UNISDR
The United Nations Office for Disaster Risk Reduction

GAR
Global Assessment Report on Disaster Risk Reduction
2013

Background Paper prepared for the Global Assessment Report on Disaster Risk Reduction 2013

Lessons Learnt From Two Unprecedented Disasters in 2011: Great East Japan Earthquake and Tsunami in Japan and Chao Phraya River flood in Thailand

Toshio Okazumi
Tadashi Nakasu
Megumi Sugimoto
Yoganath Adikari

International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO /Public Works Research Institute (PWRI)

Geneva, Switzerland, 2013

Lessons Learnt From Two Unprecedented Disasters in 2011

- Great East Japan Earthquake and Tsunami in Japan and Chao Phraya River flood in Thailand -

Toshio OKAZUMI, Tadashi NAKASU, Megumi SUGIMOTO, Yoganath ADIKARI

International Centre for Water Hazard and Risk Management (ICHARM) under the auspices of UNESCO /Public Works Research Institute (PWRI), Tsukuba, JAPAN

1. Introduction

On 13 June 2012, the UN Secretary-General's Special Representative for Disaster Risk Reduction, Margareta Wahlström, urged UN Member States to immediately address the realities of the economic and human impacts of disasters that the world has suffered since the Earth Summit 20 years ago, citing the key numbers to understand the current situations, "Over the last 20 years, it is conservatively estimated that disasters have killed 1.3 million people, affected 4.4 billion and resulted in economic losses of US$ 2 trillion. These are staggering numbers when you consider what it means in terms of missed opportunities, shattered lives, lost housing, schools and health facilities destroyed, cultural losses and roads washed away." (UNISDR, 2012)

Disaster risk reduction gained its full momentum when the Hyogo Framework for Action (HFA) for 2005-2015, first proposed and adopted at the World Conference on Disaster Reduction (WCDR) in 2005, was subsequently endorsed by the UN General Assembly (A/RES/60/195). With the plan nearing its due in 2015, the discussion for a next framework is currently underway.

In the midst of such global efforts, the year 2011 saw the unprecedented natural disaster damage in history. According to the Centre for Research on the Epidemiology of Disasters (CRED), a total of 29,782 people were killed in 302 natural disasters with an estimated damage of US$ 366 billion, an approximately 50% increase from the previous record of US$ 243 billion in 2005. In particular, much of the human and economic damages last year concentrated in high- and middle-income countries.

This paper focuses on two mega natural disasters that occurred in Asia: the Great East Japan Earthquake in March of 2011 and the Chao Phraya Floods from August to December of 2011. In a close analysis of the damage caused by each hazard, we will try to investigate why Japan had suffered such huge damages by the earthquake and tsunami although the country was thought to have a high level of protection for such hazards. In the case of the Thai floods, there were certain locations where Japanese manufacturers particularly suffered serious damages. We will also try to clarify why damages concentrated on certain locations in relation to economic incentives that Thailand had offered to attract foreign companies.

This paper also proposes potential countermeasures for mega disasters, discussing what measures are required

towards a disaster-resilient society in the future.

2. Damage by the Great East Japan Earthquake

2.1 Outline of the damage

The magnitude (M) 9.0 earthquake produced a great tsunami that killed nearly 20,000 people and wreaked destruction along the Tohoku coast of Japan in 2011. The tsunami traveled across the Pacific basin, triggering evacuations and causing severe damages in many countries; one person was killed in California, U.S., and one person in Papua Indonesia province in Indonesia. Located on the subduction zone interface off the coast of the Tohoku Region, it ruptured a 300 km-long fault extending from near the southern end of Ibaraki Prefecture to central Iwate Prefecture (Dengler and Sugimoto, 2011). It was the largest magnitude earthquake recorded in Japan in historic time, and the combined impacts of the earthquake and tsunami left 15,858 dead and 3,021 missing (Japanese metropolitan police department, 2012). Associated economic losses may approach US$ 300 billion, making it the most costly natural disaster of all time. There was thought to be fairly good knowledge on the expected sizes and locations of expected large events based on about 400 years of historical records that included M7 to 8 earthquakes in Tohoku, Japan. The seismological community was shocked by this M9 event. The highest water levels (40.1 m) at Ryouri Bay in Iwate Prefecture were the maximum ever measured in a Japanese tsunami (The 2011 Tohoku Earthquake Tsunami joint survey group, 2012). Water heights were close to or exceeded 20 m in most populated coastal communities in Iwate and northern Miyagi prefectures. The unexpected strong earthquake caused very large tsunamis that inundated coastal regions, which were probably among the best tsunami-prepared regions in the world. Tsunami inundation hazard maps and evacuation places calculated by numerical models based on M8.2 earthquake were unfortunately not very helpful to evacuate from the mega tsunamis of the time.

2.2 Issues on existing systems 2.2.1 Tsunami early warning system

The current tsunami early warning system is designed to calculate seismic magnitudes issued specifically by the Japan Meteorological Agency (JMA) within about three minutes after the occurrence of an earthquake of up to approximately M8. In case of a mega quake exceeding M8, the system will hit its calculation limit and will be no longer capable of accurate calculation (JMA, 2012).

To provide the first tsunami warning quickly, JMA proceeded with automatic calculation within three minutes based on M 7.9 and issued a warning of a 3.0-meter-high tsunami for Iwate Prefecture. Because of this underestimated tsunami height resulting from the underestimated seismic scale, many people were too late to evacuate in the coastal towns including Taro, a small town protected by the seawalls 10 meters high above sea level, which was higher than the tsunami height provided by JMA at that time. Broadband seismometers around the country hit their limits virtually at all locations and failed to provide data in time. Instead, data obtained from overseas were used to calculate moment magnitudes (Mw), but the mega tsunami had already hit the Pacific coast of the Tohoku region

when Mw8.8 was released to the press 2 hours 44 minutes after the earthquake.

2.2.2 Seawalls

Taro Town in Iwate Prefecture was protected by world-class seawalls (length: 2433m, height: 10 m above sea level). However, the tsunami caused by the M9-class earthquake destroyed the levees and devastated the town. Back in 1960, when the tsunami caused by the Chili earthquake hit the town, the levees protected the town perfectly without any victims. It has been reported that some residents may have had too much faith in the levees to evacuate in time. Another city called Kamaishi located on the Pacific coast of Iwate Prefecture was also protected by the world-class coastal levees set underwater along the bay mouth of the Kamaishi Port in addition to the 4.0-meter-high coastal levees. However, these levees, too, following the same fate as Taro's, were helplessly destroyed and let the mega tsunami continue its way over the coastal levees farther inland while washing the downtown Kamaishi away. In the post-disaster analysis, however, the bay-mouth levees did function and reduce the original tsunami height by 40% down to 8.0 m, which assumingly delayed the entry of the tsunami into the downtown area by six minutes (Port and Airport Research Institute, 2011).

Fudai Village is also a coastal community in Iwate Prefecture, but an exceptional case in this tsunami event. The Fudai water gate (height: 15.5 m) and the Otanabe seawalls have worked excellently to reduce the momentum of the tsunami. No Fudai residents were killed and all houses remained intact.

2.2.3 Tide gates

In addition to tide gates destroyed or washed away, other accidents related to tide gates have been reported since the disaster. In some cases, gates could not be closed by remote control due to power failure; in others, local fire-fighting team members took too much time in trying to close gates and were killed in action by the tsunami.

Based on these facts, local municipalities responsible for planning and implementing tsunami countermeasures decided that water gates and land-lock gates should be always kept closed, and that local fire-fighting team members are not responsible for closing gates when the arrival of tsunami is anticipated in a short period of time (Central Disaster Prevention Council, 2011) .

2.2.4 River levees

Although the current River Law clearly states floods and storm surges as hazards to cope with in river management, there is no clear definition on what to do with tsunamis in river management. In the March 2011 mega tsunami disaster, however, many cases have been reported in which the tsunami ran up in rivers and went over river levees, causing a great deal of human and property damage. Because of that, instead of planning tsunami countermeasures for each individual river, experts have proposed a new way of planning such measures by integrating river and coastal management (Ministry of Land, Infrastructure Transport and Tourism, 2011).

2.2.5 Urban development

We conducted on-site interviews with residents of Rikuzentakata City, which suffered tremendous tsunami damage, in addition to intensive literature review.

Figure 1 shows the demographic changes in Rikuzentakata after 1960, when the Chili Tsunami hit the city along with other coast areas. Comparison of the areas in the black circles reveals a rapid development of the Takata downtown area after 1960. According to demographic statistics provided by Iwate Prefecture, Rikuzentakata's population showed a 21% decrease between 1980 and 2010. On the other hand, the population of the Takata area increased from 6,461 in 1950 to 7,711 in 2005 (Iwate Survey and Statistics Section , 2012). This population increase, and hence the expansion of the Takata downtown area, reflected social conditions of the time. After the 1960 Chili tsunami disaster, tsunami protection projects were launched along with other national-land enhancement projects, thanks to rapid economic progress after the strong Isewan Typhoon Disaster in 1959. During those projects, over 5-meter-high seawalls were constructed to protect the Takata area, which accelerated the area's development.

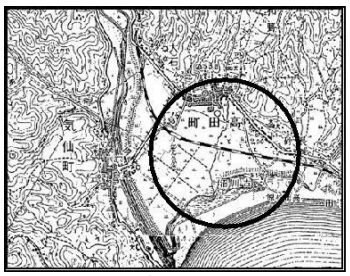

Figure 1 a. Takata area in 1952

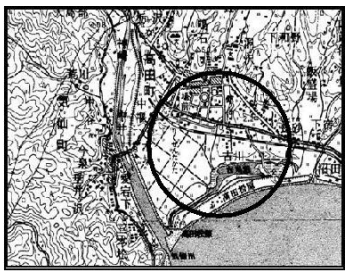

Figure 1 b. Takata area in 1968

(Yamaguchi, et al., 2011)

Based on information provided by Rikuzentakata City during our on-site investigation, the casualty rate of the downtown Takata area is 12%, which is twice as high as the second highest rate of 6% in Kesen Town. The interview comments of Takata residents coincide with these statistics and other information. The evidence from the interviews shows that the residents did not start evacuating right away, that they did not expect the tsunami to arrive so soon, and that they did not imagine the tsunami coming.

The interviews with affected local residents also revealed that the association of the initial warning on the tsunami height with their past experience delayed their evacuation. Rikuzentakata had been hit two times by tsunamis from the earthquakes in Chile; the tsunami heights were 4-5 meters high in 1960 and 1.9 meters in 2010 and did not cause serious harm to the area. Because the first warning by JMA announced the expected tsunami height being about 3 meters, many local people did not start evacuation soon enough, taking it for granted that the coming tsunami may also cause little harm to the area. The interview results clearly indicated that many people thought the tsunami would never come over the railway until they confirmed its scale with the naked eye. Most tsunami

survivors are those living on higher ground who would have a plenty of time to evacuate even if they start escaping after seeing the arrival of tsunami.

5 Analysis of damage in the Chao Phraya floods

5.1 Outline of the damage

Around the late July 2011, Tropical Strom Nock-Ten and heavy monsoon caused heavy rainfall and thus flooding from the upper northeastern part down to the central part of Thailand. Subsequently, the Chao Phraya River flooded and inundated 15 provinces of the country, killing 744 people as of December 12, 2011. (ADRC, 2012)

Damage in agriculture, manufacturing and service industries decreased the country's GDP (market value) by about 33 billion baht and its economic growth by 3.7%. Consequently, the annual GDP growth resulted in a 0.1% increase in 2011, a huge drop from the estimated growth of 3.8% (Futrakul, H. E. V., 2012). Besides these economic drops, the Chao Phraya floods drew global attention for one specific reason: the impact of the floods did not remain within Thailand but spread all over the world mainly through foreign companies and industrial complexes located at the center of the country. This section is devoted to outline economic damage, especially the chain-reaction damage, which is considered as the unique characteristic of this disaster event, including the description of damage types and responses to them based on interviews conducted in Thailand.

5.2 Economic chain-reaction damage

The 2011 Chao Phraya floods caused devastating impacts on the industrial complexes in central Thailand and manufacturers with their factories there. Table 1 shows the changes in GDP during the fourth quarter in 2011. While GDP rose by 0.7% in agriculture, it declined by 10.1% in the non-agricultural sector, resulting in a 9.0% decrease in total. The non-agricultural sector includes manufacturing, construction, and hotels and restaurants with GDP decreases of 21.8 %, 5.9% and 5.3%, respectively. This results show that the manufacturing sector was by far the most affected by the floods (Termpittayapaisith, A. , 2012).

Table.1 Thai GDP Growth Ratio (compared to the previous year's same quarter)

	2010	2011	2011			
			1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
GDP Growth Ratio	**7.8**	**0.1**	**3.2**	**2.7**	**3.7**	**-9.0**
Agriculture Sector	**-2.3**	**3.8**	**7.6**	**6.7**	**0.5**	**0.7**
Non-Agriculture Sector	**8.8**	**-0.3**	**2.8**	**2.4**	**3.9**	**-10.1**

(Termpittayapaisith, A. , 2012)

The impact of floods was particularly serious on local Japanese companies in economic terms. More specifically,

Japanese companies that based their businesses in the country earlier than others had greater damage, reportedly because many of those companies have their factories in the industrial complexes in central Thailand (Ayutthaya and Pathum Thani Provinces) that are relatively old. From October to December of 2011, well over 1,000 factories of 804 companies were inundated including 43 factories in the Saha Rattana Nakorn Industrial Estate, 198 in the Rojana Industrial Park, 143 in the Hi-Tech Industrial Estate, 89 in the Bangpa-In Industrial Estate, 572 in the Factory Land Wangnoi, 227 in the Nava Nakorn Industrial Estate, and 44 in the Bangkadi Industrial Park. Remarkably, 449 out of 804 were Japanese companies (JETRO, 2012). Japan experienced the first annual trade deficit in 2011 since 1980, supposedly in large part due to the Chao Phraya floods in addition to other economic factors (Figures 2).

Figure 2 Affected Industrial Estates and Parks

(Excerpt and alter the Figure from JETRO's Homepage)

The expansion of economic losses caused by the 2011 Thai floods is attributed to vertical specialization and a supply-chain structure on which Japanese companies have commonly relied. In most cases, Japanese manufacturers in Thailand import parts from Japan or procure them from local manufacturers, and build and export products to the global market. During the disaster last year, this vertical specialization and parts procurement system worked against them and became the principal factor for the damage to expand overseas. Thailand has been a successful case in many industries, especially cars and electronics, and thus supporting industries are also prosperous. This unfortunately has caused the rapid and broad expansion of flood damage both domestically and internationally.

The production of Hard Disk Drive (HDD) and automobile is a typical example. Thailand accounts for 43% of the

world's HDD production (Development Bank of Japan, 2012). The 2011 floods inundated HDD suppliers and factories, causing price increase and product shortages. The impacts were far-reaching throughout the world; the global production of end products requiring HDD installation, such as computers and video recorders, also decreased. In the car industry, due to its pyramid structure of supporting industries, in which the primary suppliers have over ten times more secondary and tertiary suppliers underneath, the impact of flood damages was even greater.

5.3 Historical background of settlement of Japanese companies

To identify reasons that Japanese companies chose to be in industrial complexes affected by the 2011 Thai floods, we sorted out various factors into external and internal ones. External factors include investment policies in favor of foreign companies by the Board of Investment (BOI) and the Industrial Estate Authority of Thailand (IEAT), deregulation regarding taxation and foreign workers, efforts by the Thai government to attract specific industries such as cars, and Thailand's high-quality and inexpensive labor. In addition, socio-economic conditions in Japan including Japanese youth avoiding the manufacturing industry and the strong yen are also considered as external factors. Internal (corporate) factors include the facts that the country is relatively safe and at a good location geopolitically and that people are friendly to Japanese, as well as good social and living conditions.

Historically, industrial complexes along the Chao Phraya River were developed earlier than others in the areas that used to be rice fields. Until the 1970s, industrial areas around Bangkok were confined within an approximately 50 km from the capital, and farmland lay farther outside. In the 1980s, more industrial areas were developed in five provinces around Bangkok. That was the results from efforts by the public and private sectors to attract foreign companies to Thailand by developing rice fields specifically for industrial use and by building necessary infrastructures. Consequently, industrial complexes are located in areas that used to be rice fields. Additional incentives were also provided by BOI and IEAT for foreign companies to make investment to start their businesses in Thailand.

A drastic turn took place in 1997at the Asia currency and economic crises. The Thai government started economic structural adjustment under the supervision of the International Monetary Fund (IMF), and had to address new foreign currency policy. The government deregulated the limitation of investment ratio by foreign capital and eliminated regulations on import tariff exemptions for raw and other materials. In 2001, BOI selected five target industries of agriculture and fisheries, automobile, clothing, information and communications and high-value added services and lifted investment zone regulations for certain types of business. Subsequently, BOI also designated 2008 and 2009 as the Thailand Investment Year and encouraged more investment in existing businesses related to, for example, cars and electronics to strengthen competitive edges in the industrial sector (Japanese Chamber of Commerce Bangkok, 2011).

Secondary and tertiary suppliers have also come over to Thailand and started business. Behind this corporate

decision are not only the economic incentives explained so far but also the recent trend of rising yen and a business judgment in which they think that it is better for them to move to the same location with their main business partners to continue securing strong business ties.

In May 2012, interviews were conducted to factory representatives of the Saha Rattana Nakorn Industrial Estate, the Rojana Industrial Park, the Hi-Tech Industrial Estate, the Bangpa-In Industrial Estate, the Factory Land Wangnoi, and the Nava Nakorn Industrial Estate. Many of them commonly responded that though they were aware of some flood risk, they thought that no serious flooding would ever occur in their complexes because they are located in areas previously used as rice fields.

5.4 Types of chain-reaction economic damage and countermeasures

In general, companies in a supply chain have a very strong business tie between each other based on mutual trust. In some cases, because of that, partner companies helped flood-affected companies to restore their factories and resume manufacturing as soon as possible. In particular, home appliance manufactures were under tremendous pressure, because delay in supplying end products to the market eventually means smaller shelf shares in retail stores, resulting in serious disadvantages in the market. Knowing that, in the worst case, such conditions could last for a long time, manufacturers made desperate efforts to restore their offices and factories sometimes even with help from their partners.

Our analyses found that the chain-reaction economic damage can be categorized into three types as mentioned in Figure 3.

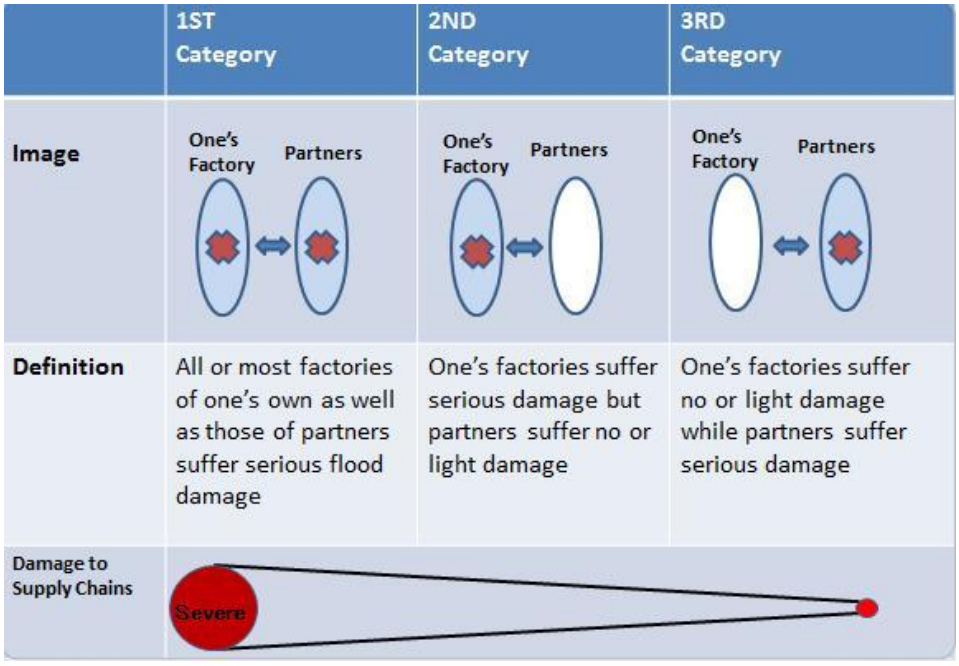

Figure 3 Categories of chain-reaction economic damage

The first category includes the most serious cases. In these cases, there will be no demand and no supply. What is possible is only to restore facilities as soon as possible. Those in this situation are required to secure sales channels for business survival, while at the same time suppliers continue working to resume manufacturing, checking progress in restoration and seeking for alternatives to supply as many parts as possible. The A corporation in the Factory Land Wangnoi, for example, took an emergency measure to continue manufacturing parts in partner factories. They took another measure to secure their business by coordinating between part suppliers and retail stores not affected by the floods.

Companies in second category responded differently. A precision instruments maker, is a case in point. This company usually imports parts from Japan, assembles products in Thailand, and ships them back to Japan. Since this regular production was no longer possible as a result of the floods, however, they sent Thai workers to Japan to have them continue doing the same work there, which then helped the corporation keep their business. The company made such a decision because their production takes special manufacturing techniques and their Thai workers are trained to be specialized in them.

In the third category, suppliers had a hard time because of huge drops in demand for their parts, thus serious sales decreases. Some companies in this situation made various efforts to minimize the impact of the floods. While waiting for regular partners to resume operation, they tried to find new partners who can use their parts and also control the production.

4 Direction of disaster countermeasure development

4.1 Enhancement of governance

Disaster risk reduction in cooperation with the private sector or led by the private sector may be effective in the process of disseminating natural disaster risk management and raising further public awareness of such risk management. However, witnessing the disasters beyond expectation caused by the mega tsunami and floods in 2011, corporate efforts are far from being sufficient to cope with such risks.

Assuming that future climate changes will bring about more intensified disasters with higher frequency, the public and private sectors need to think about how to respond to disasters beyond expectation while minimizing damage possibly caused by them.

Such efforts require the cooperation of the entire community from governments and corporations to NPOs and the general public in order to implement structural measures for securing the basic safety and to prepare response measures for minimizing damage even if the scale of a disaster exceeds the level of the safety secured by structures.

A global viewpoint is also important to address disasters beyond expectation adequately, because, as the Thai floods

have taught us lessons, damage to some factories will affect other factories in the same supply chain and also because disaster damage today will hardly end as just damage to local factories in one country but easily spread all over the world in this increasingly globalized economy.

4.2 Disaster risk management as social efforts

4.2.1 Collaboration among people, NPOs and corporations

Corporations are a member of society, and thus instead of merely enjoying public support they are entitled to receive, they are also expected to be active at making social contributions. In the case of corporations playing a pivotal role in a local community, it is all the more important for them to promote disaster management in collaboration with the community. In case of disasters, corporations should offer their spaces as evacuation sites and shelters and also provide essential lifeline utilities such as power and water by making the most of their better-equipped facilities.

Cooperation between private companies is also important during disasters. A good example is cooperation between two Japanese rival companies, Renesas and ROHM.

Renesas's Naka factory was seriously affected by the 2011 earthquake and had to stop the production of micro controllers for automobiles. Its share accounted for approximately 10 percent of the world's production at that time. Renesas's trouble immediately affected Japanese automakers, which were forced to reduce their car productions by as many as 0.5 million cars in the first month after the earthquake.

Because of the gravity of the impact caused by Renesas on the auto industry, automakers sent their workers to bring the company back to normal as soon as possible. With workers from automakers reaching the maximum number of 2,500 per day at the peak, Renesas made a quick recovery and resumed the production in June, only three months after the earthquake (SankeiBiz, 2012).

Remembering this incident, the Ministry of Economy, Trade and Industry asked Renesas whether it could do anything to help ROHM Co.,Ltd., severely affected by the Thai floods. The ministry's inquiry pushed its back as

Renesas was already wondering whether there was anything it can do to help those in trouble. Renesas temporarily covered the production of semiconductors for ROHM in order to help reduce the impact of the shortage of semiconductors for automobile companies.

This kind of cooperation between competitors may be a rare case but should be remembered as one of the good practices during a crisis, not only for competitors helping each other but also because this case suggests a possible role of governments to facilitate corporate collaboration during disasters.

Good collaboration has also emerged recently between the public and private sectors. On 11 June 2011, Ichijokomuten, a housing firm originally funded in Shizuoka Prefecture, offered US$ 300 million dollars for Shizuoka Prefecture to build seawalls along the coast of Hamamatsu City. Both prefectural and municipal governments have agreed to receive this handsome donation to start the levee construction. Ichijokomuten will donate US$ 100 million dollars every year for three years starting from the fiscal year 2012 to 2014. In addition to seawalls along the Hamamatsu City coast, the prefecture is planning to use the donation also to build water gates and other necessary structures and facilities around the mouth of the Magome River, running through the center of the city. After the mega quake disaster in spring of 2011, the housing firm contacted the prefectural and municipal governments, saying that it wanted to do something to thank its home town. This case of social contribution can be considered to be very Japanese, for the donation is not to build structures for their own benefits by protecting the property of the company. Traditionally, infrastructures for disaster prevention are thought to be constructed by national or municipal governments, but similar cases may be more to come, given the recent corporate trend in social contribution after the mega disaster and also the increased corporate awareness of self-protection against natural disasters. (Nihon Keizai Shimbun, 15 June 2012)

4.3 Global efforts in disaster risk management

4.3.1 Risk sharing with communication tools

Likewise in local efforts in individual communities, efforts in disaster risk management should be made on a global scale. The international community should provide support to aid organizations that assist developing countries in the implementation of disaster countermeasures. In addition to further enhancement of disaster management projects by UN and other international organizations, a proposal has been presented in UN and elsewhere to establish a new set of disaster risk indices that can be commonly used worldwide in order to strengthening the monitoring function.

4.3.1.1 Past efforts in disaster risk indices

Currently, numerous dataset and documents concerning disasters are sorted out and compiled, but such activities are often interrupted due to limited availability of country data and historical data. At present, the following four databases are primarily used to create various water related disaster risk indices: namely, EM-DAT of CRED, NatCat of Munich Re, Sigma of Swiss Re, and the Global Archive of Large Flood Event of the Darthmouth Flood Observatory.

Based on these datasets, a number of organizations including UN, international organizations, colleges and research institutes have created or are planning to create risk indices. For example, the Global Assessment Report 2009, 2011 by ISDR, the UNEP-GRID Global Risk Data Platform, the World Risk Report 2011 by UNU-EHS, the Natural Disaster Hotspots: A Global Risk Analysis, Synthesis Report by the World Bank and Columbia University, and Earthtrends by the World Resources Institute.

Despite the efforts in producing these indices by individual organizations, the figures shown in these indices are not very reliable because the original data on which the indices are based are not officially provided by national authorities (UNESCAP, 2010). Most evaluations are done based on past disaster records on a national basis due to the limitation of wide variation in data. Evaluations based on reproduction of flooding and inundation events on a basin are not available, neither.

At the basin level, however, there are many cases in which disaster risks are simulated in case of flooding and inundation and visualized by means of hazard maps and other types of documents, particularly in developed countries such as Japan and some European countries. Some developing countries have also started similar attempts, but those are just for individual river basins and there is still a long way for such mapping activates to be practiced worldwide. In the meantime, it is considered technically too difficult to disseminate hazard mapping worldwide because such mapping requires a great deal of topographical and other data.

4.3.1.2 Future direction of disaster risk management

To further promote global efforts in disaster risk management, it is critical to improve data reliability. The UN is expected to play a central role in the efforts by organizing statistical information on disasters around the world. Meanwhile, analytical technologies have made quite a progress. Satellite information technology and GIS technology have been improved and so has hydraulic and hydrologic simulation technology. This technological progress has, in turn, led to basin-scale risk evaluation at the global level. By mobilizing all these upgraded technologies, it is urgent to produce indices that are capable of reproducing actual events more accurately.

5 Lessons learnt from the mega disasters

5.1 Risk awareness before the disasters

Comparison between the Great Eastern Japan Earthquake and the Thai floods has found similarities in some respects. The tsunami-affected areas in the mega-quake event have been prone to tsunami disasters since ancient times. Because of that, residents there are generally aware of tsunami risk to which they are exposed. However, because the last great earthquake had never been recorded in the history, simply beyond expectation, most residents experienced such a large tsunami for the first time. In the case of the Thai floods, the industrial complexes that were severely affected this time have been recently built in the flat-lying areas used to be rice fields. Local residents may have some awareness of flood risk in the areas, knowing the local history. However, factories may not have taken such risk so seriously.

5.2 Structural countermeasures

In both Japanese and Thai cases, structural measures had been taken before the events, and in fact demonstrated their mitigation effects to some degree. Despite that, the disaster damage ended up being unprecedented in both cases because the scale of tsunami or rainfall is well over the design size of the structures.

5.3 Non-structural countermeasures

Forecasting and communication were particularly problematic in both events. In the quake case, information on earthquake and tsunami was provided through several channels. Unfortunately, however, it communicated underestimated numbers in some cases or was not provided in time in other cases. In addition, people tended to respond to the situation based on their personal experience. In the flood case, many people complained after the event that they could not evacuate in time because they were provided with little information on how and in what direction the floods may spread.

5.4 Towards a disaster-resilient society

The mega disasters this time have a huge impact on Japan and Thailand alike. The experiences this time, so devastating as they were, strongly inspired the private sector to be proactively involved in social projects, such as providing financial support for levee construction. To help this trend continue on, the public and other sectors should also provide assistance by creating systems or incentives for such socially-oriented corporate activities. Development of common risk communication tool is also required to mobilize holistic approach towards a disaster-resilient society.

6 Conclusion

Despite global efforts in disaster management, it has been hard to reduce damage caused by natural disasters. Hoping to find what is needed to reduce disaster damage, this paper has first analyzed the characteristics of damage caused by the two mega disasters that occurred in 2011, i.e., the Great East Japan Earthquake and the Thai floods. We have also discussed how to address these types of disasters and explored a future direction of disaster risk management.

Our analyses found that both disasters were caused by unprecedentedly large hazards, which are commonly pointed out as a characteristic of recent disasters. We also found that because of economic globalization, indirect damage caused by the disruption of supply chains exacerbates damage in total, in addition of direct damage caused by hazards.

Before the mega disasters, people in general thought that economic incentives and public facilities for structural damage prevention or mitigation would work effectively in the face of hazards. However, unprecedentedly large hazards such as those in the two cases are just too great for current measures to cope with. We need to tackle them with holistic approaches to minimize damage by coupling soft and hard measures and integrating public and private efforts. Furthermore, as disasters will become more intense and frequent around the world, it is important that disaster risk management should be recognized as a global priority that demands internationally organized efforts. In this respect, an international risk communication tool should be developed so that the global water sector will have

the common language to discuss urgent disaster issues.

7. Acknowledgements

The authors would like to thank Dr. Jayawardena Amithirigala and Dr. Pat Yeh for their insightful advice in the process of drafting this paper. We are also grateful to Mr. Masahiko Okubo for his support. Our gratitude also extends to many people who provide assistance in our surveys on the Great Eastern Japan Earthquake and the Chao Phraya floods.

Last but not least, we would like to express our sincerest condolences to those who died in the two disasters and hope for the earliest possible restoration in the affected areas.

References:

Asian Disaster Reduction Center (2012) *Thailand : Tropical Strom, Flood : 2011/08/03* http://www.adrc.asia/view_disaster_en.php?NationCode=764&lang=en&KEY=1544 (Accessed 20 January 2012)

Dengler, L. and Sugimoto, M. (2011) *Learning from Earthquakes the Japan Tohoku Tsunami of March 11 2011.* EERI/ERI/ITSTs special earthquake report *November, 2011.* California. http://www.eqclearinghouse.org/2011-03-11-sendai/files/2011/11/Japan-eq-report-tsunami2.pdf (Accessed 20 June 2012)

Development Bank of Japan. (2012) *Impact for HDD Supply Chains caused by Thai Flood.* Japan. (In Japanese) http://www.dbj.jp/ja/topics/report/2011/files/0000008482_file2.pdf (Accessed 10 June 2012)

EM-DAT: *The OFDA/CRED international disaster database*. Université Catholique de Louvain Brussels, Belgium; http://www.EMDAT.be (Access 29June 2012)

Futrakul, H. E. V.（2012）*Thailand's economy after the great flood*. BLL seminar handout March 23,2012. Tokyo. http://www.rieti.go.jp/en/events/bbl/12032301.pdf (Accessed 10 June 2012)

GFDRR.（2012）*Thai Food 2011:Rapid Assessment for Resilient Recovery and Reconstruction Planning*, The World Bank, Washington DC.

Darthmouth Flood Observatory, *Global Active Archive of Large Flood Events.* University of Colorado, Campus Box 450, Boulder, CO 80309 USA http://www.dartmouth.edu/~floods/Archives/index.html (Access 29June 2012)

Iwate Survey of Statistics Section（2012）Iwate Statistics Information
http://www3.pref.iwate.jp/webdb/view/outside/s14Tokei/top.html (Accessed 10 June 2012)

Japanese Chamber of Commerce Bangkok.（2011）*Economic Overviews in Thailand (2011/2012).* Bangkok. (In Japanese)

Japan Meteorological Agency. (2012) *Workshop on meteorological, seismological, and other information: Improvement in Tsunami Warning May 2012*. Tokyo. (In Japanese)
http://www.jma.go.jp/jma/kishou/minkan/koushu120518/shiryou4.pdf (Accessed 20 June 2012)

Japanese metropolitan police department. (2012 May) *The Causalities number of the Great East Japan Earthquake.* Tokyo (in Japanese)

JETRO. (2012) *Special Topics : Information on Thai Flood Disaster Recovery*. Tokyo. (In Japanese) http://www.jetro.go.jp/world/asia/th/flood/ (Accessed 10 June 2012)

Maxx Dilley, Robert S.Chen, Uwe Deichmann, Arthur L.Lemer-Lam, Margaret Arnold (2005) *Natural Disaster Hotspots: A Global Risk Analysis.* The World Bank. Washington.D.C.

Ministry of Economy, Trade and Industry.（ 2012 ）*Disaster Response for Thai Flood.* Tokyo. (In Japanese) http://www.meti.go.jp/topic/data/111028aj.html (Accessed 10 June 2012)

Ministry of land, infrastructure transport and tourism. (2011) *Emergency proposal of countermeasures for tsunami run-up in rivers.* Tokyo. (In Japanese) http://www.mlit.go.jp/report/press/mizukokudo03_hh_000376.html (Accessed 20 June 2012)

Nakasu, T. and Sato, J. (2011)Thai, Environmental Chronology Edit Committee ed. *An Environmental Chronology : Japan and the World,* Suirensya.(In Japanese)

NatCatSERVICE, Natural catastrophe database, analysis and information platform; Münchener Rückversicherungs-Gesellschaft Königinstrasse 107, 80802 Munich, Germany
http://www.munichre.com/touch/naturalhazards/en/natcatservice/default.aspx (Access 29June 2012)

Nihon Keizai Shimbun newspaper 15 June 2012, *Ichijyokoumuten donates 30 billion yen for seawalls.* Japan. (In Japanese)

Port and Airport Research Institute. (2011) *The verification of disaster-affected process by tsunami in Kamaishi bay.* Japan. (In Japanese) http://www.pari.go.jp/info/tohoku-eq/20110401.html (Accessed 20 June 2012)

Report by the expert panel on earthquakes and tsunamis based on lessons from the Great Eastern Japan Earthquake", Central Disaster Prevention Council, 28 September 2011 (In Japanese) http://www.bousai.go.jp/chubou/29/29_siryo1-2.pdf (Accessed 20 June 2012)

SankeiBiz（2011）*Renesas Helps ROHM :Thai Flood* http://www.sankeibiz.jp/business/news/111115/bsc1111150504004-n1.htm (Accessed 20 November 2011)

SC-ABeam Automotive Consulting. (2012) Thai Flood Information (In Japanese) http://www.sc-abeam.com/sc/?p=6035 (Accessed 20 June 2012)

Sigma, Swiss Re Ltd, Mythenquai 50/60, PO Box, 8022 Zurich, Switzerland http://www.swissre.com/sigma/Data_selling.html (Access 29June 2012)

Termpittayapaisith, A., NESDE Secretary General (2012) Thailand's Future Development and Water Management Plans ; http://blogs.yahoo.co.jp/festiva1202/65551342.html (Access 20June 2012)

The 2011 Tohoku Earthquake Tsunami joint survey group. (2012) *Field survey results 14 Jan.2012.* Japan. http://www.coastal.jp/tsunami2011/ (Accessed 20 June 2012)

The Japanese Society of Thai Studies ed. (2009) *Thai Dictionary*, Mekong. Japan. (In Japanese)

Termpittayapaisith, A. (2012) NESDE Secretary General Thailand's Future Development and Water Management Plans, Thai Investment Seminar(2012.3.7) ASEAN-JAPAN CENTER

Tokyo Marine &Nichido Fire Insurance Co.,Ltd.（2011）*Lesson Learned from 2011 Thai Flood : Water related disaster risk countermeasures points for overseas offices.* Tokyo Marine &Nichido Fire Insurance Co.,Ltd. Tokyo.

UNISDR. (13 June, 2012) *UNISDR COUNTS THE COST OF 20 YEARS OF INACTION ON CLIMATE CHANGE AND RISK REDUCTION -1.3 million killed, 4.4 billion affected, $2 trillion economic losses* – UNISDR Press release 2012-21. Switzerland.

UNEP/UNISDR (2011) *Global Risk Data Platform* http://preview.grid.unep.ch/index.php?preview=home&lang=eng (Accessed 20 June 2012)

UNESCAP/UNISDR (2010) *The Asia Pacific Disaster Report, 2010: Protecting Development Gains, Reducing Disaster Vulnerability and Building Resilience in Asia and the Pacific*

UNISDR (2009) *Global Assessment Report on Disaster Risk Reduction 2009: Risk and poverty in a changing climate*

UNISDR (2011) *Global Assessment Report on Disaster Risk Reduction 2011: Revealing Risk, Redefining Development*

UNU-EHS (2011) *World Risk Report*
http://www.ehs.unu.edu/file/get/9018 (Accessed 20 June 2012)

World Resources Institute (2012) *Earth Trends: Environmental Information*
http://www.wri.org/project/earthtrends/(Accessed 20 June 2012)

Yamaguchi,K.,Shimizu,Y,et al.(2011) *Japan Descriptive Geographical Memorandum : Hokkaido and Tohoku* Ⅱ,Asakurashoten (In Japanese)