

## **Integrated Natural Disaster Risk Management: Comprehensive and Integrated model and Chinese Strategy Choice**

Jiquan Zhang <sup>1</sup>, Norio Okada<sup>2</sup>, Hirokazu Tatano <sup>2</sup>

1. College of Urban and Environmental Sciences, Northeast Normal University, Changchun, 130024; 2. Laboratory of Natural Disaster Risk Management, Disaster Prevention Research Institute, Kyoto University, Uji, 611-0011, Kyoto, Japan

### **Abstract**

The integrated natural disaster risk management (INDRM) has become an important strategy and model in contemporary disaster management. It is a comprehensive and integrated approach that embraces the management of all types of natural disasters and all phases of the disaster management cycle, focuses on disaster hazard and vulnerability, i.e. the underlying conditions of disasters, and emphasizes a multi-level, multi-dimensional, multi-disciplinary coordination among stakeholders. This paper introduces INDRM necessity, concept and essentials and discusses its rationale and implementation strategies and countermeasures. This paper proposes the implementation strategies of INDRM in China.

**Key words:** natural disaster; natural disaster risk; integrated natural disaster risk management; natural disaster risk management countermeasures

Natural disasters are the production of variation on the earth surface. They contain characters as well as commonness and have affiliation with each other. The origins, occurrence of natural disasters, objects damaged and the damage degree etc. are complicatedly connected with nature, technique and social-economic system. With the quick development of economy, there is more and more damage caused by natural disaster. The new concept and strategy recently introduced in disaster prevention and mitigation by summarizing historical experiences of natural disaster management in the world is called the Integrated Natural Disaster Risk Management (INDRM). This concept has been introduced to mark the last decade as the International Decade for Natural Disaster Reduction (IDNDR) incorporating the International Strategy for Disaster Reduction (ISDR) with other related endeavors. The Integrated Natural Disaster Risk Management means that people can recognize and assess many kinds of natural disaster risk, and deal with the risk they may meet so as to receive the biggest safe guarantee by using the lowest cost. It is a comprehensive and integrated approach that embraces the management of all types of natural disasters and all phases of disaster management cycle, focuses on disaster hazard and vulnerability, i.e. the underlying conditions of disasters, and emphasizes a multi-level, multi-dimensional, multi-disciplinary coordination among stakeholders.. It represents a kind of philosophy and concept, a kind of basic system arrangement, a kind of integrated flow, a kind of mode and scientific method and a kind of future trend of disaster

management, so it has already been paid more attention, and thus it has become a frontier, a hotspot and an important research field of disaster science studies<sup>[1~2]</sup>. At the end of 20th Century and the beginning of 21st Century, Professor Okada Norio and Professor Tatano Hirokazu of Disaster Prevention Research Institute (DPRI), Kyoto University, proposed the definition and basic theory of INDRM which has been quickly agreed by other researchers<sup>[3~4]</sup>. At the same time, in order to widely popularize the INDRM in the world, the International Meeting on Integrated Disaster Risk Management is held in different places each year which is organized by IIASA and DPRI supported by World Bank since 2001. So far as today, it has been held in Vienna and Japan, etc. The 5<sup>th</sup> International Meeting on Integrated Disaster Risk Management will be held in Beijing. It will play an important role in promoting and enhancing integrated natural disaster risk management in China. Recently, America, Japan and other European countries are providing reasonable scientific and technological research works on assessment and management of different disaster risk on different spatial scales such as the whole country, region, province, and society. These researches allow using similar methods to assess disaster risk on different spatial scales, and using reasonable public policy and strategy to reduce vulnerability of social system. It is proposed to change the unacceptable disaster risk level to an acceptable level.

Looking at the latest researches in domestic and oversea, INDRM is relatively a new one both in theory and practice. The developed countries such as Japan, America have already adopted this concept and principle in disaster management field while the developing countries are just in initial stage<sup>[3~7]</sup>. Research on natural disaster risk assessment and management in China started a little late in 1950s, and focused on earthquake, flood, and drought. After the liberation of China, especially after taking part in the “The International Decade for Natural Disaster Reduction”, China began to pay more attention to natural disaster risk assessment and management and make some profitable research works, but until now China is still lack of the research on INDRM which becomes a barrier of integrated natural disaster risk prevention and mitigation. Therefore, in order to promote the research and application of INDRM in China, based on the foundation of other authors’ studies in the world widely, this paper introduces the necessity, concept and the essential of the integrated disaster risk management and discusses the rationales, countermeasures and implementation strategies of it. Furthermore, this paper probes into a systemic and operational framework, strategies, and practical ways to implement INDRM and proposes strategies and suggestions on implementing INDRM in China.

## **1. The essentials of integrated natural disaster risk management**

### **1.1 Formation mechanism of natural disaster risk and integrated natural disaster risk management**

Natural disaster means natural variation exceeds a certain level, and results in some damage to human and social-economic development. Natural disaster risk is defined as both the possibility of natural disaster’s occurrence and the degree of damage caused by it during the following several years. Therefore, according to the recognized definition, natural disaster risk (of a region, a family, or a person) is formed with four factors: hazard, exposure, vulnerability and emergency response and recovery capability<sup>[1~2]</sup>.  
<sup>[7~10]</sup>

Hazard represents an extreme natural event that adversely affects human life, property or activity and to the extent of causing a disaster with a certain degree of probability and severity. Generally, the higher probability and higher severity of an extreme, the higher the damage degree caused by it and the higher the natural disaster risk.

Exposure describes the number of people, and the value of property, structures and activities that will experience hazard and may be adversely impacted by them. Generally, the more number of people and

value of property exposed to hazard factors, the greater the level of loss that may be caused by them and the higher the natural disaster risk.

Vulnerability denotes the degree of resistance of the asset & population against hazard. It decides the loss degree caused by hazard. Generally, the higher the vulnerability, the greater the levels of loss that may be caused by them and the higher the natural disaster risk.

Emergency response and recovery capability denotes ability of managing natural disaster risk. It is made up of information, authority, institutions, partnerships, plans, resources and procedures of preventing and reducing natural disaster risk.

Fig.1 and Fig.2 show the relationship of components and formation mechanism of natural disaster risk respectively.

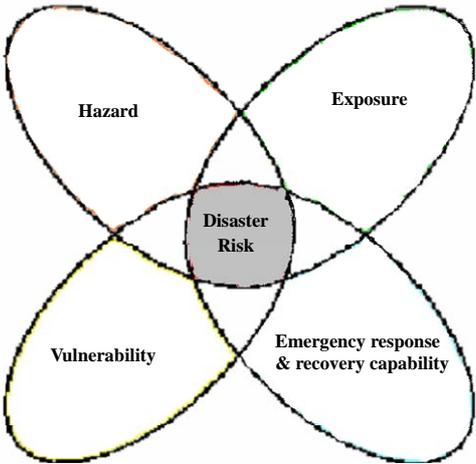


Fig.1 Three components of natural Disaster risk

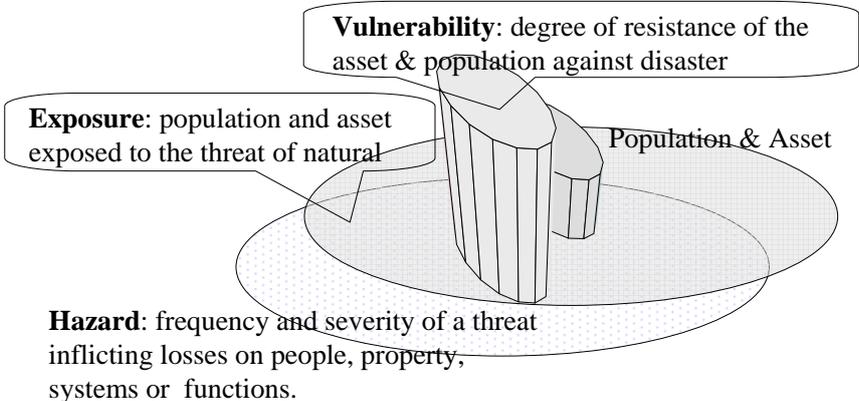


Fig.2 Formation Mechanism of Natural Disaster Risk

Therefore, natural disaster risk can be considered to be a function of hazard, exposure, vulnerability and emergency response and recovery capability. The function of it is as follows:

$$Natural\ Disaster\ Risk = f(hazard, exposure, vulnerability\ and\ emergency\ response\ and\ recovery\ capability)$$

The following formula is used to calculate natural disaster risk:

$$Natural\ Disaster\ Risk = Hazard \times Exposure \times Vulnerability \times Emergency$$

In this equation, natural disaster risk is the product of the four factors: hazard, exposure, vulnerability and emergency response and recovery capability.

Increase of exposure and delay in reducing vulnerability will cause an increased number of natural disasters and a high level of loss. To reduce disaster risk, it is important to reduce the level of vulnerability, keep the exposure away from hazard as far as possible by relocating population and property and enhancing emergency response and recovery capability

### 1.2 Dealing with the more and more natural disasters requires integrated natural disaster risk management

A number of well documented studies show that natural disasters have caused many great threats to people and their livelihood all over the world, and the number of disasters and economic damages caused by them are increasing, especially in the developing countries. As shown in Fig.3, About 4 disasters needed international assistance occurred during 1960s, while about 13 disasters needed international assistance occurred during 1990s. Comparing the 1990s to the 1960s on a global level, there is an increase of about 3.2 times in the number of disasters that need international assistance, and 8.6 times in economic damages. If the economy increase is considered, economic damages increase by 19% per year during this period. Besides, in modern society, natural disaster brings a huge damage to the society. Global disaster statistics in 1996-2000 revealed the staggering economic costs estimated at US\$ 235 billion and 425,000 lives lost (CRED International Disaster Database). Disasters caused by natural hazards affected an average of 211 million people per year in the past decade. Asia bears more from the disasters. Nearly half of the world's major natural disasters recorded occur in this region during the past three decades. As a result, Asia has become the world's most dangerous region, which has about 80 percent of the total populations affected, 40 percent of the total deaths, and 46 percent of the total economic loss (CRED statistics for 1997-2001).

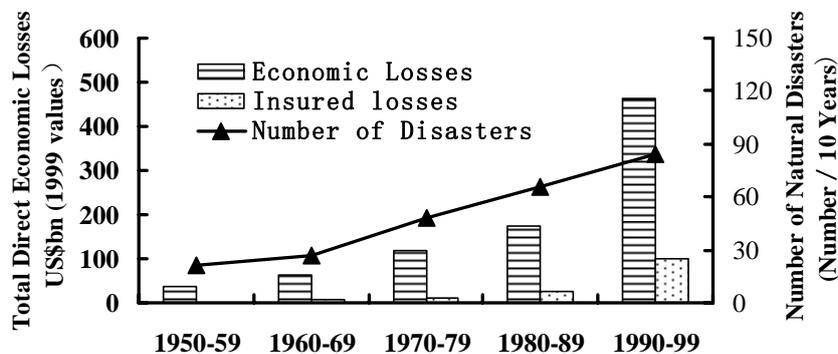


Fig. 3 Economic Losses to Numbers of Natural Disasters, 1950-1999 (Source: Munich Re, 2003<sup>[12]</sup>)

The reasons for the increase of natural disasters can be summarized as follows<sup>[12]</sup>:

- 1) Geographical location. Developing countries are particularly exposed to extreme natural phenomena.
- 2) Population explosion and urbanization.
- 3) Changes in climate and environment.
- 4) Increase of property in disaster prone regions.
- 5) Changes of the insurance density.

- 6) Development of exposed areas.
- 7) Vulnerability of modern society to disasters.
- 8) Under evaluation of hazard.
- 9) Lack of enabling disaster management approaches.

Among the reasons mentioned above, lack of effective disaster management approaches is considered to be one of the most important reasons for the increase of natural disasters.

natural disasters is not only increasing rapidly, but also presenting many new characters and tendencies: (1) Disaster is becoming a normal phenomenon instead of a single isolated event; (2) Disaster is becoming a frequent phenomenon instead of an occasional event; (3) Disaster is becoming an event that caused by multi-factors instead of an event caused by single factor; (4) Some local disasters will spread quickly, and will bring overall crisis; (5) Crisis caused by natural disasters in one country will spread to other countries at any time, even extend to the whole world.

The above characters and changing tendency of natural disaster will increase the difficulties of natural disaster management. At the same time, it represents the necessary and pressure of enhancing studies on integrated natural disaster risk management.

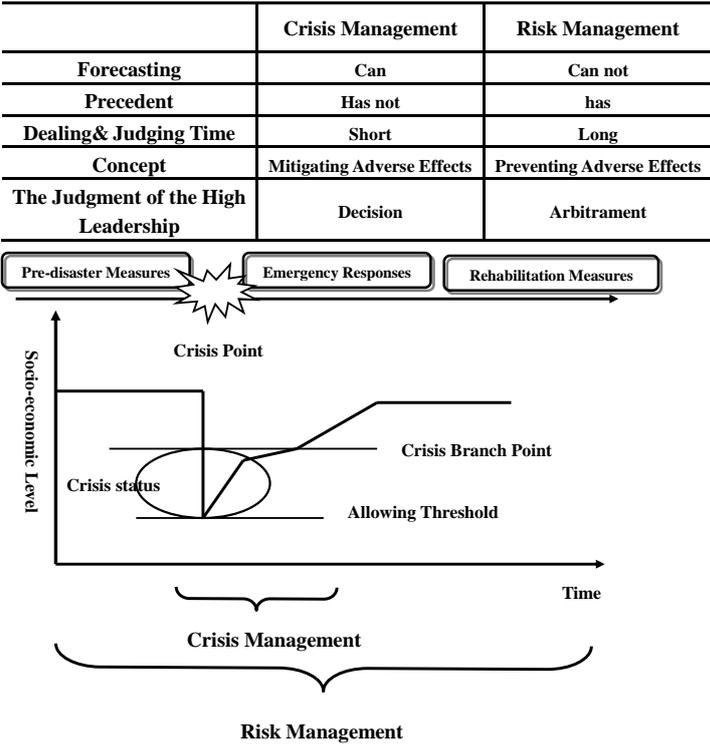
### **1.3 Improving the capacity of natural disaster management requires integrated natural disaster risk management**

For a long time, facing with so many kinds of natural disaster, people are lack of effective and operational natural disaster management approaches and modes. That's because : (1) Natural disaster has been recognized as a local and occasional event, emergency management for single disaster is controlled by only one functional department, and there is a lack of communication and coordination between disaster management departments; (2) When disaster occurs, people always deal with it by routine method and experience, which isn't based on the concept of disaster risk management in each phase of the disaster risk management cycle: Prevention/mitigation and preparedness in the pre-disaster stage, and response and rehabilitation/reconstruction in the post-disaster stage.

Because the past disaster management mainly concentrated on crisis management, which emphasizes rehabilitation/reconstruction in post-disaster stage, overlooks prevention/mitigation and preparedness in the pre-disaster stage, and the integrated disaster management capacity is not enough. Therefore, natural disasters occur frequently in our society and natural disaster risk is seldom reduced. With the enlargement of disaster impacts all over the world, people begin to pay more attention to reduce the disaster risk and make disaster risk management through the implementation of many kinds of activity in disaster reduction and response and the enhancement of management capacity and capability<sup>[13]</sup>. Systematic risk management has already been widely appreciated and applied in industrial, engineering and financial sectors. Well organized and systematic processes and procedures have been introduced in risk management to examine risks and make decisions. The innovative application of the generic methodology of risk management process to disaster management presents a new approach of understanding the nature of disasters, preventing their harmful effects, as well as seeking opportunities from their occurrences. Disaster risk management is defined as a series of actions (programs, projects and /or measures) and measures expressly aimed at reducing disaster risk of the regions which are in danger, and mitigating the extent of disasters<sup>[12]</sup>. Disaster risk management strengthens prevention/mitigation and preparedness in the pre-disaster stage to reduce the frequency of disaster, proposes effective control measures to the unavoidable disasters, and makes full preparation to deal with the disasters and reduce the damage.

Fig.4 shows the differences of crisis management and risk management of natural disaster<sup>[1-2]</sup>. From

this picture we can see that besides management method, basis, decision, etc., there are some obvious differences on management process between the crisis management and risk management of natural disaster. Crisis management focuses on the management when or after disaster occurs, while risk management contains phases of the disaster management cycle, including the risk management in the pre-disaster stage, emergency risk management during disaster and risk management of response and rehabilitation/reconstruction in post-disaster stage. It is a circulated lifecycle. Using risk management instead of crisis management and enhancing natural disaster management level to risk management level have been widely accepted by every country and scientist in the world.



**Fig.4 Comparison between Crisis Management and Risk Management of Natural Disaster**

Therefore, facing with so many kinds of natural disaster, how the government changes risk management into disaster management, constructs an integrated natural disaster management system and enhances capacity of government and society to control the disaster is a great challenge to disaster management today.

**2. The nature and objectives of integrated natural disaster risk management**

Integrated natural disaster risk management is a systemic project. It includes risk assessment, disaster prevention, mitigation and preparedness. It is used to reduce disaster comprehensively and organize all the factors contributing to risk (risk management), instead of focusing on an individual disaster. It integrates all the existed knowledge and techniques on disaster reduction and response, and risk management. This approach is to communicate these knowledge and techniques at all levels effectively and can let the governments make suitable disaster risk management for sustainable development. The INDRM approach is a viewpoint that addresses various concerns and gaps in the disaster management cycle holistically and comprehensively. And it focuses on the underlying causes of disasters, the conditions of disaster risk and

the vulnerability of the community necessarily. It also emphasizes multilevel, multidimensional and multidisciplinary cooperation and collaboration to achieve effective disaster reduction and response. This approach intends to integrate, complement, and enhance the existed disaster reduction and response strategies. Consequently, the approach promotes effective integration of stakeholders' action through multilevel, multidimensional and multi-disciplinary coordination and collaboration, and a critical strategy for improving disaster reduction and response. Also, it facilitates broad-based participation in policy and program development in disaster reduction and response as they are related to other development concerns, such as poverty reduction, land use planning, environmental protection, and food security <sup>[14-15]</sup>. Thus the INDRM concept promotes good decision-making and effective use of limited resources.

The core of integrated nature disaster risk management policy is how to optimize inherent affiliation of integrated disaster management system, and create a harmonious operation mode in natural disaster management. The main objectives of Integrated Natural Disaster Risk Management are as follows <sup>[5], [13-14]</sup>:

1) To address various concerns and gaps in different phases of disaster management cycle holistically and comprehensively by considering the underlying causes of disasters (i.e. the conditions of disaster risks) and the broad set of issues and contexts associated with disaster risk and its management.

2) To prevent, mitigate, prepare, and respond to the occurrence of disasters effectively through the enhancement of local capacity and capability, especially in disaster risk management (i.e. recognizing, managing and reducing disaster risk, and ensuring good decision-making in disaster reduction and response based on reliable disaster risk information).

3) To promote multilevel, multidimensional and multidisciplinary coordination and collaboration among stakeholders in disaster reduction and response as they ensure the participation of the community, the integration of stakeholders' action, and the best use of limited resources.

### **3. The basic meaning and principle of integrated natural disaster risk management**

Core of integrated natural disaster risk management's nature is that it is a comprehensive and integrated approach. The management system shows a kind of philosophy and theory of disaster management, a comprehensive system arrangement for comprehensive reduction in disaster risk, a level and a whole flow of disaster management and a special management approach and commanding capacity. The basic meanings of integrated natural disaster risk management are as follows <sup>[1-4, 14-16]</sup>:

1) All types of natural disasters management. There are many kinds of natural disasters people have to face. Although each disaster has different formation and different characters, they are the same in risk management. Moreover, there are some relationships between each disaster which change a single disaster to a complicated disaster. So natural disaster management has to change from a single disaster management to an integrated disaster management embracing all types of natural disasters. It includes establishing a uniformed strategy, policy, management plan, arrangement, and resource supporting system, etc. Integrated disaster management embracing all types of natural disasters can enhance the efficiency of disaster reduction and response, and cost effectiveness through sound allocation of limited resources.

2) A disaster management lifecycle. As shown in Fig.5 and Fig.6, from picture 5 and picture 6, integrated natural disaster risk management embraces phases of disaster management cycle, including routine risk management in the pre-disaster stage, emergency risk management during disaster and risk management during response and rehabilitation/reconstruction in post-disaster stage. It is a circulated lifecycle.

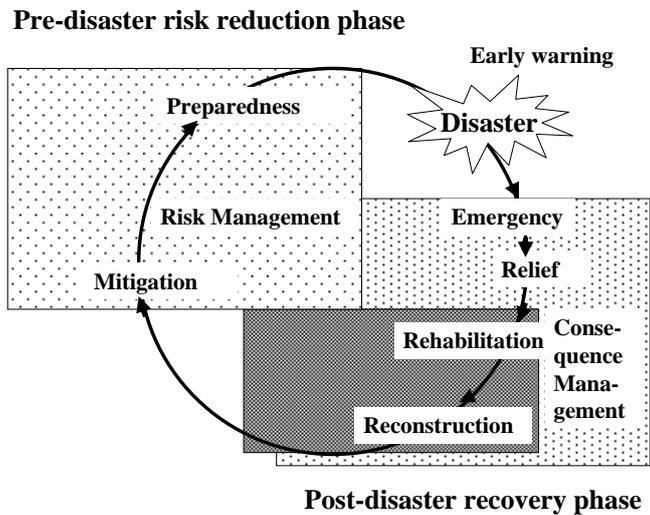


Fig.5 The Cycle of Integrated Natural Disaster Risk Management

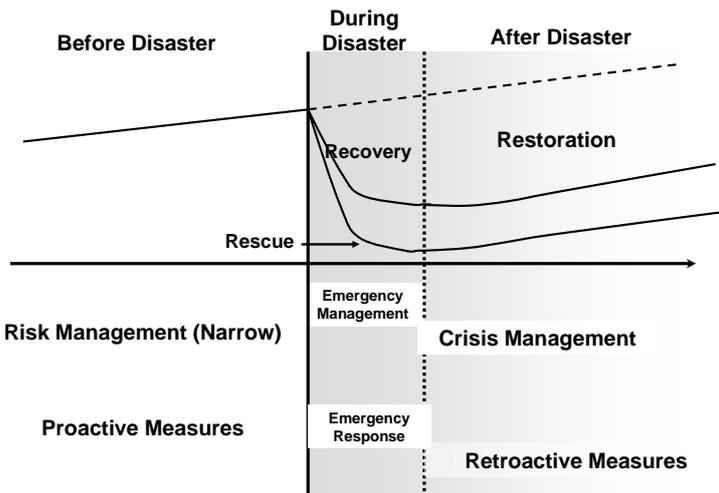


Fig. 6 The Mode of Integrated Natural Disaster Risk Management Lifecycle

3) Holistic and integrated disaster management. Total and integrated disaster management can be viewed as a series of actions (programs, projects and /or measures) and instruments expressly aimed at reducing disaster risk in endangered regions, and mitigating the extent of disasters. It integrates existed knowledge and techniques on disaster reduction and response, and risk management. It also emphasizes multilevel, multidimensional and multidisciplinary cooperation and collaboration to achieve effective disaster reduction and response. Consequently, the approach promotes effective integration of stakeholders' action through multilevel, multidimensional and multi-disciplinary coordination and collaboration, a critical strategy towards improving disaster reduction and response. Also, it facilitates broad-based participation in policy and program development in disaster reduction and response. Fig.7 shows the decision-making process for integrated natural disaster risk management. The integrated natural disaster risk management process is a process for good decision-making and ensuring the best use of limited resources. It applies the standard principles, process and techniques of risk management to natural disaster

management. The process presents a framework and systematic method for identifying and managing natural disaster risk in six systematic steps: (1) Establish natural disaster risk issues; (2) Identify natural disaster risk; (3) Analyze natural disaster risk; (4) Assess and prioritize natural disaster risk; (5) Deal with natural disaster risk and (6) Monitor, review and communicate. In general, this process helps decision-makers determine the possible outcome to disaster risk and undertake appropriate measures to control or mitigate their impact based on reliable information and the available use of risk analysis approach. In this regard, integrated natural disaster risk management promotes good disaster management practice, and therefore, should be implemented in all sectors.

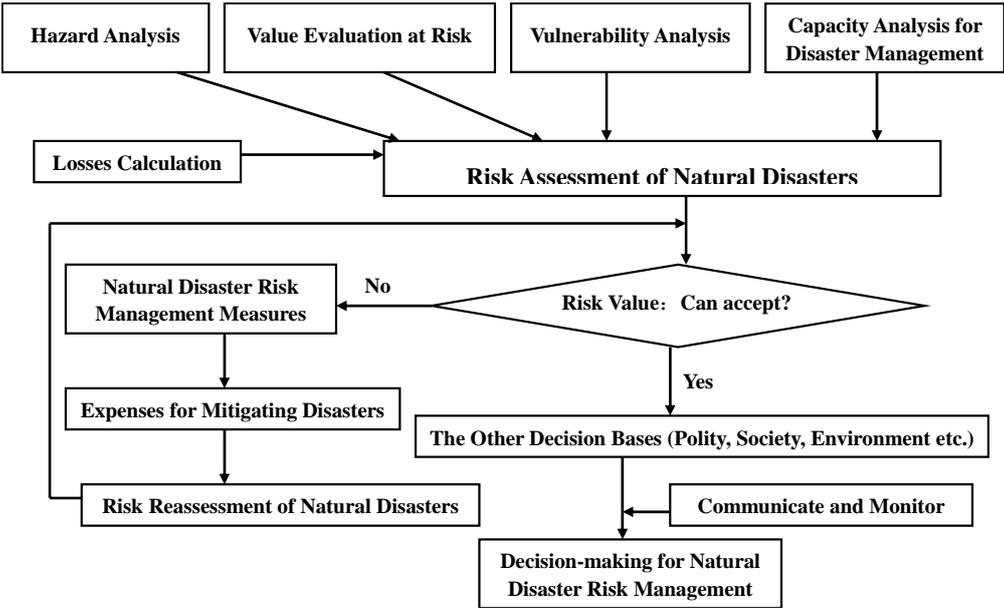
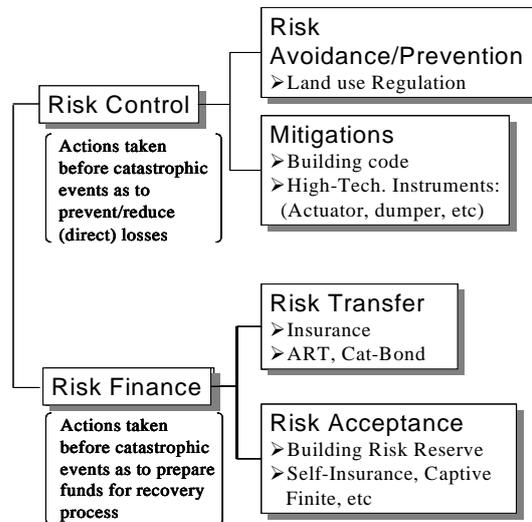


Fig.7 The Decision-making Process for Integrated Natural Disaster Risk Management

4) Performance-based disaster management. Integrated natural disaster risk management emphasizes the management based on performance. So, in order to realize the effective disaster management, the governments have to set comprehensive performance objects of disaster management.

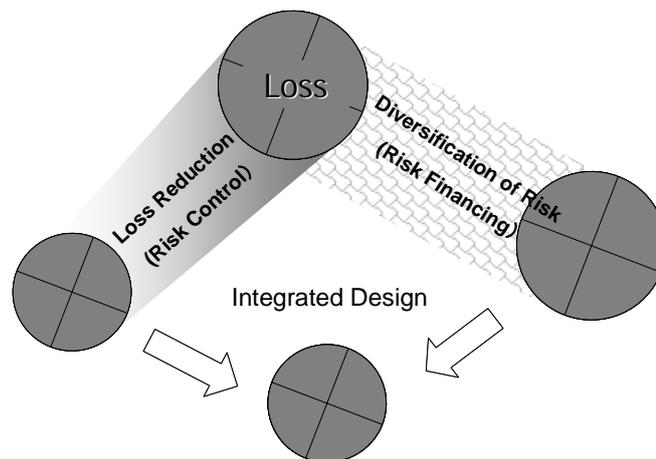
**4. The countermeasures and implementation process for integrated natural disaster risk management**

According to the theories of risk management and formation mechanism of natural disaster risk, Fig. 8 summarizes the countermeasures of integrated natural disaster risk management [7]. Generally, countermeasures for integrated natural disaster risk management are consisted with two major components: risk control strategies and risk financing options. Risk control options are divided into two categories: risk avoidance and mitigation measures. The risk avoidance measures focus on the reduction of population and properties which are exposed to hazard, e.g., land use regulation. The mitigation measures can be used for decreasing vulnerability of exposure. Risk control options can decrease damages in stocks in economy. The risk financing options are to use financial preparation for catastrophic events so as to decrease losses in production and consumption. Representative measures are insurance and alternative risk transfer (ART) measures, e.g., CAT security. The purpose of risk financing is to increase the capacity of attaining repaid recovery of economy after the disaster.



**Fig. 8 Countermeasures for Integrated Natural Disaster Risk Management**

Fig.9 shows functional mechanism and comparison of two countermeasures for integrated natural disaster risk management. From Fig.9, it can know that the risk control strategies can decrease losses and reduce risk level, while the risk financing strategies can only change risk distribution and can not decrease losses. It points out that risk control strategies and risk financing strategies have positive interactions and it is important to seek the best combination (integration) of these measures. This result requires integrated management for natural disaster risk. So the best disaster risk management approach is to integrate these nature disaster risk management countermeasures, and this is also the core content of integrated natural disaster risk management <sup>[4], [7]</sup>.



**Fig.9 Functional Mechanism and Comparison of Countermeasures for Integrated Natural Disaster Risk Management**

Fig.10 generalizes countermeasures and implementation process for integrated natural disaster risk management. The integrated natural disaster risk management contains phases of the disaster management cycle, including risk management routine in the pre-disaster stage, emergency risk management during disaster, and risk management during response and rehabilitation/reconstruction in the post-disaster stage. It

includes reducing risk before disaster, emergency response during the disaster, and restoration after disaster and relevant management countermeasures. It integrates all the contents and countermeasures of natural disaster risk management so as to achieve effective disaster prevention reduction and response and sustainable disaster reduction.

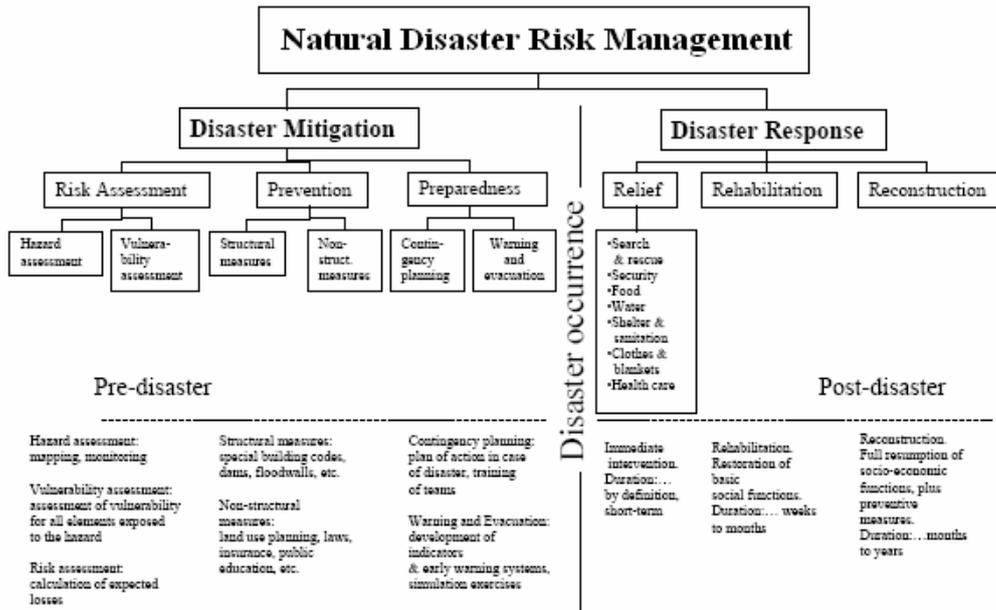
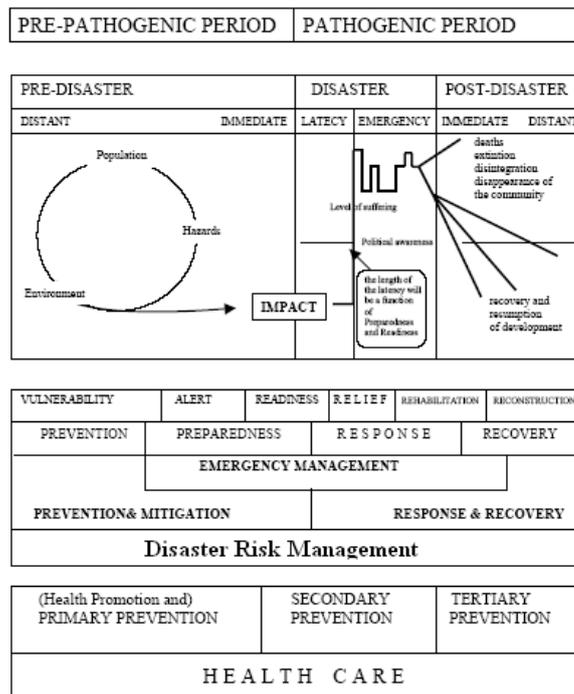


Fig.10 Countermeasures and Implementation Process for Integrated Natural Disaster Risk Management

Fig.11 shows the comparison of natural history of natural disaster with the natural disaster development continuum<sup>[17]</sup>. It indicates that disaster risk management contains all phases of natural disaster development continuum like health care of humans with whole lifecycle. So it is an effective and operational natural disaster management approach.



**Fig. 11 Comparing the Natural History of Natural Disaster with the Natural Disaster Development Continuum**

## **5. Implementation strategies of integrated natural disaster risk management**

Based on the foundation of other authors' studies and referring the latest study results in the world, the following implementation strategies of integrated natural disaster risk management are proposed:

- 1) Achieving effective disaster reduction and response through multilevel, multi-dimensional and multidisciplinary cooperation and collaboration.
- 2) Making decisions based on reliable disaster risk information from hazard mapping and vulnerability assessment.
- 3) Enhancing coordination and integration of stakeholders' action through good communication and efficient exchange of relevant and reliable information.
- 4) Ensuring that appropriate enabling mechanisms are in place, including policy, structure, capacity building, and resources.
- 5) Implementing the disaster risk management process from the national level to the community level.
- 6) Putting sustainable disaster reduction policy and integrated disaster risk management into regional plan and project construction.
- 7) Developing support tools for locals.
- 8) Consolidating existed knowledge and putting it into practice.
- 9) Establishing holistic government policies and framework.
- 10) Fostering the shift to local and regional responsibility and capability.
- 11) Striving for local consensus and a common agenda.
- 12) Bringing in the private sector and nonprofit groups.

## **6. Integrated natural disaster risk management: Chinese strategy choice**

Base on the foundation of the studies mentioned above and referring the experience of international societies and advanced counties in natural disaster management in the world, suggestions and comments for developing and enhancing integrated natural disaster risk management approach in China are proposed as follows:

1) The historical evolvement and international experiences of nature disaster management have fully verified the fundamentality and efficiency of integrated natural disaster risk management. We must recognize this change in disaster management according to actual circumstances from integrated point of view between natural science and social science. We have to build a sustainable and integrated natural disaster risk management strategy and system and integrated technological system for disaster prevention by summarizing the gains and lessons and benefit from the succeeded experiences of integrated natural disaster risk manage in the world.

2) Work over and constitute integrated natural disaster risk management policy and regulation, confirm key parts, basic framework, main contents and strategies etc. of integrated natural disaster risk management by the basic law in our country to enhance total disaster management and disaster capacity by using the reference of overseas advanced experience. The government must do a better job of coordinating and integrating disaster management policies for developing economic, social, and environmental. Furthermore, building the principles of natural disaster risk management into existed legislation should be a conscious aspect of reauthorization of ongoing programs.

3) Build a high effective and harmonious organization structures and systems of integrated natural

disaster management that facilitates and ensures coordination of stakeholders' action and contributions should be in place to ensure that appropriate enabling mechanisms are in place, including policy, structure, capacity building and resources.

4) Construct a cross-sectoral and integrated natural disaster management information system to ensure the availability and accessibility of accurate and reliable disaster risk information when required, share information, and enhance coordination and integration of stakeholders' action through good communication and efficient exchange of relevant and reliable information.

5) Strengthen development decision supporting system for natural disaster risk management and disaster prevention plan and sustain and enhance cooperation and coordination among governments, disaster researchers and public through this decision supporting system.

6) Achieve effective disaster reduction and response through multilevel, multi-dimensional and multidisciplinary cooperation and collaboration. With the immensity and complexity of the disaster problem, no stakeholder could deal with the problem alone effectively. Cooperation in disaster reduction activities among governments at national or local levels, governmental organizations and various sectors of communities are essential. The broadened participation of relevant sectors, such as environment, finance, industry, transport, construction, agriculture, education, health, media and so on, in disaster reduction activities, needs greater understanding of local vulnerabilities and risk of disasters and integration of actions of stakeholders.

7) Mobilize the whole people to participate the disaster prevention and mitigation and popularize "disaster prevention culture" and "risk management" to raise public awareness of natural disaster risk and disaster prevention, and enhance public capacity in disaster reduction and response.

## **7. Conclusions**

Recently, integrated natural disaster risk management is relatively an advanced approach and system for disaster prevention, mitigation and management, and is being paid more attention by disaster managers and researchers in the world. Moreover, it has become a frontier, hotspot and an important research field of disaster science studies. This paper discusses the rationales, countermeasures and implementation strategies of integrated natural disaster risk management based on sustainable development and systematic viewpoints. Integrated natural disaster risk management is a new concept, so this paper only proposes some cursory opinions and still needs further research.

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## **Reference**

- [1] Zhang Jiquan, Norio Okada, Hirokazu Tatano. Integrated Management on Natural Disaster Risk. *Cities and Disaster Reduction*, 2005, 2.
- [2] Zhang Jiquan, Zhao Wanzhi, Norio Okada, Hirokazu Tatano. Theories, Countermeasure and Approaches of Integrated Management on Natural Disaster Risk. *Journal of Basic Science and Engineering (supplement)*, 2004:263—271.
- [3] Okada, N. and Amendola, A. Research Challenges for Integrated Disaster Risk Management. Presentation to the first annual IIASA-DPRI Mmeeting on Integrated Disaster Risk Management: Reducing Socio-Economic Vulnerability, at IIASA, Laxenburg, Austria (Aug 1-4, 2001), 2001.

- [4] Okada, N.. Urban Diagnosis and Integrated Disaster Risk Management. Proceedings of the China-Japan EqTAP Symposium on Police and Methodology for Urban Earthquake Disaster Management on 9-10 November 2003 in Xianmen, China, 2003.
- [5] Dennis S, Mileti. *Disaster by Design: A Reassessment of Natural Hazards in the United States (Natural Hazards and Disasters)*. Washington, D.C.: Joseph Henry Press, 1999.
- [6] Togo Akatuki, Kato Takaaki and Koide Osamu. *The Disaster countermeasure system of Japan*. Beijing: China Building Industry Press, 2003.32~103.
- [7] Tatano Hiorokazu. Major Characteristics of Disaster risk and its Management strategies. *Paper Collection of Social Technology Research*, 2003, (1): 141-148.
- [8] Rachel A. Davidson, Kelly B. Lamber, Comparing the Hurricane Disaster Risk of U.S. Coastal Counties. *Natural Hazards Review*, 2001:132-142.
- [9] Jiquan Zhang, Tomoharu Hori, Hirokazu Tatano, Norio Okada, Chao Zhang and Takuya Matsumoto. GIS and Flood Inundation Model-based Flood Risk Assessment in Urbanized Floodplain, *GIS & RS in Hydrology, Water Resources and Environment, Volume 1*, Chen et al. (eds), Sun Yat-Sen University Press, 2003.
- [10] Nishikawa, S. Total Disaster Risk management for sustainable Development. Proceedings of the International Conference on TDRM on 2-4 December 2003 in Kobe, Japan, 2003.
- [11] Munich Re. Annual Review: Natural Catastrophes 2002, 2003, [http://www.munichre.com/pdf/topcs2002\\_e.pdf](http://www.munichre.com/pdf/topcs2002_e.pdf).
- [12] GTZ. Disaster Risk Management – Working Concept, GTZ GmbH, 2002.
- [13] Wilhite, Donald A., Hayes, M. J.,Knutson, Cody L. and Smith, K. H. Planning for drought: Moving from crisis to risk management[J]. *Journal of the American Water Resources Association*, 2000, 36 (4): 697-710.
- [14] Manny de Guzman. Total Disaster Risk Management Approach: Towards Effective Police Action in Disaster Reduction and Response. Regional Workshop on Total Disaster Risk Management on 7-9 August 2002 in Kobe, Japan, 2002.
- [15] Emmanuel M. de Guzman. Towards Total Disaster Risk Management Approach. Summary Report of Asian Conference on Disaster Reduction 2003--- Living with Risk: Towards Disaster Resilient Societies --- on 15-17 January 2003 in Kobe, Japan, 2003.
- [16] Chengfu Zhang. Public Emergency Management: Comprehensive and Integrated model and Chinese Strategy Choice. *Chinese Public Administration*, 2003 (7): 6-11.
- [17] WHO/EHA. Disasters & emergencies definitions, Panafrican Emergency Training Centre, Addis Ababa, 2002.