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Regional Resilience Based on Natural Disasters

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Abstract

This paper analyses the concept of resilience, and summarizes the regional differences of recovery performances and innovations when coping with crisis. Taking flood as an example, constructing conceptual model of resilience with analytic hierarchy process (AHP) method, we get five of the most important indicators in a crisis: the government's credibility, crisis experience, medical and health level, population density and informal organization. Thereby this paper provides information support for government decision-making before and after the crisis.

Key words: Crisis; Flood; Resilience; AHP

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1. THE PROBLEM

Series of crisis indicate that China has been the age of crisis .Whether a natural disaster or sudden events, each crisis events has posed a great threat to the security and stability of our society. Among those crises, the destructive power of natural disasters on the social system is often extremely shocking. Domestic natural disasters occur more frequently, and flood is one of the most common natural disasters (Wang & Peng, 1998). In 2012, all of 31 provinces (area, city) were suffered from flood disaster, causing the direct economic loss of 267.5 billions yuan. Minister of water resources Chen Lei pointed out that many problems was exposed in the process of flood relief. For example, facilities for flood control and drainage are weak, attention to the flood prevention is insufficient, flood management lags behind, and collective consciousness is not enough. These are performance of lack of flexibility to flood disaster in areas. A macro understanding of the bear and the recovery ability of the affected area before natural disasters is beneficial to crisis prevention beforehand, rescue, and repair afterwards to develop more effective measures.

The most important core concepts in IHDP are resilience, vulnerability and adaptation (Fang & Yin, 2007). The social elasticity is used to measure comprehensive performance of the social group facing all kinds of crises. Resilience Alliance's definition of resilient region is the ability that city system can absorb the outside interference, while maintain the original features and structure and key performance (Alliance, 2007). The resilient region not only requests adjustment of itself to has ability to cope with various negative uncertainty and unexpected events, but also need to be able to transform those negative opportunities into available resources (Berkes, Colding, & Folke, 2003).

ISDR defined that resilience of organize is that a group or society's ability to stand up to the crisis, or change for a better operating to adapt to the new environment, which decided by self organization, learning and adaptation ability, including recovery ability to the state of crisis (Handmer, 2003). Therefore, resilience includes organizational performance of aspects in face of crisis: resistance, recovery, creativity (In this paper, recovery is the ability that the area with social characteristics restores in a relatively short

time, not self repair ability in long cycle of ecological system). This is the three system property what Kimhi and Shamai agreed to reflect the resilience (Maguire & Hagan, 2007) (As shown in Figure 1).

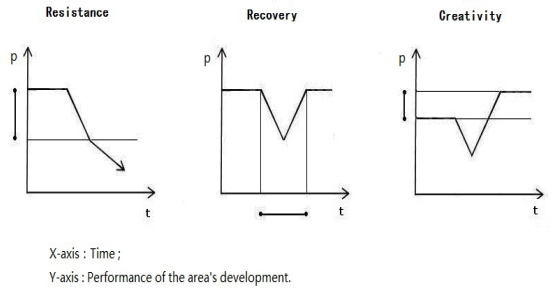

Figure 1
Resistance, Recovery, & Creativity

Resistance refers to the maximum degree of disaster that regional can withstand. As shown in the picture: compared with area which is lack of resistance, region with resistance is more difficult to be destroyed in the disaster, and have the opportunity to continue to operate in a new state. Recovery is the speed restoring to the original operation after attack. In general, the region will always restore from affected state slowly and adjust to back to original state after disaster, but length of period needed in areas with different recovery is not the same. Creativity means that the affected area not only could restore to the original state within a certain period of time, but also learn a lot and get a better operational level than before by reasonable control and guidance. Therefore, optimization of above three attributes is the main way to improve the regional social resilience.

In fact, area won't have recovery without resistance, and won't have creativity without recovery as the same. Those three should be series:

resistance→ recovery→ creativity

The former is the foundation of the latter, and the latter is expanding of the former, correct measurement of resilience's level of regions will be better to take appropriate measures to optimize itself. A measure of regional social resilience is process of value evaluation. Resources are limited during the crisis, so how to distribute available resources fairly and reasonable in the crisis is becoming the most important problem. Based on the national conditions, this paper evaluate the resilience of each region by using the information collected during period of monitoring, and study which indexes in social system can affect their performance in response to flood disaster, so then to post crisis information to support decision-making and policy recommendations.

2. THE CONSTRUCTION OF SOCIAL RESILIENCE EVALUATION SYSTEM

Measurement of social resilience needs different aspects. Resilience alliance proposed four priority areas in the study of resilient city: (a) Metabolism of city to support the city' function and promote human's health and quality of life; (b) social power including humanistic care, formation of human capital and decreasing social inequality; (c) Governance Network related to ability of social study, social adaption and self-organizing; (d) Construction of environment including entity model of the city, and interaction among them (Handmer, 2003). This actually explains is the development direction of resilient city's construction in four angles of ecology, engineering, economic and society (Leichenko, 2011). In the study of economic development's affection to crisis resilience, Buckle (2000) concluded that low income means raise of difficulty to acquire service resource, and most scholars also believe that the developed area has stronger adaptability. However, the impact of personal wealth for disaster relief operations throughout the region is not significant, and the role of economic level in response to natural disasters is mainly reflected in construction of Infrastructure, so we combine economic resilience into engineering resilience.

2.1 Ecological Resilience

The natural ecological system is the basis of society's maintenance. The role of the ecosystem in flood is mainly manifested in two aspects of vegetation and terrain. Except for windbreak, sand fixation, soil and water conservation, forest vegetation is also beneficial to climate regulation, water conservation and so on; topography can affect the range and severity of flood greatly. Tian & Liu (2006) considered that multiple factors such as coverage decreased, soil erosion, flat terrain, precipitation and forest can promote the occurrence of flood hazard.

On the other hand, there are complicated relationship between multiple regions in China, and the resource abundance of regions around also impacts on the relief action to a certain extent. Compared to center city in traffic economic belt with convenient transportation, the relatively remote areas have great difference in the agility of action from external assistance. Based on cities in or close to shaft and the economic sector along the technical relation and cooperation of production and taking incomprehensive transportation corridor as the main shaft of development, Traffic economic belt form out of industry, population, resources, information, urban, passenger and freight flow (Tian, 2006) . It can be directly measured to evaluate the capacity of receiving surrounding information and resources in a city. So we evaluate level of difficulty to acquire assistance by Traffic economic belt.

2.2 Engineering Resilience

In a macroscopic perspective, the regional engineering resilience mainly played a role in the infrastructure construction of whole area. The city infrastructure is public facilities providing general condition for not only material production, but also people's daily life, it

is the basis for the survive and development of the city (Adger, 2000) . Disaster prevention infrastructure of city includes facilities of resistance and prevention for city earthquake, flood control and drainage and flood control facilities, city's facilities for fire and civil air defense (Han, 2004). Being in a crisis, infrastructure with engineering resilience is capable of showed strong resistance, recovery and creativity. Key Link of resilient facilities system is public service departments about water, electricity, health and others, which will not only improve the emergency management during the crisis, but also is important to weak the influence of major public events. For example, the advanced medical level and complete rescue equipment play the biggest role in the relief of the "prime time". Based on the above principle, we set as the engineering resilient index about flood with firmly for buildings, sewage capacity, communication, traffic, medical and health level, the per number of lifeboats.

2.3 Social Resilience

The focal point of society is the human factor added in the whole ecosystem. Compared to the single ecosystem, social system always faced diverse and much more complex crises, and ways to solve problems are also more flexible. For example, population density determined by the larger population increased possibility of all kinds of disasters and difficulty of disaster rescue relief, but it also brings the diversity of ability and knowledge which can improve the capacity to save oneself all over the area suffered from crisis. Social resilience mainly reflects in population scale and structure, the experience and the leadership of government etc. Note that although the central government of China has a strong ability to mobilize, but the different credibility of the local government also affects leadership of the area during each period. Region with the better credibility can mobilize the masses' strength in short time, but the weaker one may act slowly (Hunter, 2006). Urgency of disaster's rescue requires improvement of higher requirements in the work of the government, so we will take the credibility of the government as an index in the regional resilience analysis system (King, 2000).

Table 1
Evaluation System of Social Resilience

First indicator	Second indicator
Ecological	Hypsography Forest cover Economic belts
Engineering	Building soundness Sewage capacity Communication Transportation Health care Survival equipment
Social	Informal organization scale Population density Aging Population quality Floating population The crisis experience Government's credibility

After analysis above, we get the evaluation system of social resilience (as shown in Table 1). Not all indexes of partial evaluation are suitable for overall evaluation model, and there is different correlation in different conditions; on the other hand, some indicators' affection on regional resilience may be chronic, persistent. This paper is mainly aimed at measures which can take effect quickly to resist and recover in a short period of time. In the case analysis, this paper will research and analysis so as to eliminate indicators of weak relativity.

3. CONSTRUCT THE MODEL AND CASE ANALYSIS

At present, the national parts of the study are limited in the crisis resistance, and haven't investigated the performance of the region to natural disasters from this perspective of recovery and creativity. Many aspects of society have themselves' resilience evaluation system, but in the period of the crisis, the indicators have to play a relatively strong and timely action. From the point of scientific, objective and operational, this paper selects 16 indexes from 3 aspects of coping ability in index system of social resilience.

3.1 Establish the Hierarchical Structure Model

Using the above selected indexes to construct the hierarchical structure model (Figure 2):

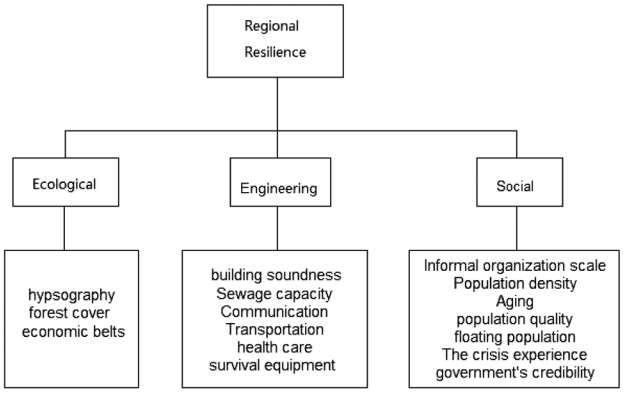

Figure 2
Regional Resilience Evaluation System for Flood

3.2 Weigh the Index by AHP Method

We take ecological resilience, engineering resilience and social resilience as primary indicators, and determine the weights of each index in system by contrast method (Data comes from the survey). Using the comparison we could get judge matrixes of first and second levels:

Table 2
Matrix of First Level

A	B1	B2	B3	w	C.R
B1	1	1/5	1/7	0.0738	
B2	5	1	1/3	0.2828	0.0559
B3	7	3	1	0.6434	

Table 3
Matrix of Second Level

B1	C1	C2	C3	w	C.R
C1	1	1/3	1/5	0.1062	
C2	3	1	1/3	0.2605	0.0559
C3	5	3	1	0.6333	

Table 4
Matrix of Engineering Resilience

B2	C4	C5	C6	C7	C8	C9	w	C.R
C4	1	3	3	2	1/3	4	0.2081	
C5	1/3	1	1	1/2	1/5	2	0.0786	
C6	1/3	1	1	1/2	1/6	2	0.0760	0.0153
C7	1/2	2	2	1	1/4	4	0.1402	
C8	3	5	6	4	1	7	0.4518	
C9	1/4	1/2	1/2	1/4	1/7	1	0.0453	

Table 5
Matrix of Social Resilience

B4	C10	C11	C12	C13	C14	C15	C16	w	C.R
C10	1	1/2	3	2	4	1/4	1/5	0.0909	
C11	2	1	4	3	5	1/3	1/5	0.1296	
C12	1/3	1/4	1	1/2	2	1/5	1/7	0.0416	
C13	1/2	1/3	2	1	3	1/5	1/7	0.0594	0.0403
C14	1/4	1/5	1/2	1/3	1	1/7	1/9	0.0273	
C15	4	3	5	5	7	1	1/3	0.2375	
C16	5	5	7	7	9	3	1	0.4137	

We can figure out the Weight of each indicator:

W = (0.0078,0.0192,0.0467,0.0589,0.0222,0.0215,0.0397,0.1278,0.0128,0.585,0.0834,0.0268,0.0382,0.0176,0.1528,0.2662)

C.R<0.1, this result is reliable.

3.3 Quantify and Standardize Indexes, and Value of Indexes Standardized Is X_i

3.4 Calculate Social Resilience by Using the Weighted Average Method

Social resilience $R_i = W_i * X_i$

Table 6
Classification of Social Resilience

Level	No resistance	Have resistance but no recovery	Have recovery but no creativity	Have reativity
Range	<0.2	0.2~0.4	0.4~0.7	>0.7

3.5 Conclusion Analysis

The weights of each index can be found in the evaluation of above flood resilience system:

$W_{16} > W_{15} > W_8 > W_{11} > W_{10} > W_4 > W_3 > W_7 > W_{13} > W_{12} > W_5 > W_6 > W_2 > W_{14} > W_9 > W_1$

CONCLUSION

We can get five indices with significant impact on social resilience: the government credibility: leadership of government, the crisis experience, level of medical and health, population density, informal organization's scale. If it is detected that index performance is weak in the stage of monitoring, we should take measures timely to improve its overall crisis resilience. After crisis, we should forecast by information, distribute resources reasonably and formulate effective policy.

Different indicators need to take different measures. To ameliorate the government public credibility, it is important to the achieve government information transparency, improve leaders' qualities and the system, strengthen interaction with the masses. During crisis, we should put the power of informal organizations in leadership and improve its ability of management for the information transmission and other works. To enhance index of crisis, it better to strengthen the crisis awareness in crisis monitoring period. Among those indexes, the informal organization is an index to consider. Informal organization is a loose group based on feelings, preferences and emotion forming in the process of common life or working, it is firstly proposed by USA management scientist Meo by the "Horthon test" (Xu, 2004). Sometime, this kind of organization can even exhibited higher cohesion than the formal organization (Li, 1997). In respect of security and compactness, we can be divide informal organizations into categories as positive, interested, destructive and negative. Destructive groups rarely appear for common aim when in crisis, the government should focus on managing and guiding the informal organization which are active or interested. If there are too few informal organizations, it should be better to increase public activity in the usual period to strengthen the links within population to reinforce the cohesion. In crisis, we should combine power of formal organization (government) and informal organizations to increase the system resilience. All regions need to take the fact condition of national area into account, and blind pursuit of index optimization and imbalance of regional operation is not desirable.

In this crisis era, having a clear picture of resistance, recovery and creativity of affected colony is beneficial to crisis departments to formulate effective policies in all periods of the crisis, which is the focal point of the research in crisis management. According to the literatures and

analysis, this paper shows that: For the greater weight and controlled indexes, we should take targeted measures and formulate policies to improve regional disaster resilient, such as the level of communication and medical care; while for indicators difficult to control, we should enhance preparations to prevent negative impact on the region, such as population density and ecological indexes. Population is the most subjective initiative indicator in social activity changes, how to use group characteristics data to survey their resilience and vulnerability is the key point in this paper. Improving resilience of areas is a process of long period, advance understanding regional resilience and "bottleneck" indicators will help adjust the area elasticity so to provide information support for the decision of the government with the limited resources and time.

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