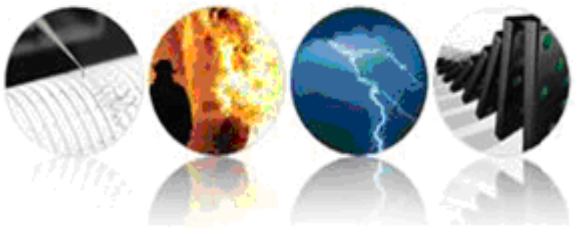

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An Integrated Large Scale Disaster Risk Governance Paradigm: Experiences and Lessons in Human Responses

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ABSTRACT

In the age of accelerated globalization and complexity of global production chains and supply chains, this paper proposes a "Consilience Model" for governments, public service units and enterprises and individuals as an integrated response to Large Scale Disasters (LSD). This integrated risk governance partnership needs to involve the United Nations, governments, corporations and businesses of different countries. In our view, the United Nations should, under the ISDR framework, formulate laws governing its response to LSD; governments of all the countries should make greater efforts to strengthen their defenses against LSD, encourage the uptake of private sector insurance and focus on improving the efficiency of disaster reduction efforts as well as increasing the national capacity of the response systems. The public service, together with research institutes and universities, need more investment in R&D into the causes of LSD. Businesses, especially the transnational enterprises, should establish a system of stockpiling goods and emergency production capacity in response to LSD. The general population needs a greater awareness of LSD risks and to be educated in behaviours that will reduce loss of life and in this way the world can be full of love and life will become bright and colorful.

INTRODUCTION

There has not yet been any international standard for Large Scale Disasters (LSD) (Shi et al, 2009a). However, there have been a number of disasters regarded as LSDs such as the Indian Ocean earthquake-tsunami in 2004, Hurricane Katrina of USA in 2005, Wenchuan earthquake in China in 2008, and the earthquake-tsunami-nuclear power plant disaster that afflicted communities in the Eastern Japan in 2011. A LSD

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will by definition cause a large number of human casualties, effect property losses and communities over a wide area (Shi, et al, 2009a), as well as creating ripple effects through global production and supply chains to impact even greater populations well beyond the directly impacted area. Examples may include the delay and cancellation of international flights, interrupted production chains or supply chains of transnational corporations and damage to the terrestrial or marine ecosystems. Hence, in the age of globalization, it is necessary to consider countermeasures, approaches and modes for integrated protection against LSD and promote the world's capacity to respond to such events. By analyzing a number of case studies in recent years and integrating the experiences and lessons of China in responding to LSDs, this article proposes a new paradigm for integrated governance against LSDs.

DISASTER-CHAINS AND LSD

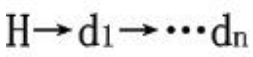
Disaster-chains and multi-hazards are often used in various references of natural disasters, but there is still no clear definition for these events (Shi et al., 2010a). Disaster chains are usually identified with a severe natural hazard event, that initiates a series of secondary disasters to form a LSD. A LSD may comprise multiple hazards occurring in one disaster-stricken region. The overlapping nature of those multiple types of hazards can usually cause more severe damages to the affected than the case of single hazard. However, disaster chains and multi-hazards are essentially different. Misuse of the two terms demands clarification for a better understanding of the relationship between disaster chains and LSD (Avouac, 2011).

Disaster chains and Multi-hazards

The difference between disaster chains and multi-hazards has been thoroughly discussed (Shi et al., 2010a). Disaster chains may take many forms, but can be categorised into two types: serial and parallel (Shi, 1991). Disaster chains differ from hazard chains. The former is the process of a series of secondary disasters triggered by one or more hazards happening in one specific geographical area, i.e. a chaining phenomenon from hazard (natural event) to disaster (losses), whereas the latter is a concurrent phenomenon of different types of hazards triggered in specific areas due to the natural processes of the earth system, e.g. drought and flood occurring in different regions due to El Nino or La Nina process. The two are common in the chaining (cascading) process in which one event triggers another event or many other events. Nevertheless, disaster-chain mainly depend on the specific geographical environment. For instance, an earthquake under the sea is likely to trigger a tsunami while an earthquake in the mountainous area is likely to initiate landfall and landslide. Hazard-chains do not depend on the specific geographical environment, but on its geo-spatial location where it is located. For instance, in the year of El Nino, China observes frequent flooding in the south and frequent drought in the north.

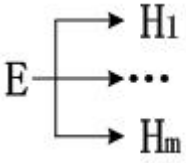
Disaster-chains are closely associated with the interconnectedness of human

systems, while hazard-chain mainly depends on the interaction among different natural elements of the earth system. In a word, disaster-chains are a process that extends from local hazard to global disaster (Figure 1). Hazard-chains are a concurrent process of multiple hazards (Figure 2). Parallel disaster-chains are closely related to hazard-chains, but need multiple hazards to trigger cascading impact series (Figure 3). For disaster chains initiated by technical accidents or public security issues, their concatenation is basically the same as natural disaster chains.



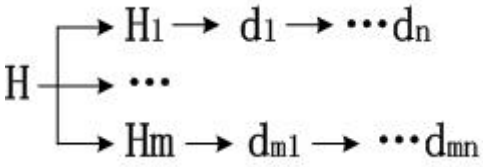
Explanation: H = hazards, d1 = primary disaster, dn = secondary disaster of nth order

Figure 1: General Structure of Disaster Chains ("Domino Effect")



Explanation: E = natural dynamic process of earth system; H1,…, Hm = primary hazards.

Figure 2: General Structure of Hazard Chains (one trigger, multiple hazards)



Explanation: E= natural dynamic process of earth system, H1,…, Hm = primary hazards, d1,dn,dm1,dmn,… = secondary disasters

Figure 3: Parallel Disaster Chains (Ripple effect)

In recent years, attention has been drawn to the study on multi-hazards and extensive concerns have been given to the comprehensive analysis of global, regional or national disasters and their risk assessment (Dilley et al., 2005). Multi-hazards are hazards occurring together in a specific region (Shi, 1991). Shi et al. (2010a) has pointed out that multi-hazards often found in transition zones on the earth surface, such as coastal transitional zones, farming-grazing transition zones (semi-arid area or Sahara zone), and outskirts of metropolitan areas (Shi et al., 2010a). Multi-hazard is a statistical concept of diversified hazard types under a specific temporal-spatial context. Generally there is no causal or triggering relationship between hazards. Disaster-chains and hazard-chains are processes with such triggering, cascading or ripple effects (Shi, 1991). They are usually the generalization of multiple disasters triggered by a severe disaster or extreme manifestation of our earth system. The study of multi-hazard mainly aims at the need of regional integrated disaster risk assessment. Researchers from EU, China, the World Bank, as well as other regions,

countries, and international organizes have successively carried out studies on multi-hazard, and some achievements have been published (Wang et al., 2006; Dilley et al., 2005).

Disaster chains and LSD

Disaster-chains triggered by a severe or enormous disaster event are generally the reason for the huge losses of LSD. Severe and enormous earthquakes on the sea floor often initiate a tsunami and create a LSD as did the Indian Ocean earthquake-tsunami in 2004 and the earthquake-tsunami of Japanese northeastern seas in 2011. Earthquakes in a mountainous areas often induce landslides, such as was the case in China with the Wenchuan Earthquake in 2008. Hurricane Katrina of USA in 2005 not only induced losses due to its wind strength, but also led to the breach of levees causing widespread flooding in New Orleans.

The rain-snow freezing Disaster in 2008 in southern part of China had an extremely complicated disaster-chain. The cold front was associated with different meteorological hazards, such as cold rain, snow, ice and freezing. Due to the topography of the Southern Hilly area, hanging ice accumulated layer by layer with the arrival of each new cold wave, until finally overwhelming the carrying capacity of the power grid, inducing large scale black-outs and the interruption of Beijing-Zhuhai Expressway and Beijing-Guangzhou Electrical Railway. This combined with peak seasonal population flows during the traditional Spring Festival of China, brought the commuting and transport system in the stricken areas to a state of paralysis. All of the above factors combined with the huge financial cost, making the entire event a LSD. From all the cases the above, it can be observed that due to the existence of the disaster-chain, the spatial extent of the impacted region may be enlarged, the intensity of hazards enhanced, until eventually a far more severe disaster eventuates to become a LSD.

In our view, the existence of multi-hazards is not a necessary condition for the formation of a LSD; only when the regional disaster prevention capacity is extremely low will it be possible to trigger a LSD.

CASE ANALYSIS OF GLOBAL RESPONSE TO LSD: EXPERIENCES AND LESSONS LEARNED

LSD response requires working on various aspects: pre-disaster preparedness, emergency response during disaster and post-disaster recovery and reconstruction. There are different ways to respond to different LSD. Countries and regions also have different modes of responding. LSD response has become a major challenge for sustainable development. In recent years, some countries have gained experience in responding to LSD, but also have learnt some extremely profound lessons.

Response to the East Japan Great Earthquake-Tsunami

Japan is an island country suffering from earthquake and tsunami. In historical times, several earthquakes have caused huge losses to the society and economy. The 7.9-magnitude earthquake hitting Japanese Kanto area on September 1, 1923 caused 99,331 death, 43,476 missing and 103,733 injured, while the fire disaster triggered by the earthquake almost burned out the whole city of Tokyo, resulting in an economic loss up to USD 30 billion (in the currency of the day). The Kobe 7.3-magnitude earthquake hit the southern region of Hyogo Prefecture on January 17, 1995 caused 6,437 deaths and more than 40,000 injured, while the fire disaster initiated by the earthquake claimed further damage, with the economic losses of up to USD 100 billion (in the currency of the day).

Given this history, Japan has attached great importance to its response to earthquake-tsunami disasters. After 1923 Kanto Earthquake, Japanese government formulated a law, requiring home construction to take into account the seismic hazard risk. After 1995 Kobe Earthquake, the Japanese government amended the Building Standard Law three times, increasing the seismic capacity for all types of buildings and requiring that office buildings in particular should be able to resist an 8-magnitude earthquake and with a Average Recurrence Interval period of more than 100 years.

Japan has always been at an advanced country in terms of its seismic shock insulation and absorption technology. It attaches great importance to national education and disaster prevention and reduction and has established a relatively complete national system for guiding behaviors that will reduce loss of life. The 1923 Kanto Earthquake is remembered with the national “Disaster Prevention Day” and the week of the “Disaster Prevention Day” has been defined as the “Disaster Prevention Week”. Every year large-scale disaster evacuation practices are held nationwide. Many of the families and employees of major companies are equipped with “disaster emergency kits” so as, in case of a disaster, to maximize the time that survivors can wait before being rescued. The Japanese government has established more than 3000 seismic monitoring stations and tsunami alarming stations, to enhance the earthquake-tsunami warning system. From the above, it may be observed that Japan responded to the 9-magnitude earthquake and the enormous tsunami disaster on March 11, 2011. Figure 4 shows the complexity of the human and ecological systems impacted by this disaster.

From a technical view, Japan did not make any long-term, short-term and pre-quake forecasting of the “3.11” earthquake. Research outcomes in the past 10 years did not identify the zone as a priority area for research and prevention. However, upon occurrence of the earthquake, it promptly published the epicenter and intensity of the quake, and forecast the arrival of tsunami, providing a powerful technical support for entire nation’s response.

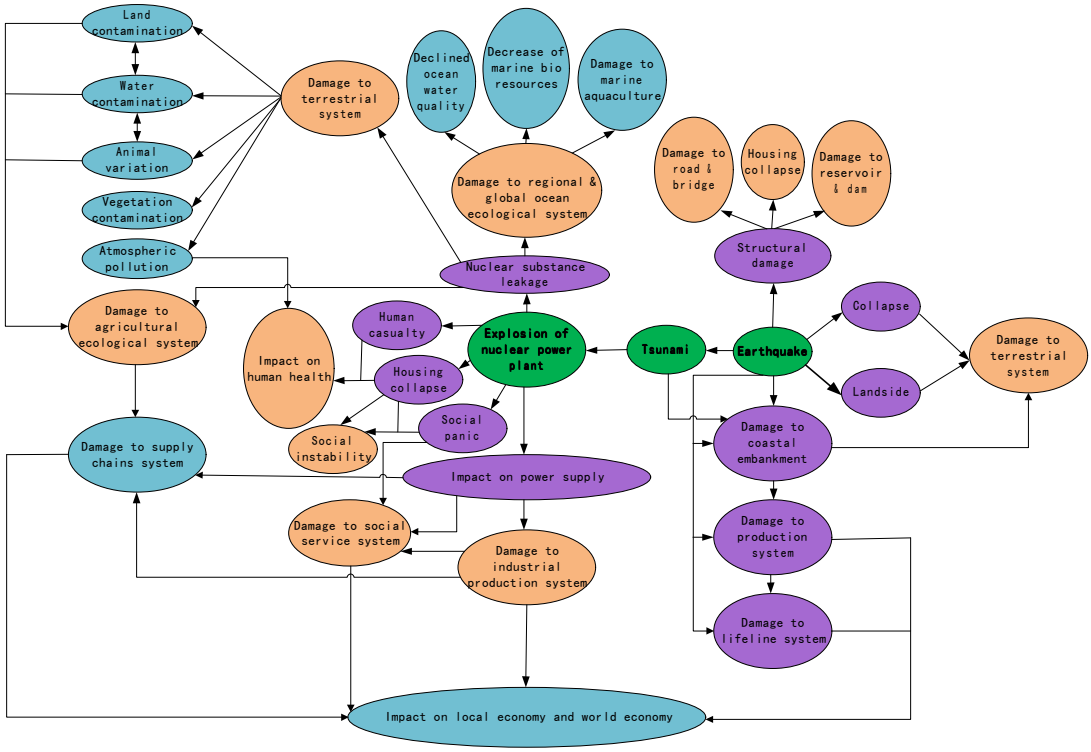


Figure 4: Earthquake - Tsunami Disaster Chain of Japan in 2011

In view of the government, except for some officials exposed by the media as delinquent, the overall response was effective. The military and relevant governmental departments were mobilized for the emergency response and efforts were made to coordinate with the enterprise and properly handle the leakage of radioactive material. All possible efforts were made to assure the supply of disaster relief goods into the disaster areas, and the supply of relevant goods for the whole society. Meanwhile, communication was maintained with the international society and adequate play was given to the role of international assistance forces in emergency handling. Through the prompt sharing of information, panic of people in the disaster areas and in the wider public was avoided. As a result of the above efforts, emergency work was competently done, and prompt undertaking of post-disaster recovery and reconstruction was ensured.

Except for Tokyo Electric Power being directly impacted by the LSD, most other enterprises responded properly in accordance with the emergency response plan during LSD. Fukushima Nuclear Power Plant under Tokyo Electric Power was severely damaged, but its employees responded actively, some risking their own lives to protect the nuclear power plant and control leakage of radioactive material from the plant. However, in responding to the LSD, Tokyo Electric Power demonstrated inadequate disaster preparedness, improper emergency response and showed an incapacity to carry out necessary post-disaster recovery and reconstruction activities, instead relying on the government to get it out of the trouble. As was exposed by the media, it is likely that the company will be acquired by the government and even have part of its enterprises declared as bankrupt due to its huge losses.

The Japanese public maintained a good consciousness of disaster prevention and reduction as well as relatively sophisticated disaster evacuation skills. In their response, they showed a good social order and public morality. The victims accepted emergency assistance goods in an orderly way. Social order was maintained in the disaster areas, and the victims of the stricken area effectively assisted each other. In some of the most-damaged areas, victims spontaneously organized themselves for emergency rescuing. When talking about the recovery and reconstruction, the victims demonstrated adequately respect for the views of scientific and technical experts, and expected a safer and better homeland to be built in the disaster areas with the support of the government, domestic society and international aid programmes.

In terms of its policies, regulations and disaster preparedness measures, emergency response and scientific efforts, Japan provides a positive example to the world in way it responds to LSDs. However, from the huge loss of life caused by the LSD, catastrophic economic losses, severe secondary disasters, and extremely difficult emergency rescue conditions, we can still learn some lessons. According to a report in the Japanese media, as by May 2, 2011, the LSD caused loss of life of 14,728 persons and 10,808 persons are still missing; the mortality being the highest in Japan since the World War II. The economic losses caused by the earthquake is estimated to be of order USD 500 billion, including the direct economic loss of more than USD 200 billion, (Shi et al., 2011a). 5 minutes after the earthquake, the Japanese Meteorological Agency posted the tsunami warning via television, radio and SMS messages on mobile phones. In the early warning, the maximum height of the tsunami was given as only 10m, but the actual height reached up to 30m according to some reports, the highest tsunami ever recorded in the history of Japan. The coastal region of East Japan was hit by tsunami waves three times.

The severity of the leakage of radioactive nuclear factor from the damaged Fukushima Nuclear Power Plant was comparable with the nuclear leakage of Chernobyl Nuclear Power Plant in the former USSR. According to the media, Fukushima No. 1 Nuclear Power Plant was built to withstand a earthquake of magnitude 7.9-magnitude. The tsunami only damaged the cooling system of the plant, but the accident was continually upgraded and eventually to 7, the most severe grade for nuclear accidents, due to delay in making decisions and improper measures. It resulted in worldwide nuclear panic and became the biggest nuclear disaster accident in the history of Japan. According to the China International Search and Rescue Team, the disaster rescue for this disaster was extremely difficult because the LSD caused severe damage to the stricken areas, most of which was submerged by the sea water, with significant destruction of infrastructure and the LSD initiated the unknown levels of leakage. Even though there were 150,000 Self Defense Forces involved in disaster response, it was still hard to meet the emergency needs for handling such a LSD effectively. Rescue organizations of several countries joined in the response. The Japanese Prime Minister, Kan Naoto, admitted, Japan had suffered from unprecedented difficulties in disaster relief.

Obviously, today when it is rather difficult for the modern science and technology to

improve on the accuracy of forecasting LSD, an effective measure is to improve the mitigation. It is urgent to pay attention to the potential huge calamities that may result from disaster chains triggered by severe or enormous disasters. The Japanese eastern old trench fault, near which the enormous earthquake occurred, had been ignored in the research projects of Japan, with profound consequences. Attention needs to given to other faults with less significant activities in recent years but which have the potential to cause LSD.

Response to China Wenchuan Earthquake-Collapse-Landslide

China is also a country with frequent earthquakes and in mountainous disasters these can generate mountainside collapses, landslide and mud-rock flows (Wang et al., 2006). In history, various earthquake LSD have brought huge losses to the country. The 7.8-magnitude earthquake in Tangshan, Hebei, on July 28, 1976 caused some 242,500 deaths, 708,000 injuries and a direct economic loss of RMB 13.275 billion (in the currency of the day). After this earthquake, the Chinese government successively strengthened special administrative agencies for earthquake and gradually improved policies and regulations for responding to these. A number scientific research institutions are now engaged in seismic research and R&D funds was enhanced for structural seismic technology. Under the guidance of UN International Decade for Natural Disaster Reduction (UN/IDNDR, 1999-2009) and UN International Strategy for Disaster Reduction (UN/ISDR, 2010—), the Chinese government has strengthened integrated disaster prevention and reduction capacity and continued to improve the institutional mechanism and legal systems for disaster response, and mobilized all the social forces needed to respond to LSDs. It was with such a background that China had successfully responded to 8-magnitude earthquake hitting Wenchuan, Sichuan, China in 2008 and the resulting landslides and debris flows (Figure 5).

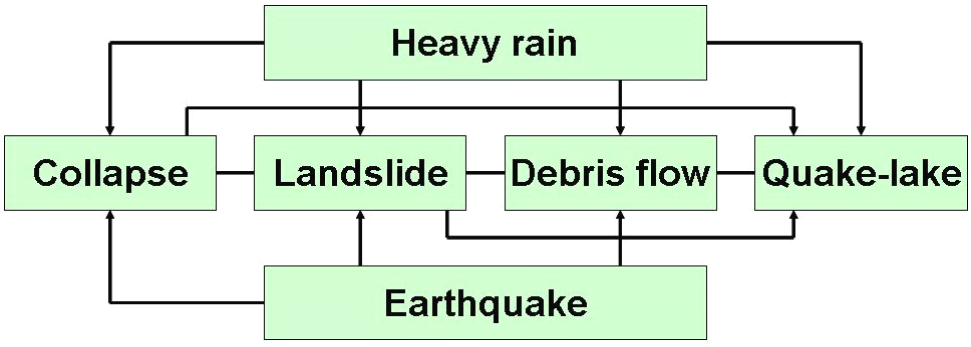


Figure 5: Earthquake Disaster Chain of Wenchuan,China in 2008

From a technical angle, in this region in the South-North seismic zone, the Ministry of Science and Technology and China Earthquake Administration had enhanced the observation and monitoring of the activity in this region and comparatively promptly published the epicenter and intensity of the earthquake. Immediately after the

earthquake, experts from various special fields nationwide were organized for an integrated assessment of this LSD, and, during the emergency period, the status of aftershocks was monitored and published, including the distribution of large-area mountainside collapses, huge landslides and other geological disasters initiated by the seismic shaking. In the meanwhile, the distribution and seismic intensity of the ground motions were promptly monitored. Other hazards were blocked rivers due to mountainside collapse, landslides and mud-rock flows in the main quake areas and such secondary disasters as barrier lakes. With a combination of field observations and remote sensing technology to monitor the disaster conditions, the consequences caused by the LSD were published in a prompt way. As of September 25, 2008, the LSD killed 87,100 persons (including those missing) and injured 375,000 persons and caused a direct economic loss of RMB 845.1 billion.

From the government perspective, the media spoke highly of the Chinese central and local governments for their response to this LSD. 2 hours after the quake, Premier Jiabao Wen left for the disaster area, actuated the national grade-I response and established the State Council Headquarters for Quake Resistance and Disaster Relief to steer the emergency rescue. The guidelines of “human-oriented” and “scientific response to LSD” were followed throughout the disaster relief period. CPC Central Committee made a decision to rescue people as the first priority and Premier Jiabao Wen emphasized repeatedly that to “save one second is to save one more life”, “as long as there is a hope, we will make all efforts” and to “spare no means and no cost”.

Under the uniform steering of the State Council Headquarters for Quake Resistance and Disaster Relief, China undertook the quake resistance and disaster relief at a rapid manner, in a widest range of mobilization and with the most input of forces in its history and thus saved many lives and minimized losses. 84,017 persons were rescued from the ruins of buildings, 1.49 million people were provided with disaster supplies and more than 4.3 million patients and injured people treated, with more than 10,000 severely injured persons promptly transferred to 375 hospitals in 20 provinces, regions and municipalities nationwide. 146,000 People’s Liberation Army officers and soldiers and armed policemen and 75,000 reserve militias participated in the rescue and recovery efforts. The government mobilized forces nationwide for quake resistance and disaster relief. Additionally, under the effective organization of the central and local governments, the recovery and reconstruction planning was promptly compiled for the severe disaster areas. By means of partner assistance, central support and input of disaster areas, within less than three years, the recovery and reconstruction of the disaster areas had been basically completed, showing again the capacity of the national response to LSD.

From the view of businesses, in the whole disaster area, almost all except for an extremely few state-owned large-scale enterprises suffered severe losses. Local infrastructure, especially the highway communications in Longmen mountain areas, was almost completely ruined. Such enormous losses reflected the high intensity of the hazard, but it also exposed the low resilience of local enterprises and infrastructures in the disaster-stricken areas. Even some large state-owned

enterprises such as the Dongfang Steam Turbine Works in the severely impacted area had almost all the workshops destroyed or damaged.

From a social perspective, the whole economic society was in a relatively backward state with a weak public consciousness for disaster prevention and reduction. Residential houses, community schools and hospitals were generally poorly constructed to withstand seismic shaking and, with this enormous LSD, a huge panic was initiated. In the capital city of Sichuan Province, Chengdu, upon experiencing aftershocks greater than magnitude 6, all people moved out of the city area, blocking all the city-exits. In the disaster area itself, the social system remained orderly not only during the emergency period, but also during the entire period of recovery and reconstruction, as has been noted by Chinese and foreign commentators. Since this severe disaster area was in an active-seismic zone in mountainous terrain, a major part of which is not suitable for human habitation, part of the disaster area had to be relocated for reconstruction. Under such circumstances, many minority peoples in the rural and forest areas of West Sichuan were unwilling to move out to live in other places and reluctant to accept the facts about the dangers. This indicates that the victims in the rural and forest regions of the disaster area had at a relatively low level of understanding of the disaster risks compared with the level of public knowledge in Japan.

From the above four aspects, it is observed that the “national response” mode formed by China in responding to LSD has been effective. It is to make use of the national forces, partner assistance, uniform leadership, organization and steering of the central government, implement a “human-oriented” and “scientific response”, and promptly participate in LSD emergency so as to minimize the disaster consequences, carry out the recovery and reconstruction at a fastest speed possible and increase the capacity of the disaster area to respond to future LSDs. For the purpose of adapting, more appropriately, to the natural risk level of the disaster area, the systems aim to adjust the spatial pattern and change industrial structures in order help the economy in the disaster area recover promptly and develop quickly. These experiences are worthy references for other countries in the world. However, from the huge human casualties, economic losses, severe secondary disasters and extremely difficult emergency rescue conditions, we can still learn lessons about responding to such LSD.

The huge damage was not only due to the seismic damage, but also was closely associated with relatively low building standards. Actually, in the mountainous areas of West Sichuan, most of residential houses had no building codes and even public facilities were mostly designed to meet a magnitude 6 earthquake. The level of insurance for enterprise properties, public property and family properties was extremely low, and out of the total direct economic losses of RMB 845.1 billion, less than 0.1% was insured. In many developed countries, this proportion could be as high as 40-44%.

GLOBAL IMPACTS OF LSD AND INTEGRATED LSD RISK GOVERNANCE PARADIGM

The development of Internet, WTO, WTN and global telecommunications and production and supply chains of transnational enterprises means that an extreme event can have potential impacts in every corner on the world. The global extent of the impacts of LSDs demands global countermeasures for LSD risk governance.

Global impacts of LSD

This is mainly shown in the following three ways:

(1) The importance of a LSD-impacted region to the global economic society and ecological system determines the range and level of its impact. A LSD hitting a big economic power even with its higher resilience and abundant resources for response and recovery may still have impact on the global economy. Hurricane Katrina of USA in 2005 not only caused a great impact on USA, but also on the countries and regions with the economic relationships with the USA, especially for the international insurance and reinsurance companies such as Swiss Reinsurance and Munich Reinsurance who underwrite risks in the disaster areas and the transnational companies with assets located in the disaster area, e.g. BP Amoco. In other hot-spot regions of the world, such as Egypt, Syria and Libya with severe social conflicts, the winter snow of 2008 worsened the lives of the public in the region, causing a huge difficulty for the international aid agencies. The leakage of radioactive nuclear factor from Fukushima Nuclear Power Plant created big impacts on the terrestrial and ocean ecological system, the ramifications of which remain hard to assess.

(2) The importance of a LSD-hit region to the global networks of transport, communication, and internet determine the global level of its impact. The Iceland Volcanic Eruption affected major parts of Europe with one of the most intensive aviation network, especially the hub airport, e.g. Heathrow Airport in UK. 60,000 flights were cancelled and millions of travellers affected. According to IATA, the loss caused by Iceland volcano event to flights amounted to 200 million USD per day. The rain/snow Freezing Disaster in Southern China 2008 led to the interruption of the most important South-North railway and road transportation artery in China – the Beijing-Guangzhou Railway and Beijing-Zhuhai Expressway - affecting vast numbers of people and interrupting the transportation of goods imported and exported through Guangzhou, causing disruption to Southeastern countries and major trade partners such as Japan, USA and EU - of China. The Taiwan Chi-chi Earthquake the interrupted the undersea cable cross the Pacific Ocean, not only affecting the communication between Mainland China and North America, but also the exchange of Internet information between Mainland China and North America.

In that year, many students in Mainland China applying for overseas study visas in North America missed the deadline for application.

(3) The importance of a LSD-hit region in the global production chains and supply chains determines the range and level of its impact. The earthquake hitting Wenchuan of Sichuan destroyed the Dongfang Steam Turbine Works, a central enterprise of China. Since it produced more than two thirds of large-scale steam turbines for power plants around the world, many power plants under construction were affected. The Earthquake-Tsunami in Japan 2011 severely damaged Japanese automobile and chemical industries along the coast, thus affecting international businesses dependent upon their production. China was severely affect by the Japanese Northeastern seas earthquake, especially those automobile and fine chemical enterprises in Shandong, Liaoning and Tianjin, with estimated losses of nearly RMB 10 billion.

In sum, the global reach of catastrophic impacts is closely associated with the importance of LSD-hit regions to the global, political, economic, social and ecological networks (Figure 6). In a globalized networked world, LSD impacts are a major hindrance for global sustainable development and it has become imperative to seek countermeasures for their integrated governance.

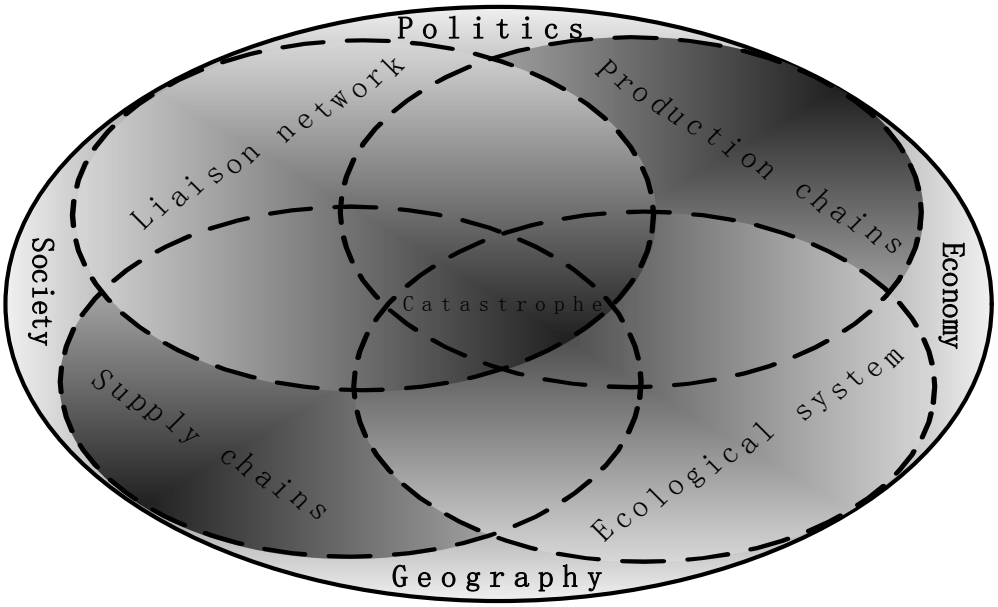


Figure 6: Global Network of Large-Scale Disaster Impact

PARADIGM FOR INTEGRATED LSD GOVERNANCE

While it has been argued that the global nature of LSD requires an integrated LSD risk governance paradigm, no consensus has been yet been reached amongst the political, industrial and economic, social and technology communities about how to do this. Generally politicians expect to be able mobilize all the social forces needed to

respond to LSDs and their main concern is how to handle a state of emergency, in order to stabilize the political situation. The industrial and economic community expect to establish risk transfer of LSD risk by establishing the public-private (inclusive of government) partnerships, and especially pre-disaster LSD insurance and reinsurance, catastrophe bonds, LSD lottery, disaster reserves and so on. The community expects governance to increase the safety level of the whole society, and show special concerns over the education and knowledge of disaster prevention and reduction and the practice of evacuation skills. The science and technology community expects to deepen its understanding of LSDs, their prediction, forecasting and warnings.

In view of the different understanding and perspectives of different groups about integrated LSD risk governance, we propose the 4D Mode of "Structural and Functional Optimization" for LSD protection (Shi, 2009b). This has three components that comprise the following actions: 1 - "establish National LSD Response Mode"; 2 -"build the warning information integration platform" and 3 - "establish the financial management system for LSD" (Shi et al., 2009a). The role of the government lies "in leading and managing the cooperation and integration of international humanitarian efforts" (Shi, 2011b), to actualize the integrated governance of LSD. For this purpose, we advocate the establishment of IHDP-IRG for integrated risk governance under the condition of global environmental changes (Shi, etal, 2010b). Based on the above, we propose the Consilience Model for LSD governance (Figure 7) (Shi, 2009b). The conceptual idea is to "condense" the political, social, economic and cultural and other core actions, and coordinate the co-operation, construction, communication and other key functions of governments, including the public service, enterprises and individuals to form the action system of an integrated system of LSD risk governance.

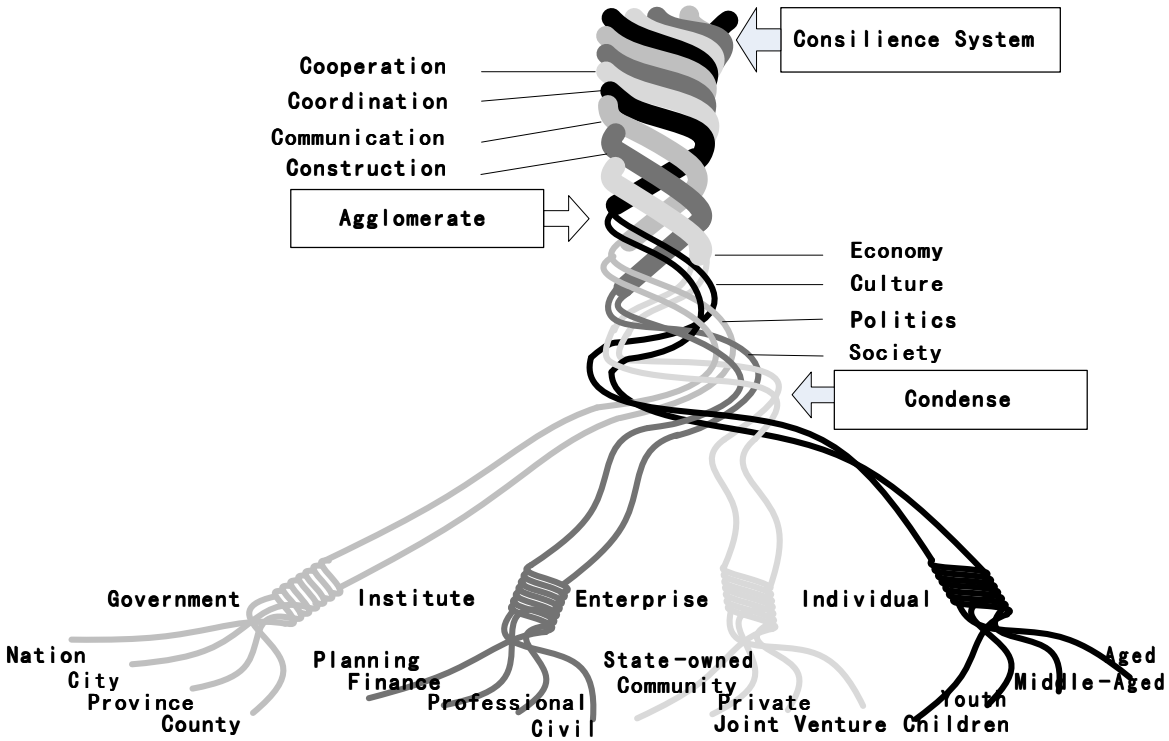


Figure7: Consilience Model for LSD Governance

Based on the above Consilience Model for integrated LSD governance, the following risk countermeasures are presented:

(1) Give full play to the rule of the United Nations, establish the global LSD governance partnership based on the current UN-ISDR framework. Starting from the actual condition of “one LSD spreading everywhere”, build the government mutual assistance system of “one for all, all for one”. At the national and local scale, establish the “national LSD response” system, and completely increase the capacity of disaster preparedness, emergency response, and recovery and reconstruction of LSD governance. In this regard, reference can be made to the experiences of China in responding to LSD, such as “partner assistance”, and “mobilize every possible resources for LSD response”.

(2) Enterprises, especially transnational corporations, after continuing to increase their prevention capacity should scientifically define their level of acceptable LSD risk, that which is controllable and the proportion of LSD risk to be transferred using insurance instruments. As for all the enterprises, the cost of risk governance should be viewed as a key cost factor.

(3) In view of public service development, especially the scientific and technical personnel of research institutes and universities engaged in disaster prevention and reduction, strengthen the in-depth studies of LSD, strive for milestone breakthroughs in such areas as prediction, forecasting and early warning systems, improving the information service delivery and developing engineering and non-engineering technologies for the betterment of mankind.

(4) Individuals, by means such as education and practice must completely embrace the consciousness for disaster prevention and reduction, master basic common knowledge about disaster prevention and evacuation proceedures, and completely cultivate a safety culture and to actualize the ideal for the world full of love and bright and colorful life.

CONCLUSIONS AND DISCUSSION

This paper demonstrated the relationship between disaster-chain and LSDs and proposes that the existence of a disaster-chain impacted by a natural disaster is the necessary and sufficient condition for a LSD. Only with an extremely high disaster mitigation level will a LSD not be initiated. A multi-hazard phenomenon is not a sufficient condition for a LSD and only with an extremely low level of resilience and mitigation efforts will it initiate a LSD .

After analyzing several case studies cases, this paper concludes that the global nature of LSD are mainly reflected in their impacts on the global networks such as transport and communication, and on production and supply chains, and on earth

ecological systems.

Only by mobilizing the initiatives in LSD risk governance will it be possible to systematically increase the world's capacity to adequately respond to LSDs. For this reason, this article proposed the Consilience Model for LSD Governance, i.e. "condensing" the political, social, economic and cultural and other core actions and aggregating the coordination, cooperation, construction and communication and other key functions of governments, public service, businesses and individuals into an integrated LSD system of governance.

In view of the global impact of LSD, we must give full play to the role of the United Nations, governments, businesses, especially transnational enterprises and individuals. The need to establish the UN Global LSD Governance Partnership is advocated to improve the international response to LSD, increase the mitigation capacity of enterprises, increase insurance participation and penetration, strengthen the study of LSD, and promote the awareness, knowledge and evacuation proceedures of the public against LSD.

For the in-depth analysis of LSD impacts and the establishment of LSD risk governance paradigm, it is still necessary to absorb the successful experience of human beings in each response to LSD and learn from the lessons of failure. It is still necessary to absorb the wisdom and talent of different nationalities and learn from the profound lessons of human beings in the history of fighting with LSD. There is need to absorb experiences in the high-efficiency mode of different countries and regions for "top-down" or "bottom-up" approaches and learn from lessons in the low-efficiency cases.

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