

How is Japan managing the devastating disaster on March 11

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Introduction

I was given the title of this article by the Editor-in-chief of the magazine “Coordinates” but I dare to say that Japan is not yet managing the disaster but suffering from the hardships. Though all Japanese people are in mourning over the horror of this event, I feel it is my duty as an old scholar to report to the rest of the world on the worst earthquake and Tsunami in living memory to hit Japan. I hope that my report will be useful to prevent the similar misery for others.

What happened?

At 2:46pm on the 11th March 2011, the huge earthquake of M9.0 (firstly it was 8.8) occurred offshore of Sanriku (north east of Japan) with its epicenter covering a region 500km long (north-south) and 200km wide (east-west) in the Pacific Ocean (see Fig.1). Accordingly the damaged areas were also 500km long including a part of Hokkaido (the north island of Japan) in the north and Tokyo in the south. We have had many big earthquakes in the past, for example Kobe Great Earthquake in 1995, but the damaged area from this earthquake was limited in several 10s of km. I was in my house located in the west of Tokyo at the time of the earthquake. When I felt that it was dangerous to stay in my room I rushed out of my house together with my wife. The shaking continued for almost 3 minutes (normally most earthquakes only last about one minute even in the case of very big earthquakes) and many after-shocks followed. After the earthquake has settled I switched on TV because I had not realized that very serious damage had occurred in the Tohoku Area (north east of Japan) and that a Tsunami would be coming soon.

The damages are as follows; 11,168 dead (so far confirmed), 16,407 missing (still increasing), 2,778 injured, 151,868 houses destroyed, 240,000 people evacuated, 2,200 roads damaged, 56 bridges collapsed, 6 fuel power stations destroyed, Tohoku Shinkansen (partially recovered) and Tohoku Highway (now recovered) but damaged (as of 29th March, 18 days after the earthquake). The main damage was caused by the Tsunami which swept away huge number of people, cars, houses, fishing boats, ports and harbors see (Fig.2a and 2b). A quick measurement of the height of Tsunami showed as follows; 23m at O-funato, 16m at Minami Sanriku, 15m at Onagawa, 14m at Fukushima nuclear power plant, 13m at Kuji port, 7~8m at Kamaishi, 5m at O-arai etc.

The Tsunami hit small coastal towns 5km upstream along a river in the Sanriku Area, where the bay has a V shaped topography which exaggerates the height of Tsunami. Along the River Kitagami, the 5m Tsunami hit the mouth where it swept away all harbor facilities and boats, at the 4km point along the river a bridge collapsed, at the 6km mark riverside villages were flooded, at 14km along the river agriculture fields were inundated and at the 49 km mark the water level at the gauge station suddenly rose 10cm one hour after the earthquake. [Even at Toda, 28km upstream on the River Arakawa, flowing into Tokyo Bay, the water level rose 1m 20cm after the earthquake.](#) Such Tsunami propagation would normally be unexpected.

The most serious accident was the destruction of the Fukushima Nuclear Power Plants at which the cooling system and electric and electronic facilities were severely damaged by the Tsunami (see Fig.3). It resulted in the extraordinary heating up of the nuclear reactors and protection vessels. Atomic radiation was spilled out polluting the air, water and soil as well as vegetables and milk. People within 20km radius had to move out of the residences and people within 20~30km had to stay inside their houses. The total number of people evacuated was a maximum of 450,000 as result of not only the earthquake and Tsunami but also the nuclear power plant accident. The survivors and evacuees have had to stay in congested houses without lighting, heating, water, food, blankets etc. in spite of sub-zero temperatures, until supporting materials arrived.

People in the metropolitan area of Tokyo were also panicking as all trains and subways were stopped making it impossible for several million people to go back home and very difficult to even move around. Within 30 minutes of the earthquake, all drinks and food were sold out in shops. From the next day, water, food, toilet papers etc. were also sold out at super markets, department stores, convenient stores and so on. Electricity failures also commenced as the electric power stations stopped operations leading to shortages of electricity. Tokyo Electric and Power Supply Company (TEPCO) had the capacity of 52 million KW before the earthquake which was reduced to 31 million KW after the disaster. Fukushima Nuclear Power plant was providing about 9 million KW. There were serious shortages of gasoline as oil refinery facilities were also damaged. Almost all gas stations and tanks were swept away in the coastal areas. This led to problems in transporting relief supplies to the damaged areas because of lack of gasoline. Even in Tokyo two weeks after the disaster, we have had to queue an hour for gasoline supplies which are limited to only 10 litres. In addition, almost all ports were damaged by the Tsunami, while roads and railways were unusable. Only defense helicopters were available to the rescue parties. Mobile phones and Internet at the sites were not available for many days, which made communications between safe

and damaged areas, as well as among family and relatives difficult. Many survivors lost their mobile phones but even if they had their mobile phones, they could not use them because there were no electricity services.

Lessons from the past disasters in Japan

Japanese people are well educated on evacuation procedures in the case of earthquakes and Tsunami as so many terrible disasters have occurred in the past. Particularly the area of Sanriku was heavily damaged by the Great Tsunami in 1896 which killed almost 22,000 people including my great grandfather. Following this terrible lesson, many coastal towns constructed breakwaters to protect them against future Tsunamis. For example, Kamaishi City, Iwate Prefecture constructed huge breakwaters 2km long, 20m thick, 8m above sea level and 65m deep, which have been registered as the deepest breakwaters in the Guinness World Records (see Fig.4a and 4b). Taro fishing village, Miyako District, Iwate Prefecture constructed 10m high breakwaters against Tsunami, as the village was most seriously damaged by the 1896 and 1933 Tsunamis. But those breakwaters were completely destroyed by the Tsunami this time, which was 14m high, much higher than authorities had prepared for. Many people said that the Tsunami was higher than expected, but the Tsunami in 1896 was 38m high! We should have learnt the lessons that 'hardware' including very high breakwaters, cannot save people but we need to use 'software' including procedures for providing early warning and evacuation systems.

There was a small village in Aneyoshi District, Miyako City, Iwate Prefecture which was thoroughly damaged by the 1896 Tsunami and 1933 Tsunami with only 2 and 4 survivors respectively. An ancestor built a memorial stone on which an important lesson was written, "Don't build any house below this point!" The stone is located 60m above sea level. The villagers followed this lesson and built their houses in the upper area. When the Tsunami came all villagers ran 800m up the slope and escaped to their houses built on the hill. The Tsunami stopped 50m in front of the hill and all villagers were saved.

In the case of the 1995 Kobe Earthquake, which killed more than 6,000 people the establishment of a GIS database was so important for recovery from the damage. Many local governments started a GIS database but everything including computers, databases, backups, even city and town halls/offices were swept away. Most people lost ID cards and passports which made it difficult to identify them by documentary evidence. In several towns, the official registration data bases were also lost as well as town offices.

Lessons from the disaster

First of all, I have to say that there is nothing absolutely safe. Though many Japanese doubted the safety of nuclear power plant, the Japanese government and industry convinced people to support the construction of nuclear power plants as they believed them to be absolutely safe. In spite of their aversion to nuclear matters, as the Japanese have been the only nation to experience atomic bombs, the majority of local people accepted the construction of nuclear power plants through a referendum. Electric power companies and consultants always said that power would be cheapest if produced by nuclear power stations. But now we Japanese realize that the cost has been tremendously high and in addition the accident is robbing them of their life and their use of land more than 250km wide (Tokyo is 250km away from the Fukushima Nuclear Power Plant and its drinking water is in danger of contamination from atomic radiation). We are learning how difficult, complicate and time consuming it is to control a nuclear plant after an accident.

Many local people have made mistakes and misjudgments though they were given lessons by their ancestors on how to evacuate from a Tsunami. But some people did not know enough about the behavior of Tsunamis. For example, Asahi City, Chiba Prefecture located on the sea coast was hit by the first Tsunami at 3:45pm, one hour after the earthquake when local people had succeeded in evacuating to a hill. After the Tsunami withdrew, some people went down to their houses or the coast, even some people tried to fill their cars with gasoline. But a second Tsunami came at 4:20pm, 35 minutes after the first Tsunami when these people were swept away and died. After the withdrawal of the second Tsunami, the survivors wanted to search for victims in the city area near the coast as they did not think that the Tsunami would return. Unfortunately a third Tsunami, an even higher one hit the coast at 5:26pm, an hour after the second Tsunami and killed the remaining people. One of the survivors said that there would no more Tsunami after the second one. The occurrence of Tsunamis and their repetitions were different from place to place. The earliest Tsunami was 15 minutes after the earthquake while most Tsunamis came 30 minutes after. But we Japanese did know that sometimes it takes a long time for Tsunamis to arrive. For example, the big 6m high Tsunami hit the Sanriku Area 22 hours after the Great Earthquake occurred in Chile in 1960, killing 142 people. NHK TV immediately announces whether we have to prepare for a Tsunami but not after every big earthquake. At this time many people evacuated second or third floors of concrete buildings. They would or should be safe, but the Tsunami came up to the fifth floor of some buildings for which the roof was the only safe place.

In Japan, all local governments must produce hazard risk maps which show places of refuge or shelter and roads leading to them. Some villagers followed these guide maps and successfully reached the refuge, but in other cases they were unsuccessful as the estimated height of the Tsunami was lower than the actual Tsunami. There was an interesting report in which Sumo Hama, Miyako District, Iwate Prefecture succeeded to evacuate 109 people out of 110 villagers onto a safe hill even though the village had no breakwater against the Tsunami. Those villagers used to rehearsal Tsunami evacuation procedures every year including communication among villagers and evacuation routing. At Funakoshi Primary School located in Yamada Town, Iwate Prefecture, the school itself was designated as a place of shelter as it is located 13m above the sea level. 176 school children were first evacuated to this school, but Mr. Shuzo Tashiro (55), a school helper judged the shelter was not high enough when he saw the Tsunami wave at the coast. He urged all children and teachers to escape up to a hill 40m higher. Then Tsunami came and swallowed the school. If he had not guided them to the higher hill, all people would have died.

There was another successful story in the city of O-arai, Ibaraki Prefecture which was hit by a 5m Tsunami. A young fire man 19 years old continued to shout in front of the disaster wireless microphone which warned people through 45 speakers; "Escape to a higher hill immediately!" even though the Tsunami came to his legs, he continued to shout after the Tsunami went away "stay there and don't move" for two and half hours. It resulted in all local people including an old lady of 91 years old being perfectly safe. The lesson was obvious that 'software', particularly communication systems could work much better than hardware such as super high breakwaters.

Who survived and who did not?

Besides the above mentioned stories, I would like to introduce several fortunate and unfortunate stories as follows.

- When an old lady, 60 years old was swallowed by the Tsunami and was bobbing up and down in water and trying to get to the surface, luckily a "Tatami", Japanese mat floated in front of her. She jumped onto the "Tatami" but she was in a whirl and vortex rotating at high speed. Again luckily a wooden house floated by so she jumped onto its roof. Finally she was rescued by a helicopter.
- A young mother with two children tried to escape to a place of refuge in her car, but she could not move because of a traffic jam. She decided to go back but she could not make U-turn, she went onto the opposite lane and accelerated in reverse gear. Finally she could escape from the Tsunami but many cars in front were washed

away.

- Another young mother tried to evacuate to a refuge on a hill by car together with her mother and children. She listened to a voice of a policeman shouting “Tsunami is coming!” She decided to get out of the car and took her mother with her children to a hilly forest nearby. In only a few seconds, the Tsunami came and swept away her car together with other cars in front of her. Five days later she discovered her car turned over and crashed.
- The town mayor of Otsuchi Town, Iwate Prefecture organized a rescue party immediately after the earthquake with other staff outside of the town office. The deputy town mayor realized the Tsunami was coming and shouted to escape to the top of the fifth floor building of the town office. When the deputy town mayor reached the roof of the building, the town mayor was on his way but was swept away by the Tsunami. There was no more than 30 seconds difference between safety and death. Similarly in Onagawa Town, a gentleman ran up to the fifth floor (15m high) and safety but he said no one could believe that the Tsunami would come up to such height (see Fig. 5).
- One journalist of Iwate Tohoku Newspaper tried to drive his car to collect information about the damage. He brought his personal computer from the second floor office into his car. His wife also helped him but she recognized the Tsunami coming soon. She shouted to her husband to escape to the second floor immediately, but it was too late for him though his wife could escape. She saw her husband’s face in the wave of Tsunami.
- A woman escaped to the second floor of her house where the Tsunami came up almost to the ceiling. There was only a small space, say 20cm for her to breath. She grasped a curtain rail to prevent from being swept away for more than 30 minutes until the Tsunami went down. She was lucky to be rescued in the next morning but she had to spend a very cold night being wet in below zero degree temperatures.
- A grandmother aged 80 years old and a grandson aged 16 years old were rescued 9 days after the earthquake. Their house was swept away about 100 m from its original location in the direction towards the coast, Ishinomaki City, Miyagi Prefecture. The house collapsed but luckily the kitchen floated in the water and they were forced to stay inside the room for several days as neither she could move to escape. As the grandson could move about in the narrow kitchen, he found water, cakes and yogurt in the refrigerator which were given to his grandmother. Finally the grandson succeeded in escaping 9 days later and called out to be rescued and was discovered by rescue patrol. This would be a very rare case.

- At a hospital located in Rikuzen Takada City, Iwate Prefecture, Secretary General of the hospital tried to bring a satellite communication device placed on the ground floor up to the fifth floor. He handed it over to one of his staff and tried to climb up to the fifth floor, but it was too late. The staff could escape to the roof of the hospital with the satellite communication device and survived. The Tsunami came up to the fourth floor and killed all patients who stayed on the third and fourth floors, and even the fifth floor. The speed of Tsunami is said to be 800 km per hour in the ocean and 60km per hour at coast and on land. It was much faster than expected.
- Mr. Ohtomo, Wakabayashi District, Sendai City, Miyagi Prefecture had recognized long before the earthquake that it was not appropriate for Sendai City to designate a primary school as a shelter for a Tsunami and requested Sendai City in September 2010 to change the hazard risk map to another place. When Tsunami hit the district Mr. Ohtomo did not go to the school but a higher road where he looked down to see the school swallowed by the Tsunami at the level of the second floor. The road he selected was safe, which was on the border of the Tsunami safe area. 300 people could survive on the road, but many other people who followed the hazard risk map died at the school.

Prediction of earthquakes

No one has succeeded so far to predict earthquakes. It is one of the most difficult sciences and technologies in the world. Japanese seismic scientists and engineers have not yet succeeded either. I tried to make a prediction using GPS fixed stations located all over Japan, which are constructed by Geo-spatial Information Authority (GSI). Dr. Harumi and I have developed a method for prediction by checking whether the changes in dimensions of triangles between GPS Stations exceed a threshold. I have already submitted a paper on “Prediction of Earthquakes with GPS Data” to GIM, Coordinates and Journal of Digital Earth. Unfortunately Dr. Araki and I are retired persons who have no assistants or research funds. We could confirm that all earthquakes in the past showed early signals before they occurred but we could not predict exactly on which day the earthquake would occur. The longest period between detected changes and the occurrence of the earthquake was two months and shortest case was only one day. Sadly not many people showed interest in our research and the method has been neglected even though we succeeded to register the method as a Japanese patent in 2006.

Dr. Araki and I are not interested in business but contributions to help people. I hope someone can follow our method of the prediction in future.

Role of geo-spatial technologies for the disaster management

RS and GIS are useful for damage assessment to compare between situations before and after the earthquake and Tsunami. There are two remarkable issues on this occasion. One was that high resolution satellite images clearly showed the damage and accidents at the Fukushima Nuclear Power Plants. Air survey was not available because of the high level of atomic radiation in air, as well as the destruction of local airports. Satellite images showed the condition of the power station buildings destroyed by the hydrogen gas explosion, which was useful for recovery planning. Another issue was damage assessment by comparing images before and after the Earthquake and Tsunami. As the damaged area was so huge, helicopters were inadequate. High resolution satellite images and also SAR were very useful to realize the scale of the damage (see Fig.6). Pasco analyzed high resolution satellite images and reported that 70% of the damaged areas by Tsunami were still inundated on the 24th March, almost two weeks after the earthquake. Insurance companies in Japan announced that they will provide compensation for earthquake insurance by assessing high resolution satellite imagery or aerial photographs without the site investigation, as access to the damaged areas was difficult and hence buildings could not be located or assessed.

A GPS wave height recorder located a few kilometers from offshore showed mostly 6~7m high waves which would usually be doubled depending on the sea depth and topographic conditions on land. A GPS recorder cannot be an early warning system as the speed of Tsunami is 800km per hour in deep sea areas and reduces to 60~100 km per hour on the coast and land. This means that cities 10km across will be inundated by the Tsunami waves in only 10 minutes. UAV was very useful to photograph Fukushima Nuclear Power Plants for analyzing the damage in detail and planning the next action, as ordinary aerial surveys cannot be made due to high risk of atomic radiation, while high resolution satellite images were also useful in the early stages.

We thank Digital Globe, Google, JAXA, RESTEC and many other organizations for releasing satellite images for comparison purposes on the Internet. I also thank YouTube for publicizing video images of the Tsunami and other scenes. Many Japanese took videos and pictures of the damage of the earthquake and Tsunami using Japanese digital cameras and video cameras which would be very good references in future for establishing countermeasures on how to prevent, reduce or mitigate the effects of the disaster.

Concluding remarks

Although my family and my house in Tokyo are safe without any damage, I could not

stand to watch the TV scenes as the real situation was too miserable. I sympathized with the affected people and those who lost their lives but as an old man living in Tokyo I cannot directly help those people except by donations. What I can do is to inform my friends and colleagues around the world about the real situation and stories. It could be somehow useful for our society to assist in saving human lives.

In conclusion, Japan committed a big mistake in listing nuclear power plants as a sustainable development which has proved to be not sustainable.

I would be pleased to know if you have become wiser by reading my article.

Finally I extend my condolences to those victims and their family who were lost as a result of the Tohoku Kanto Great Earthquake 311. I thank many friends from foreign countries and regions who have sent me kind words to encourage me as well as Japanese people.