and two main lines of schemes and a number of research contents. One research goal is to point out the practical existing problems in the construction of urban water system by analysing the evaluation results of urban water system accessibility, and put forward the suggestions of water system optimization based on the current situation and planning of urban development; the main line of two schemes is mechanism model method and experience model method, and the whole research process is based on these two methods to achieve objective and subjective comprehensive evaluation; numbers of research contents refer to the exploration on travel cost factors, citizen demand factors and water quality factors in the evaluation process.

![Figure 1. Comprehensive assessment and analysis framework of urban water system accessibility.](image)

2.3. Evaluation method

2.3.1. Time threshold and radiation range of water system. The basic content of water system accessibility research in urban water system planning is time willingness. The important way to analyse accessibility and measure space is by the walking time, and then to analyse the service radius of water system landscape in the planning scope and the evaluation of its layout. Based on the research results of scholars and the authors, found that most residents wish to walk 3-5 minutes (400-500 m) to reach the park [3-6], and few residents use more than 30 minutes, so this part of the journey is classified as less accessible. Time threshold is an important parameter in urban water system planning of the study area. In order to meet the public's ornamental needs to the greatest extent, water system planning has to determine the location of water system in combination with the time threshold of water landscape appreciation, so that the welfare of urban water system construction can benefit more citizens. In water system planning, the new water systems should ensure appropriate distance between each other. Too long distance will affect the public's viewing needs, and too short distance will cause a certain degree of waste of resources.

Paper analyses citizens’ walking limit time, ideal time, optimal time and stay time. Limit time is the maximum travel time cost that citizens are willing to pay for viewing the water system, usually 30
minutes, corresponding distance is about 2400 m. Ideal time is the minimum travel time cost that citizens are willing to pay, referring to urban water system planning cases, usually 10 minutes, and corresponding distance is about 800 m. Stay time is for citizens to enjoy a certain range of water system, and the cost of staying time is usually 60 minutes. The range that can be easily reached within 5 minutes is identified as the best time to form a region with a higher degree of reachability.

2.3.2. Mutual confirmation of urban water system accessibility results under two evaluation methods. Macroscopic level - mechanism model method: calculating the per capita accessible area of urban water system. By consulting the Standards for Classification and Planning of Urban Land Use (GB50137-2011), it is known that the per capita green space area of urban planning should not be less than 10.0 m²/person, and the per capita green space area of parks should not be less than 8.0 m²/person. On this basis, by referring to other urban water system planning cases and combining with the author's practice of water system planning, the assessment level of urban water system accessibility is divided into four levels: excellent (>8.0 m²/person), good (3-8.0 m²/person), medium (0.8-3 m²/person) and poor (0-0.8 m²/person).

Medium Level - Combining the two methods: According to the quantitative evaluation results of urban water system accessibility, a survey was conducted on the satisfaction of residents in the study area. The interviewees included local citizens and local experts. The questions included "Can the area of urban water system meet the needs?" "Can the distance between urban water systems be acceptable?" "How often do you visit the city water system?" According to the semantics of the selected words, the three levels of satisfaction degree of urban water system accessibility are finally obtained: "very satisfied", "more satisfied" and "unsatisfactory".

Micro level - Empirical Model Method: Through interviews with local citizens, we can understand the psychological accessibility of urban water system, including the area of urban water system, the number of waterscapes, the ecological environment, the experience of play and the insufficiency of problems. On this basis, we make a comparative analysis with the objective perspective at the macro level.

3. Demonstration of three cases
Paper chooses three water system plans as the research objects for demonstration. The choice of the research object mainly considers its planning area. By many analyses, it is considered that the accessibility analysis has certain limitations and should not analyse too large or too small areas. The method of accessibility research is mainly suitable for medium-sized or large cities at the district level [7]. If the planning area is large, there are many resistance factors to be considered, the workload of the evaluation model may be relatively large, so the accessibility evaluation of larger-scale regional planning needs to be further studied [8]. If the planning area is too small, the accessibility is very high and there is no difference. The three selected plans are the special water system planning in the overall planning of Xianxin District in Xi'an, and the special water system planning of Jinghe New City and Fengdong New City in two of the five districts in Xixian New District.

According to the important parameters of time threshold, paper considers that the limit time to reach the water system is 30 minutes, the corresponding distance is about 2400 m, the ideal time is 10 minutes, the corresponding distance is about 800 m, the optimal time is 5 minutes, and the corresponding distance is about 400 m. According to the overall layout of the water system, taking the planned rivers and lakes in the study area as the center, and taking 2400 m, 800 m and 400 m as radius, to draw the radiation range maps of the water system in the study area.

3.1. Spatial accessibility analysis of water system planning in Xixian New Area
Xixian New Area is Ground Xi'an City's New Centre, which is located between Xi'an City of Shaanxi Province and the built-up area of Xianyang City. It consists of five zones: Fengdong New City, Fengxi New City, Qin and Han New City, Airport New City and Jinghe New City. The general planning of Xixian New Area (2016-2030) includes the special water system planning. Paper chooses the water
system planning as the research object, and two other districts which have done the special water system planning are selected for analysis, and they are Fengdong New City and Jinghe New City, location map is shown in figure 2.

![Figure 2. The location map of Fengdong and Jinghe New Cities in Xixian New Area.](image1)

![Figure 3. The spatial accessibility range analysis in Xixian New Area.](image2)

The limit time 30 minutes and the ideal time 10 minutes of Xixian New Area are graphically expressed in figure 3.

3.2. Spatial accessibility analysis of water system planning in Fengdong new city and Jinghe new city

Fengdong New City is connected with Xi'an City to the east, which is an important part of the Weihe River south bank in Xixian New Area. Figure 4 is the spatial accessibility analysis of Fengdong New City. Since the limit time of 30 minutes almost covers the whole area, the ideal time of 10 minutes and the optimal time of 5 minutes are selected to express the analysis results graphically.

Jinghe New City is an important part of Xixian New Area and the northern center of Xi'an International Metropolis. Figure 5 is the spatial accessibility analysis of Fengdong New City. Similarly, because the limit time of 30 minutes almost covers the whole area, the ideal time of 10 minutes and the optimal time of 5 minutes are selected to express the analysis results graphically.

3.3. Spatial accessibility analysis results

The accessibility analysis of three planning areas in several dimensions shows that the reachable area in 30 minutes accounts for 79.5% of the total area in Xixian New Area from the point of view of time parameters. Because this area belongs to the arid area in Northwest China, it can achieve such reachable coverage, should belongs to good distribution of water system and better layout of water system planning. The spatial accessibility of river system landscape is higher, and the 10-minute coverage area is higher than the average level of Xixian districts. At the optimal 5-minute coverage level, Fengdong New City is slightly higher than Jinghe New City. It can be seen that the distribution
of river system resources is more uniform than Jinghe New City, and the connectivity of river system is better. They connect the belt-like landscape corridor into a network space, thus forming a surface-like space, forming a good situation. The specific area ratio is shown in table 2.

![Figure 4](image1.png)  
**Figure 4.** The spatial accessibility range analysis in Fengdong New City.  

![Figure 5](image2.png)  
**Figure 5.** The spatial accessibility range analysis in Jinghe New City.

|                   | Total Area | 30 min accessible area | Proportion of total area | 10 min accessible area | Proportion of total area | 5 min accessible area | Proportion of total area |
|-------------------|------------|------------------------|--------------------------|------------------------|--------------------------|------------------------|--------------------------|
| Xixian New Area   | 880.9 km²  | 700.3 km²              | 79.5%                    | 336.5 km²              | 38.2%                    | -                      | -                        |
| Fengdong New City | 159.3 km²  | 157.2 km²              | 98.7%                    | 125.3 km²              | 78.7%                    | 83.0 km²               | 52.1%                    |
| Jinghe New City   | 141.2 km²  | 139.4 km²              | 98.7%                    | 94.2 km²               | 66.7%                    | 56.6 km²               | 40.1%                    |

4. Conclusions and discussion

4.1. Hierarchical discussions on the accessibility of water system planning

4.1.1. Macro level. The accessible water system in the study area mainly includes rivers, canals and lakes. According to the predicted permanent population in planned area at the end of the plan year, the per capita water surface occupancy rate is obtained, and combined urban water system accessibility
evaluation by four grades: excellent (>8.0 m²/person), good (3-8.0 m²/person), medium (0.8-3 m²/person) and poor (0-0.8 m²/person). The ratings are shown in table 3.

|                | Water surface area | Planning population | Per capita surface occupancy | Evaluation grade |
|----------------|--------------------|---------------------|------------------------------|------------------|
| Fengdong New City | 26812.96mu        | 670,000             | 26.7%                        | excellent        |
| Jinghe New City   | 9100.19mu         | 150,000             | 40.4%                        | excellent        |

From the analysis results, it can be seen that the per capita water surface rate of the two cities with special water system planning is much higher than the average level. In addition to the better water system conditions and reasonable water system layout, another important factor in Fengdong New City is the planning and design of Kunming Pool Project. Kunming Pool is a well-known spectacle water conservancy project in history, and its lake surface was once a place for training navy in Han Dynasty. The reason for the high per capita water surface rate in Jinghe New City is that it is positioned as a new idyllic city. The planning guarantees a large number of reserved farmland and low population density. Moreover, it has been one of the most famous irrigation districts in Guanzhong Area in history. The low population and high water surface rate have resulted in a higher water accessibility evaluation level.

4.1.2. Medium level. According to the quantitative evaluation results of urban water system accessibility and the survey of citizen satisfaction, the evaluation conclusion is drawn. From the point of view of overlapping analysis of urban land use, it can be seen that the ideal water system of the two new cities, i.e. the 10-minute accessible range, covers most of the urban residential land and improves the settlement environment of the city. Especially in Fengdong New City, the best distance is 5 minutes to reach the coverage of more than half of the area, most of the residential land, the time to reach the water system landscape is less than 5 minutes, and the distance to the core water system landscape Kunming Pool Park is less than 30 minutes. It really achieves people-oriented and meets the multi-level living and recreational needs of residents in the area, so the satisfaction degree of urban water system accessibility is determined as “very satisfied”.

4.1.3. Micro level. Referring to the typical cases of urban water system planning at home and abroad, combined with the questionnaire survey of spatial accessibility of water system, it is concluded that the study area can effectively enhance the psychological accessibility of citizens to urban water system by reducing distance, optimizing traffic and beautifying water scenery. In addition, the northwest cities have some problems, such as lack of water resources, bad ecological environment and slow economic development, so in the process of water system planning, we should follow the principles of protecting water resources, restoring water ecology, promoting water culture and developing water economy. Among them, water culture is most closely related to the psychological accessibility of citizens. In the shaping of scenic spots and architectural sketches, regional folk culture can be highlighted to enhance water quality, and it’s a sense of cultural penetration of waterscape. The water system layout of Fengdong New City and Jinghe New City will also connect the green space parks in series, connecting the dotted green space to the belt green space, greatly improving the ecological and landscape benefits of the green space.

4.2. Thoughts on urban water system planning
The analysis and evaluation of water system landscape accessibility can be used to demonstrate the layout suitability of water system planning, which will provide new ideas for water system planning. Appropriate layout of water system planning, firstly can enable people to reach different levels of
water system landscape in an appropriate way, using 30 minutes to walk, or 10 minutes to reach larger urban core waterscape park, riverside park, wetland park, etc. 10 minutes to walk to riverside waterscape area, small-scale urban waterscape park, etc. 5 minutes to walk to reach residential areas. The surrounding River channels, streams, wetland landscape, etc. Accessibility level has a profound impact on the frequency of urban poor groups, the elderly, children and disabled people using public services such as green space [9]. The hierarchical water system landscape system can meet the different needs of different groups of people, and can be further divided into different traffic modes, meeting driving and walking conditions, different physical fitness of residents and limited activity ability, different situations of long-term exercise and short-term recreation in available time, daily walking, exercise and recreation in goal, and weekends, different situations of concentrated activities; different situations of young people, middle-aged people and family play in the composition of the crowd; as well as the need to care for the activities of children and the elderly. To build a livable city, we should respect people, respect people's age and physical ability, meet the basic needs of people who can pay different length of time and economic costs, as well as the aesthetic promotion at every level, so as to realize cultural inheritance and create a good urban style.

Paper discusses the layout of water system planning only from the perspective of spatial accessibility, and takes Xixian New Area as a case study. In this regard, more perspectives and case studies are needed to provide more scientific basis for the establishment of evaluation index system of water system landscape function and comprehensive and multi-level basis for water system planning.

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