ISSN: 2688-8653

Assessment of Urban Disaster Resilience and Its Improvement Path: A Case Study of Northern Henan

Xiaowei Li[1,*]

[1]School of Emergency Management, Henan Polytechnic University, Jiaozuo Henan, 454000, China

[*]Corresponding Author: lxwhpu@163.com

Abstract

The rapid development of urbanization has aggravated the impact of natural disasters on cities. Cities are facing increasingly diverse disaster risks, which have seriously affected the safety of people's lives and property. As an important part of society, the population density of counties and districts is not lower than that of cities, but the infrastructure, social security and various emergency measures to deal with disaster risks lag far behind those of cities. As a result, county-level units are facing a greater risk of disasters and have seriously affected the safety of people's lives and property. Disaster resilience has become an important research object in resilience governance and social governance.

Keywords

Disaster; Resilience; Public Health; Lifting path.

1. Introduction

As of 2020, China's urbanization rate has jumped from 17.9% in 1978 to 63.9% in 2020. At the same time, however, cities are also suffering from unavoidable disruptions and shocks caused by natural disasters such as earthquakes and hurricanes, as well as various terrorist attacks and the spread of diseases. These shocks are the embodiment of the objective laws of social and natural development, which have strong uncertainties and therefore cannot be completely avoided.

In recent years, the frequency of natural disasters in China has been increasing, and the losses caused by various disasters have also continued to rise. On the one hand, with the vigorous implementation of the new urbanization strategy around 2010, the scale of development boundaries in urban planning has been expanded. On the other hand, the increasingly severe food security situation and the increasing importance of rural farmland protection have made the development of county-level units difficult. Compared with rural areas, county-level units are densely populated and have a rapid industrialization process. However, in terms of infrastructure, social security and economic development, it is far inferior to that of cities. The dense population, irrational industrial structure, imperfect infrastructure, and social security all make county-level units unable to respond in a timely manner and in the face of various emergencies, resulting in serious losses to the safety of people's lives and property in county-level units. According to statistics, the heavy rain in Henan in 2021 caused 89 counties and cities to be affected, with 25 deaths, 7 people missing, and 1.25 million people affected. Under the premise of external constraints and high uncertainty, how to improve the resilience of county-level units, achieve sustainable development, and minimize the losses caused by disasters has become one of the focuses of disciplinary research.

Starting from the influencing factors affecting the resilience development of county-level units, this paper takes the northern Henan region of Henan Province as the research object of this paper, analyzes the key factors restricting the resilience development of the northern Henan region, and proposes reasonable countermeasures, hoping to fundamentally improve the resilience level of the region and promote the better development of the region.

2. A Review of Research on Resilience

As the most complex social and ecological system, cities have been continuously subjected to various shocks and disturbances from the outside world and themselves since their formation. These disturbances not only include natural disasters such as earthquakes and hurricanes, man-made disasters such as terrorist attacks and disease transmission, but also cumulative shocks caused by energy shortages, climate change and other factors. From an etymological point of view, Alexander analyzed that resilience was first derived from the Latin word "resilio", which originally meant "to return to the original state". Around the 16th century, the French language borrowed the word "resiler", which means "to withdraw or cancel". In the middle of the 19th century, with the development of Western industry, the term toughness was widely used in mechanics to describe the ability of metals to recover after deformation under the action of external forces. In the 50s and 80s of the 20th century, Western psychological research generally used "resilience" to describe the recovery after trauma [1]. Canadian ecologist Holling first applied the idea of resilience to the field of systems ecology to define the characteristics of the stable state of ecosystems. Since the 90s of the 20th century, scholars' research on resilience has gradually extended from natural ecology to human ecology [2].

2.1. Three perspectives on resilience and their development

Since its inception, the concept of resilience has undergone two more thorough conceptual revisions. From the initial engineering resilience to ecological resilience and then to evolutionary resilience, each revision and improvement has enriched the extension and connotation of the concept of resilience, marking the gradual improvement of the depth of the academic community's understanding of resilience[3].

Engineering resilience is one of the first ideas to be put forward for cognitive resilience. Hollin first defined the concept of engineering resilience as the ability of a system to return to an equilibrium or stable state after the application of disturbance [2]. According to Berkes and Folke [4], engineering resilience emphasizes stability around a given equilibrium state, and thus can be measured by the system's resistance to perturbation and the speed at which the system returns to equilibrium. Wang and Blackmore [5] argue that this view of resilience is compatible with the low probability of failure of the system and the ability to quickly return to normal operating levels in the event of failure. In summary, engineering resilience emphasizes that a system has one and only one steady state, and the strength of the system's resilience depends on how quickly it returns to its initial state after being disturbed out of the steady state.

On the basis of the evolution of ecological resilience, scholars have put forward a new concept, that is, evolutionary resilience. In this new conceptual framework, Walker et al. propose that resilience should not be seen as merely a recovery of the system to the initial state, but rather as a change, adaptation, and transformation ability of complex socio-ecological systems in response to pressures and constraints [6]. Falk et al. also believe that the current idea of resilience mainly focuses on the three aspects of the socio-ecological system, namely, resilience as persistence, adaptability, and transformation ability [7]. The idea of evolutionary resilience is essentially derived from the adaptive cycle theory proposed by Gunderson and Holling. Contrary to the previous description, they believe that the development of the system consists of four phases: the exploitation phase, the conservation phase, the release phase, and the reorganization phase[8].

It can be seen from the above perspectives put forward by different scholars that the transition from engineering resilience to ecological resilience to evolutionary resilience reflects the change in the academic community's understanding of the operating mechanism of the system, which paves the way for scholars to continue to study resilience in the future.

2.2. The emergence of urban resilience

Following the above three types of resilience research, urban resilience emerged. On the basis of the above three types of resilience, urban resilience provides a more detailed, comprehensive and in-depth interpretation of the ability of systems and regions to achieve normal operation of public safety, social order and economic construction through reasonable preparation, buffering and response to uncertain disturbances. Godschalk argues that resilient cities should be a combination of sustainable physical systems and human communities, and that the planning of physical systems should play a role through the construction of human communities [9]. In contrast, Campanella places more emphasis on the power of human community. He analyzed the performance of New Orleans in the aftermath of Hurricane Katrina and concluded that urban resilience essentially depends on a function of more resilient and resourceful citizens [10]. Jha, Miner, and Stanton-Geddes further argue that there are four main components of urban resilience: infrastructure resilience, institutional resilience, economic resilience, and social resilience [11].

Although many scholars have recognized the importance of resilient city research, how to systematically recognize urban resilience has always been a difficult point of controversy in the academic community. The Resilience Alliance summarizes the main framework of resilient city research from four aspects: governance networks, metabolic flows, built environment, and social dynamics. These four dimensions are mutually reinforcing and work together to enhance the resilience of urban systems [12]. Similarly, Ireni-Saban argues that community-based urban resilience depends mainly on the community's capacity for public management, which is manifested in three aspects: advocacy, competency, and social inclusion [13]. Jabareen hopes to establish a fundamentally pluralistic theoretical approach through the resilient city planning framework. The framework consists of four main parts: vulnerability analysis matrix, urban governance, prevention, and uncertainty-oriented planning. Although different scholars have different perspectives on resilient cities, their essence is basically the same [14].

To sum up, from the 50s of the 20th century to the present, the research on resilience by relevant scholars at home and abroad has turned from the exploratory stage to maturity, and the research results are also abundant. However, in general, there are the following shortcomings: first, in the selection of research objects, most scholars mainly take super-large cities or communities as the research objects to analyze their resilience, and rarely analyze their resilience by county; Second, in terms of research methods, most scholars adopt macro theoretical analysis or subjective evaluation, and few use mathematical statistical methods to conduct empirical research. Therefore, this paper analyzes the main factors affecting the resilience of 6 cities and 26 county-level units in northern Henan by using principal component analysis (PCA), and comprehensively evaluates the resilience of 6 cities and 26 county-level units in northern Henan by combining the RSR rank-sum ratio comprehensive evaluation method, in order to further improve and enrich the existing research results.

3. Research Area and Data Methodology

3.1. Overview of the study area

In this paper, the northern Henan region of Henan Province was selected as the study area. The northern Henan region includes 5 prefecture-level cities of Hebi, Xinxiang, Anyang, Jiaozuo and Puyang, 1 provincial county-level city and 26 county-level units in Jiyuan, with an area of 28,500 square kilometers and a population of about 21 million. The area is a drought and flood disaster area in North China, which is controlled by the unstable East Asian monsoon circulation, and there are many types of natural disasters. According to the research of relevant scholars, in the heavy rainstorm in Henan Province in July 2021, the area of water bodies before the flood in northern Henan was 9.16 km2, and the total area of water bodies in the flood was 268.91 km2, which increased the area of water bodies by 259.75 km2 due to flooding, and about 6.9 million people in 205 towns and villages in the region were affected by heavy rainfall. As of 2022, the urbanization rate of the region is more than 55%, and the rapid development of urbanization has also brought a series of problems. Frequent natural disasters, high population density, poor industrial structure, declining birth rate, and low quality of the population have all greatly reduced the resilience of the region.

3.2. Data Sources and Processing

Since the evaluation of regional resilience needs to be combined with multiple factors for comprehensive analysis, this paper selects the data of four dimensions (population, economy, infrastructure and social security) from Henan Statistical Yearbook (2020), and uses IBM SPSS Statistics 27 analysis software to first normalize the data, and then obtain the analysis results through factor analysis, rotation, extraction and other steps, and extract the principal components according to the analysis results. The administrative division data comes from the 1:250,000 national basic geographic database of the National Geographic Information Resources Directory Service System (https://www.webmap.cn/).

3.3. Index evaluation system

Table 1. Initial indicators for regional resilience evaluation

Level 1 indicators	Secondary indicators
population	The total number of households at the end of the year, the registered population at the end of the year, the permanent resident population, the number of employed persons in urban units, the total number of students in school, primary schools, junior high schools, the total number of full-time teachers, primary schools, junior high schools, urban areas, and urbanization rates
economy	General public budget revenue, general public budget expenditure, operating income, total profit, gross domestic product, total retail sales of consumer goods, average wage of employed persons in urban units, per capita gross domestic product, per capita disposable income of residents, per capita disposable income of urban residents, and per capita disposable income of rural residents
infrastructure	Number of beds in health institutions, total number of schools, primary schools, junior high schools, education, agriculture, forestry and water affairs, primary, secondary and tertiary industries
social security	The number of urban residents, rural residents, health technicians, occupational physicians, assistant physicians, and registered nurses

In recent years, many scholars have tried to construct an evaluation index system for urban resilience, and Joerin et al[15]. preliminarily constructed an evaluation index system for urban community resilience from five dimensions: infrastructure, society, economy, institution, and nature. Cutter et al[16]. selected 27 regional resilience evaluation indicators from five dimensions: society, economy, infrastructure, institutions, and environment. Hudec et al[17] .evaluated the differences in urban resilience in Slovakia in response to the financial crisis

ISSN: 2688-8653

from 12 indicators from three dimensions: economic, social, and community management capacity. For example, Yang et al [18] .drew on the BRIC measurement model to select 23 indicators from the five dimensions of natural environment, built environment, society, economy, and institutions to evaluate the differences in community resilience in response to public health risks in Guangzhou. Bai Limin et al [19]. used 38 indicators in four dimensions, including economy, society, ecology, and infrastructure, to construct a comprehensive measurement index system for urban resilience.

Based on 6 municipal-level and 26 county-level units in northern Henan Province, this paper preliminarily selects 38 regional resilience evaluation indicators (Table 1) from four dimensions: population, economy, infrastructure and social security, after comprehensively considering the many factors affecting regional resilience and the comprehensiveness, authenticity and validity of the data, to provide data support for the study of regional resilience.

3.4. Indicator Processing

When processing the above-mentioned indicators, considering that the dimensions and units of different indicators are different, the number is very different, and it is necessary to standardize these indicators in a unified manner. After processing, these data are transformed into dimensionless index evaluation values, and the index values are at the same magnitude level, which effectively avoids overemphasizing the higher characteristic indicators in the index and causing numerical problems. At the same time, considering the positive and negative effects of different indicators on regional resilience, it is necessary to treat the positive and negative correlations of relevant indicators. Here's how to deal with it:

(1) Positive index processing method(MMS): (x-xmin)/(xmax-xmin) (1)

(2) Inverse index processing method: (xmax-x)/(xmax-xmin) (2)

X represents the original indicator, xmax represents the maximum value, xmin represents the minimum value, and the processed value falls within the range of [0,1].

Considering the limited sample size and the difficulty of reducing the complexity of the topic, the principal component analysis method was used in the subsequent analysis of the indicators, and for all the variables mentioned above, the variables with repeated relationships (high degree of tightness) were deleted, and new variables were established as few as possible, so that these new variables were unrelated, and these new variables still maintained the original information in terms of response research information.

Principal Component Analysis (PCA) is an important statistical analysis method for non-random variables proposed by scholar Karl Parson in 1901, and popularized to the use of random vectors by scholar Hotelling in 1933. It is often used to find a comprehensive index to judge a certain thing or phenomenon, and to give a proper explanation to the information contained in the comprehensive index, so as to profoundly reveal the internal laws of things.

3.5. Introduction to the Rank-Sum Ratio (RSR) Method

In this paper, the RSR (rank-sum ratio) comprehensive evaluation method was selected to study the resilience of northern Henan. Rank-sum ratio (RSR) method, it is a new set of statistical information analysis methods, rank-sum ratio refers to the average or weighted average of the total rank of rows (or columns) in the table, is a non-parametric comprehensive index, with the characteristics of continuous variables in the 0-1 interval, and the sum of the rank sum ratio of all comparison groups is (n+1)/2; If the rank of traversal does not follow the classical rank transformation method, the sum of the rank sum ratios of each group may not be (n+1)/2. The formula and results are as follows:

ISSN: 2688-8653

$$RSR_R = \sum_{1}^{m} R\,/m \cdot n \text{（formula1）}$$

$$RSR_C = \sum_{1}^{n} R\,/m \cdot n\text{(formula2）}$$

In formula 1 or 2, “m” is the exponent and “n” is the grouping number.Method of combining multiple RSRS: Group RSR-R- Combine RSRS.

4. Analysis of Results

4.1. Indicator Selection

Table 2. Principal components and principal component loading values (economic)

index	x1	x2	x3
General Public Budget Revenue (100 million yuan)	.895	.233	.230
General Public Budget Expenditure (100 million yuan)	.580	.339	.672
Operating income (100 million yuan)	.787	-.201	.270
Total profit (100 million yuan)	.584	-.665	.062
Gross Domestic Product (100 million yuan)	.893	-.146	.059
Total Retail Sales of Consumer Goods (100 million yuan)	.724	.246	-.142
Average wage of employed persons in urban units (RMB) (1).	-.036	.808(2)	-.100
GDP per capita (RMB) (1).	.898	-.134	.069(2)
Per capita disposable income of residents (RMB) (1).	.904(2)	.162	-.215
Per Capita Disposable Income of Urban Residents (RMB)	.842	.198	-.306
Per Capita Disposable Income of Rural Residents (RMB)	.806	-.086	-.507

Note: (1) is the selected evaluation index; (2) the maximum load value in the factor; The per capita disposable income of rural residents is the largest in the load value of principal component x2, but considering that component x1 includes this factor, the average wage of employed persons in urban units is selected when selecting principal component x2.

Table 3. Principal component and principal component loading values (population)

	x1	x2	x3
Total number of households at the end of the year (10,000 households)	-.286	.756	.571
Registered population at the end of the year (10,000 people)	-.270	.692	.651
Permanent population (10,000 people)	-.304	.810②	.463
Employed Persons in Urban Units at Year-end (Person)	.014	-.704	.507
Total number of students (1).	.981②	.038	.046
Elementary School (Person)	.905	.129	-.141
Junior High School (Person)	.910	-.048	.272
Total number of full-time teachers	.910	-.048	.272
Elementary School (Person)	.556	.497	-.212
Junior High School (Person)	.615	.240	.573
Urbanization Rate(1)	-.128	-.654	.680②
town	.128	.654	-.680

Note: (1) is the selected evaluation index; (2) The maximum load value in the factor.

Table 4. Principal Component and Principal Component Load Values (Social Security)

	x1	x2
The number of urban residents with minimum subsistence allowance (proportion).	-.260	-.439
Number of Rural Residents with Minimum Livelihood Security (Proportion)	.347	.457
Health technicians (person) (1).	.977	-.086(2)
Licensed physician (person) (1).	.988(2)	-.037
Physician Assistant (person).	.025	.817
Registered Nurse (Person)	.972	-.177

Note: (1) is the selected evaluation index; (2) The maximum load value in the factor.

Table 5. Principal Component and Principal Component Loading Values (Infrastructure)

	x1	x2	x3
Number of beds in health institutions	-.484	.430	-.477
Total number of schools	.908	.272	-.010
Elementary school (1).	.923(2)	.180	-.111
Junior High School	.077	.592	.429
Education (1)	-.101	.744(2)	-.456
Agriculture, forestry and water affairs	.681	.495	-.016
Primary	.714	.058	.375
Secondary Industry(1)	-.520	.371	.543(2)
Tertiary industry	-.799	.452	.216

Note: (1) is the selected evaluation index; (2) The maximum load value in the factor.

Table 6. Evaluation indicators, contribution rates of Sprincipal components and relative weights

Evaluation indicators	Principal component contribution rate /%	Relative authority /%
Primary school	42.3	7.71
Educate	19.8	10.45
Secondary industry	12.4	11.34
Total enrollment	36.7	6.26
Permanent population	28.2	6.81
Urbanization rate	22.4	9.03
Per capita disposable income	58.2	8.87
Average wage of employed persons in urban units	13.4	8.02
Gross domestic product per capita	9.2	7.82
Medical practitioner	51.1	11.22
Health technician	18.5	12.46

Table 2-5 shows the steps of extracting principal components by SPSS software for the indicators of four dimensions, in the table (1) the principal components extracted by SPSS analysis software in the initial indicators of a certain dimension, and (2) the maximum load value in the factor, and the principal component is determined according to the maximum load value in the factor. Table 6 shows the final selection of the 11 principal components, the contribution rate and relative weight of the principal components.

After the above calculation steps, a total of 11 principal components were retained (Table 6) (the index with the largest load value in each principal component represented the principal component, which was used for the calculation and analysis of the evaluation results). These indicators can not only fully reflect the main information of the original variables, but also greatly reduce the number of variables.

Table 7. Extracted principal components

Level 1 indicators	Secondary indicators
population	Total number of students, permanent population, and urbanization rate
economy	Per capita disposable income of residents, average wages of
infrastructure	Employed persons in urban units, and per capita gross domestic product
social	Primary schools, education, secondary industry
security	Occupational physicians and health technicians

4.2. Analysis of evaluation results

Table 8. RSR calculation table

Item	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	RSR	RSRRanking
1	9	1.5	1.5	1.5	8	13	15	31.5	1.5	1.5	1.5	0.243	32
2	30	31.5	12	26	21	20	14	11	13	19	15	0.064	10
3	23	26	10	31.5	1.5	7	5	28	8	15	17	0.489	17
4	31.5	23	3	30	13	1.5	1.5	26	6	11	14	0.456	21
5	10	28	27	25	4	28	31.5	22	27	16	13	0.658	8
6	27	9	20	16	15	8	13	1.5	16	9	10	0.411	24
7	20	24	31.5	14	29	30	20	3	31.5	29	28	0.739	2
8	14	21	29	17	28	27	30	7	29	23	19	0.693	6
9	26	27	14	15	22	19	10	4	15	21	20	0.548	14
10	18	8	9	18	11	12	6	16	7	18	21	0.409	25
11	25	20	7	20	20	9	11	21	10	17	18	0.506	16
12	22	22	8	21	12	10	4	25	9	8	11	0.432	23
13	21	30	24	22	5	29	26	20	21	24	22	0.693	5
14	15	25	11	27	18	16	12	23	12	31.5	31.5	0.631	9
15	8	18	16	28	7	18	19	5	14	13	12	0.449	22
16	13	29	21	7	31.5	22	22	29	23	26	25	0.706	3
17	1.5	19	13	10	27	31.5	25	8	17	20	24	0.557	12
18	12	14	18	9	14	17	21	12	18	14	16	0.469	19
19	11	11	17	8	23	24	24	13	19	22	23	0.554	13
20	16	1.5	23	5	25	14	17	6	25	6	5	0.408	26
21	7	3	30	1.5	30	11	16	16	30	10	8	0.459	20
22	19	7	4	12	19	1.5	8	14	3	4	3	0.268	30
23	29	5	5	23	24	3	7	17	5.0	1.5	1.5	0.344	29
24	28	6	15	19	26	4	3	24	11	3	4	0.406	27
25	31.5	15	6	24	31.5	5	1.5	1.5	4	7	9	0.386	28
26	24	4	1.5	13	9	6	9	10	1.5	5	6	0.253	31
27	17	16	26	29	1.5	25	27	27	20	30	29	0.703	4
28	4	17	28	11	17	23	23	9	26	25	26	0.594	11
29	5	13	25	6	3	31.5	28	30	28	31.5	31.5	0.661	7
30	1.5	10	19	3	6	21	29	19	22	27	27	0.524	15
31	3	31.5	22	31.5	10	26	31.5	31.5	24	28	30	0.764	1
32	6	12	31.5	4	16	15	18	18	31.5	12	7	0.486	18

Note: Items 1-32 are "Anyang County, Tangyin County, Huaxian County, Neihuang County, Linzhou City, Jun County, Qi County, Xinxiang County, Huojia County, Yuanyang County, Yanjin

County, Fengqiu County, Changyuan City, Weihui City, Huixian City, Xiuwu County, Boai County, Wuzhi County, Wen County, Qinyang City, Mengzhou City, Qingfeng County, Nanle County, Fan County, Taiqian County, Puyang County, Anyang City, Hebi City, Xinxiang City, Jiaozuo City, Puyang (Hualong District), Jiyuan City"; A1-A11 are "primary schools (institutions), education, secondary industry, total number of students, permanent population (10,000 people), urbanization rate, per capita disposable income of residents (yuan), average wage of employed persons in urban units, per capita GDP (yuan), licensed physicians (person), health technician (person).

Table 9. File sort results table

Item	RSR	RSR Ranking	RSR Fitted Value	Grading
1	0.243	32	0.242	1
2	0.604	10	0.587	2
3	0.489	17	0.505	2
4	0.456	21	0.460	2
5	0.658	8	0.614	2
6	0.411	24	0.423	2
7	0.739	2	0.768	3
8	0.693	6	0.647	3
9	0.548	14	0.538	2
10	0.409	25	0.410	2
11	0.506	16	0.516	2
12	0.432	23	0.436	2
13	0.693	5	0.667	3
14	0.631	9	0.600	2
15	0.449	22	0.448	2
16	0.706	3	0.721	3
17	0.557	12	0.562	2
18	0.469	19	0.483	2
19	0.554	13	0.550	2
20	0.408	26	0.396	2
21	0.459	20	0.472	2
22	0.268	30	0.319	1
23	0.344	29	0.343	1
24	0.406	27	0.380	2
25	0.386	28	0.363	1
26	0.253	31	0.289	1
27	0.703	4	0.691	3
28	0.594	11	0.574	2
29	0.661	7	0.630	2
30	0.524	15	0.527	2
31	0.764	1	0.846	3
32	0.486	18	0.494	2

Note: The level of binning is obtained by fitting the value by RSR; The higher the level number, the higher the level level, that is, the better the effect.

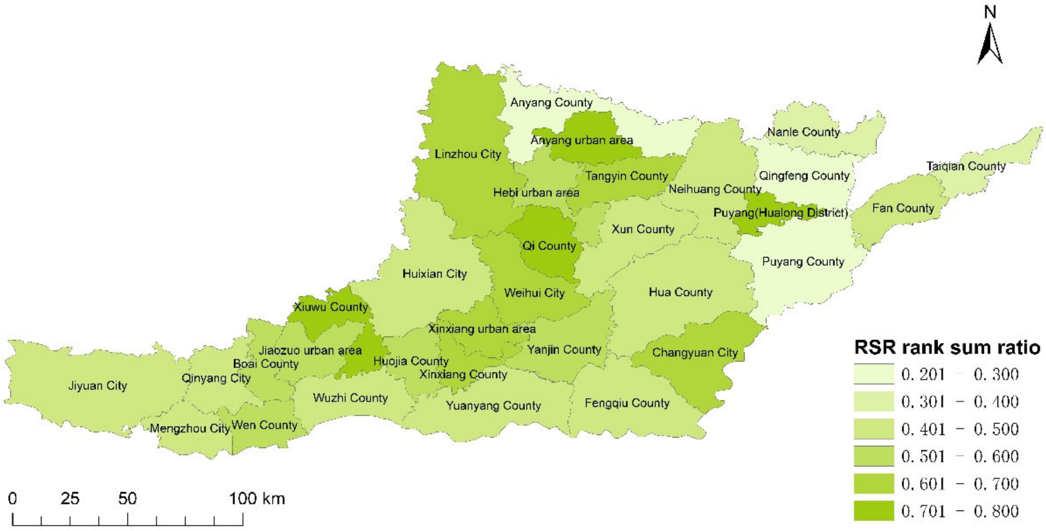

Figure 1. Toughness index of each region in northern Henan Province

With the development of urbanization, compound disasters are frequent and frequent, constantly invading cities and causing serious consequences, and the assessment of urban resilience is helpful to timely and quickly understand the risks and the hazards caused by risks and respond in a timely manner, so as to reduce urban risks, reduce losses, improve urban adaptability, and to a certain extent, help cities allocate resources and provide decision-making information.

It is not an independent factor that affects the level of urban resilience, but the result of the joint action of different variables, and urban resilience has a concurrent relationship with multiple factors to a certain extent. According to the RSR value and bracket level, the 32 regions were divided into 3 grades, among which Anyang County, Qingfeng County, Nanle County, Taiqian County and Puyang County performed well in RSR value, and the RSR level ranked 1, indicating that the resilience of these five regions performed well in the overall study area. The RSR values of Qi County, Xinxiang County, Changyuan City, Xiuwu County, Anyang Urban District and Puyang Hualong Districtranked third, indicating that the resilience of these regions was the worst in the overall study area.

4.3. Resilience analysis of the study area

The resilience level values of 32 regions were calculated by the rank-sum ratio comprehensive evaluation method, and the resilience levels of the 32 regions in the study area were different, and they were divided into 6 levels by equal interval method in ArcGIS: 0.201-0.300 was level 1, 0.301-0.400 was level 2, 0.401-0.500 was level 3, 0.501-0.600 was level 4, and 0.601-0.700 was level 5. 0.701-0.800 is a level of 6, and the higher the bracket level, the better the resilience benefit of the region.

It can be seen from Table 9 that the toughness value of Hualong District of Puyang is the highest, which is 0.764, and that of Anyang County is the lowest of 0.243, a difference of more than 3 times. According to the distribution of RSR grades, 15.6% of the study area had the highest resilience level, 65.6% of the study area had the middle resilience level, and 18.8% of the study area had poor resilience level, which needed to be focused on to improve the resilience level of the study area. The average resilience level of each region was 0.516, and about 50% of the regions in the study area had resilience values below the average. As can be seen from the RSR value and resilience index diagram (Fig. 1), there are many medium- and high-resilience regions in the study area, but there are great differences in the level of resilience development between regions, and countermeasures should be formulated according to the actual situation of the region.

4.4. Spatial correlation analysis of resilience

In order to reflect the spatial pattern and changes of resilience level in northern Henan, the average urban resilience index of 50%, 100% and 150% (referring to the World Bank's regional economic classification method and criteria) was divided into low-level resilience, medium-level resilience and high-level resilience regions. Combined with the RSR values of each region above, it can be obtained that the medium-level resilience areas dominate the study area, accounting for 70% of the total number of study areas, and the low-level and high-level resilience areas account for 15% respectively, indicating that the resilience level of the region needs to be further improved. In addition, there is significant spatial heterogeneity in regional resilience, and there is significant spatial heterogeneity in the resilience level of each region in the study area. Most of the high-level resilience counties are concentrated in the central region, mainly Qi County, Anyang City, Tangyin County, Weihui City, and Xiuwu County, and are distributed in clusters and blocks. The counties with medium and low resilience levels are mostly distributed in the northeast, west and southern regions, including Anyang County, Qingfeng County, Nanle County, Taiqian County, Puyang County, Qingfeng County, Jiyuan City, Mengzhou City, Wuzhi County and Yuanyang County, and they are continuously distributed.

5. Discussion

5.1. Robustness analysis of evaluation results

Regional resilience is often closely related to robustness. The more robust regions in the study area tend to show higher regional resilience. Robustness indicates the ability of an area to maintain stable and reliable survivability of the system in abnormal and dangerous situations. As can be seen from Figure 1, the resilience index of the central and northern regions of the study area is relatively high, and the region can respond quickly and timely in the face of natural disasters and public health emergencies, which has strong robustness. The resilience index of the southern region is lower than that of the central region, and the resilience index of the region fluctuates around the average resilience of the overall study area (0.516), which can cope with various emergencies such as natural disasters and public health events, but the response measures may be relatively imperfect, and the robustness of the region is relatively average. However, it can be seen from Figure 1 that the resilience of the northern and eastern regions of the study area is the worst, and the resilience index of this region is the lowest in the whole region, both below the average value (0.516). As a result, the region is the least robust. It is necessary to propose improvement measures according to local conditions to improve regional resilience and protect the safety of people's lives and property in the region.

5.2. Analysis of the driving factors of resilience

From the analysis of the degree and rationality of the influencing factors of the index weights and different factors on urban resilience, it can be seen that economic and social security have a great impact on the level of regional resilience development, followed by infrastructure and population factors.

In terms of economic environment, the per capita disposable income of residents, the average wage of urban employees and the per capita GDP all have positive effects on regional resilience. The higher the economic level and residents' income, the more conditions for high-quality social development can be given, and sufficient material security can be provided for the society and residents, effectively improving the pre-disaster stress resistance and post-disaster recovery capacity of the urban ecosystem. At the same time, through the investment and support of funds, the government can also improve the efficiency of urban operation and

ISSN: 2688-8653

increase the social and ecological resilience, thereby improving the overall resilience development level of society.

In terms of social security, the number of licensed physicians and health technicians has a positive impact on regional resilience. The level of social security can not only effectively respond to various public health emergencies, provide timely assistance to urban and rural areas, alleviate the shortage and shortage of medical resources, and improve the efficiency of urban safe operation, but also effectively prevent the occurrence of extreme public health events, improve the quality of life of residents, and enhance the overall resilience of society. For example, when the new crown epidemic broke out in early 2020, our country's well-developed medical resources and strong medical team played a strong role in this public health security incident, ensuring the safety of people's lives and reducing property losses.

In terms of infrastructure, the number of primary schools, the development of the education sector and the development of the secondary industry have a significant positive impact on the resilience level of cities. The development of the education industry and the number of schools determine whether the educated groups can enjoy the education in a timely manner, the completeness of educational resources and the level of education, so as to improve the overall education level of the society and promote the improvement of urban resilience. The development of the secondary industry can effectively drive the development of the regional economy, improve the level of economic development, and have a direct impact on the level of regional resilience. However, the industrialization development for the purpose of economic orientation will have an adverse impact on the society, and the overexploitation of resources, the aggravation of industrial waste emissions, and the irrationality of the industrial structure will hinder the society in the process of development.

In terms of demographic factors, the total number of students enrolled and the urbanization rate have a significant positive impact on regional resilience. The higher the total number of students in school, the more it can prove the perfection of social security and infrastructure, improve the overall education level of society, and also help improve and enhance the development resilience of society and regions through scientific and technological means such as knowledge and technology. However, the increase of urbanization rate premised on the overexploitation of resources has a negative impact on the output of regional resilience, and the overexploitation of resources is easy to damage the regional ecology. The rapid development of urbanization rate leads to the discharge of wastewater and pollution from industrial production, which not only endangers ecological resources but also easily causes various disasters, resulting in a reduction in social resilience and a great threat to the development of regional resilience. The number of permanent residents also has a negative impact on regional resilience, and excessive growth in permanent population will reduce the network smoothness of roads, increase road congestion, and reduce urban operational efficiency.

5.3. Countermeasures and suggestions for improving resilience

Due to the different geographical locations of different regions, coupled with the combined influence of demographic, economic, natural and social factors, there are great differences in resilience among regions. The improvement of regional resilience is of great help to the prevention, rescue and response to natural disasters, and can effectively protect the safety of people's lives and property.

In summary, based on the factors affecting regional vulnerability, the long-term goal is to promote regional sustainable development and enhance the potential of cities to cope with disasters from the aspects of population, economy, infrastructure and social security. Specifically, there are several measures:

Improve infrastructure, improve the living environment, and narrow the gap between urban and rural areas.

ISSN: 2688-8653

Infrastructure is the basic guarantee for the sustainable development of the region, and as the main carrier, infrastructure is crucial to the resilience of the region, and the infrastructure has a great role in promoting the long-term economic development of the region. Education is also an important part of infrastructure, and increasing investment in education costs is important to improve the quality of residents, the economy and long-term development of the region. The government should increase investment in regional infrastructure, transform and upgrade old and old infrastructure, strengthen the management and construction of grassroots organizations, improve regional production and living facilities, improve people's living environment, and enhance the quality of life. While ensuring the rapid development of cities, it is necessary to pay more attention to rural areas. Governments need to shift resources to poor and backward rural areas, and narrowing the development gap between urban and rural areas is also crucial for regional resilience.

Adjust the industrial structure and improve the level of economic development.

The diversity of regional economic development plays a very important role in promoting the improvement of regional economic resilience. The strength of a region's economy not only affects economic resilience, but also underpins other resilience. In order to achieve sustainable regional development, it is necessary to change the traditional monolithic industrial structure, promote the diversified development of industries, and the coexistence of multiple economies. Once a region chooses a single industrial structure, it will follow this fixed industrial model for a long time in the future, and it is difficult to resist the impact of external economic changes. A diversified industrial structure can effectively resist external risks, effectively promote local economic development, and enhance economic resilience. For rural areas with backward economic development, the government should increase assistance and rapidly develop the rural economy, which is particularly important to enhance the resilience of rural areas, including cities.

Improve the social security system and enhance the overall resilience of society.

Many cities in northern Henan have obvious shortcomings in social resilience, and with the increasing aging of the population and the increasing frequency of various health outbreaks, the scale of social security spending is increasing. Social security can provide security for residents in urban and rural areas when various types of disasters occur, reduce various losses caused by disasters, and provide strong help in medical care, unemployment and social assistance, which can effectively help residents recover from disasters quickly. The government should improve the social security system, innovate the social security system, narrow the development gap between regions, and improve the overall resilience of regions.

Fourth, advocate the concept of "security-coordination" development and improve the level of regional governance.

In the face of the increasing frequency of highly uncertain and complex disasters, to achieve sustainable regional development, it is not only necessary to ensure various external hardware facilities, but also to put forward effective governance measures from the root cause. For a long time to come, we will have to deal with far more types of disasters and hazards than before, which requires us to change the traditional concept of developing to deal with disasters and establish new development ideas. Security is an important guarantee for the sustainable development of the region, and it is also the first priority of development. Regional managers should change their development thinking, change the traditional situation of passive response to disasters, and actively and reasonably avoid risks in the process of development, and put forward a safer development concept. In the era of big data, we should combine digital technology to build smart cities, combine information technology with governance systems, create a new digital governance model, and improve the overall resilience of regions.

6. Conclusion

Resilience itself is a complex concept, and with the continuous development of society, terms such as resilient city construction and urban resilience appear more and more frequently, and have also attracted the attention of scholars. As an important place for residents' activities, the learning, disaster resilience and post-disaster recovery capabilities of cities are important prerequisites for their sustainable development, and improving regional disaster response capacity by improving urban resilience has become a research hotspot. From the perspectives of economy, infrastructure, social security and urban governance, this paper extracts, calculates and analyzes the factors affecting the resilience of northern Henan by using principal component analysis, rank-sum ratio comprehensive evaluation and GIS, and presents them in the form of charts, and proposes measures to enhance the resilience of northern Henan on the basis of the above. Enhancing regional resilience will not only improve the region's ability for sustainable development, but also improve its ability to learn, adapt, resist disasters and recover from within, which not only meets the development requirements of the times, but also improves the quality of life of residents.

References

[1] Alexander D E. Resilience and Disaster Risk Reduction: An Etymological Journey[J]. Natural Hazards and Earth System Science, 2013, 13(11): 2707-2716.

[2] Holling C S. Resilience and Stability of Ecological Systems[J]. Annual Review of Ecology and Systematics, 1973: 1-23.

[3] Shao Yiwen, Xu Jiang. Understanding Urban resilience: A Concept Analysis Based on Integrated International Literature Review [J]. Urban Planning International,2015,30(02):48-54.

[4] Berkes F, Folke C. Linking Social and Ecological Systems for Resilience and Sustainability[M] // Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge: Cambridge University Press, 1998: 13-20

[5] Wang C H, Blackmore J M. Resilience Concepts for Water Resource Systems[J]. Journal of Water Resources Planning and Management, 2009, 135(6): 528-536.

[6] Walker B, Holling C S, Carpenter S R, et al. Resilience, Adaptability and Transformability in Social-Ecological Systems[J]. Ecology and Society, 2004, 9(2): 5.

[7] Folke C, Carpenter S R, Walker B, et al. Resilience Thinking: Integrating Resilience, Adaptability and Transformability[J]. Ecology and Society, 2010, 15(4): 20.

[8] Holling C S, Gunderson L H. Resilience and Adaptive Cycles[M] // Panarchy: Understanding Transformations in Human and Natural Systems. Island Press, 2001: 25-62

[9] Godschalk D R. Urban Hazard Mitigation: Creating Resilient Cities[J]. Natural Hazards Review, 2003, 4(3): 136-143.

[10] Campanella T J. Urban Resilience and the Recovery of New Orleans[J]. Journal of the American Planning Association, 2006, 72(2): 141-146

[11] Jha A K, Miner T W, Stanton-Geddes Z. Building Urban Resilience: Principles, Tools, and Practice [M]. World Bank Publications, 2013.

[12] Resilience Alliance. A Research Prospectus for Urban Resilience: A Resilience Alliance Initiative for Transitioning Urban Systems Towards Sustainable Futures[EB/OL]. (2007-02)[2014-12-01].

[13] Ireni-Saban L. Challenging Disaster Administration: Toward CommunityBased Disaster Resilience[J]. Administration and Society, 2013, 45: 651-673.

[14] Jabareen Y. Planning the Resilient City: Concepts and Strategies for Coping with Climate Change and Environmental Risk[J]. Cities, 2013, 31: 220-229.

[15] Joerin J, Shaw R, Takeuchi Y, et al. Action-oriented resilience assessment of communities in Chennai, India [J]. Environmental Hazards, 2012, 11(3): 226-241.]

ISSN: 2688-8653

[16] Cutter S L, Kevin D A, Christopher T E. The geographies of community disaster resilience [J]. Global Environmental Change, 2014, 24(11): 65-77.

[17] Hudec O, Reggiani A, Šiserová M. Resilience capacity and vulnerability: A joint analysis with reference to Slovak urban districts [J]. Cities, 2018, 73(3): 24-35.

[18] YANG Ying, LIN Lin, ZHONG zhiping, Ou Yingying, Xu Qian, MENG Meiyun, HAO Shan. Comprehensive evaluation and spatial differentiation of community resilience in Guangzhou based on response of the city public health hazards [J]. Acta Geographica Sinica,2019,74(02):266-284.

[19] BAI Limin XIU Chunliang FENG Xinghua MEI Dawei WEI Ye. A Comprehensive assessment of urban resilience and its spatial differentiation in China[J]. World Geographical Research 2019,28(06):77-87.