Coping with natural disasters through resilience

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Abstract:

The frequency of occurrence of natural disasters has increased substantially in recent years and posed tremendous challenges to those dealing with natural disaster response. However, emergency logistics, as a critical way in answering disaster relief, has not been extensively studied. The purpose of this paper is to develop an integrated perspective on emergency logistics management research by referring the concept of resilience and further distinguishing the concept as hard resilience and soft resilience. Drawing on the lessons from reviews of four cases (the Wenchuan earthquake, the Indian Ocean earthquake and tsunami, Hurricane Katrina, and the snow disasters in South China), it addresses some of the common practical gaps in emergency logistics management for proactive preparation and response to natural disasters, and it finds that there is considerable scope for the improvement of soft resilience rather than the enhancement of hard resilience, even though both are interdependent and interconnected. Potential multi-dimensional ways for complementing hard resilience with soft resilience for emergency logistics and best practice are discussed. The paper identifies the approaches and determinants for building resilience mechanism for emergency logistics, and it provides an essential element for ensuring the successful practices. It harmonizes the two fields of emergency logistics management and resilience thinking, and provides new insights into best practice for proactive preparation and response to natural disasters.

Keywords: natural disaster, soft resilience, hard resilience, emergency logistics

1. Introduction

In October 1998, Hurricane Mitch with maximum speed of 180 miles per hour swept through Central America and North America, causing at least 11,000 fatalities with 9,191 missing (University of Rhode Island, 2010). Additionally, 2.7 million or so were left homeless and property losses were estimated at over $5 billion (1998 US Dollars) (University of Rhode Island, 2010). However, most deaths were concentrated in the areas such as Honduras and Nicaragua, and there was barely any loss of life in the United States. What caused such a distinct difference? Logistics played a key role in saving life, as the communication network was much better developed in the US,
with an early warning system that allowed evacuation before the arrival of the hurricane. The transport infrastructure played a critical role in this event, as strong transport infrastructure can consolidate the logistics network and support the distribution of disaster relief supplies to the stricken areas effectively. Rapid response and extensive coverage of the logistics system can reduce the loss of life by 50% (Beaudoin, 2011).

As far as the concept of emergency is concerned, it inevitably involves such events of low probability and high impact that may spark social unrest and pose severe challenges for social risk management and response (Boin and 't Hart, 2010). Emergency logistics covers the distribution of emergency supplies to the affected areas immediately after the disaster to meet immediate needs and to ease the local tensions (Ozdamar et al., 2004), and it originates from military logistics. After World War II, scholars in the US studied American war logistics supply to see whether the same or similar principles could be applied to emergency situations in peacetime. Emergency logistics, as a special kind of logistics activities, is applied to handle unexpected disasters or sudden public events in modern time for the purpose of providing emergency supplies to achieve the maximization of time benefit and the minimization of disaster loss.

Currently, research in logistics is primarily concentrated on the business logistics mode, where the best quality of service or product can be provided at the most economical cost under normal operating conditions. Although the frequency and severity of natural disasters are growing in terms of the numbers of casualties and the scale of financial impact, the expense of response and recovery related to these events are both underestimated (Christopher and Tatham, 2011). There is an obvious less concern about emergency logistics as compared with the popular research about the business logistics. Most people failed to perceive logistics as a potential core competence for mediating the severity of the impacts resulting from natural disasters. Therefore, it is necessary to conduct in-depth studies about the issues related to emergency logistics and the means for coping with natural disasters.

Table 1 shows the deaths and economic costs arising from a number of recent global natural disasters such as earthquakes and climate related events. Natural disasters can result from a range of events, and the losses incurred depend on the vulnerability of the affected population, the location and the scale of the event, with the ability of the affected population to resist the hazard being a measure of the resilience. This paper briefly reviews the literature on emergency logistics, which is mainly concerned with the technical issues and it then comments on the need for coordinated strategies. It also focuses on the concept of resilience in both its hard and soft forms before taking four case studies from the recent disaster relief experience to illustrate these themes. The conclusions present the potential for a multidimensional approach to complement hard resilience with soft resilience in emergency logistics management and best practice, so that the severity of the consequences of natural disasters can be reduced.

*Table 1: Recent global natural disasters: earthquakes and climate related events*
<table>
<thead>
<tr>
<th>Year</th>
<th>Earthquakes</th>
<th>Number of Fatalities</th>
<th>Economic loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004</td>
<td>Indian Ocean earthquake and tsunami – Magnitude 9.0 (Section 3.2)</td>
<td>above 200,000</td>
<td>$4.45 billion</td>
</tr>
<tr>
<td>2005</td>
<td>Kashmir earthquake (Pakistan) – Magnitude 7.6</td>
<td>72,763</td>
<td>$2.3 billion</td>
</tr>
<tr>
<td>2008</td>
<td>Wenchuan earthquake (Sichuan, China) – Magnitude 8.0 (Section 3.1)</td>
<td>69,196</td>
<td>$20 billion</td>
</tr>
<tr>
<td>2010</td>
<td>Haiti earthquake – Magnitude 7.0</td>
<td>222,517</td>
<td>$14 billion</td>
</tr>
<tr>
<td>2010</td>
<td>Chile earthquake – Magnitude 8.8</td>
<td>about 700</td>
<td>$30 billion</td>
</tr>
<tr>
<td>2011</td>
<td>Tohoku earthquake and tsunami – Magnitude 9.0</td>
<td>over 13,000</td>
<td>$181 billion</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Climatic events</th>
<th>Number of Fatalities</th>
<th>Economic loss</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003</td>
<td>European summer heat wave</td>
<td>around 40,000</td>
<td>$10 billion</td>
</tr>
<tr>
<td>2005</td>
<td>Hurricane Katrina (Section 3.3)</td>
<td>1836</td>
<td>$100 billion</td>
</tr>
<tr>
<td>2008</td>
<td>South China snow disaster (Section 3.4)</td>
<td>129</td>
<td>$20.8 billion</td>
</tr>
<tr>
<td>2008</td>
<td>Cyclone Nargis, Burma</td>
<td>approximately 140,000</td>
<td>$4 billion</td>
</tr>
</tbody>
</table>

Source: Margesson (2005); Peiris et al. (2005); Xinhua News Agency (2008a, b, c); Free et al. (2009); OCHA (2010); Sheridan (2010); Nevil Gibson and agencies (2010); Moore et al. (2011); RMS (2011); Garcia-Herrera (2010); Dyson (2006); Post Nargis Knowledge Management Portal (2011).

2. The complementary hard resilience and soft resilience

Emergency management and aid in the preparation, response, and recovery operations to natural disasters are extended to their limits, because the disturbances produced turn normal conditions into chaotic ones (Holguin-Veras et al., 2007). After natural disasters, delivering critical supplies (e.g., food, water, and medical supplies) becomes an immediate and a very difficult task due to the severe destruction to infrastructures and the limited transport capacity (Holguin-Veras et al., 2007). Currently, emergency logistics has emerged as a worldwide phenomenon, as natural disasters occur at anytime with devastating consequences (Sheu, 2007a). Swift response to the emergency aid demands immediately after natural disasters is required through a combination of efficient emergency logistics distribution and coordination, so that critical disaster relief can be channelled to the affected areas, and this provides the key objective for action in emergency logistics management (Sheu, 2007b).

Emergency response to disasters cannot be carried out without properly understanding practical logistics operations, no matter how good the preparation might be, as the implementation of these plans may still not work due to intrinsic difficulties in emergency response, and due to the problems of coordination and communication between organizations (Thevenaz and Resodihardjo, 2010). In addition, the set of issues to be resolved may not be addressed by operational efforts that are popularly used in business logistics (Sheu, 2007a). The literature on crisis
management and emergency management is helpful in studying the relevant issues of emergency logistics, but many researchers seem to take an idealistic approach rather than a more realistic one (Auf der Heide, 2006; Sheu, 2007a). For example, the special issue of Transportation Research devoted to emergency logistics (2007) mainly concentrated on technological solutions and used a range of optimization methods (Chang et al., 2007; Sheu, 2007b; Yi and Kumar, 2007; Yi and Ozdamar, 2007; Balcik and Beamon, 2007), as have more recent papers (Sheu, 2010; Gao, 2010).

The elements and operations involved in emergency logistics should be considered in a holistic approach that covers “the process and systems involved in mobilizing people, resources, skills and knowledge to help vulnerable people affected by disaster” (Van Wassenhove, 2005). The process and systems are created by a wide-ranging set of actors that cooperate to deliver urgently needed goods and services to victims as a rapid response to large-scale natural disasters (Boin et al., 2010). The main actors include experienced NGOs, well-trained public organizations and volunteers that may have never worked together before (Boin et al., 2010). An effective process for emergency logistics is difficult to create and maintain (Van Wassenhove, 2005), as this involves a series of skilfully managed and closely cooperating duties: these include making an inventory for the needs of people in the disaster area, mapping the disaster-stricken areas, increasing financial allocations, procuring what is needed in the stricken area, transporting supplies to the stricken zones, and allocating the supplies to the consumers. The creation and maintenance of the emergency supporting infrastructures must be an ongoing process, since disaster events generally have the potential to break the original plan in unexpected ways (Clarke, 1999). For example, the well planned system of dikes, pump stations and canals built to shield New Orleans from flood intrusion failed to cope with Katrina Hurricane, and exhibited the weakness of the emergency management system in facing a predicted disaster. This case betrayed the lack of resilience in the wider emergency management system designed to mitigate the severity of natural disasters (Comfort et al., 2010). Moreover, the actor network in the emergency situation must act in a cooperative and mutually supportive way to be effective (Boin et al., 2010). There is also a requirement for flexibility and adaptive mechanisms that can respond to events as they happen. These essential challenges to emergency logistics management are increasingly getting attention from both practitioners and academic circles (Boin et al., 2010), and this may relate to the increasing scale and frequency of these events.

Although there have been an increasing number of papers on disaster and crisis management literature, little attention has been paid to logistics issues (Boin et al., 2010). At the same time, the scholars who study business logistics have attached little importance to the particular challenges that natural disasters pose. There is an obvious gap between emergency management and business logistics management.

One of the core issues is the effective coordination mechanisms for getting many actors to cooperate across geographical and functional borders (Stephenson, 2005). The research literature on disaster management, as well as the research findings on
humanitarian disaster response, suggests that command-and-control approaches may work for parts of the challenge (e.g. organizing logistics), but on their own they will not be enough. A more spontaneous, bottom-up type of coordination is also needed, but how to design these bottom-up mechanisms remains unclear (Boin et al., 2006 and 2010).

The perspective of resilience offers one means to study this problem, as it embraces the mechanisms by which a system can come back or resume its initial stage or state after compression, bending, etc (Blackmore and Plant, 2008). However, resilience has not been used as an operational tool to serve the policy and emergency management requirements. It has been considered as a vague overarching concept and thus causes confusion when applied in social systems, as compared with more structured physical systems.

Given the wide ranging nature of the resilience concept (Ponomarov and Holcomb, 2009), this paper divides the concept into two complementary parts,

\[
\text{Resilience} = \text{Hard resilience} + \text{Soft resilience}
\]

Where,

\[
\text{Hard resilience} = \text{Robustness} + \text{Redundancy}
\]
\[
\text{Soft resilience} = \text{Flexibility} + \text{Agility}
\]

Hard resilience is more physically oriented, and refers to (1) the physical facilities that are strong and the links between facilities that are loosely coupled to fight against outside disturbance while maintaining overall performance (Robustness); (2) they possess redundant reserve resources and facilities so that once some physical components are damaged, so that they will be timely replaced by spare components (Redundancy), similar to the spare tyre for a car (Ratick et al., 2008). The hard resilience of a system can be achieved by planning, optimization, construction, reinforcement, storing redundant resources, and it is mainly operationalized through physical or technical means (Allenby and Fink, 2005).

Soft resilience is realized through the process of risk management and emergency response, and depends on the preparation, coordination and collaboration among organizations to achieve: (1) timely communication between departments and the full range of relief organisations, including the clear and accurate identification of risk evolution, collaboration to solve problems and reduce systemic risk. This is equivalent to enhancing the flexibility of the response (Flexibility); (2) rapid response to the disaster, through quickly and accurately mobilizing important resources and effectively dispatching proper goods for critical emergency relief (Agility).

Although hard resilience and soft resilience can be seen as complementary aspects, it is crucial that they are integrated in natural disaster preparation and response. At present such complementarity in the planning and actions is not taking place for various reasons. The next section re-examines four well-known natural disasters to present lessons and reflections that may help to improve current theory and practice for harmonizing soft resilience with hard resilience in emergency logistics management, so that the costs in terms of loss of life and financial outcomes can be minimized.
3 Challenges and reflections from natural disasters
Four different examples have been selected to illustrate the different types of global natural disasters (Table 1), one an earthquake, the second and earthquake and tsunami, the third a hurricane, and the fourth a severe snow event. Each demonstrates the various short fallings of current approaches to emergency logistics management and the need for both hard and soft forms of resilience.

3.1 The Wenchuan earthquake in May 2008

The Wenchuan earthquake, measured at 8.0 on the Richter scale (Xinhua News Agency, 2008b) and occurred on May 12, in Sichuan province (China). Official figures (as of 12:00 of July 7, 2008), state that 69,196 are confirmed dead, and 374,176 injured, with 18,379 listed as missing (Xinhua News Agency, 2008c). The earthquake left about 4.8 million people homeless (Relief Web, 2008), though the number could be as high as 11 million (Hooker, 2008).

The world-known Wenchuan earthquake brought overwhelming destruction to eight provinces and cities in China, and it posed huge unexpected challenges to emergency logistics management. Road transport for major rescue delivery was handicapped by the earthquake. The sources of relief supplies for the earthquake affected area are complicated, including regional contribution, military support, state allocation and international voluntary contribution. The agents for distribution (the truck hauliers) are also diverse, including not only small and large enterprises but also the army. Tens of thousands of rescuers from all over the country rushed into disaster affected areas and this increased the difficulties for coordination of the emergency logistics, leading to chaos and delays in the rescue work.

The temporary emergency rescue plan introduced also suffered from a lack of coordination among diverse relief suppliers and rescuers. The absence of a unified action, the indeterminacy of responsibility and the lack of communication and understanding all caused adverse consequences.

A few days after the Wenchuan earthquake, the distribution of relief supplies fell into turmoil as a result of the different distribution channels and different command structures. Some relief supplies failed to be delivered in time. The lack of effective organization for emergency logistics encouraged low efficiency in distributing urgent needed goods within the golden 72 hours immediately after the disaster. The lack of professional emergency rescue personnel presented a further problem, as the lack of disaster relief experience means that some rescue work cannot be properly implemented. China's air force airdropped 2,482 tons of relief supplies into the disaster affected area in the three weeks following the Wenchuan earthquake. Although these supplies partly solved the difficulty of emergency logistics, aerial delivery failure and goods damage were unacceptably high due to the lack of experience in emergency disaster relief. These problems revealed the inexperience of China’s army in natural disaster response. In a situation of this magnitude, it is important that all parties work together so that the military and civilian logistics agencies are complemented by other more specialized transport agencies.

3.2 The Indian Ocean earthquake and tsunami in 2004 (adapted from Christopher and
Deficient telecommunication infrastructure and limited logistics capacity were highlighted in this disaster, provoking a series of issues about emergency logistics management, including the preparation and implementation of proper planning, the dissemination of crisis information, and other factors.

The earthquake and tsunami destroyed villages, roads and telecommunication infrastructure. Physical hindrances to emergency logistics after the earthquake and tsunami included a paralyzed communications network, a lack of necessary equipment to clear the debris, severe limitations on the movement of traffic and heavy flooding. These factors resulted in a chaotic situation, which meant that the delivery of basic relief aid could not match up with requirements. At the same time, the paucity of coordination resulted in oversupply, mismatch, or undersupply of certain items.

Moreover, district officials and relief workers lacked the necessary skills and they were ill-equipped in dealing with this unexpected large-scale event. A general lack of understanding and poor cooperation between and within organizations made it difficult for individual sectors to fully realize their own role in responding to the complexity of relief operation, resulting in territorial rivalry and other conflicts. These soft reliance issues led to a questioning as to whether if a similar situation occurred again, the authorities would be better prepared for it, in terms of their respond to it, so that the unfavourable consequences would be minimized. This questioning concerned whether lessons were really learned from the previous experience.

Another difficult issue covered the hugely divergent needs between one stricken area and another stricken area, and the imbalance between supply and demand of relief materials. But the wrong relief supplies were often delivered to the severely affected areas during the initial emergency response period. Thailand, for instance, received many donations of clothing (including winter clothes) from garments export corporations, which was quite improper for the initial emergency relief aid. Improper relief aid and mismatch of relief materials posed another challenge for emergency logistics management. The main requirements in disaster area include safe drinking water, food and medicines.

3.3 Hurricane Katrina in 2005 (adapted from Holguín-Veras et al. (2007))

Communication infrastructures were seriously damaged by Hurricane Katrina. About three million people were affected by power failure and interruptions to their telephone services, and the emergency information service centres were seriously damaged. Nearly 50% of the radio stations and 44% of the television stations were not functioning, and more than 50,000 utility poles were destroyed in Mississippi State alone.

The absence of a reliable telephone, television or radio network service, meant that the voice from the disaster area was hardly heard by the relief workers, and there was no effective communication within and between various relief agencies. Demand for relief goods had to be written on paper by hand, and officials did not know when or whether those demands had been satisfied.

Meanwhile, the media became the single best source of direct information as a
result of the crippled communication facilities. Many journalists were actively involved in providing and sharing critical information between disaster refugees and the authorities. The media were useful in drawing public attention and accordingly receiving more needed donations and not inappropriate materials. On the other hand, some media reports were distorted or unsubstantiated, and this resulted in a negative impact since no other information channels could be used to clarify the facts.

Despite thousands of relief volunteers, relief aid was still handicapped as a result of the lack of experience or skills. Most volunteers are unfamiliar with logistics operations and local conditions that often resulted in mismatches between supply and demand.

The absence of integrated solutions between logistics systems caused resource allocation discrepancies that led to disorder and emergency response delay. Government agencies and other NGOs established strategic accumulation spots throughout the regions attacked by Katrina. Relief supplies received from various sources in these sites were then delivered to a designated place for sorting and dispensation, so they could be allocated in time to victims. Regrettably, the relief volunteers and staff available in this period were insufficient to deal with a large stock of donations received. Moreover, it was obvious that there was shortcoming in donation planning. There were many complaints about organizers’ ignorance of urgent demand from the victims, especially those in the remote areas. The arrangement for the distribution of relief materials became a focus of the debate about the response by the many agencies to the disaster.

The relief supplies like clothing were given low-priority, and they seriously hindered other more important relief activities, such as water and food. But so much such material was delivered to the shelters and stricken areas that additional relief workers had to be sent to erect tents to sort and give out these lower-priority supplies. Serious delay in procurement accounted for the inefficient supply of important goods in the initial phase of the disaster. The delivery of medical supplies took 1 to 3 weeks as the general logistics staff were unfamiliar with the specific supplies and where best to obtain them. In some cases, the lack of skilled staff and the absence of secure purchasing protocol also contributed to this delay. The delivery of relief materials was often delayed unnecessarily due to improper purchasing protocols.

3.4 The snow disaster in South China in early 2008

“China is one of the countries suffer the most disasters in the world” (Chen et al., 2010). Frequent natural disasters pose severe challenges to the sustainable development of China’s economy and society. In boreal winters, the snow disaster has provided one of the severest meteorological events internationally and in China. The extreme low-temperature and freezing events impact negatively on industry, agriculture, transportation and other sectors, and it results in serious human and economic losses (Hui, 2009). But it seldom snows in South China, so the snow disaster in early 2008 surprised many people, and there was no experience about how to respond to the event, and as a result 129 people died. Between January 10 and February 2, 2008, there were four episodes of severe and persistent snow,
low-temperature and freezing weather in the Yangtze River basin, in the South China and South-West China regions (Shi et al., 2010). As reported by the Ministry of Civil Affairs, this severe weather was the worst experienced in the past five decades for the Southern part of the country. In most regions, the snow and freezing weather, the minimal temperatures and the economic damages broke the 57-year records (Hui, 2009). This disaster claimed 129 lives, devastated 485,000 houses and damaged about 1.67 million hectare in crops, resulting in a direct economic loss of 151.6 billion China Yuan (about 20.8 billion US dollars) (Xinhua News Agency, 2008a).

Disasters caused by the prolonged low temperatures, icy rain and heavy snow in the southern part of China also resulted in homes collapsing, power blackouts, closed highways, as well as stranding millions of passengers and destroying crops. The heavy snow broke the local electricity grid and this led to the power failure, paralyzing electric trains. At the same time, the lack of transport caused a shortage of coal and this could lead to the closure of power plants. Passengers and commodities were blocked and many industries were affected. The slow response of local government led to public resentment. Many passengers had to stay at railway stations, and the number of complaints increased, as did the level of disturbances. China’s premier Wen Jiabao visited several railway stations to placate the stranded passengers. This sequence of events illustrates the causal chain effects resulting from the severe weather, and it demonstrates the interconnectedness between the sectors and the important role that transport plays in maintaining economic activity. But the transport system itself was both affected directly (snow blockages) and indirectly (lack of power).

Under the snow disaster, relevant local government agencies had no training and they had a lack of risk awareness, and at the same time the lack of communication and collaboration. These factors resulted in crucial delays in organizing emergency logistics. In addition, the ice and snow impacted on the road and rail transport, and many logistics enterprises declined the request for emergency delivery of goods. This demonstrated their absence of corporate social responsibility. From another point of view, most distribution enterprises are scattered and small sized, and acted in their own interests and independently. Many volunteers were prevented from acting as emergency logistics helpers in this disaster.

4 Lessons and comments

The above four examples of major natural disasters in different parts of the World can be regarded as a window, from which potential common issues can be identified for emergency preparation and response. The disadvantages related to emergency logistics can be classified into two categories by referring to hard resilience and soft resilience, as shown in Table 2.

Table 2: Common disadvantages related to emergency logistics in natural disasters

<table>
<thead>
<tr>
<th>Hard aspects</th>
<th>Collapse of communication infrastructure</th>
<th>Road and rail interruptions</th>
</tr>
</thead>
</table>
Inefficient inter-organizational communication
Lack of interaction, cooperation or integration
Lack of knowledge, skill or experience
Poor management of donations
Poor management of procurement

Hard resilience is important but difficult to improve in view of the high uncertainty of natural disasters. For example, the communication networks were severely damaged by Hurricane Katrina. The U.S. communications technology industry deployed some technologies to re-establish communication lifelines during the Katrina recovery effort. But Clark (2006) investigated the response process and concluded that these technologies were actually not good enough to be counted as a successful disaster response, and argued that flexible solutions should be introduced to facilitate timely restoration of communications infrastructure. The recent Japanese earthquake and tsunami (March 2011) had severe implications for the Fukushima nuclear power plant, which was designed in accordance with the highest water flooding standard (5.7m), so the reactor and back-up diesel unit were placed at about 10~13 meters height to ensure a sufficient safety margin. However, when the tsunami came, the flood surged to a height of 14 meters, leading to flooding and the failure of the nuclear power unit. The destructive power of natural disasters may result in an overwhelming impact on any physical facilities that are designed to withstand exceptional events, but they are actually not strong enough to withstand disasters. All parts of the infrastructure may become vulnerable when faced with a devastating natural disaster, as its force is beyond imagination. It is not possible to withstand every natural disaster through only strengthening infrastructure and investing in backup facilities. As the magnitude or scope of any natural disaster is uncertain, no one knows which facilities will be impacted by the next natural disaster. In addition, the costs would be prohibitive, and this makes it less feasible to invest in the hard resilience by reinforcing each part of the infrastructure or to enhance the design criteria of facilities to deal with the unpredictability of natural disasters.

There are many more cost effective opportunities to enhance the soft resilience by “management” approaches to reduce the reliance on hard resilience in anticipating natural disasters. As stated by John Telford, the former senior emergency preparedness and response officer of United Nations High Commissioner for Refugees, “the most deadly killer in any humanitarian emergency is not dehydration, measles, malnutrition or the weather, it is bad management” (Gad-el-Hak, 2008). “Management” deserves to be the focus of soft resilience. The following section discusses seven different but related means to compensate for the lack of anticipatory action that can be taken to improve hard resilience, and the means by which a greater role can be allocated to soft resilience in the preparation stage as well as the response stage.

4.1 Potential countermeasures for collapse of communication infrastructure

In the initial emergency response phase immediately after a natural disaster,
satellite communication needs to be the first choice for use as communication lifeline. Immediate acquisition of accurate information about the disaster affected areas and swift rescue actions are critical in saving lives, and communication between the disaster affected area and the outside world is the first determinant. Satellite communication is a global communication means and can realize seamless signal coverage. It is characterized by wide coverage, flexibility and resilient to terrestrial disasters. Satellite phone is suitable for the initial emergency response due to the paralyzed communication infrastructures. Therefore, more satellite phones should be made available, together with the necessary training, before a predicted natural disaster and located in areas susceptible to natural disasters.

In the subsequent disaster relief process, urgent repairs to the mobile communications infrastructure should be a priority. Mobile communications will constitute a key demand as it will form the central core of the emergency response, as well as the central point for the command, coordination, dispatch, delivery and distribution of assistance. Although mobile communications circuitry between switchboard and base station is often connected by ground lines, the network operation can be quickly recovered through building satellite relay transmission link, which makes mobile communication more flexible in the event of any interruption. The restoration of mobile communication should be a key first step during the rescue process, and this is seen as an essential element in soft resilience (flexibility and agility).

4.2 Potential countermeasures for road interruption

Road and rail infrastructures are the backbone in building hard resilience for emergency logistics. However, the local roads are often severely damaged in most natural disasters. One way to handle this key issue is to swiftly seek alternative transport means. For instance, the Indian Ocean Tsunami wrecked about 200 km of coastline in Banda Aceh, making it inaccessible. It washed away roads and bridges, and turned the coastline into new sandbars and debris impeding the relief effort from the sea. Accordingly, the only possible access to the coastline is undertaken by helicopters or small boats (Gad-el-Hak, 2008). Similarly, Hurricane Katrina, the costliest natural disaster in American history, also devastated a large part of the transport infrastructure such as highways and bridges, and made the initial rescue and aid dependent on helicopters.

Road interruption can also be addressed through the mobilization of human capacity to act collectively and constructively in safeguarding any unblocked lifeline to the stricken area. But this depends on the damage degree of road infrastructure, stable local conditions, and the availability of human capacity and equipment. In many locations, affected areas only have one route into the villages and towns, and this raises the question about whether greater redundancy should be built into the transport system.

4.3 Potential countermeasures for inefficient inter-organizational communication

Communication may be improved through both technical and managerial ways.
On the one hand, inter-organizational communication can be greatly improved through appropriate usage of information technology. A comprehensive information management system for emergency logistics should be built based on cross-network integration of governmental public information platforms (Miao et al., 2011) to achieve reliable and effective information exchange and sharing. This can provide a common knowledge base to support collective action against threats under various disaster circumstances (Comfort, 2007). On the other hand, inter-organizational mutual communication agreements should be enacted to guarantee timely interactions.

Early involvement of various actors in the planning stage is also important in making protocols for mutual communication among key actors in both their preparations and their responses. Information sharing is imperative in providing the best available emergency response. The timeliness of information collection, analysis and dissemination by related participants are all needed to provide the necessary support for emergency response. Maxwell and Watkins (2003) have pointed out that the preparation and response phases of emergency management are both driven by information. The operation of emergency logistics needs a large amount of information related to the disaster status, the stricken people and the available resources in the face of a disaster.

The gathering of disaster information may be extremely difficult due to inaccessibility of the stricken areas in the context of damage of infrastructures, such as telecommunications and roads. For some time, only piecemeal information can be obtained by governments and relevant actors, and the initial information gained through various channels is critical, since it might offer support for further collective decisions and actions. Timely communication and information sharing among various actors should be encouraged before any major action takes place. Therefore, a set of well designed and predefined emergency communication clauses is necessary, such as rules in guiding efficient inter-organizational communication. These forms of soft resilience again encourage greater flexibility and agility in responses.

4.4 Potential countermeasures for lack of interaction, cooperation or integration

Considering the extensive involvement of the different actors, unique social capital should be developed for effective interaction and cooperation. Social capital covers the intangible social resources that come from social relationships, which, in turn, can be utilized to obtain beneficial outcomes (Bourdieu, 1986; Lin, 2001; Beaudoin, 2011). Social capital theory can be traced back to as far as the 1960s and has drawn increasing attention from the 1990s (Currie and Stanley, 2008). Three scholars, Bourdieu (1984), Coleman (1988, 1990) and Putnam (1993, 1995a, b, 2000) have contributed significantly to the foundation of social capital theory. Putnam (1993) initially utilized social capital to partly explain the discrepancy between institutional performance, governance and economy growth in Italy, and later, focused on citizen participation in the USA. Putnam defined social capital as the “features of social life—networks, norms and trust—that enable participants to act together more effectively to pursue shared objectives” (Putnam, 1995b), and this approach has been extensively used in many subsequent studies (Pelling and High, 2005).
In the context of natural disasters, social capital refers to social networks, social support and social trust (Ferlander, 2007). Yamamura (2010) has demonstrated that community social capital can reduce the damage done by natural disasters. In his article, the number of public baths was adopted as a proxy for social capital of Japanese community because public baths were used by community members from all sectors of the society as places for daily interpersonal communication in Japan. This custom makes public baths as wonderful places for communication and learning about the experiences of survival from and coping with earthquakes and hurricanes since Japan is a coastal country often affected by earthquakes and hurricanes. As a place for experience sharing and knowledge diffusion among community members, a public bath is naturally bear the function of strengthening community social network and promoting social trust, and accordingly afford support for coping with natural disasters in Japan. Yamamura found statistically significant relationships between the number of public baths in a community and the damage resulting from earthquakes and hurricanes, implying that higher levels of local social capital has a positive effect on decreasing the damage from natural disasters. Considering the potential for overwhelming destruction resulting from natural disasters and the corresponding vast obstacles and challenges facing relief organizations, social capital for emergency logistics is better represented by networks, interactions and trust more at the interorganizational level than at the interpersonal level.

Military, large-scale enterprises, NGOs and local communities are the principal actors involved in this type of social network. It is critical for related actors to be efficient and effective. The social network ties need to be strong and well developed, so that they can be maintained throughout the process in an adaptive way that aims to cultivate the capability to respond swiftly and appropriately. This is the cornerstone of emergency logistics management (Papadopoulou et al., 2011). The strong and trustworthy relationships must be established in advance (Perry, 2007), so that there is responsiveness and agility in the social network in its reaction to natural disaster. The development of corporate social responsibility and public private partnership is a feasible means by which that objective can be achieved. The collaboration between public and private sectors is considered as a win-win option. Public-private partnership may provide greater flexibility and enable participating enterprises to adapt and interact more efficiently and address the response and recovery issues that emerge in the aftermath of a natural disaster (Stewart et al., 2009). In order to ensure the smooth-running of emergency work, emergency logistics management must have a strong leading organizer. Managers at the state level supervise macroscopic flows of resources and information. The local leading agency of emergency logistics is best seen as a permanent government institution specialized in storing, transporting and distributing of relief materials.

4.5 Potential countermeasures for lack of knowledge, skill or experience

A systematic emergency training plan is needed for the successful organisation of relief work, so that relief participants can be provided with the necessary skills and experience. In addition, emergency exercises are also an indispensable part of
emergency training. The aim is to make participants understand the special conditions and to master specific requirements in extreme events, and to test how the emergency responses would successfully cope with an unexpected emergency (Holguín-Veras et al., 2007).

Natural disasters have occurred from time to time over the past decade, which have left us with many lessons and questions that are worthy of discussion. On the one hand, a specialized international organisation might be established as an agency to with the necessary knowledge and expertise to help train local managers; in addition, local managers could conceive possible disaster scenarios and design concrete training plans based on actual local conditions. Policy support and financial support for such training and exercise would be given by national government or local government.

4.6 Potential countermeasures for poor management of donations

An appropriate emergency donation plan could be made in advance to ensure the smooth progress of emergency logistics activity. This would assist in the prompt distribution of key materials, and it may reduce the chance of inessential relief materials being sent. A systematic method for the smooth delivery and distribution of “right” donations is needed. Critical information, such as what kinds of efforts are ongoing and where the decisive gaps exist between supply and demand, should be open for sharing among the media, emergency response institutions, private and voluntary sectors (Holguín-Veras et al., 2007). Adequate funding and distribution centres should be set up in major geographical regions that are vulnerable to natural disasters, and traffic channels should be set up after a large-scale natural disaster. Such centres are mainly responsible for the storage, cargo handling and repacking of relief donations. At the same time, these centres should also have “information exchange” capabilities and collect type and quantity of relief materials timely and accurately through the use of use Radio Frequency Identification Devices (RFID) for effective management of donations and feed back the information to disaster relief headquarters. The disaster relief headquarters would coordinate the supply and demand balance of relief supplies according to their importance.

4.7 Potential countermeasures for poor management of procurement

The demand for emergency relief goods is difficult to forecast or predetermine. Emergency procurement is part of a dynamic supply chain alliance led by the government in facing a devastating natural disaster. The supply chain alliance should be flexible and be able to make a quick response to emergency demand. Therefore, this alliance is better to have the foundation of long-term cooperation so as to act efficiently and swiftly. The Public Private Partnership (PPP) is a good way to build up such long-term cooperation. The government acts as the core enterprise in the supply chain. Relevant suppliers are selected and evaluated by the government. Collaborative protocols between suppliers and the government should then be enacted. The supply chain has different functions in different periods. In an ordinary period without disasters, this chain may be used for reserving material for potential usage. When a
disaster arises, the enterprises in the supply chain act according to the pre-arranged planning or the command of the government to make a sound and swift response. The enterprises can also get involved in emergency decision making as assistants or partners by using their expertise and experience.

This PPP based procurement mode means that there is a strong integration between the government and the relevant enterprises. The related enterprises centre on the command and coordination of the emergency management agency affiliated to the government to form a flexible and agile supply chain, which is characterized as the systematic coordination of key work flow. After an emergency supply task, the government should evaluate the performance of suppliers to judge the effectiveness and efficiency, and identify problems in operation for further improvement.

5 Conclusions

This paper has argued for a greater emphasis to be placed on the concepts of soft resilience when dealing with natural disasters, as reliance on only hard resilience in responding to the question of emergency logistics has severe limitations. The main points from the discussion in the previous Section are summarized in Table 3, using the same headings.

Table 3: Summary of the main points of potential countermeasures for common disadvantages related to emergency logistics

<table>
<thead>
<tr>
<th>Common disadvantages</th>
<th>Potential countermeasures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Collapse of communication infrastructure</td>
<td>Equip satellite communication; Urgent repair on mobile communication infrastructure.</td>
</tr>
<tr>
<td>Road and rail interruption</td>
<td>Seek alternative transport means; Safeguard an unblocked lifeline.</td>
</tr>
<tr>
<td>Inefficient inter-organizational communication</td>
<td>Build comprehensive information management system based on cross-network integration of governmental public information platforms; Enact inter-organizational mutual communication agreements and clauses.</td>
</tr>
<tr>
<td>Lack of interaction, cooperation or integration</td>
<td>Develop unique social capital for effective interaction and cooperation; Develop corporate social responsibility and public private partnership; Integration of government, military, enterprises, NGOs and local communities.</td>
</tr>
<tr>
<td>Lack of knowledge, skill or experience</td>
<td>Implement systematic emergency logistics training; Learn from the past experience and constitute concrete training plans as per local conditions.</td>
</tr>
<tr>
<td>Poor management of donations</td>
<td>Lay down emergency donation plan in advance; Make donation information open for sharing; Set up enough centers equipped with RFID for donation collection and distribution; Coordinate comprehensively by headquarters.</td>
</tr>
<tr>
<td>Poor management of procurement</td>
<td>Develop PPP based supply chain alliance; Constitute collaborative protocols, select and evaluate suppliers.</td>
</tr>
</tbody>
</table>

In view of many limitations in the current operation of emergency logistics under
natural disasters, resilience makes a useful intellectual and strategic contribution to find solutions for coping with those disadvantages that might happen again. It is appropriate to regard emergency logistics management as a comprehensive process that falls centrally into resilience building. With the division between hard resilience and soft resilience, there is much more opportunity for the improvement of soft resilience than the enhancement of hard resilience, although both are interdependent and interconnected. Soft resilience is seen as a promising research direction, as it views organizational strategy as a defensive mechanism. Better management can be seen as a clear advance against the disadvantages presently inherent in emergency logistics, and it provides a new perspective to for creative efforts. There are some general principles to achieve effective soft resilience:

- Education and training is an essential way of learning from the past and similar disasters to enrich the experience in coping with potentially adverse futures.
- Integration between agencies is important to collectively cope with a devastating natural disaster. In this regard, some of the main issues as discussed above are to develop interorganizational social capital, promote PPP based supply chain alliance and establish collaborative protocols.
- Communication is critical as interpersonal influence, media relations, technology showcase and interorganizational networking (Garnett and Kouzmin, 2007). Therefore, building a comprehensive information management system, based on cross-network integration of separated information platforms, and enacting interorganizational mutual communication agreements and clauses, may be the most effective way to improve communication.
- Community leadership is pivotal in the context of responding to the aftermath of natural disasters (DeChurch et al., 2011). Effective leadership often shares community members’ perspectives concerning the present, yet offer a unique and compelling vision for the future in facing with collective stress from a natural disaster. Visionary leaders who offer novel solutions to the community’s predicament will attract more followers, mobilize collective action, and effectively regulate community members’ emotions and reactions to disasters (Halevy et al., 2011).
- Investment and finance is the necessary guarantee of an effective process of action and implementation, and this means that the flexibility and agility offered by soft resilience cannot be overlooked. To maintain sustained soft resilience, the managers should understand that the nature of soft resilience is an ongoing, continuous improved process that requires ongoing support. This process involves many actors and it should be considered as a systematic operation.
- Policy packages might be helpful to support this process of effective action and implementation. The package may include education and training programs, incentive mechanisms for multi-district collaboration, preference and protocols for those organizations that are involved, together with appropriate investment and financial plan.

Climate related events and earthquakes have been used here as typical natural
disasters, but they have differences as well as similarities. Although the recommended principles and package are applicable to both, some differences still exist in emergency practice. Climate related events are usually predictable, at least in the short term and last for a few days, while earthquakes generally occur in an unexpected way. This means that more preventive measures should be carried out before the drawing near of a climate related event, while the quick response may be more demanded in the initial stage of the aftermath of an earthquake. The key elements for building soft resilience for different types of natural disasters merit further exploration and discussion.

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