An Evaluation Study on the Coupled Coordination Between the Level of Urban Infrastructure Development and Urban Drought Resilience

—— Based on the Analysis of Cities in the Yellow River Basin

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Abstract. In order to improve urban drought resilience and promote sustainable urban development, this paper combines urban infrastructure with urban drought resilience, establishes an evaluation index system and evaluation model for the level of urban infrastructure construction and urban drought resilience, and studies the coupling and coordination between the level of urban infrastructure construction and urban drought resilience of the Yellow River Basin, with the provincial capitals of the Yellow River Basin of China as the representative of each city in the Yellow River Basin and show its temporal and spatial evolution. The results show that there is a synergistic relationship between the level of urban infrastructure development and urban drought resilience. There are differences in the coordination between the level of urban infrastructure construction and urban drought resilience in the Yellow River Basin, and there is a certain improvement during 2017-2021, which roughly shows the characteristics of "strong in the southeast and weak in the northwest", and there is a great space for development, which requires the efforts of many parties to play a regional driving role. Our study reveals the developmental differences in the coupling and coordination between the level of infrastructure construction and urban drought resilience among cities, which is of universal significance for other cities and helps to achieve the goal of sustainable urban development.

Keywords: Urban Management; Drought Disaster; Urban Drought Resilience; Urban Infrastructure; Yellow River Basin

1 INTRODUCTION

The increase in the frequency and severity of drought events in recent years, the decline in reservoir levels and the continued decline in global biodiversity pose challenges to the sustainable development of human societies. A new report, Global Drought Snapshot 2023: The Need for Positive Action, prepared by the United Nations Convention to Combat Desertification (UNCCD) in collaboration with the International Drought Coalition (ICDC), points out that drought disasters claim far more lives than any other

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disaster, cause more economic losses and have a much greater impact on all components of society. The urgency that the drought crisis brings to the human society is well illustrated.

In the "14th Five-Year Plan", China clearly put forward the construction of resilient cities, and improve the ability of cities to cope with natural disasters. As the process of urban development continues to accelerate, the pressure on water use is increasing, water shortages are becoming more serious, and urban droughts are occurring frequently, with serious impacts on the social order, public economy, and ecological environment. In recent years, many scholars have taken root in the field of urban resilience, but there are fewer studies that combine urban drought hazards with urban resilience, and there is a very poor understanding of urban drought resilience. The assessment of urban development is seldom carried out from the perspective of drought resilience, and the study of cities is relatively homogenous and lacks the study of different time and space.

Modern societies cannot function properly without sound infrastructure [1], and natural disasters affect the interconnected network of urban infrastructure. Urban infrastructure plays a critical role in sustainable urban development and is directly related to social security, economic prosperity and the quality of life of people [2]. As infrastructure is also closely linked to other sectors of the city, disruptions in one sector under the impact of a drought disaster can lead to disruptions in other sectors, leading to a cascading effect that threatens the normal functioning of the city [3].

Building upon this premise, the present study innovatively directs its attention towards urban drought resilience, aiming to address a notable void within the realm of urban disaster and management research. By integrating the status of urban infrastructure development with urban drought resilience, an evaluation index system and model were devised to obtain a comprehensive understanding of the ongoing progress in urban infrastructure development and urban drought resilience within the Yellow River Basin. Furthermore, the study seeks to investigate the coupling and coordination dynamics between these two dimensions, showcasing the spatiotemporal evolution of urban coupling and coordination across the Yellow River Basin using ArcGIS. Subsequently, the article proposes policy recommendations to strengthen the coupling and coordination among cities in the Yellow River Basin, aiming to enhance urban drought resilience and promote sustainable development.

2 ANALYSIS OF URBAN DROUGHT RESILIENCE IN RELATION TO URBAN INFRASTRUCTURE

2.1 Basic Concepts

Urban drought resilience. Since the 1990s, scholars' research on resilience has gradually extended from natural ecology to human ecology [4]. At present, some scholars address the concept and definition of urban resilience and establish the theoretical system of urban resilience to help improve the city's ability to cope with the crisis. For example, Shao Yiwen and Xu Jiang [5], summarise the relevant literature in the academic community, comparing the essential difference between three kinds of resilience cognitive perspectives and describing the content framework of resilient city research.

Jha, Miner and Stanton-Geddes [6] discuss that there are four main components of urban resilience, namely infrastructure resilience, institutional resilience, economic resilience and social resilience. There are also scholars, such as Li Ya [7], who use the extreme value method to standardise data from different cities, combined with expert consultation methods, to construct China's urban disaster resilience evaluation index system from six aspects.

Drought, a meteorological disaster caused by severe or extreme drought, usually implies a lack of soil moisture due to insufficient rainfall and an imbalance in the water balance of crops leading to a reduction in food production or crop failure. How to assess droughts and prevent and mitigate disasters is an important topic in the field of water resources management. Drought disaster management is to prevent and mitigate the damage and impacts of drought disasters on natural physics and socioeconomics from the perspective of risk management [8].

Combining the above concepts of urban resilience and drought disaster as well as assessment methods, urban drought resilience is defined as the ability of cities and their constituent systems to resist, adapt and recover together under the influence of drought disaster, specifically including the process of preparation and response before drought, coping and adaptation during drought, and recovery after drought.

Urban infrastructure. Urban infrastructure provide basic services for urban residents and units in order to meet the needs of urban material production and urban residents living in the provision of public facilities and related industries and sectors. It is the infrastructure of the national economic system in the extension of the urban area as well. Urban infrastructure is mainly divided into six systems: urban energy system, water supply and drainage system, transport system, post and telecommunications system, eco-environmental protection system and urban disaster prevention system [9], as shown in Fig.1. We focus on the four major systems related to the present study - the urban energy system, the water supply and drainage system, the transport system, and the postal and telecommunication system.

Energy system: The energy system is the entire process of transforming natural energy resources into specific forms of energy services required for human social production and living.

Water supply and drainage system: The water supply and drainage system is to meet the public, industrial, municipal and fire water demand and sewage treatment facilities in general. Its purpose is to provide services according to the different needs of users for water quality and quantity.

Transport system: The transport system is a three-dimensional integrated system consisting of five modes of transport: railway, road, water transport, aviation and pipeline, which ensures the orderly flow of people and goods, meets the various transport needs of production and social life.

Post and Telecommunication System: The post and telecommunication system is mainly responsible for the exchange and transmission of all kinds of information among city residents and units. It is one of the important infrastructures of modern cities.

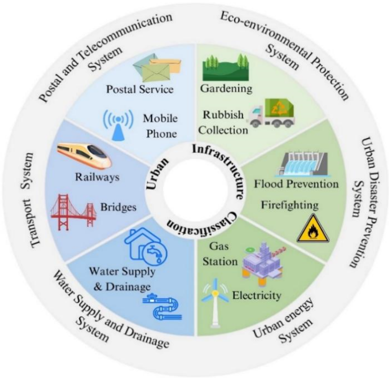

Fig. 1. Urban Infrastructure Classification

2.2 Relationship Between Urban Drought Resilience and Urban Infrastructure

Infrastructure is a basic guarantee for the operation of the city and the production and life of the citizens. However, excessive infrastructure can provide adequate protection for the residents, but will cause low utilization [10] and irrational allocation of financial resources. Although lagging infrastructure can reduce financial expenditure and avoid the waste of resources, it will not be conducive to the city's economic and social development of high quality, so that it is vulnerable to disasters. The upgrading and improvement of the infrastructure system plays an important role in resisting drought disasters and affects urban drought resilience in many ways. High-quality infrastructure construction can bring good economic, social and ecological benefits, which in turn enhance the ability of cities to withstand drought, adapt to climate change, and quickly recover [4].

3 METHODS AND MATERIALS

3.1 Evaluation Index System and Weights of Urban Infrastructure Development

This paper defines the scope of urban infrastructure as four systems: transport system, water system, energy system, postal and telecommunication system, and from which it constructs the index system.

The comprehensive analysis method is used to summarise the indicators of the level of urban infrastructure development mentioned to determine the preliminary selection of indicators. Then, according to the frequency of occurrence and the specific situation of urban infrastructure in the Yellow River Basin, the indicators are further screened, and finally 13 indicators selected to construct the evaluation index system of the level of urban infrastructure development. The weights of the indicators in the evaluation index system of the level of infrastructure development are determined by the hierarchical analysis method, and the calculation results are shown in the Table 1.

Table 1. Evaluation Indicator System for the Level of Urban Infrastructure Development

Goal	Criteria	Weighting factor	Alternatives	Unit(of measure)	Weighting factor
Urban Infrastructure	Transport System	0.2748	Road area per capita	m^2	0.0187
			Road network density	km/km^2	0.1671
			Freight turnover	0.1 billion ton-km	0.0379
			Total passenger traffic	million	0.0512
	Water System	0.1981	Density of water supply pipes	km/km^2	0.0913
			Daily domestic water consumption per capita	L	0.0144
			Water penetration rate	%	0.0615
			Water Supply	million m^3	0.0309
	Energy System	0.3873	Electricity consumption per capita	kWh/person	0.0475
			Gas penetration rate	%	0.2158
			Total gas supply	million m^3	0.1240
	Post and Telecommunication System	0.1397	Mobile phone subscribers per 100 people	Households/100 people	0.0349
			Internet users per 100 people	Households/100 people	0.1048

3.2 Urban Drought Resilience Evaluation Index System and Weighting

Resilience primarily hinges on a systemic approach, which underscores the capacity to navigate dynamically shifting non-equilibrium states, promptly restore equilibrium following system disruptions, and adaptively address similar risks [11]. It also encompasses the collective ability of urban component systems to resist, adapt to, and recover from disasters. Building upon this understanding, the author conducted a systematic search and screening of 158 pertinent research papers to refine indicators with notable impacts. Subsequently, the indicators were categorized into five dimensions—economic, social, ecological, infrastructure, and organizational systems—as part of the initial indicator selection process.

According to the results of the preliminary selection, this paper uses qualitative methods to screen the indicators, and on the basis of determining the five dimensions, distinguishes them according to their resistance, adaptability and resilience, and determines the indicators contained in each dimension, and selects a total of 23 indicators to construct the urban drought resilience evaluation index system. The weights of the indicators in the evaluation index system of urban drought resilience are determined by the hierarchical analysis method, the calculation results are shown in the Table 2.

Table 2. Urban Drought Resilience Evaluation Index System

Goal	Criteria	Weighting factor	Sub-criteria	Alternatives	Weighting factor
Urban drought resilience	Economy	0.0944	Resistance	Gross domestic product per capita	0.0106
				Revenue from the general public budget of the government	0.0250
			Adaptability	Total investment in water conservation measures	0.0512
			Resilience	Ratio of tertiary industry	0.0075
	Ecological	0.1271	Resistance	Annual precipitation	0.0296
				Water Resource Per Capita	0.0573
			Adaptability	Green space per capita	0.0150
			Resilience	Groundwater production capacity	0.0252
	Social	0.0536	Resistance	Urban disposable income	0.0238
				Density of resident population	0.0057
			Adaptability	Percentage of employees in public administration, social security and social organisations	0.0030
				Mobile phone subscribers per 100 people	0.0071
			Resistance	Expenditure on social security and employment	0.0140
	Infrastructure	0.4369	Resistance	Density of water supply pipes	0.1419
				Urban road area per capita	0.0531
			Adaptability	Centralised sewage treatment rate	0.0230
				Cargo turnover	0.1308
			Resistance	Intelligent degree of infrastructure	0.0880
	Organisation	0.2880	Resistance	Drought disaster monitoring and forecasting capacity	0.0291
				Completeness of disaster emergency plan	0.0399
			Adaptability	Urban emergency water supply price system	0.0135
				Government emergency response capacity	0.1098
			Resistance	Urban water resources coordination capacity	0.0957

3.3 Coupled Coordination Assessment Model

Coupling refers to the phenomenon that 2 or more systems or forms of motion influence each other through various interactions [12]. The degree of coupling coordination can reflect the effect and level of coordinated development between systems, and further assess the integrated coordination between the level of urban infrastructure construction and urban drought resilience in the Yellow River Basin. the model of the degree of coupling for multiple system interactions is established as follows.

$$C_n = \left\{ \frac{u_1 \cdot u_2 \ldots \cdot u_n}{\prod (u_1 + u_2)} \right\}^{1/n} \quad (1)$$

Where C_n is the coupling degree of the n-element system; $u_1 \ldots \cdot u_n$ are the contributions of the first subsystem to the nth subsystem to the total system ordering degree, respectively, calculated as follows:

$$u_i = \sum_{i=1}^{m} w_{ij} u_{ij} \tag{2}$$

$$\sum_{j=1}^{m} w_{ij} = 1 \tag{3}$$

In Eq. (3), u_i is the contribution of the ith subsystem to the total system orderliness; u_{ij} is the normalised value of the j th indicator in the i th subsystem; and w_{ij} is the weight of the j th indicator in the i th subsystem, and the weight of the indicators in each subsystem has been calculated. Here the maximum-minimum value method is used for the normalisation process.

Due to the coupling degree index in some cases, but it is difficult to reflect the overall "efficacy" and "synergistic" effect of the subsystem, relying solely on the coupling degree to judge may be misleading. Therefore, this paper refers to the practice of Jiao, Zheng and Yin [13] to establish the coupling coordination model. Take the binary coupling coordination model of infrastructure development level and urban drought resilience as an example:

$$C = 2\left\{\frac{(u_1 \cdot u_2)}{(u_1+u_2)^2}\right\}^{1/2} \tag{4}$$

In Eq. (4), C is the degree of coupling between the level of infrastructure development and urban drought resilience. Larger values of C indicate a better state of coupling.

$$\mathrm{T} = \alpha \mathrm{S}_1 + \beta \mathrm{S}_2 \tag{5}$$

Where S_1 and S_2 denote the combined score index calculated using TOPSIS method, respectively; T denotes the overall efficiency index; α and β denote the coefficients to be determined, and in this paper, we consider that the two major systems of infrastructure development and urban drought resilience are equally important, i.e., α=β=0.5.

$$\mathrm{D} = \sqrt{\mathrm{C} * \mathrm{T}} \tag{6}$$

D is the coupling coordination degree, the larger the value of D , the higher the level of infrastructure development and urban drought resilience coordinated development.

Finally, drawing on the distribution function of Liao Chongbin [14], the grade division standard of coupling coordination degree is constructed, as shown in Table 3.

Table 3. Criteria for Classification of Coupling Coordination Degrees

Level of Coordination	Coordination Degree
1	Extreme Disorder
2	Severe disorder
3	Moderate disorder

4	Mildly dysfunctional
5	Nearly dysfunctional
6	Barely coordinated
7	Elementary coordination
8	Intermediate coordination
9	Good coordination
10	Quality coordination

3.4 The Case Study Region

The selected study area is the capital city of the Yellow River Basin, with the following two considerations. The Yellow River Basin is one of the major climate-sensitive areas in China, and climate change has a significant impact on its ecological evolution and sustainable economic and social development [15]. Since the 1980s, there has been an increasing trend in the frequency of both extreme droughts and droughts in the Yellow River Basin [16], which poses a great risk to the safety of the basin's water resources. The contradiction between supply and demand of water resources in the Yellow River Basin is prominent [17], which seriously affects the sustainable development of cities. Secondly, city selection is based on the principle of typicality and theoretical sampling strategy. Provincial capital cities gather more resources and policy support than other cities in the same province, have larger populations, and cover different population structures. Nine cities were selected for the study, covering different types of industries, with a large geographical span and obvious differences between cities, which fulfils the logic of "differential replication" in the case study.

3.5 Data Sources

The data used in this paper mainly come from the Statistical Yearbook, Water Resources Bulletin, National Economic and Social Development Bulletin, and 5-year Statistical Yearbook of Urban Construction in China for the period of 2017-2021 for each provincial capital city. In addition to this, the qualitative indicators involved are scored by the author through field visits and expert interviews.

4 EVALUATION RESULTS AND ANALYSES OF THE YELLOW RIVER BASIN

4.1 Evaluation Results

Evaluation of urban infrastructure development. Combined with the above evaluation system to collect the data of each provincial capital city in 2017-2021, the TOPSIS method is used to derive the comprehensive score index of its urban infrastructure development.

Table 4. The Comprehensive Score Index of Urban Infrastructure Development Level of Provincial Capital Cities

	2017	2018	2019	2020	2021
Xining	0.4105	0.4416	0.4439	0.4489	0.4495
Chengdu	0.4531	0.5362	0.6121	0.6426	0.6663
Lanzhou	0.3837	0.4965	0.4758	0.4559	0.5122
Yinchuan	0.3724	0.4401	0.4552	0.4705	0.4700
Hohhot	0.3575	0.2836	0.4109	0.4628	0.4789
Taiyuan	0.5298	0.5439	0.4592	0.5567	0.5624
Xi'an	0.4539	0.5291	0.5389	0.5501	0.5579
Zhengzhou	0.3353	0.3432	0.3686	0.3264	0.3684
Jinan	0.4260	0.4351	0.4413	0.4465	0.4576

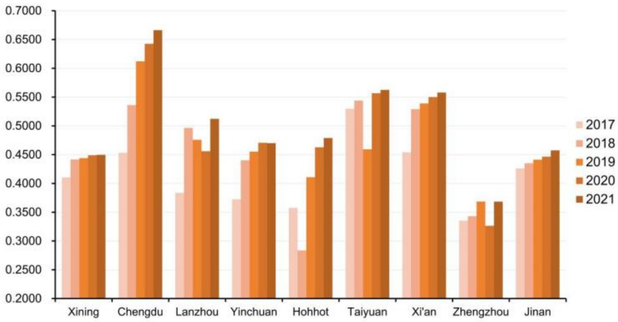

Fig. 2. Comprehensive Score Index of Urban Infrastructure Development of Provincial Capital Cities, 2017-2021

Evaluation of urban drought resilience. Combined with the above evaluation system to collect the data of each provincial capital city in 2017-2021, the TOPSIS method is used to derive the comprehensive score index of its urban drought resilience.

Table 5. Calculation Results of Urban Drought Resilience Comprehensive Score Index of Provincial Capital Cities

	2017	2018	2019	2020	2021
Xining	0.3252	0.3394	0.3566	0.3553	0.3634
Chengdu	0.4664	0.5072	0.4974	0.5048	0.4898
Lanzhou	0.3112	0.3404	0.3484	0.3482	0.3297
Yinchuan	0.1924	0.2036	0.2479	0.2395	0.2362
Hohhot	0.2520	0.2717	0.2943	0.2940	0.2781
Taiyuan	0.4294	0.4280	0.4283	0.4982	0.5150
Xi'an	0.4061	0.4150	0.4227	0.4572	0.4500
Zhengzhou	0.5175	0.5099	0.5092	0.5069	0.5322
Jinan	0.5704	0.5903	0.5940	0.5819	0.6023

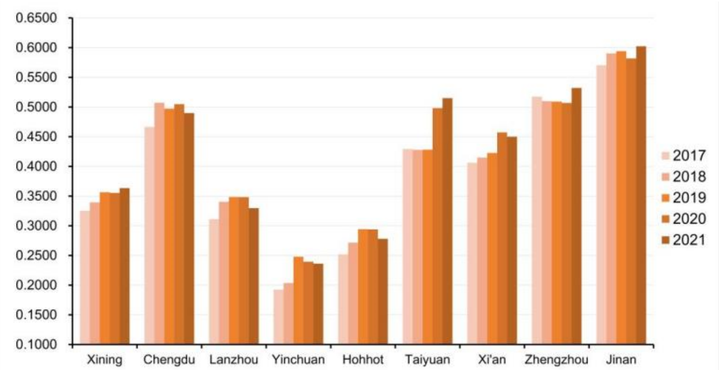

Fig. 3. Urban Drought Resilience Comprehensive Score Index of Provincial Capital Cities, 2017-2021

Coupled coordination assessment. According to the coupled coordination model that has been established, the coupled coordination degree of drought resilience and infrastructure development of each provincial capital city is calculated using the calculated urban infrastructure development and the comprehensive evaluation index of urban drought resilience, and the results are shown in Table 6.

Table 6. The Coupled Coordination Degree of Urban Drought Resilience and Urban Infrastructure Development of Provincial Capital Cities, 2017-2021

City	Year	C	T	D	Coordination Level	Degree of coupling coordination
Xining	2017	0.9999	0.3312	0.5755	6	Barely coordinated
	2018	0.9976	0.3880	0.6222	7	Elementary coordination
	2019	0.9998	0.4117	0.6415	7	Elementary coordination
	2020	0.9992	0.4164	0.6451	7	Elementary coordination
	2021	0.9998	0.4269	0.6533	7	Elementary coordination
Chengdu	2017	0.9799	0.5547	0.7373	8	Intermediate coordination
	2018	0.9972	0.7097	0.8413	9	Good coordination
	2019	0.9975	0.7952	0.8906	9	Good coordination
	2020	0.9948	0.8431	0.9158	10	Quality Coordination
	2021	0.9876	0.8555	0.9192	10	Good quality coordination
Lanzhou	2017	0.9988	0.2801	0.5289	6	Barely coordinated
	2018	0.9781	0.4595	0.6704	7	Elementary coordination
	2019	0.9909	0.4425	0.6622	7	Elementary coordination

	2020	0.9966	0.4169	0.6446	7	Elementary Coordination
	2021	0.9613	0.4669	0.6700	7	Elementary coordination
Yinchuan	2017	0.3939	0.1237	0.2207	3	Moderate Dissonance
	2018	0.5493	0.2238	0.3506	4	Mild Dissonance
	2019	0.8552	0.2960	0.5032	6	Barely coordinated
	2020	0.8007	0.3057	0.4947	5	Nearly dysfunctional
	2021	0.7853	0.3010	0.4862	5	Nearly dysfunctional
Hohhot	2017	0.9911	0.1759	0.4175	5	Borderline dysfunctional
	2018	0.4262	0.1049	0.2114	3	Moderately dysfunctional
	2019	0.9902	0.2948	0.5403	6	Barely coordinated
	2020	0.9541	0.3609	0.5868	6	Barely coordinated
	2021	0.9134	0.3625	0.5754	6	Barely coordinated
Taiyuan	2017	0.9986	0.6086	0.7796	8	Intermediate coordination
	2018	0.9966	0.6249	0.7892	8	Intermediate coordination
	2019	0.9939	0.5169	0.7167	8	Intermediate coordination
	2020	0.9998	0.7252	0.8515	9	Good coordination
	2021	0.9993	0.7526	0.8672	9	Good coordination
Xi'an	2017	0.9970	0.4837	0.6944	7	Primary coordination
	2018	0.9967	0.5904	0.7671	8	Intermediate coordination
	2019	0.9964	0.6122	0.7810	8	Intermediate coordination
	2020	0.9993	0.6678	0.8169	9	Good coordination
	2021	0.9979	0.6692	0.8172	9	Good coordination
Zhengzhou	2017	0.7203	0.4648	0.5786	6	Barely coordinated
	2018	0.7591	0.4659	0.5947	6	Barely coordinated
	2019	0.8402	0.4976	0.6466	7	Elementary coordination
	2020	0.6850	0.4408	0.5495	6	Barely coordinated
	2021	0.8237	0.5247	0.6574	7	Elementary coordination
Jinan	2017	0.9084	0.6443	0.7650	8	Intermediate coordination
	2018	0.9101	0.6797	0.7865	8	Intermediate coordination
	2019	0.9156	0.6920	0.7960	8	Intermediate coordination
	2020	0.9268	0.6843	0.7963	8	Intermediate coordination
	2021	0.9292	0.7228	0.8195	9	Good coordination

Based on the above results of coupling coordination degree measurement, the data of the provincial capital city is used instead of the whole province, and show the spatial and temporal evolution of its coupling coordination degree.

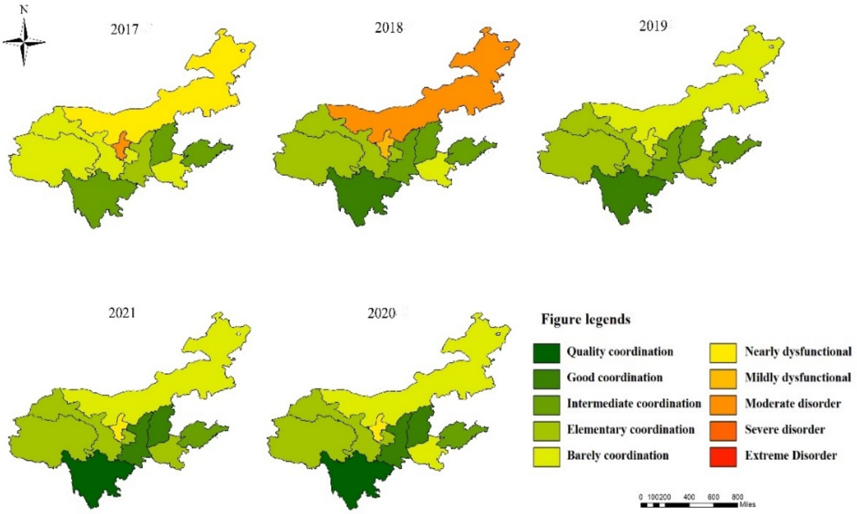

Fig. 4. Spatial and Temporal Distribution of Coupling Coordination in the Yellow River Basin, 2017-2021

4.2 Analysis of the Results of the Study

Analysis of the Level of Urban Infrastructure Development. From Table 4, it can be seen that the level of urban infrastructure development in Xining and Jinan rises steadily during the period 2017-2021, while the level of infrastructure development in Yinchuan, Hohhot, Taiyuan, and Zhengzhou has a large number of ups and downs during the assessment period with an overall positive trend.

Overall, the gap between the urban infrastructure development of Xining and Yinchuan is relatively small. Over the past few years, the municipal governments have increased their investment in infrastructure development. However, due to the combination of historical development, geographical location, economic development and urban planning, there is still a certain gap between them and Chengdu and Xi'an. Zhengzhou City's overall infrastructure level fluctuated greatly over the five-year period due to a larger population, lower freight turnover and a decline in infrastructure levels in 2020 as a result of the 19-year epidemic and the impact of rain and snow.

Analysis of Urban Drought Resilience. From Table 5, it can be observed that during the period from 2017 to 2021, the drought resistance level of provincial capital cities experienced relatively minor changes, while the overall spatial equilibrium situation exhibited significant variations. The downstream cities are far ahead.

Jinan and Zhengzhou in the downstream of the Yellow River are more abundant in water resources and their urban planning is more scientific than that of the midstream and upstream cities, and they take into account the protection and use of water resources in the process of urban construction. While upstream Yinchuan, Hohhot and other four provincial capital cities are more restricted by water resources, and due to the sparsely populated area, urban construction planning is more difficult.

Analysis of the coupled coordination between the level of Infrastructure Development and Urban Drought Resilience. From Table 6 and Fig.4, the typical cities in the Yellow River Basin show the characteristics of "strong in the southeast and weak in the northwest". The average coordination level of the nine cities in the five-year study period is primary coordination, but the overall coordination level among cities in the Yellow River Basin is not high, and there is uneven development among cities.

Chengdu has the fastest growth rate of coordination and reaches quality coordination between 2017 and 2021. As a large city in the west and a sub-provincial city, Chengdu has a unique geographic location and policy support, and is located at the lowest latitude with a favourable ecological environment, good infrastructure and a positive effect on the city's resilience to drought, which make it stronger to cope with the risk of urban drought.

Jinan, Taiyuan, and Xi'an have similar coordination levels and have developed to well-coordinated cities over the five-year period. The three cities are located in the east-central part of the Yellow River Basin, with well-developed transport and stronger economies, which have contributed to their more advanced technological innovations and technological means of coping with drought; the public is more aware of water conservation and environmental protection.

Lanzhou, Xining, and Zhengzhou have similar levels of urban coordination, all developing from barely coordinated in 2017 to preliminarily coordinated in 2021. Lanzhou is a typical arid region with scarce water resources; Xining relies on alpine glaciers and groundwater, is vulnerable to climate change and environmental impacts, and faces uncertainty in its water resources; and Zhengzhou, with its uneven precipitation and high population density, is a large water-scarce city. This, coupled with the city's poor implementation of policies on water resource management, conservation and utilisation, and its vulnerability to geological hazards, poses a challenge to coordinated urban development.

The degree of coordination between Yinchuan and Hohhot is still at a low to medium level, and there exists a great deal of space and potential for development. Due to the higher latitude of the two cities, sparse population density, the city's economic and social development is slower with other cities. In recent years, with increased government investment in water-saving measures and continuous improvement of infrastructure, there has been some improvement in urban coordination. This serves as a reference for other cities with lower resilience levels in the same basin

5 CONCLUSION OF THE STUDY AND SUGGESTIONS FOR COUNTERMEASURES

5.1 Research Conclusion

From the perspective of infrastructure and urban drought resilience, this paper obtains the following research conclusions with the provincial capitals in the Yellow River Basin as the representatives.

(1) During the study period, the Yellow River Basin cities have been investing more and more in infrastructure construction and the government and citizens have been strengthening their awareness of disaster prevention and adopting active countermeasures according to local conditions. However, there are some developmental differences among the cities in the basin, with higher coordination in the southeastern part of the Yellow River Basin and lower coordination in the northwestern part.

(2) The construction level of urban infrastructure and the drought resistance capability of cities in the Yellow River Basin have a significant synergistic effect. A good level of urban infrastructure construction plays a positive role in enhancing urban drought resilience, while a lagging level of urban infrastructure construction weakens the ability of cities to cope with drought disasters.

(3) At present, the degree of coordination of cities in the Yellow River Basin is not high, and the average level of coordination is primary coordination, there is a great space for development, and it is necessary to make joint efforts and play the role of a regional driving force to promote the coordinated development of the level of urban infrastructure construction and urban drought resilience.

(4) Chengdu, the capital city of Sichuan Province, belongs to the Yangtze River Basin, and in the findings of this paper, Chengdu City is ranked at the top of the list of each evaluation index, and its urban infrastructure construction level and urban drought resilience coupling and coordination degree is the highest. This may indicate that the coupled coordination in the Yellow River Basin is weaker than that in the Yangtze River Basin, and is an issue worthy of further exploration.

5.2 Suggestions for Urban Management Countermeasures

To address the measured results, propose strategies and suggestions for the coupled and coordinated development of urban infrastructure development and urban drought resilience.

(1) For all Yellow River Basin cities, a reasonable comprehensive assessment system of urban resilience should be established in accordance with the actual situation of regional development, and the construction of drought-resistant and resilient cities should be assessed regularly.

(2) For the relatively backward cities in the northwestern part of the Yellow River Basin, capital investment should be increased to prioritise support for urban infrastructure construction. Long-term planning for urban development should be formulated and utilize water resources scientifically.

(3) For Zhengzhou and other barely coordinated, initially coordinated cities, the level of infrastructure construction should be actively promoted steadily, the coordination of elements within the Yellow River Basin city circle should be strengthened as well as exchanges.

(4) For the eastern cities of Xi'an and Jinan, where infrastructure construction is more developed in the southeast of the Yellow River Basin, focusing on improving the refinement and intelligence of infrastructure construction, improving the disaster risk management system, and playing the role of a support point to drive the high-quality development of the Yellow River Basin cities.

5.3 Limitations and Future Directions

Due to the limited research time, this paper only selects the capital cities of the Yellow River Basin as the research object. The coupling and coordination strength between urban infrastructure development and the drought resistance capability have profound implications for the sustainable development of cities in the Yellow River Basin. In view of this, the assessment of the whole Yellow River basin can be further developed in the future to further enrich the research in the urban field.

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