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Review Article

Crisis Management of Tohoku; Japan Earthquake and Tsunami, 11 March 2011

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Abstract

The huge earthquake in 11 March 2012 which followed by a destructive tsunami in Japan was largest recorded earthquake in the history. Japan is pioneer in disaster management, especially earthquakes. How this developed country faced this disaster, which had significant worldwide effects? The humanitarian behavior of the Japanese people amazingly wondered the word's media, meanwhile the management of government and authorities showed some deficiencies. The impact of the disaster is followed up after the event and the different impacts are tried to be analyzed in different sectors. The situation one year after Japan 2011 earthquake and Tsunami is overviewed. The reason of Japanese plans failure was the scale of tsunami, having higher waves than what was assumed, especially in the design of the Nuclear Power Plant. Japanese authorities considered economic benefits more than safety and moral factors exacerbate the situation. Major lessons to be learnt are 1) the effectiveness of disaster management should be restudied in all hazardous countries; 2) the importance of the high-Tech early-warning systems in reducing risk; 3) Reconsidering of extreme values expected/possible hazard and risk levels is necessary; 4) Morality and might be taken as an important factor in disaster management; 5) Sustainable development should be taken as the basis for reconstruction after disaster.

Keywords: Japan, Earthquake, Tsunami, Disaster, Crisis Management, Fukushima

Introduction

The magnitude 9.0 Japan's Tohoku Earthquake occurred at 14:46 local time on Friday, 11 March 2011, 125 km east coast of Honshu and 380 km far from Tokyo and rattled the large parts of Japan and some part of east China and Russia with 30 km depth of the hypocenter (1). This earthquake that lasted approximately 3 minutes (170 seconds) caused a 130 km long by 159 km wide rupture zone on the pacific plate subduction zone and followed by a huge tsunami with more than 40 meter waves. The destructive aftermaths of this incident made an irreparable disaster not only for the Japan, but also for the whole world because except for the enormous death toll and debris, the damages of nuclear power plants were a hazardous unexpected tragedy.

Casualties and damages

According to the report of the Japanese National Police Agency, 15854 dead, 3167 missing and 26992 injured across twenty prefectures are the result of this devastating earthquake and tsunami which ruined more than 125000 buildings. Moreover, it caused long blackouts for more than 4.4 million buildings and left 1.5 million buildings out of water for days (2), also large fires were triggered one after another even for weeks after the main quake. Explosion and demolition of the Fuku-

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shima I Nuclear Power Plant (Fukushima Daiichi), which generated radioactive contamination near the plant's area with irreversible damages to the environment, was one the most significant issues of this catastrophe and ranked 7 (the most sever level for nuclear power plant) based on the International Nuclear Event Scale, similar to the Chernobyl disaster on 26 April 1986 (3). Therefore, it is not strange to consider to this earthquake as the most important destructive seismic event of the beginning of the twenty first century in the advanced industrial world.

Losses intensified by hit of the tsunami as the statistics shows it was more fatal (Fig. 1) and also more buildings destroyed by its strike; However, the quake was the main cause of the partial damage of buildings (4). Figure 2 manifests the building losses distribution through affected areas and Fig. 3 reveals the relative impact of the earthquake vs. tsunami in each prefecture of Japan (4).

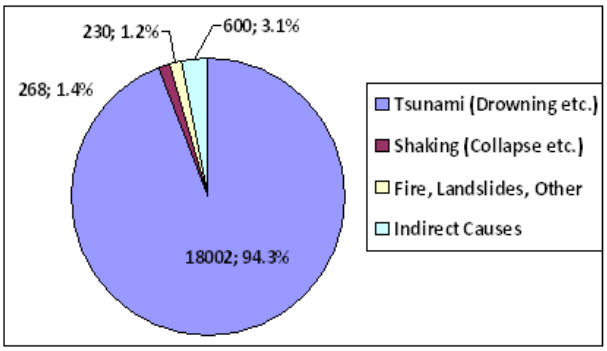

Fig. 1: Division of total 19100 death and missed people by the reason as of 10th March 2012 (CATDAT)

Fig. 2: Building damage distribution (CATDAT)

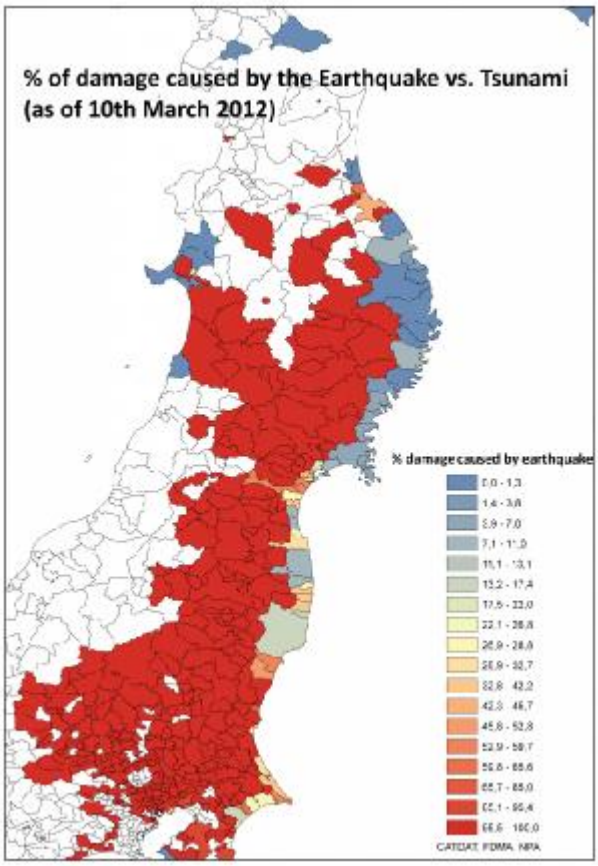

Fig. 3: The relative impact of the earthquake vs. the tsunami in each location

Seismology and Seismic History

This mega thrust earthquake is categorized as a great earthquake with the magnitude more than 8 in scientific seismological classification (5). Over 1000 aftershocks, some of which were larger than the recent catastrophic earthquakes in Iran such as Bam, Iran 2003, hit the area since the main shock. Regardless of the consequent tsunami, the Tohoku Sendai Earthquake (2011) is the largest recorded earthquake in the history of Japan in terms of magnitude while the territory of Japan is known by numerous and critical earthquakes. There are two momentous calamitous earthquakes in history of Japan: The great Kanto earthquake with magnitude of 7.9 on 1 September 1923 which destroyed Tokyo and Yokohama rigorously by the severe quake and subsequent fires and caused more than 143000 deaths (6, 7); and the Kobe earthquake (also known as Hanshin- Awaji earthquake) with magnitude of 6.9 on 17 January 1995 that left more than 6400 demises (6, 8). The Kanto incident is still the deadliest earthquake in Japanese history and the Kobe earthquake was the most costly natural disaster of the world since Tohoku Earthquake 2011 (9).

Methodology

Japan crisis management system

Japan has an overall population of 127 million and is one of the most densely populated countries in the world (340 persons per Km), where the population highly concentrated around Tokyo (6). This earthquake-prone country as a pioneer in crisis management has a comprehensive plan for preparing against disasters, consists of the Central Council for Accident Prevention, chaired by Prime Minister, set of cohesive rules for immediate response to all of the unexpected incidents, the advanced research system and the extensive public education about disasters. As the result of this plan, in the case of an accident, people, government officials and rescue departments know exactly what to do while the alarm is sounded, without chaos.

It was after the disastrous Kobe earthquake of 17 January 1995 (M6.9) that crisis management of Japan greatly promoted since the government set up a GIS system and a general computer network. This system contains different subsystems to operate all disaster related functions from prevention before the disaster to damage evaluation after it (10). Additionally, the most advanced earthquake and tsunami early warning system of the whole world is installed in Japan during 2003 to 2007, which is one of the main parts of this crisis management system. This warning system had a considerable role in Tohoku 2011 earthquake to reduce losses and save lives. Several Japanese media such NHK channel and also mobile phone networks have the most responsibility of broadcasting the news of early warning system.

In management of the 11 March 2011 crisis, one of the most facilitative factors for emergency managers was proper behavior of people who follow the commands cautiously. In other words, the "*social capital*" in this country had a significant role in recovery after the incident as people's high respect to roles and moral values and their solidarity prevent them from influx for aid and looting and motivate them to consider the public benefits instead of self-interests.

Response to the disaster

Immediately after the event, The Government of Japan (GOJ) held National Committee for Emergency Management, headed by Prime Minister. The government declared an emergency in effected area and dispatched the Japan Self Defense Forces for rescue operations (11). All ministries and departments such as Foreign Ministry, Ministry of Transport and Ministry of Health were involved in this response, also local offices of disaster response in all prefectures begins their operations as their duty was already clear. The Ministry of Health was in charge of preparing suitable vehicles for supplying water and assigning hospitals for remedy of casualties and people who have been exposed to radiation. Ministry of Agriculture, Forestry and Fisheries with Ministry of Finance were responsible for providing food, portable toilet, blanket, radio, gasoil, torch, dry ice and other

essential things. By the command of the government, all of the main highways in north of the country were completely occupied for emergency response activities. Besides, the transport systems includes subway, shipping and the Shinkansen bullet train ceased their activity in Sendai and Tokyo instantly after the quake.

Moreover, at the day of event the Government of Japan declared "the state of nuclear emergency" due to the threat posed by reactors in two Fukushima nuclear power plants (I and II) and 140,000 residents within 20 km of the plant evacuated. At 15:36 JST (Japan Standard Time) on 12 March, there was an explosion in the reactor building at Unit 1 in Fukushima Daiichi (I) power plant. At 11:15 JST on 14 March, the explosion of the building surrounding Reactor 3 occurred. An explosion at 06:14 JST on 15 March in Unit 2, damaged the pressure-suppression system. When the disaster began on 11 March 2011, reactor unit 4 was shut down for periodic inspection and all fuel rods had been transferred to the spent fuel pool on an upper floor of the reactor building. On 15 March, an explosion damaged the fourth floor rooftop area of the unit 4 reactor.

Japanese Red Crescent Society (JRC), which had a substantial role in initial relief operations and temporary housing, deployed its teams promptly. JRC performed properly for accommodation of refugees and evacuees in schools, public buildings, and shelters. This society adapted its operations to all other rescue organizations and NGOs, which deployed to the area later.

Construction of temporary housing in quake-stricken prefectures was begun 8 days after the event and the first set of buildings was expected to be ready within a month (12). In addition to medical aids, therapists and social workers were dispatched to the affected zone by Health ministry and then in coming days the concentration of treatments was shifting to psychotherapy from physical sicknesses. In addition, this Ministry performed required actions in order to control and inhibit infectious diseases and encouraged people to use masks (2).

Fire was reported in eight prefectures after the quake. Fire suppression of gas pipeline took a few days and fires in Cosmo Oil Installations and some other refineries lasted 3 days. Generally, the number of fires increased from 44 to 325 in a week, but its growth rate declined. All the fires, which were triggered after the earthquake, were under control of Japanese Police and it can be said that they could prosperously cease and extinguish them (13). On the other hand, these fires and breakdown of six out of nine oil factories faced the affected areas with fuel shortage. The gas pipeline repairing operation had a slow progress, too. Therefore, about one million liter gasoline per day had been carried to the damaged areas by tankers and then by cargo train in order to compensate lack of fuel. Low displacement capacity of oil and coal shipments caused delays in delivering fuel loads, which were importing from countries such as South Korea and Russia, to consumers (13).

Due to the shutting down of the power plants which were cracked by the quake and tsunami, authorities begun imposing sporadic power cuts nationwide to make up for production losses. Correspondingly, large factories like Toyota and Sony halted their production activities and many citizens in Kanto reduced their power consumption in order to abridge the time of blackouts (14).

Nuclear crisis

There are 54 reactors in Japan, but since the tsunami on March 2011 that destroyed Fukushima plant (Fig. 4) and triggered the world's worst nuclear crisis in 25 years, the government did not allow to restart any reactor that have undergone maintenance due to public safety (15). The first nuclear power plant of Japan was initiated with collaboration of English corporations in 1973, but these kinds of power plants then developed by American technology. All the 11 reactors in Fukushima 1, Fukushima 2, Onagawa and Tokai nuclear power plants automatically safe shut down after the quake; however, arrival of tsunami debris with high waves damaged reactor's cooling systems and eventually, resulted hazardous explosions. This could have been prevented if the designers had estimated the probable maximum altitude of the tides more prudently. The explosion

occurred in 4 of the 6 reactors of Fukushima 1 power plant one after another, while the unit 3 reactor was more damaged and more intensively contaminated the surrounding area. A few hours before each of these explosions, authorities warned about the cooling system breakdown, ordered to evacuate neighboring people and tried to drop the pressure of vapors, but in all of them the hydrogen explosion finally happened.

The owner of the Fukushima Plant, The Tokyo Electric Power Company (TEPCO), is accused of mismanagement and hiding the truth about the real damage caused by the disaster at the expense of saving the company (16). Moreover, according to reports, it was expected that TEPCO safely shutdown reactors of Fukushima 1 nuclear power plant approximately a month before the 11 March earthquake, but apparently the company avoided this action because of economic issues.

Over 140 thousand residents were evacuated from 20 Km around the Fukushima plant. Radiation penetrated in foods and drinking water in 30 kilometer far from the evacuated area, and authorities inhibited distribution of these polluted foodstuffs (13). U.S. Department of Energy announced a wide area beyond 80-kilometer radius around the Fukushima plant is affected by radiation (17).

The explosion of Fukushima power plant and its aftermaths aroused public concerns about nuclear energy in Japan and other earthquake prone countries. Consequently, other power plants, which were not resistant to the probable future quakes with magnitude more than 8, ceased they activity gradually sequentially by the command of The Prime Minister. TEPCO shut its last operating nuclear reactor in 26 March 2012 for regular maintenance, leaving just one running reactor supplying Japan's creaking power sector (15). Then again, on 10 April 2012 (less than a month later), as the summer arrives, while Japan is going to struggle with electricity shortage, the government planned to restart one of the atomic plants in Kansai after approval its safety (18) and faced with people's disagreement.

Furthermore, the nuclear crisis has led to growing opposition against atomic power plants in other countries, particularly in Germany, where thousands of citizens participated in an anti-nuclear demonstration. This disapproval also affected the regional election results unbelievably. In the state of Baden-Wurttemburg, which traditionally had gone with Christian Democratic Union party for 58 years, most of people voted for the Green Party who was against with 17 nuclear reactors in this country (19).

Fig. 4: Fukushima 1 NPP explosion, 14 March 2011 (DigitalGlobe)

Results: Crisis consequences

The 11 March 2011 earthquake had many deleterious environmental impacts that take a long time to recover. Apart from radioactive materials dispersed due to nuclear plant explosions and discharging polluted radioactive water of cooling systems to the sea, the subsequent tsunami induced huge amount of debris contains building materials, broken boats, cars, trees and etc. that cause environmental harmful issues.

Radioactive pollutions and radiations as the most harmful repercussions of the earthquake induced fear and concern among resident. Most evacuees did not return to their home even after the safety of the regions was assured. However, the government tried hard to convince people to return to their homes by checking and promulgation the radiation doses constantly, but just the population of old people gradually increased. Therefore, satisfying young people to come back will be a demanding challenge for the government.

- A year after the event, anecdotal evidence suggests that fear of radiation, rather than contamination itself, is triggering stress-related problems among nuclear evacuees (20), despite the experts emphasized that the doses are too low to develop cancer. Even in more distant areas, where completely secure, parents do not allow their children to play outside. Although there have been no recorded deaths from radiation in Fukushima, according to the *Yomiuri Shimbun* newspaper, psychological trauma associated with evacuation, pneumonia and heart disease were much more fatal based on statistics. Therefore, in months after the event, Japanese Red Cross concentrated on mental health issues.
- Also, the tsunami had adverse effects on agriculture and requires long-term reconstruction at least for 2 or 3 years. In addition, the fishing industry faced to critical continuing problems. Most reports acknowledged that Japan's food exports could be limited by Japan's current Production and supply shortages, along with boosting food safety concerns and possible long-term radiation threats to its food production, in contrast possibly its need for food imports will increase in future (21).
- Moreover, since Japan is a country covered by jungles, wooden houses are very prevalent in this country and despite the dropping rate of wood imports in recent decade, due to boom reduction of this kind of homes; the Tohoku earthquake caused a 70% rise in wood import rate by enhancement of the wood demand. This made a competition for wood exporters from different countries such as Australia, America, and China.
- One of the important impacts of the Fukushima power plant explosion is its psychological consequences. Regardless of common diseases such as infectious ones that break out after earthquakes, the radioactive contamination permeated to the residential areas where people was living, working and planting brought a ten times fatal disease, which is hopelessness and untruthfulness. People know they should leave anything they had include home and agriculture plant and this lead them to an ambiguous future which is unstable and they should build everything from beginning. The increase in number of suicides in power plant's surrounding areas even far from them and farmers concern about safety of their productions and land even 100 kilometers far from the affected zone prove the strength and influence of this issues.
- Japan should also challenge with the problem of enhancing of unemployment. Large number of refugee and evacuees left their home and moved to other cities. Also, workers of car and electronic factories are now jobless by factory closure so they are forced to immigrate (22). Japanese government created around 20 thousands of jobs in the emergency measures to combat the effects of the disaster in a month, but the number of the unemployed ones was much more than created jobs (23). Additionally, women especially in rural areas, who used to were involved in tough works such as agriculture and fishing, after the disaster have to work in other posts and try different occupations in order to help to family economic. Many of these women take apart in protests against Fukushima power plant issues in Tokyo in October and November 2011. It seems that this earthquake has modified the women life style in affected prefectures as now they have more important roles in family issues and it is big change in an almost traditional male-dominated Japan.
- Following the shutting, the Fukushima power plant, on February 2012, the House Foreign Relations Committee off Japan approved to export its nuclear equipment to Vietnam and Jordan. Also Japanese companies signed agreements with India, Bangladesh, and Turkey about construction, operation, and management of nuclear power

plants in these countries, despite environment activist's oppositions in recent months against these transactions and their high costs and permanent detriments for humans and earth. Actually, the nuclear power in spite its approximate low costs, have many hazardous disadvantages that the Japan 2011 accident and the Chernobyl 1986 are good samples for this fact. Unfortunately, developing countries do not consider these consequences and endanger the environment and people's lives while Japanese authorities are just accenting their own country's benefits.

Conclusion

In Tohoku earthquake and tsunami of 11 March 2011 despite the unprecedented scale of the quake itself, infrastructures and buildings mostly remained standing and proved the resilience of Japan is planning laws especially in constructions and earthquake technology. Hence, if the earthquake had been the sole problem, then Japan could have claimed for itself a momentous prosperous in planning for the impact of a major earthquake. The reason of Japanese plans failure was the large-scale tsunami, which had higher waves than what was assumed in designing. In addition, the fact that Japanese authorities considered economic benefits more than safety and moral factors exacerbate the situation. Even after the disaster, this country just cared about economic benefits and sought to export its technology to other countries.

However, this disaster was a motivation for people and governments worldwide to replace clean energy with the hazardous one and it was a reminder to decommissioning the old and unsafe operating power plants. Thus, the Metsamor nuclear power plant in Armenia, Iran's neighboring country, is a critical threat in the region with high seismic risk. Governments had to plan long-term and costly solutions to replace the nuclear energy with clean and renewable forms of it with respect to criteria and moral values, not only the benefits.

Although energy issues and management of power plant's crisis was a blind spot in Tohoku disaster management, Japanese social ethics and their manner in dealing with the problem were the most advantageous points. Discipline, maintaining calm, public confidence in managers and scientific management based on the plans helped to improve the situation more quickly (Figure-5). Long queues of Japanese People for food and facilities instead of chaos, which we mainly consider in developing countries, could be a good proof for other countries that enterprising on educating people about how to act in crisis is very operative and effective in enhancement of disaster management.

The 11 march 2011 earthquake was an alarm for seismologist all over the world, particularly in Tehran as a capital city, to revise their methods and evaluation of estimating the plausible time and magnitude of earthquake. It could be an alarm for us to be more meticulous and cautious about the earthquake hazard as prepared and industrialized Japan with the most modernized technology confronted many extensive troubles, which were out of their predictions. Now we should ask this question "how much we are prepared in an earthquake prone country with a capital located exactly on active faults?"

Fig. 5: These two photos taken over a six-month period showing aftermath of the March 11, 2011, tsunami and its cleanup progress in Wakabayashi-ward in Sendai, Miyagi Prefecture, in northeastern Japan. (pacificcitizen.org)

Ethical considerations

Ethical issues (Including plagiarism, Informed Consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc) have been completely observed by the authors.

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