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Evaluation on Social Vulnerability to Natural Disasters

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ABSTRACT Recently, the study about social vulnerability of human system and coupled human-environmental system has become more popular in the field of vulnerability research and sustainability science. In this paper, the researchers discuss the progress of social vulnerability research about characteristics, analytical frameworks, and assessment methods of social vulnerability.Then the researchers make comprehensive evaluation of social vulnerability by using factor analysis method ,the data was collected from 31 provinces in China during 2000-2011.The result shows that the evaluation index of social vulnerability in four aspects, such as basic social development pattern and social security vulnerability, social stratification and population vulnerability, regional health vulnerability and disadvantaged groups vulnerability. On this basis, the researchers analyze the regional difference and spatial pattern from these four aspects, and makes comprehensive evaluation of social vulnerability to natural disasters.

INTRODUCTION

China as one of the most serious countries affected by natural disasters is now in transition of social development. From 1990s, the direct economic losses become more and more serious. In recent 25 years, large flood disaster occurred 172 times in China. Among them, flood disasters occurred most frequently in 2002, 2005, 2006 and 2007, which are more than 10 times every year. With population growth and social development, the demand for resource is increasing, the conflicts between human and nature are upgrading, and natural disasters becoming more frequently, which seriously hampered the development of social economy, caused huge economic losses and a very serious negative effects on the social development (Guo 2005). The disaster research based on social vulnerability is an important part of disaster prevention research. To evaluate natural disaster social vulnerability and analyzes its spatial distribution pattern and difference of regional development have important theoretical and practical significance for perfecting the system of the comprehensive disaster prevention and mitigation and disaster emergency management.

Social vulnerability is one dimension of vulnerability. Social vulnerability refers to negative impacts of social system exposed to natural or human factors due to its own sensitivity characteristics and lack of ability to cope with adverse disturbance. This paper introduces several analytical frameworks of social vulnerability from economy, social-ecological system and comprehensive perspectives. Generally, current studies on social vulnerability have the following problems: a unified conceptual and analytical framework has not been formed; assessment methods of social vulnerability are too simplistic; a comprehensive evaluation index system is absent; studies on mitigation and countermeasures are insufficient. In the future, social vulnerability study needs to establish a unified concept and analytical framework, expand the research contents, improve theoretical system, and promote multi-disciplinary integration. At the same time, it is necessary to improve evaluation index system and method of social vulnerability, strengthen research on social vulnerability mitigation and countermeasures, and integrate social vulnerability and social adaptation. The researchers hope social vulnerability research can provide the scientific basis for social adaptability and sustainable development.

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Literature Review

Natural disasters, which are the combined products of natural variability and anthropogenic influences, caused huge losses for people's life and property (Ma et al. 1998). Based on the number of studies, natural factors, including genetic mechanism, rule of development etc., have made a large number of research results (Guo 2008). The 1994 World Conference on disaster reduction, 1995 international day for natural disaster reduction, and "the international strategy for disaster reduction plan (ISDR) marks the social factors of the disaster, disaster vulnerability research has become an important subject of research and study on disaster management (Jiang et al. 1996). Over the past 20 years, "vulnerability" has not only become a central concept in the field of disaster research, but also the basis of the international social class poverty, population, development and environmental issues (Guo 2005). The foreign scholars have carried on the long-term research and the consummation to the disaster vulnerability research, such as the coastal hazard (Saxena et al. 2013), the storm surge hazard (Frazier et al. 2010), the tsunami (Eckert et al. 2012), the urban heat wave (Depietri et al. 2013), the climate change (Marshall et al. 2014), the flood (Kazmierczak et al. 2011), the environment (Collins et al. 2009) and so on. They built regional disaster vulnerability evaluation index system mainly from population indicators (including population density, vulnerable population, etc.), disaster response capability indicators (including disaster management planning, early warning system, emergency response mechanism, etc.), social indicators (including employment, education, disaster awareness, etc.), infrastructure indicators (including network number, road accessibility, with car number, medical conditions, etc.), building indicators (including construction type, vulnerable building number, etc.). They used comprehensive evaluation method. Saxena (2013) thinks that vulnerability of a community is a reflection of risk exposure and coping capacity of its individual members. Based on the MOVE framework, Depietri (2013) developed the indicators and used the GIS applications to spatially assess the relative vulnerability of the 85 districts of Cologne to heat waves. Marshall (2014) measured social vulnerability according to ten indicators of climate sensitivity (resource dependency) and four indicators of adaptive capacity and identified four main 'types' of cattle producers using a K-means clustering analysis. Kazmierczak (2011) explored the spatial distribution of surface water flooding, the vulnerability of communities to flooding, and the characteristics of physical environment and land use that affect people's exposure to flooding, particularly concerning green cover in Greater Manchester, UK. The domestic scholars have done a useful research in the flood (Ge et al. 2013), debris flow (Tang et al. 2005), landslide (Shi et al. 2009), geological disasters (Chen et al. 2012), regional disaster (Tang et al. 2013) and other vulnerability assessment.

It can be seen that disaster vulnerability research currently focuses on vulnerability definitions, concepts, influencing factors and evaluation index system of the model and has achieved abundant results. In terms of empirical research, most domestic scholars only take an area or some year data as an example, and then evaluate natural disasters social vulnerability by using the principal component analysis, gray system analysis method. But due to the abstraction and complexity of disaster vulnerability, there are a number of problems to be solved. So it is necessary to build a more scientific and reasonable evaluation index system of natural disaster vulnerability and analyze the spatial distribution pattern and difference of regional development of natural disasters social vulnerability.

Based on the summary of previous research results, the paper builds a set evaluation index system for Chinese province scale natural disasters social vulnerability. Using factor analysis-projection pursuit-clustering method, the spatial pattern analyses will be done in 31 provinces, which included the basic pattern of social development and social security vulnerability, social stratification and population vulnerability, regional medical vulnerability and vulnerability of vulnerable groups. In this paper, the researchers aim to provide targeted and operable decision in China, and in different areas of disaster prevention and mitigation.

Evaluation Index System of Social Vulnerability to Natural Disasters

Natural disasters social vulnerability is the damage degree of human society caused by potential natural disasters. It involves multiple aspects of losses, including the life and property

of human society, health, living environment, social material wealth, social productivity, social structure, social order, resources, etc. the losses including not only the society individual's, but also the social overalls, is the result of the interaction of natural and social factors. Experts at home and abroad are generally believed that influencing factors of natural disasters social vulnerability include: (1) the lack of resources, information, knowledge and technology, (2) limited political rights and representation, and (3) lack of social capital; (4) vulnerable and disadvantaged groups, and (5) the condition and density of infrastructure.

Natural disasters social vulnerability is a complex system, involving regional population, vulnerable population, economy, social structure, infrastructure and other issues. Considering the principle of indicators accessibility, high-frequency principle of authority typical indicators, the principles of optimal selection from similar information, the paper constructs the primary vulnerability assessment index system of Provincial Natural Disaster Society, as shown in Table 1.

METHODOLOGY

Research Framework

In this paper, the researchers evaluate the provincial social vulnerability to natural disasters in China, and construct the primary vulnerability assessment index system of provincial natural disaster society considering regional population, vulnerable population, economy, social structure, infrastructure etc. After filtering and reducing dimensions, the primary assessment index system would be divided into four common factor index systems, and then the four types of indicators data will be clustered by projection pursuit and analyzed their spatial pattern. Finally, the comprehensive evaluation model will be constructed, and vulnerability comprehensive evaluation will be carried out. The performance includes four steps:

1. Index dimension reduction. Through quantitative analyzing, screening primary evaluation index system using factor analysis, combining the repeat information indicators, the paper ultimately establishes a set of independent, strong representative index system.

Table 1: Primary indicators of disasters social vulnerability assessment

No.	*Index*	*Formula*	*The index attribute*
1	The proportion of agricultural population (%)	Agricultural population / Area total population	Positive
2	The female population proportion (%)	The female population/ Area total population	Positive
3	Above 65 years old population proportion (%)	The population over 65 tears of age / Area total population	Positive
4	Below 14 years old population proportion (%)	The population below 14 years old / Area total population	Positive
5	The minimum living security number proportion (%)	Enjoy the lowest security population / Area total population	Positive
6	Population density (ºN/ km$^{2)}$	Area total population / Area	Positive
7	The density of GDP (ten thousand RMB/km^2)	GDP / Area	Moderate
8	The highway density (km/km^2)	Length of highway / Area	Reverse
9	Building density (m^2/km^2)	Commercial housing completed in the area / Area	Reverse
10	Social security contribution (ten thousand RMB)		Reverse
11	The number of beds in health institutions densityÿ/ ten thousand people	The number of beds in health institutions / Area total population	Reverse
12	The rate of urban community service facilitiesÿ/ ten thousand population	A number of community service facilities to urban area / Area total population	Reverse

2. Dimension reduction projection. In this paper, by using projection pursuit model, every common factor with 31 provinces data, which would be obtained by factor analysis, will be reduced dimension and projection. Dimension reduction, on the one hand is easy for cluster analysis of each common factors and analysis of spatial pattern; on the other hand, is easy for vulnerability comprehensive evaluation.
3. The projection clustering method for subfactors. In this paper, the projection pursuit results of each common factor will be discussed respectively, which include basic social development pattern and social security vulnerability, social stratification and population vulnerability, regional health vulnerability and disadvantaged group's vulnerability.
4. Comprehensive Evaluation of natural disasters social vulnerability. The researchers construct comprehensive evaluation model for evaluating and ranking the natural disasters social vulnerability in 31 provinces.

Data Sources

In this paper, the researchers selected data from 31 provinces in China during 2000-2011 as the sample, all data was collected from China Statistical Yearbook 2013, and China Population Statistics Yearbook 2013, after sorting calculated the researchers got a total of 4464 provincial data.

RESULTS AND DISCUSSION

Factor Analysis

The researchers make 12 index about 31 provinces in 2011 will be imported into SPSS software, and then factor analysis will be carried out, where KMO value is 0.671, the ball-test significance probability of sig is 0.00, and both of them meet the requirements.

As seen from the eigenvalues of the matrix, all eigenvalues of the first four common factors are greater than 1, which respectively are: 42.8 percent, 19.2 percent, 11.3 percent, 9.1 percent, the accumulative contribution rate is 82.4 percent. Though factor analysis method, the 12 evaluation index will be converted into 4 comprehensive evaluation indexes to achieved the purpose of the classification and data dimension reduction.

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From the factor loading matrix after rotating, it can be seen that the first common factors reflect overall basic social development pattern and social security vulnerability, where the larger load value are x7, x8, x9, x10, x12; the second common factors reflect social stratification and population vulnerability, where the larger load value are x1,x2,x3,x6ÿthe third common factors reflect regional health vulnerability, where the larger load value are x11; the fourth common factors reflect the disadvantaged groups vulnerability, where the larger load value are x2,x3.

On the basis of the above analysis, according to provincial natural disasters social vulnerability analysis, the paper rebuilds an evaluation index system with the more reasonable logical structure, as shown in Table 2.

Projection Pursuit Clustering Analysis

Projection Pursuit Clustering Analysis of the First Common Factor (Basic Social Development Pattern and Social Security)

After the dimension reduction in projection pursuit, the first factor cluster analysis will be carried out, so in this paper, Projection pursuit model is each area 12 years 5 indexes value reduce to 5 indexes in 1 years the index value.

The following provides specific steps: firstly, as requested, the Beijing's 5 indicators, 12 years data will be import into DPS software to enable "other projection pursuit comprehensive evaluation method" function to get the optimal projection direction of Beijing (0.4683, 0.4263, 0.3168, 0.2933,0.2647,0.2874, 0.2532,0.2240, 0.2149, 0.2183, 0.1895,0.1261), and the projections value= (0.0006,0.0334, 0.0009,0.0079, 3.3106). By analogy, projection pursuit evaluation values of natural disasters and social vulnerability of 31 provinces and cities nationwide 2000-2011 years will be obtained. Considering the limited space, as shown in Table 3.

As requested, the projection pursuit data of the first common factor are imported into SPSS soft-

Table 2: Indicators of disasters social vulnerability assessment

	Index	*Formula*	*The index attribute*
The first common factor, basic social development pattern and social security vulnerability	The density of GDP, χ_7	$\frac{\text{GDP}}{\text{Area}}$	Moderate
	The highway density,χ_9	$\frac{\text{Length of highway}}{\text{Area}}$	Reverse
	building density,χ_9	$\frac{\text{Commercial housing completed in the area}}{\text{Area}}$	Reverse
	social security contribution,χ_{10}		
	The rate of urban community service facilities,χ_{12}	$\frac{\text{A number of community service facilities in urban area}}{\text{Area total population}}$	Reverse
The second common factor, social stratification and population vulnerability	The proportion of agricultural population,χ_1	$\frac{\text{Agricultural population}}{\text{Area total population}}$	Positive
	Below 14 years old population proportion,χ_4	$\frac{\text{The population below 14 years old}}{\text{Area total population}}$	Positive
	The minimum living security number proportion,χ_5	$\frac{\text{Enjoy the lowest security population}}{\text{Area total population}}$	Positive
	population density,χ_6	$\frac{\text{Area total population}}{\text{Area}}$	Positive
The third common factor, regional health vulnerability	The number of beds in health institutions density, χ_{11}	$\frac{\text{The number of beds in health institutions}}{\text{Area total population}}$	Reverse
The fourth common factor, disadvantaged groups vulnerability	The female population proportion,χ_2	$\frac{\text{The female population}}{\text{Area total population}}$	Positive
	Above 65 years old population proportion,χ_3	$\frac{\text{The populationover 65 years of age}}{\text{Area total population}}$	Positive

ware to enable "Analyze-Classify- Hierarchical Cluster" function, meanwhile to select the "average method-Mahalanobis distance -Z standard" in "Method" to carry out the Q-cluster analysis, and then the first common factor clustering results could be obtained, which will get the clustering map of the first common factor vulnerability.

The basic social development pattern and social security reflects the regional emergency rescue ability for natural disaster and the ability of recovery. In general, the lower level of the basic social development pattern and development of social security, the higher degree of regional natural disasters social vulnerability is. It means capacity to respond to disasters and a disaster recovery capability is low. In this paper, the density of GDP and building will be regard as an indicator of regionals economic level; the density of road will be regard as an indicator of lifeline disaster recovery security; social security expenditure and the rate of urban community service facilities will be regard as an indicator of social organizations and social security. Though the projection pursuit cluster analysis to the above data, the paper obtains the spatial distribution pattern map (see Fig.1). In China, the basic social development pattern and social security vulnerability have the following characteristics:

Table 3: Projection pursuit partial results of the first common factor

	Beijing	*Tianjin*	*Hebei*	*Shanxi*	*Inner Mongolia*
The density of GDP,	0.000582455	0.000553324	0.001409224	0.002183722	0.005439491
The highway density,	0.033432562	0.033104313	0.046059265	0.046814213	0.109660315
building density,	0.000886095	0.000991866	0.004127549	0.005595233	0.01096272
social security contribution,	0.007942524	0.004735279	0.00347735	0.004251881	0.004323849
The rate of urban community service facilities,	3.310643494	2.697214179	3.400450753	4.660525282	2.706377533

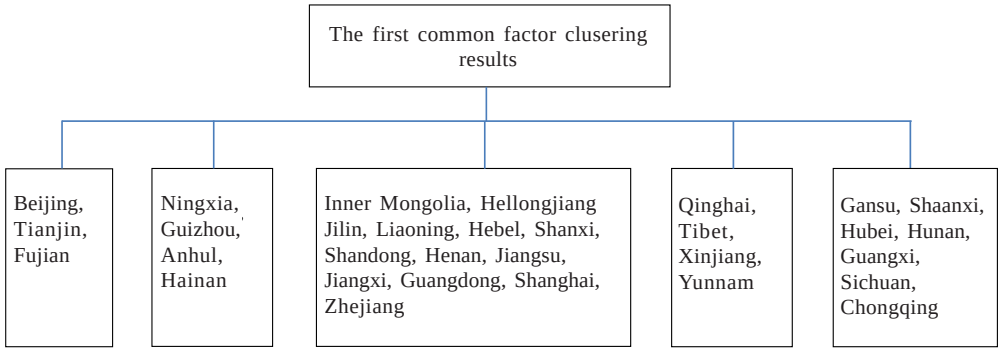

Fig. 1. Provincial natural disasters vulnerability clustering map for the first common factors (basic social development pattern and social security)

(1) The basic social development pattern and social security vulnerability are closely related to the level of economic development. Xinjiang, Tibet, Qinghai, Yunnan, belonging to the same class, whose basic social development pattern and social security vulnerability are relatively high.

(2) Shanghai, Zhejiang, Guangdong, Shandong and other coastal economic area belongs to the same class, the basic social development level is relatively good, social security, rescue and emergency management mechanism construction is relatively sound, prevention, response and recovery capability is relatively high.

(3) From a geographical point of view, on the Yunnan-Guizhou plateau, the Qinghai-Tibet plateau and other places, due to the higher risk index of nature disaster, such as debris flow, landslide, avalanche etc., the level of basic social development pattern and social security vulnerability is high, road accessibility is low; in middle and lower reaches of the Yellow River and the Yangtze River and other areas along the rivers, flood disaster risk level is higher, so the level of basic social development pattern and social security vulnerability is high too.

Projection Pursuit Clustering Analysis of the Second Common Factor (Social Stratification and Population)

In the same way, cluster analysis was performed on second common factor. Projection pursuit model is each area 12 years 4 indexes value reduce to 4 indexes in 1 years the index value. The Q-cluster analysis will be carried out, and then the second common factor clustering results could be obtained, which will get the clustering map of the second common factor vulnerability (see Fig. 2).

Human is not only the disaster causing factors but also disaster bearing body, is an important part of the natural disaster system. From the perspective of the bearing body, agriculture such as farmland water conservancy, economic crops, food production is easy to be threatened by various natural disasters, so the agricultural production has a certain risk, the agricultural population can be as vulnerable groups of social stratification; the increase in the proportion of children under 14 years old, minimum earners and population density may lead to an increase for the potential social population vulnerability. Though the projection pursuit clusters method the researchers obtain the spatial distribution pattern map. Social stratification and the spatial pattern of population vulnerability have the following characteristics:

(1) High population density city such as Shanghai, Beijing, and Tianjin etc. classified as a class, their social population vulnerability level is relatively high.

(2) Xinjiang, Yunnan, Qinghai, Gansu, Guizhou is classified as a class. Minority concentrated in those areas, the low level of economic development has resulted in higher social population vulnerability.

(3) The area of the agricultural population proportion around 50 percent is classified as a class, the area of proportion around 60 percent is classified as a class, the area of proportion more than 60 percent is classified as a class, that is, as the index

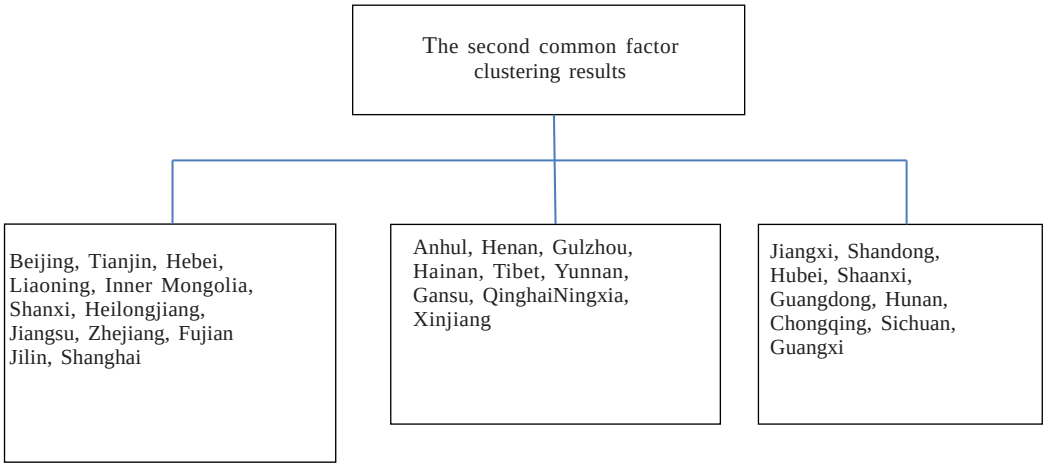

Fig. 2. Provincial natural disasters vulnerability clustering map for the second common factors (social stratification and population)

of the social stratification, the agricultural population has the close relation with the provincial nature disasters social vulnerability.

In the same way, the clustering graph of the third factors vulnerability can be obtained (see Fig. 3).Casualties caused by natural disasters are inevitable, so the medical security is an important part of natural disaster system. The density of number of beds in health institutions will be used as medical vulnerability evaluation index. In general, the greater index value, the lower provincial natural disasters social vulnerability is, it is a reverse index. It can be seen that in some areas with the better economic development, centralized medical institutions, prefect medical conditions, such as Beijing, Tianjin, Shanghai, the social security investment is high, the social security system is more perfect, medical vulnerability degree is relatively low; otherwise, the areas with the worse economic development, weaker medical conditions, such as Qinghai, Ningxia, Guizhou, Xinjiang, the social security system is weak, medical vulnerability degree is relatively high.

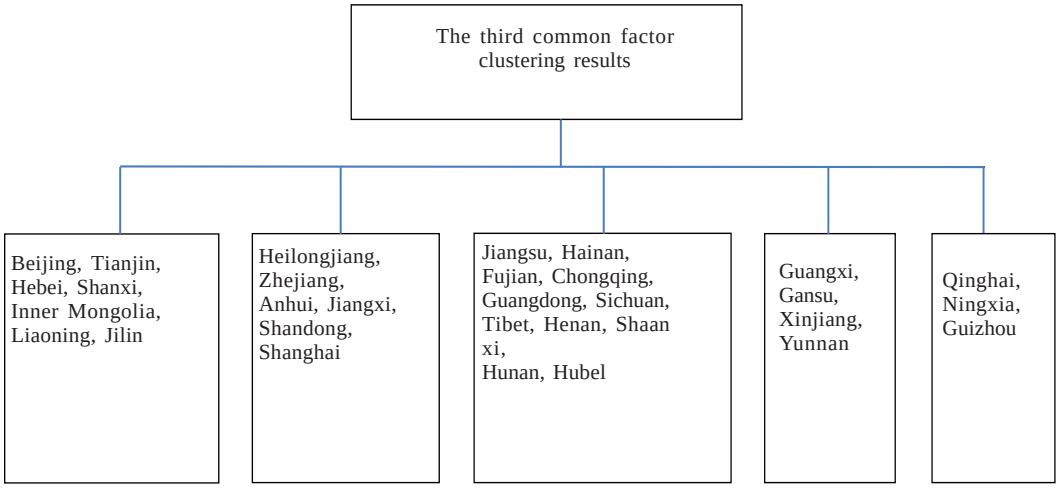

Fig. 3. Provincial natural disasters vulnerability clustering map for the third common factors (regional health vulnerability)

Projection Pursuit Clustering Analysis of the Fourth Common Factor (Disadvantaged Groups)

In the same way, the clustering graph of the third factors vulnerability can be obtained (see Fig. 4). The two factors as "female population" and "the population over the age of 65" belonging to the regional disadvantaged group which is in a fragile and disadvantaged status in the society. Though the projection pursuit cluster analysis to the above data, the spatial distribution pattern map could be obtained, which is shown in Figure 4. During 2000-2011, with the development of economy and medical condition, proportion of over 65 years old population is increasing year by year. In 2010-2012, the proportion of some provinces has been more than 10 percent. There is a strong correlation between the proportion of elderly population and the fourth common factor clustering results. Tibet, Xinjiang, Qinghai, Ningxia is classified as a class, where the proportion of population over 65 years old is less than 6 percent, the vulnerability of vulnerable groups is low; Guangdong, Henan, Guangxi, Yunnan etc. is classified into a class, where the proportion of population over 65 years old is greater than 6 percent and less than 9 percent, meanwhile the proportion of female population is low, the vulnerable groups vulnerability level is relatively weak.

The Comprehensive Evaluation of Vulnerability to Provincial Social Natural Disasters

Social vulnerability evaluation model can be able to fully reflect the elements, from a macro point of view, which mainly included the economic development vulnerability, population vulnerability, the vulnerability of vulnerable groups and the vulnerability of social stratification etc. In this paper, natural disasters and social vulnerability evaluation indexes are divided into four common factors, including: basic social development pattern and social security vulnerability, social stratification and population vulnerability, regional health vulnerability and disadvantaged group's vulnerability. Therefore, the social vulnerability comprehensive evaluation can be established for the four public factor weighted superposition model.

The comprehensive evaluation of vulnerability to provincial social natural disasters as:

$$\sum_{i=1}^{4} k_i X_i$$

Where, k_i is proportion of the i^{th} common factor, data comes from the proportion of characteristic value of the factor analysis to the accumulative contribution rate, namely, 42.8 percent / 82.4 percent =0.52019.2 percent / 82.4 percent =0.23011.3 percent / 82.4 percent =0.1409.1 percent / 82.4 percent =0.110

X_i is the vulnerability of the i^{th} common factors, it can be obtained by projection pursuit. For instance, the projection pursuit method for first common factor vulnerability values is as follow: each area 12 years 5 indexes value would be reduce to 5 indexes in 1 years the index value, and then by the arithmetic mean to calculate the vulnerable value of the first common factors for each area. In the same way, the other common factors of 31 provinc-

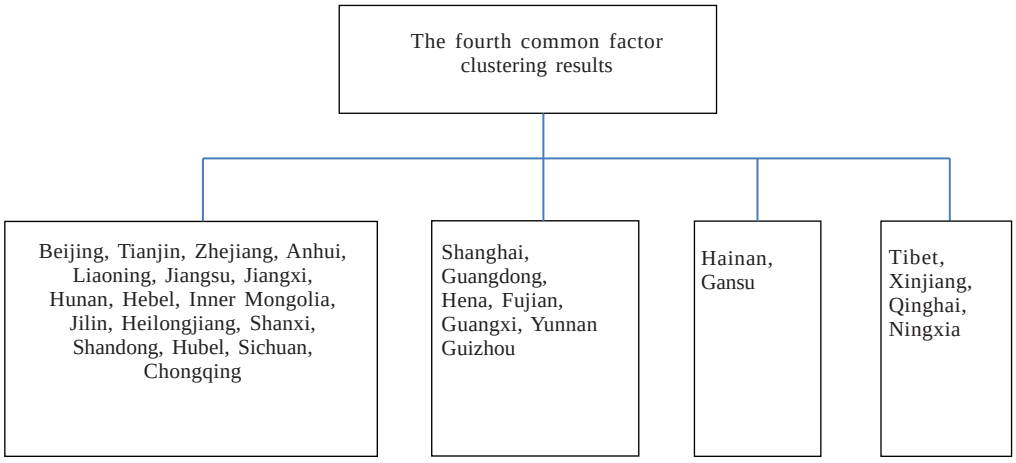

Fig. 4. Provincial natural disasters vulnerability clustering map for the fourth common factors (disadvantaged groups)

Table 4: The provincial natural disasters social vulnerability evaluation value and sort results

Province	*Projection pursuit value of The first common factorweight =0.52*	*Projection pursuit value of The second common factor weight =0.23*	*Projection pursuit value of The third common factor weight =0.14*	*Projection pursuit value of The fourth common factor weight =0.11*	*Comprehensive evaluation*	*No.*
Shanghai	0.4812	55.4816	0.0673	0.8219	13.3126	1
Tianjin	0.7808	31.2767	0.0255	0.8297	7.8081	2
Beijing	0.9170	30.8769	0.0197	0.8253	7.7841	3
Henan	1.7242	23.5181	0.0405	0.8260	6.4870	4
Guangdong	1.1356	22.9480	0.0431	0.8247	6.0483	5
Shandong	0.9106	22.7707	0.0349	0.8345	5.8899	6
Zhejiang	0.4481	21.8614	0.0351	0.8222	5.4359	7
Hainan	1.9811	15.2075	0.0400	0.8128	4.6772	8
Anhui	1.0436	16.8390	0.0438	0.8304	4.5739	9
Jiangxi	1.3985	15.4290	0.0448	0.8232	4.4281	10
Shanxi	1.3377	14.5065	0.0285	0.8275	4.1793	11
Liaoning	0.0063	16.7266	0.0231	0.8340	4.0064	12
Guizhou	0.8919	14.4799	0.0522	0.8225	3.9442	13
Guangxi	2.0326	11.7028	0.0465	0.8132	3.8860	14
Hunan	0.0160	16.0203	0.0390	0.8226	3.8473	15
Yunnan	3.1837	8.6388	0.0388	0.8220	3.7679	16
Chongqing	1.2110	10.8301	0.0386	0.8936	3.2631	17
Ningxia	0.0182	10.6637	0.0334	0.8265	2.5966	18
Tibet	2.8735	0.3742	0.0390	0.8379	1.6776	19
Xinjiang	1.0418	3.0235	0.0237	0.8288	1.3421	20
Shaanxi	0.9062	2.9691	0.0326	0.8296	1.2602	21
Jilin	1.1888	2.2267	0.0286	0.8317	1.2333	22
Qinghai	1.5357	0.9615	0.0321	0.8261	1.1177	23
Sichuan	1.1912	1.5528	0.0377	0.8393	1.0791	24
Hebei	0.0069	4.0416	0.0367	0.8300	1.0443	25
Fujian	1.0761	1.3562	0.0402	0.8292	0.9727	26
Gansu	1.2418	0.7395	0.0371	0.8357	0.9149	27
Heilongjiang	0.9572	0.8004	0.0296	0.8290	0.7796	28
Hubei	0.8623	0.9957	0.0370	0.8524	0.7795	29
Jiangsu	0.6057	0.7925	0.0367	0.8792	0.6016	30
Inner Mongolia	0.0164	0.8239	0.0327	0.8245	0.2963	31

es could be getting. The final provincial natural disasters social vulnerability evaluation value and sort results as shown in Table 4.The comprehensive social vulnerability reflects the ability of the area to response the natural disasters. The comprehensive social vulnerability to natural disasters include: basic social development pattern and social security vulnerability, social stratification and population vulnerability, regional health vulnerability and disadvantaged groups vulnerability. From the Table 4, the result shows:

(1) The highest value of the comprehensive social vulnerability appeared in the areas with a developed economy, high population density, and high density of buildings, such as Shanghai, Tianjin, and Beijing etc. Although in these regions there are a better economic development, education and consciousness of prevention and reduction, the comprehensive social vulnerability is still high. The reason is that: compared with the high density of building and population , infrastructure construction is still not perfect and scientific, meanwhile, compared with the serious environmental damage, the ability of society to withstand natural calamities is relatively low, so it is more difficult for disaster recovery (Tang 2013).

(2) In the area with the low population density, even no population, such as Xinjiang, Tibet, Inner Mongolia etc., social comprehensive vulnerability degree is relatively low.

(3) In the area along the Yangtze River Valley, such as: Anhui, Chongqing, Hubei, Hunan, Jiangxi, Shanghai, landslide, debris flow and flood disasters are frequently, which lead to a fragile ecological environment, so social comprehensive vulnerability is high. By contrast, the area with a lower economic development, a worse transportation accessibility and a higher population density, the social comprehensive vulnerability is higher.

(4) In the traditional agricultural production areas, such as Shandong, Henan, Anhui and so on, population density is high, the drought and flood disasters occur frequently, the social and economic development level is relatively low, so the comprehensive social vulnerability level is relatively high. In addition, the area with many mining cities also has a high the comprehensive social vulnerability.

(5) On the eastern region, the northern comprehensive vulnerability level is higher, especially in the Bohai Bay, pan Bohai area. This is mainly because the weak social and economic development resulting in the backward basic facilities. The Beijing Tianjin Tang Jin area is typical a heavy industrial economic area, in which most cities are the mining cities. The increasingly serious environment pollution and destruction of ecological environment lead to a higher social comprehensive vulnerability.

(6) Six provinces of Central Economic Zone, northern region's (such as Henan, Anhui, Shanxi) disaster comprehensive social vulnerability is higher than the South Regions' (such as Hubei, Hunan, Jiangxi). The reason is that: in Shanxi, the mainly industry is coal resources exploitation, which lead to a larger proportion of mining practitioner, so occupational risks is high. Meanwhile, because the dry farming is a majority in agricultural production, its capacity to resist natural disasters is low, which increases the society comprehensive vulnerability of Shanxi. Henan and Anhui belong to a traditional agricultural production area with complex types of natural disasters, drought and flood are frequent, ecological environment is fragile. All of those lead to an increase of the comprehensive social vulnerability (Odeku 2015).

CONCLUSION

Through the above analysis, the main conclusions drawn are as follows:

(1) Using factor analysis, the various index of natural disasters social vulnerability can be combined into four common factors, including: basic social development pattern and social security vulnerability, social stratification and population vulnerability, regional health vulnerability and disadvantaged groups' vulnerability.

(2) Four common factors are clustered by the projection pursuit to obtain the totally different spatial distribution patterns.

(3) The highest value of the comprehensive social vulnerability appeared in the areas with a developed economy, high population density, and high density of buildings.

(4) On the eastern region, the northern comprehensive vulnerability level is higher, especially in the Bohai Bay, pan Bohai area, in which most cities are the mining cities and the serious environment pollution and destruction of ecological environment is increasingly.

(5) Six provinces of Central Economic Zone, northern region's (such as Henan, Anhui, Shanxi) disaster comprehensive social vulnerability is higher than the South Regions' (such as Hubei, Hunan, Jiangxi).

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