

KNOWLEDGE NOTE 2-6

CLUSTER 2: Nonstructural Measures

Evacuation



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Community evacuation measures should be the centerpiece of disaster risk management (DRM) systems. Because the Sanriku region has suffered from frequent tsunamis, its local communities have passed their knowledge from generation to generation, mainly by constructing commemorative monuments and by conducting education and drills. Nevertheless, about 20,000 people died or are missing as a result of the catastrophic tsunami on March 11, 2011. Various factors, such as underestimating tsunami heights in warnings and on hazard maps, as well as a lack of awareness, influenced the number of human lives lost. Since neither the local governments nor the electric power company had prepared properly for possible nuclear accidents, evacuation from the accident at the Fukushima Daiichi nuclear power station was chaotic.

FINDINGS

PREPARING EVACUATION MEASURES

Because predictions and other measures to foresee or prevent potential disasters are often unreliable, community evacuation measures should be at the center of DRM systems (figure 1). Other measures, such as hazard maps, education programs, practice drills, and warning systems all contribute to successful evacuation.

Since the Sanriku region has often sustained severe tsunami damage, its local governments and communities have developed a high level of disaster preparedness. The Meiji-Sanriku Tsunami of 1896, with a maximum run-up height of 38.2 meters (the highest point that a tsunami reached inland), killed over 22,000 people; the Showa-Sanriku Tsunami in 1933 with a maximum run-up height of 23 meters killed approximately 3,000; and a tsunami following the Chilean earthquake in 1960 killed 142. After each of these disasters, the local governments revised their DRM plans accordingly, designating shelters, procedures, and other mechanisms to facilitate speedy evacuation (KN 2-2).

FIGURE 1: **The relationship between evacuation and other DRM measures**



Communities in the Sanriku region have built 150 monuments to raise public awareness among future generations (box 1). Community-based groups, such as the volunteer fire corps and disaster management organizations, conduct training and regularly schedule practice drills (KN 2-1). Schools give classes on local experiences with past disasters and on disaster preparedness (KN 2-3). Earthquake and tsunami evacuation drills are also conducted, and local governments designate evacuation routes and shelters at higher elevations based on past tsunami heights. Tsunami hazard maps including the locations of evacuation shelters are displayed on sign boards in town (figure 2) and distributed to every household. Past tsunami water levels are posted on electricity poles and elsewhere on the roadside (figures 3, 4, and 5). Evacuation routes have been developed to reduce evacuation times, even if only by a few minutes (box 2).

Local governments conduct tsunami evacuation drills every year on days commemorating past large-scale tsunamis, and residents learned how to evacuate safely and quickly from their own houses to designated shelters. Volunteer organizations and private companies also participate, demonstrating, for example, how to assist people with disabilities, how to guide evacuees, and how to close tsunami dike gates. In sightseeing areas, tourists are also encouraged to participate in these drills.

Certain issues had been identified in evacuation measures even before the March 11 disaster. Public awareness about the possibility of a tsunami disaster had decreased since large-scale damage had not been sustained in many years. It was mainly the elderly and children who took part in the drills, while other age groups assigned them a lower priority.

BOX 1: Stone monuments transfer local knowledge to the next generations

In Aneyoshi District, Miyako City, Iwate Prefecture, villagers who followed the practices of their ancestors survived and saved their properties from the tsunami. A stone monument, set up after the 1933 Showa Sanriku Tsunami, is 60 meters above sea level—20 meters higher than the level of the 1933 tsunami. The inscription reads as follows:

“Living on higher ground will make the lives of our descendants more peaceful. Remember the catastrophic tsunami. Never build houses below this point. The tsunamis of 1896 and 1933 reached this point, and the villages were completely destroyed, leaving only 2 and 4 survivors. Be careful now, even after many years.”

When the tsunami occurred on March 11, villagers working on the coast immediately ran up the winding path toward this monument. A huge, black wave rushed up from the port, stopping 70 meters short of the monument.

FIGURE 2 (left): **Evacuation map**

FIGURE 3 (right): **Information on past tsunamis**



The number of participants in the drills had also been decreasing every year. Also, local organizations exhibited varying degrees of evacuation preparedness (box 3).

EVACUATION SCENARIOS ON MARCH 11

Of the approximately 602,000 people in the inundated areas, 582,000 escaped the tsunami, with 20,000 dead or missing. The Japan Meteorological Agency's (JMA's) underestimation of the tsunami's height issued three minutes after the earthquake is likely to have delayed

FIGURES 4 AND 5: **Evacuation signs**



BOX 2: **Tsunami evacuation routes for schools**



The evacuation bridge. The tsunami nearly reached the roof of the three-story Okirai Elementary School in Ofunato City, Iwate Prefecture, but all students got away safely over the evacuation bridge. The bridge had been built in October 2011, connecting the school building with a nearby road on higher ground. It shortened the evacuation route from 250 meters to 110 meters, and the evacuation time from 6 minutes to 3 minutes.

The evacuation stairway. The Omoto Elementary School in the town of Iwaizumi, in Iwate Prefecture, is located right in front of a cliff more than 10 meters high. To evacuate to safer ground, children had to take a roundabout route, so an evacuation stairway 30 meters long was built in March 2009. The school building and the gymnasium were inundated by the March 11 tsunami.

Source: Cabinet Office (CAO) and the Ministry of Land, Infrastructure, Transport and Tourism.

the evacuation. Although the agency revised its warnings later through real-time monitoring of the tsunami, all local governments and communities did not receive them because of power and communication failures (see KN 2-5). Others, believing that the coastal dikes would protect them, may have delayed evacuations. A survey of evacuees conducted by the government at the evacuation centers revealed the following:

FIGURE 6: **Evacuation timing**

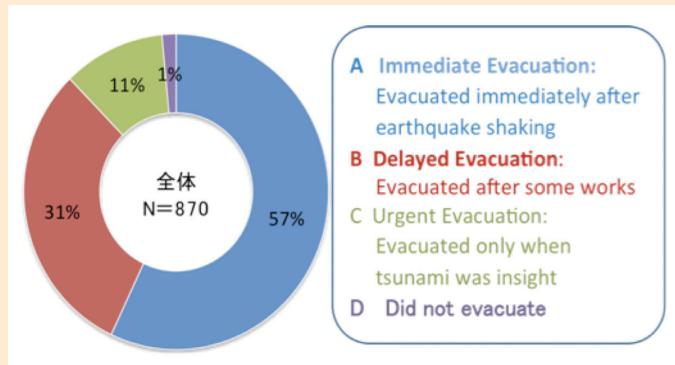
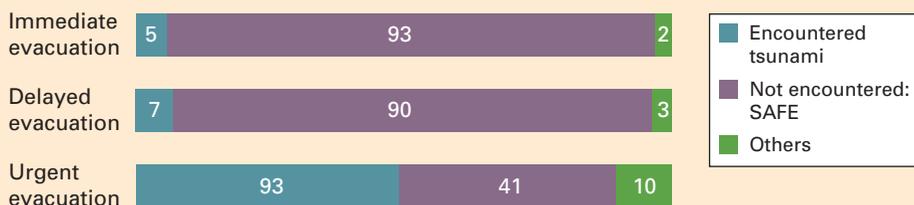


FIGURE 7: **Evacuation pattern and encounter with the tsunami**



Source: CAO.

Not all people evacuated immediately after the earthquake. Fifty-seven percent of the residents evacuated immediately (immediate evacuation), 31 percent evacuated after taking some other actions (delayed evacuation), 11 percent left only when the tsunami was in sight (urgent evacuation), and 1 percent of the residents did not evacuate as they lived on higher ground (figure 6).

Early evacuation is the key to staying safe. Most residents who evacuated immediately after the earthquake (immediate evacuation) were safe. But half of residents who did not evacuate immediately (urgent evacuation) had to contend with the tsunami (figure 7).

Residents with a high level of awareness are likely to evacuate immediately. Half of the residents who evacuated immediately (immediate evacuation) thought that the tsunami would reach them, while 70 percent of urgent evacuees didn't think it would or were not concerned about it.

Over half the residents evacuated by vehicle. Many wanted to leave with their family members, or thought that the tsunami would catch up to them if they left on foot. One-third of them were stuck in traffic jams. The average evacuation distance on foot was 450 meters, while the average distance to evacuate by car was 2 kilometers. While evacuation on foot is the general rule, vehicles are also needed to carry the elderly and disabled. Measures for evacuating by vehicle need to be improved.

Some designated evacuation shelters were submerged. Some 40 percent of the evacuees went to shelters that had been designated by the local governments. Among them, some 30 percent of the evacuees were submerged at the shelters by the tsunami.

People's behavior is influenced by group actions—during the GEJE, residents were influenced by their neighbors' decisions. People escaped as a group, though they were encouraged to escape the tsunami independently—“*tendenko*.” A survey found that some families were saved with their adjacent families, but others were not in Yuriage village in Natori City. In New York City on 9/11, too, people escaped from the World Trade Center with their office colleagues or in groups.

COMMUTERS AND SCHOOL CHILDREN STRANDED IN TOKYO

On March 11, 5.15 million people in the national capital region, including Tokyo, could not get home from schools, offices, and other venues because of traffic disruptions. In Tokyo City, some 94,000 people stayed in about 1,030 facilities, including a city hall building. In Sendai City, 50,000–100,000 people, including tourists, had to stay at evacuation shelters. In November 2011, local governments asked private companies to shelter their employees for three days following future disasters. This promises to facilitate response activities by keeping people off the streets. Companies are required to store emergency food rations, water, and other amenities for a three-day stay.

SAFETY FOR TOURISTS AND VISITORS

Tourists and other visitors do not have enough information on tsunami risks and emergency evacuation centers in unfamiliar places. The Japanese government proposed pictographic signs of tsunami disasters to the International Organization for Standardization, based on global and national standards (figure 8).

THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR STATION

THE FIRST STAGE

The Government Investigation Committee on the Accident at the Fukushima Nuclear Power Station (2011) explains “Evacuation instructions from the central government did not reach all the relevant local governments in a timely manner; and there was a great deal of confusion during the evacuation. Moreover, the instructions were not specific or detailed

FIGURE 8: **Pictographic signs: Safe place from tsunamis, tsunami evacuation shelter, and tsunami risk area**



Source: Ministry of Economics, Trade and Industry

enough. With insufficient information the local governments had to make decisions about whether to evacuate and evacuation procedures, locate evacuation sites, and so forth.” Fifty patients evacuated from the Futaba Hospital died by March 31. One of the main reasons for the confusion was that neither the central government nor the electric power companies had prepared well enough.

The governments issued six different evacuation directives within 24 hours: four revisions for the Daiichi Station and two for the Daini Station are as follows:

THE DAIICHI STATION

March 11

20:50 Fukushima’s governor gives an order to evacuate the area within a 2-km radius of the station.

21:52 The chief cabinet secretary gives another order at a press conference to evacuate the area within 3 km, and in-house evacuation within 10 km.

March 12

09:35 The chief cabinet secretary orders evacuation within 10 km at another press conference.

20:32 The prime minister gives an order to evacuate from within 20 km, also at a press conference.

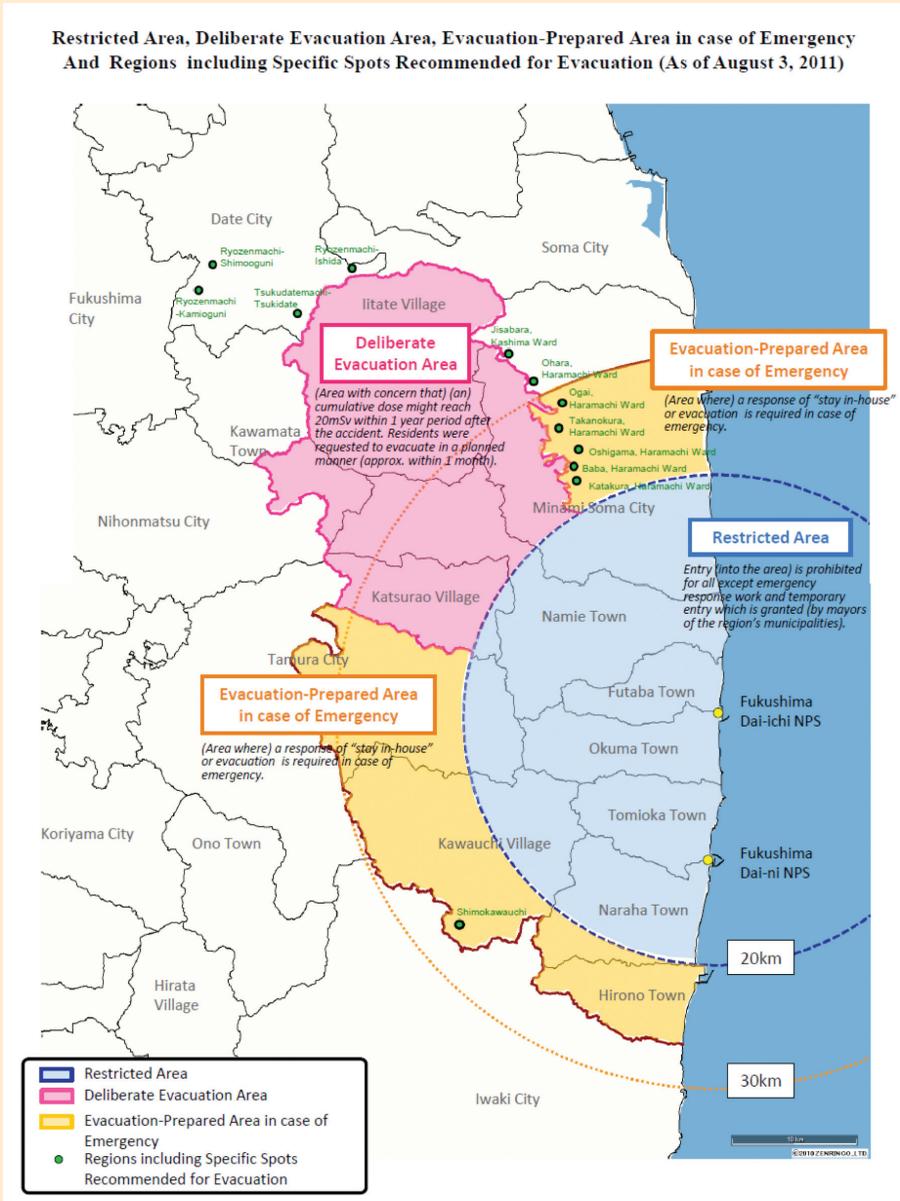
THE DAINI STATION

March 12

07:45 Evacuation order within 3 km, and in-house evacuation within 10 km.

17:39 Evacuation order within 10 km.

FIGURE 9: Evacuation area



Source: http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/evacuation_map_a.pdf.

In addition, the prime minister issued an in-house evacuation order within 30 km at a press conference at 11:00 hours on March 15.

LONG-TERM EVACUATION

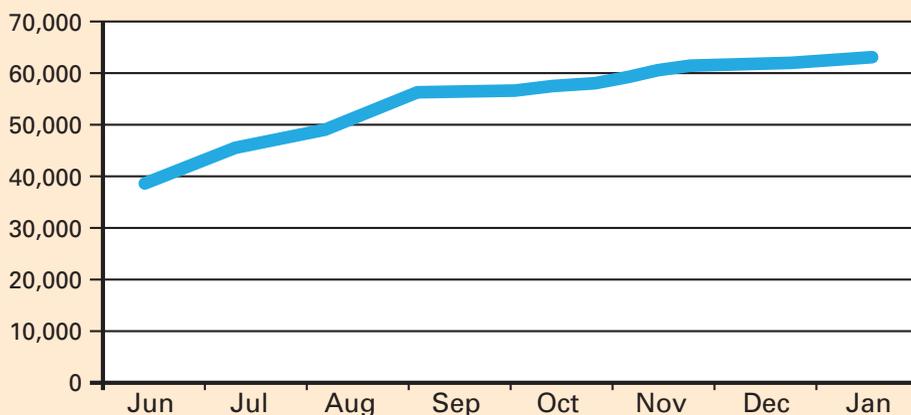
On April 22, 2011, the government defined the following zones (figure 9):

- **Restricted area.** The area within a 20-km radius where some 78,000 people live.
- **Deliberate evacuation area.** The area where the cumulative dose of radiation might reach 20 mm Sievert within one year. Some 10,000 residents were requested to evacuate within a month.
- **Evacuation-prepared area in case of an emergency.** The area where a directive of either “stay in-house” or an evacuation might be required in case of an emergency, affecting some 58,500 people. This was lifted on September 30, 2011.

People in the affected areas experienced all kinds of difficulties during the evacuation. They were forced to change shelters as the government expanded the evacuation zone. Some 82 percent of the evacuees changed shelters more than three times, and one-third of them changed more than five times. The death toll among the elderly who were evacuated from long-term care facilities increased substantially in 2011. It was also reported that dementia worsened among the elderly.

People in the Fukushima Prefecture continue to be evacuated (figure 10). More than 150,000 people have been evacuated, of whom over 60,000 were located in other prefectures across the country as of end 2011. Also, nine city governments moved to other

FIGURE 10: **Number of evacuees moved to other prefectures, June 2011–January 2012**



BOX 3: The Okawa tragedy



Seventy-four of the 108 students (70 percent) in the Okawa Elementary School, Ishinomaki City, died or went missing after the tsunami. The school is located about 5 km from the mouth of the Kitakamigawa River. Following the earthquake on March 11, teachers led the children from the school buildings to the playground as they had been trained to do. Since tsunami evacuation sites had not been identified before the disaster, they headed toward an elevated bridge not far away. The tsunami engulfed the students and teachers on the way to the bridge.

A statue was erected in front of the school for bereaved families to pray in memory of their children.

locations. This evacuation scenario is expected to continue, since detailed plans for relocation back to hometowns have not been formulated. According to an interview survey, one-fourth of the evacuees say they are “unwilling to return” to their towns of origin, and another one-fourth say that they would “return only after others have returned.” Younger people show less willingness to go back.

LESSONS

Japan has experienced many tsunamis, and has made ongoing efforts for over a century to strengthen evacuation measures and mitigate damages. Japan has already started modifying its DRM plans and developing new systems to prepare for the next tsunami by incorporating the following lessons:

Public awareness programs must be supported by action. Although most residents had enough knowledge about earthquakes and tsunamis, some failed to survive because they waited too long to evacuate. Public awareness programs must be designed to encourage evacuation. Without practice drills and trainings during normal times, people fail to evacuate properly and in a timely manner.

Public awareness programs should include practical knowledge. The programs should include the following messages:

- **Don't stick to past experiences.** No one knows how big a tsunami can be, and every tsunami is a new event. If someone says, “It is safe here because no tsunami has ever in my lifetime come this far up,” this only reflects a few decades of experience.

- **Don't wait for your family to return.** Some people went to meet their children, or waited for family members to get home. These people lost valuable evacuation time.
- **Don't wait for others to decide.** Some people couldn't decide whether to evacuate. They waited and watched what their neighbors were doing.
- **Don't stay in your car.** Some people evacuated in vehicles and got stuck in heavy traffic jams; they didn't leave their vehicles until the tsunami caught up with them.
- **Keep up to date with tsunami evacuation information.** Designated tsunami evacuation sites are sometimes changed based on recent scientific tsunami simulations or new developments in cities. Participating in evacuation drills in your own community, school, or company is an important way of keeping up to date with new information
- **Don't try to figure out for yourself what will or will not happen next,** as tsunami waves come repeatedly.
- **Never go back home to pack an evacuation bag before leaving.** Some people returned to their houses to retrieve valuables and other household items, and the second tsunami came and swept them away.
- **Update information after evacuation.** After the quake, blackouts occurred in most of the affected areas and telephone lines were congested. Portable radios are useful for staying abreast of the latest information and local news.

The limitations of various technologies must be understood. People who believed that tide walls and seawalls would hold off the tsunami delayed their evacuation. Also, some people felt secure because they believed that the tsunami levels estimated by the Met Agency would be lower than the walls, but at many points the tsunami exceeded the estimated heights. People who lived in areas that were indicated as being safe on hazard maps also delayed leaving. Others evacuated to shelters that appeared on the hazard maps, which had been officially designated as safe by the government, but were nevertheless engulfed by the tsunami.

Evacuation by vehicle should be considered as needed. The elderly cannot walk for long distances; and, in flat areas, it is difficult to walk several kilometers. Measures for evacuation by vehicle should be improved.

Procedures for evacuation from nuclear accidents should be prepared. The Government Investigation Committee on the Fukushima Accident (2011) stressed that "organizations concerned had not prepared because of the myth that all nuclear power stations are perfectly safe, and they therefore ignored the risks." The committee recommended the following:

- **Activities to raise public awareness are needed** to provide residents with a basic knowledge of how radioactive substances are released during a major nuclear accident, how they are dispersed by wind and other agents, and how they

fall back to earth; also, the harmful health effects of radiation exposure should be made known.

- **Local governments need to prepare evacuation plans** that take into account the exceptionally serious nature of a nuclear accident, to conduct evacuation drills periodically under realistic circumstances, and to encourage residents to participate in those drills.
- **During normal times, there is a need to make preparations**, such as drafting detailed plans for choosing and arranging of transportation, establishing of evacuation sites in outlying areas, and ensuring water and food supplies at evacuation shelters, considering that evacuees may number in the thousands or tens of thousands. It is especially important to develop measures for the evacuation of the disadvantaged, such as the seriously ill or disabled, including those in medical institutions, homes for the aged, and social welfare facilities.
- **The types of measures listed above also need to actively involve prefectural and national governments** to draw up and administer evacuation and disaster management plans, in the event that a nuclear emergency were to affect a large area. These precautions should not be left up to local municipal governments alone.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Promote evacuation measures as the heart of DRM. Evacuation, along with other nonstructural measures, is relevant to any other country, while the more sophisticated communication systems are costly and need many years to develop. Other measures, such as education and warnings, should be developed as support to the evacuation measures.

Support the community. Governments should support communities to prepare evacuation measures by providing hazard maps and warnings, mobilizing drills, constructing shelters and evacuation routes, and conducting education programs at school as explained in figure 1. Also, governments should formulate DRM plans by incorporating these measures.

Transfer memory to next generation. Memories and experiences of dealing with disasters should be passed from generation to generation. In Japan local communities constructed stone monuments recording tsunami disasters. Simeulue Island, northwest of Indonesia's Sumatra Island, had less damage than other areas after the Indian Ocean tsunami in 2004. The local residents evacuated as soon as they felt the earthquake, because they knew that after the tremor, sea water would come rushing in. They have passed along their tsunami experiences to the next generation through children's songs. Also, they had already relocated their towns from the coast to higher ground after the 1907 tsunami.

Raise public awareness. DRM education in schools, including evacuation drills, is essential to ensure successful tsunami evacuation at the community level. Children will bring back and share their knowledge with their families, which will help educate the whole neighborhood.

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