KNOWLEDGE NOTE 1-1

CLUSTER 1: Structural Measures

Structural Measures against Tsunamis
Structural Measures against Tsunamis

Structures such as dikes play a crucial role in preventing disasters by controlling tsunamis, floods, debris flows, landslides, and other natural phenomena. However, structural measures alone cannot prevent all disasters because they cannot mitigate damages when the hazard exceeds the level that the structures are designed to withstand. The Great East Japan Earthquake (GEJE) demonstrated the limitations of Japan’s existing disaster management systems, which relied too heavily on dikes and other structures. Damage can be kept to a minimum by multilayered approaches to disaster mitigation that include structural and nonstructural measures and that ensure the safe evacuation of residents.

Dikes, dams, and other structures are regarded as core measures in disaster risk management in Japan. Japan has constructed dikes to mitigate flooding for nearly 2,000 years. The first dike system was constructed in the Yodogara River in Osaka in the fourth century. The Japanese used dike systems to protect crucial areas, such as castles and residential areas, in the middle and early modern periods. The government established after the Meiji Revolution in the late nineteenth century has promoted structural measures to control floods, high tides, landslides, and tsunamis by employing modern technology introduced from the Netherlands and other Western countries. Disaster damage had substantially decreased because of concentrated investment in structural measures (KN 6-1).

Surrounded by seas, Japan has an extremely long, geographically complex coastline of approximately 35,000 kilometers. People, productive assets, and social capital are concentrated on small coastal plains over a limited land area. Not only are Japan’s coastal areas situated where earthquakes are exceptionally common, but they are also subject to harsh natural events, such as typhoons and winter ocean storms. Historically, the country has suffered severe damage from tsunamis, storm surges, ocean waves, and other natural phenomena. To protect life and property concentrated near its coastline, the country has been developing coastal and port facilities for the last half century.
FINDINGS

COASTAL STRUCTURES IN THE REGION AFFECTED BY THE GREAT EAST JAPAN EARTHQUAKE

When the tsunami hit eastern Japan in March 2011, 300 km of coastal dikes, some as high as 15 meters high, had been built (figure 1). Prefectural governments, which have the main responsibility for building the dikes (supported by national subsidies that cover two-thirds of the cost), built 270 kilometers of the total, with the national government building the remaining 30 km. The national government also had developed technical standards, guidelines, and manuals for use in the design and construction of coastal structures. In response to the economic damage caused by the GEJE – ¥300 billion ($3.75 billion) in destroyed dikes—the government has invested several hundred billion yen in dike construction in the Iwate, Miyagi, and Fukushima prefectures. It has also invested ¥400 billion ($5 billion) in constructing bay mouth breakwaters in major ports, such as Kamaishi, Kuji, and Ofunato, to protect them from tsunamis. A cost-benefit analysis of these investments appears in KN 6-1.

The disaster-affected region had frequently sustained devastating damage from tsunamis, including the Sanriku tsunamis of June 1896 and March 1933, and a tsunami caused by a massive earthquake off the coast of Chile in May 1960. The 1933 Showa Sanriku Tsunami was the first disaster to provoke modern tsunami countermeasures at the initiative of the central and prefectural governments. Those countermeasures included mainly relocation to higher ground and the building of dikes, albeit at just five sites (box 1).

The Chilean Earthquake Tsunami of 1960 prompted extensive construction of coastal dikes in the region. The dike height was initially based on the height of the 1960 tsunami but was revised several times thereafter to take into account other major tsunamis that had

BOX 1: The enormous tsunami walls of Taro, Miyako City, Iwate Prefecture

The people of the Tohoku region have built and maintained tsunami dikes for decades. Following the Meiji Sanriku Tsunami of 1896, the village of Taro was hit by a 15-meter tsunami that washed out 285 houses and killed 1,447 people. The 7.6-meter Showa Sanriku Tsunami of 1933 also hit Taro, washing out all 503 houses and killing 889 of the village’s 2,950 residents. Because insufficient high ground could be found for 500 houses, the village chose to build dikes. Construction began in 1934 using borrowed money and took more than three decades to complete. The largest dike was 2,433 meters long and 7 meters high (10.65 meters above the sea level). It was 3 meters wide at the top and as much as 25 meters wide at the base. The March 11 tsunami swept over this dike before destroying it, leaving a path of death and destruction across the community.
Structural Measures against Tsunamis

occurred in the previous 120 years, as well as predictions of future storm surge levels. These dikes are designed to withstand the largest of the predicted tsunami heights and storm surge levels. In Iwate and northern Miyagi, the heights were based on historical records, whereas in southern Miyagi and Fukushima they were based on the predicted storm surges. Methods of risk assessment are explained in KN 5-1.

Source: MLIT.
HOW STRUCTURES PERFORMED AGAINST THE GEJE TSUNAMI

Some towns in the region were well protected by the structures in place, even though the tsunami caused by the earthquake far exceeded their design height. In Iwate’s Fudai Village, the 15.5-meter floodgate, built in 1984, protected the village and its 3,000 inhabitants. The village was severely damaged by the Meiji Sanriku Tsunami of 1896 (height 15.2 meters), the Showa Sanriku Tsunami of 1933 (11.5 meters), and the Chilean Earthquake Tsunami of 1960 (11.5 meters). The mayor of the village in the early 1980s was convinced that a 15-meter tsunami would hit the village again at some point, and built the 200 meter-wide floodgate about 300 meters inland from the mouth of the Fudaigawa River, which runs through the village. Although the 20-meter-high GEJE tsunami did top the floodgate, the gate kept the water from reaching the town center (figure 2). The topography of Fudai Village, being surrounded by cliffs with a narrow opening to the sea, was a major factor in enabling the construction of such a high gate.

The dikes also served to protect communities in areas where the tsunami was lower than the dike (northern Iwate, Aomori, Ibaraki, and others), as shown in the example of Hirono Town (figure 3).

Certain breakwaters were also effective in mitigating damage from the tsunami. The breakwater at the mouth of Kamaishi Bay in Kamaishi City, Iwate, was completed in 2009, at a total cost of some ¥120 billion ($1.5 billion). It was the world’s deepest breakwater. Although destroyed by the GEJE tsunami, it reduced its force, and therefore its height, by

FIGURE 2: Inundation area in Fudai Village, Iwate

Photo taken on March 28, 2011

Source: MLIT.
about 40 percent and delayed its arrival by some six minutes, allowing more time for people to evacuate to higher ground (figure 4).

The GEJE tsunami destroyed many coastal structures. Of the 300 km of dikes along the 1,700 kilometer coast of the Iwate, Miyagi, and Fukushima prefectures, 190 kilometers were destroyed or badly damaged. In many cases the tsunami was twice the height of the dikes (figure 1). All 21 ports along the Pacific coast in the Tohoku region (from Aomori to Ibaraki) sustained extensive damage to their breakwaters, quays, and other coastal facilities, suspending all port functions.

Run-up from the tsunami caused significant damage along major rivers in the region. Traces of the run-up were found as far as 49 kilometers upstream from the mouth of the Kitakami River. Ishinomaki City in the Miyagi Prefecture, where the Kitakami flows out to the sea, experienced severe tsunami run-up in addition to the direct attack along the coast. Approximately 73 square
kilometers along the river, or about 13 percent of the entire city, were inundated (figure 5). The city suffered badly, with 3,280 dead and 539 missing (as of March 11, 2012). 20,901 houses were completely destroyed, and 10,923 houses badly damaged (as of October 21, 2011).

**NEW THINKING ABOUT STRUCTURAL MEASURES IN LIGHT OF THE GEJE**

The GEJE exposed the limitations of disaster risk management (DRM) strategies focused disproportionated on structural measures. Dikes and breakwaters built before the GEJE were designed to protect against relatively frequent tsunamis, and were effective in preventing damage from those of limited height. In the GEJE, however, the height of the tsunami far exceeded predictions. Although the structures helped to reduce water levels, to delay the arrival of the tsunami, and to maintain the coastline, many of them were breached, resulting in enormous inland damage.

Planning for the largest possible event is a significant policy shift in Japan’s thinking about DRM. Building 20- or 30-meter tsunami dikes is neither realistic nor financially, socially, or environmentally practical. But lives can and must be protected by other means, notably multi-layered approaches that combine structural and nonstructural measures to ensure the safe
TABLE 1: Countermeasures against level 1 and level 2 tsunamis

<table>
<thead>
<tr>
<th>Tsunami to be considered</th>
<th>Required performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1 tsunami</td>
<td></td>
</tr>
<tr>
<td>Largest in recent history (return period of approx. 100 yrs.)</td>
<td>Disaster prevention • Protect human lives • Protect properties/economic activities</td>
</tr>
<tr>
<td>Level 2 tsunami</td>
<td></td>
</tr>
<tr>
<td>Maximum level (return period of approx. 1000 yrs)</td>
<td>Disaster reduction • Protect human lives • Mitigate economic loss • Prevent major secondary disasters • Enable early recovery</td>
</tr>
</tbody>
</table>

Source: MLIT.

**FIGURE 6: Countermeasures against level 1 and level 2 tsunamis**

**FIGURE 7: Structure of a highly resilient breakwater**

Source: MLIT.
evacuation of residents (KN 6-5). Nonstructural measures are discussed in the knowledge notes of cluster 2. Planning for the new generation of multilayered DRM approaches is based on a comprehensive assessment of historical records, documents, and physical traces of past tsunamis, and by drawing on the latest seismological research and simulations.

Since the GEJE, the Japanese government has taken a two-level approach. Level 1 includes tsunamis that occur as frequently as every 100 years and that cause significant damage, whereas level 2 covers the largest possible tsunami, which has an extremely low probability of occurrence (once every 1,000 years) but that has the power to cause devastating destruction (figure 6). Conventional structural measures such as dikes and breakwaters protect human lives and property, and stabilize local economic activities, in the face of level 1 tsunamis. To withstand level 2 tsunamis, however, coastal structures must be improved to be more resistant to collapse and to reduce the likelihood of their complete destruction through scouring (figure 7). Some 87 percent of dikes that had been reinforced against scouring were not damaged in the GEJE, although the tsunami spilled over them.

The government has issued new guidelines for rebuilding river and coastal structures, taking into consideration their appearance as well as local characteristics, ecosystems, sustainability issues, and financial feasibility.

**OPERATION OF FLOODGATES AND INLAND LOCK GATES**

Although floodgates and inland lock gates can protect against tsunamis, their operation posed problems during the GEJE. Such gates should be closed before the tsunami arrives, but in the case of the GEJE tsunami this operation could not be completed in time, and a number of volunteer fire fighters and other workers were killed in the process. In addition, many gates were left open because equipment failed or because operators were caught in traffic jams and could not reach the site. Other gates became nonfunctional owing to power losses.

In December 2011, the Flood Prevention Act was amended to require local governments to ensure the safety of volunteer firefighters and other workers who operate floodgates, inland lock gates, and similar facilities. In March 2012, MLIT and the Fire and Disaster Management Agency issued the following recommendations to local governments and other concerned organizations:

- Remove unnecessary floodgates and ensure that the remaining floodgates can be operated automatically, semi-automatically, or by remote control.

- Keep inland lock gates closed at all times. Introduce automatic floating gate systems or install ramps or steps.

- Install emergency power supplies and make facilities earthquake-resistant.
LESSONS

The enormous tsunamis experienced in the GEJE have revealed the limitations of DRM measures that rely too heavily on structures. Structural measures cannot completely prevent tsunami disasters.

Many dikes and breakwaters were destroyed by tsunamis. They were nevertheless effective to some extent in reducing inundation areas and mitigating damage.

It is important to learn from past disasters and to revise countermeasures accordingly. In the GEJE-affected areas, various structural measures had been implemented in light of historical disasters, and they were successful in mitigating damage until the GEJE.

Scenarios that envision the greatest possible hazard should be taken into consideration when designing DRM measures. An appropriate combination of structural and nonstructural measures is required in order to achieve maximum mitigation of damage.

Structural measures should be designed to prevent damage to human lives and properties caused by level 1 events and to mitigate damage from level 2 events.

Though it is unrealistic to build structures large enough to protect against the largest conceivable events, the resilience of conventional structures must be enhanced. These should be built to mitigate damage even when the hazard level exceeds their design specifications. It is possible for structures to “fail gracefully” (meaning that they do not fail completely failure or collapse), thereby delaying the onslaught and reducing the energy of tsunamis. The concept of failure should be incorporated into the design to take into account unforeseen events.

Coastal facilities such as floodgates should be designed so that they can be properly managed even in the event of power failure and in the absence of operators. Standardized guidelines should be established for their safe operation in emergencies.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Prepare for disasters by integrating structural and nonstructural measures. DRM measures should account for two levels of hazard. Level 1 events are relatively frequent and produce major damage; level 2 events, the largest possible disasters, have an extremely low probability but produce devastating impact. Every possible structural and nonstructural measure should be employed to protect against level 2. Structural measures should be designed to protect people, property, and socioeconomic activities against level 1 and to mitigate damages at level 2.*

* The two-level approach has already been adopted in the design of other key infrastructure, such as dams and flood-prevention dikes. Dams typically consider the maximum probable flood or a flood with a 10,000-year return period when designing structural safety, and a 100–200 year flood for flood-control operations. For flood-prevention dikes to protect some critical areas of Tokyo and other locations, the government has increased design standards beyond the norm of 100–200 year floods.
Provide technical and financial support for local governments. The central government plays a crucial role in reducing disaster risks across the country. The central government should encourage local governments to promote structural measures by providing financial support and guide them in meeting minimum requirements for structures by producing technical guidelines and manuals. Also, the central government should provide the local governments with technical support, such as conducting training for technical staff in planning, design, operations, and maintenance.

Consider designs and improvements to enhance the resilience of structures and to prevent sudden and complete failure. Extraordinary external loads caused by earthquakes, floods, and other events should be considered in designing structures such as dams and dikes, which should be designed in a way so that they will mitigate damage even when the hazard level exceeds their design levels. Their effectiveness in mitigating damage should be ensured even in the event of their technical failure.

Raise dike levels in a phased manner, considering the country’s financial and social conditions. Safety standards and structural design upgrades against level 2 events should reflect the concentration of population and economic assets in the protected areas. Although it may not be possible to build dikes capable of withstanding level 2 disasters, appropriate and feasible targets for dike design safety should be identified.

Assure reliable operation of key facilities during emergencies. The safe and reliable operation of infrastructure must be ensured in emergency situations. Structural measures such as floodgates cannot provide reliable protection if they cannot be operated under extreme conditions, such as power failures and the absence of operators. Multiple layers of operation should be assured. A sufficient number of qualified operators should be available during disasters, but not necessarily onsite. Developing manuals and conducting regular drills are required during normal times. The danger to which operators are exposed should be minimized.

KEY REFERENCES


———. 2011. Design and operation of weirs and gates in light of the lessons of the Great East Japan Earthquake (Higashinihon daishinsai wo fumaeta seki suimon nadono sekkei sousa


KNOWLEDGE NOTE 1-2

CLUSTER 1: Structural Measures

Building Performance
Building Performance

The strong main shock of the Great East Japan Earthquake (GEJE) of March 11, 2011, caused little damage to buildings. Buildings designed under the current building code and those with base isolation fared well. However, seismic design guidelines for nonstructural members had not been considered adequately, which resulted in problems such as the collapse of ceiling panels. Soil liquefaction occurred in reclaimed coastal area along Tokyo Bay and riverside areas. The key lessons of the GEJE are that seismic-resistant building design prevent collapse of buildings and protects human lives, that retrofitting vulnerable buildings is essential to reduce damage, that seismic isolation functioned well, and that nonstructural building components can cause serious damage. When applying these lessons to developing countries, local technical and socioeconomic conditions should be taken into account.

FINDINGS

HISTORY OF BUILDING CODES IN JAPAN

The world’s first national seismic design code. Due to its location and tectonic settings, Japan is prone to large earthquakes. The Great Kanto Earthquake in 1923 caused some of the most serious damage in Japanese history, as fires consumed a large part of Tokyo, killing more than 100,000 people (table 1). Based on the lessons learned from the disaster, a seismic design code was introduced in the building code of 1924, the first national seismic design code applied anywhere in the world.

Building code updates following major earthquakes. After every major earthquake, Japan’s national government and academic community carry out detailed surveys of building damage, and the building code is revised accordingly. Technical recommendations are based on the most recent lessons. The Tokachi-oki earthquake in 1968 caused serious damage to reinforced concrete (RC) buildings and inspired a major revision of the building code in 1981. Until 1981, the building code required buildings to withstand a lateral force of 20 percent of the total weight of the building without damage in structural members. The revised code, part of which is still in use, requires that buildings be strong enough to with-
stand a lateral force equal to 100 percent of the building’s weight. Damage to the building is permissible as long as human lives are not threatened.

**Current building code (1981) in Japan.** The main aspects in the current building code of 1981 are as follows:

- Buildings should be able to withstand within their lifetime several large earthquakes without structural damage.

- Building should be able to endure, without collapse or other serious damage, an extremely large earthquake with a return period of 500 years.

Technical guidelines for assessing and retrofitting existing RC buildings constructed under building codes in effect prior to 1981 were produced.

**Initiative to retrofit buildings following the Great Hanshin-Awaji Earthquake (Kobe earthquake) in 1995.** The 1995 Kobe earthquake caused heavy damage, 6,437 casualties,
Building Performance

and economic losses estimated at more than $120 billion. Of the buildings that collapsed in the Kobe quake, 97 percent were built before 1981 (figure 1). Based on this finding, the government implemented a new law in 1995 to promote retrofitting of old buildings.

Under the Act for Promoting Seismic Retrofitting of Existing Buildings (1995), the national and local governments offer incentives to private homeowners, such as:

- Subsidies for assessments of structural soundness
- Subsidies for the cost of retrofitting
- Reductions in income tax and property tax
- Low-interest loans to cover the cost of retrofitting.

Some 80 percent of local governments have established subsidy programs to encourage owners to assess the structural integrity of their homes, and, as of April 2011, some 64 percent of the local governments had programs that subsidized retrofitting work. The government’s target is to increase the ratio of earthquake-resistant houses to 95 percent before 2020. In 2008, the ratio was 79 percent, with some 10.5 million houses still requiring retrofitting. In spite of efforts to promote retrofitting, only 300,000 houses were retrofitted between 2003 and 2008. These numbers show that it is difficult to motivate homeowners to retrofit.

**DAMAGE TO BUILDINGS BY THE GEJE**

**Minimal damage by large shaking.** Table 2 shows the summary of the damage caused to the buildings following GEJE. Most of the collapsed residential buildings were washed
TABLE 2: **Damage to buildings following the GEJE**

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential buildings</td>
<td></td>
</tr>
<tr>
<td>Total collapse</td>
<td>107,779</td>
</tr>
<tr>
<td>Partial collapse</td>
<td>117,019</td>
</tr>
<tr>
<td>Burned</td>
<td>263</td>
</tr>
<tr>
<td>Partial damage</td>
<td>434,327</td>
</tr>
<tr>
<td>Nonresidential buildings</td>
<td>32,445</td>
</tr>
</tbody>
</table>

*Sources: NILIM and BRI (2012).*

FIGURE 2: **Houses and cars were washed away by the tsunami**

*Source: Yamada-machi.*
The tsunami destroyed the outer walls of steel structures.

Reinforced concrete buildings withstood the tsunami even though it was submerged. Note the car on the roof.

Sources: BRI and NILIM.

away or destroyed by the tsunami rather than the earthquake. The death toll from earthquake ground shaking is estimated to be less than 200.

The earthquake produced violent shaking over a very wide area. The strongest peak acceleration of 2,933 gal was recorded in Tsukidate, Miyagi Prefecture, but 18 observation stations in six prefectures observed acceleration greater than 1,000 gal. In spite of the strong acceleration, damage from shaking was minimal, owing partly to the characteristics of the ground motion (the dominant frequency was relatively high). Damage to buildings constructed under the 1981 and later building codes was limited and within the range anticipated by the design code.

Serious damage by the tsunami. The cause of most of the damage to houses was the tsunami that followed the main shaking. Most wooden houses in deeply inundated
FIGURE 5 (top): Reinforced concrete building damaged by scouring

FIGURE 6 (middle): Reinforced concrete building damaged by liquefaction

FIGURE 7 (bottom): Overturned building of reinforced concrete with pile foundation

Sources: BRI and NILIM.
Building Performance

areas were washed away or totally destroyed (figure 2). Many steel structures were also severely damaged (figure 3). By contrast, buildings of reinforced concrete performed well against the tsunami. Although many were completely submerged, they did not suffer structural damage (figure 4). Those reinforced concrete buildings that were damaged tended to be small and without a pile foundation (figures 5 and 6). Figure 7 shows a damaged building where the probable causes of the damage were a combination of weak connections between piles and footings, strong water pressure from the tsunami current, and liquefaction.*

EFFECTIVENESS OF SEISMIC COUNTERMEASURES ON BUILDINGS

Good performance of seismic base isolation system. Japan’s Building Research Institute (BRI) reported that the seismic base isolation systems† in all 16 buildings in Miyagi Prefecture performed well, reducing lateral motion by 40–60 percent. No damage was observed to the structures or to mechanical and electrical facilities inside the buildings. No fittings or furnishings fell. The dampers and the cover over the slits between the isolated and nonisolated parts were damaged as expected.

Enhanced seismic design and retrofitting of transportation infrastructure facilities. A major campaign to reinforce key infrastructure such as bridges following the Kobe earthquake in 1995 was undertaken by highway and railway companies and governmental agencies. As a result, serious structural collapses of infrastructure were avoided following the GEJE. The East Japan Railway Company had reinforced more than 17,000 bridge piers under the Shinkansen (bullet train) lines, and the central government had retrofitted 490 bridges in the Tohoku Region. Because of these works, some 1,500 bridges on national routes in the region were spared serious damage. Five bridges collapsed under the force of the tsunami. Because damage was generally limited, it was possible to repair the main highways and roads to the affected areas within one week of the event. However, serious damage in the coastal areas affected by the tsunami took longer to repair. Shinkansen service to the Tohoku region resumed after 49 days (KN 4-1), a huge improvement over the situation after the Kobe earthquake, when reconstruction of the roads required more than 18 months and repair of the Shinkansen line took 82 days.

AREAS FOR IMPROVEMENT

Damage to nonstructural building components. Much of the damage observed in buildings following the GEJE involved nonstructural components attached to structures, such as ceiling panels, nonstructural walls and finishing materials (figure 8). To date, no guidelines or codes cover the wide variety of materials and designs used on nonstructural components. In Japan, few engineers have devoted attention to the matter.

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* In an earthquake, soil behaves like a liquid, losing its strength and bearing capacity.

† Isolated structures damp the effects of earthquake ground motion through decoupling of horizontal components. Isolation systems may be laminated steel with high-quality rubber pads, or other energy-absorbing materials.
Liquefaction. Liquefaction occurred on reclaimed lands and river banks over a wide area. Small buildings without pile foundations built on plots that had not been treated for liquefaction were affected (figure 9). Existing building codes cover countermeasures against liquefaction for reinforced concrete and other buildings, but not for the detached wooden houses owned by most ordinary people. The Ministry of Land, Infrastructure, Transport and Tourism has now produced technical guidelines to fill these gaps. Some local governments have provided liquefaction risk maps to encourage building owners to take countermeasures.

Damage from failure of retaining walls. In Sendai City, more than 4,000 houses were damaged by landslides caused by the strong ground shaking (figure 10). Since 1961, to prevent landslide disasters the city government has regulated housing in hilly areas under the Act on the Regulation of Housing Land Development. Most locations that experienced...
landslides following the GEJE were developed before the act came into effect. In 2009, in response to landslides caused by earthquakes since 2000, the central government established a subsidy mechanism whereby local governments were tasked to carry out geotechnical work to stabilize the ground for large-scale housing projects in high-risk areas. However, stabilization work had not started by the time the March 2011 disaster struck.

**Effect of ground motion of long periods on skyscrapers.** The potentially devastating effect of ground motion of long periods on skyscrapers and seismically isolated buildings has been recognized in the recent years. Recently skyscraper designs take into account the effects of ground motion of long periods. Some skyscrapers had been retrofitted by installing devices to control deformation or absorb energy. On March 11 strong and sustained ground motion of long periods reached Tokyo (approximately 400 km from the epicenter) and even Osaka (800 km), affecting the skyscrapers in both of these metropolitan areas. Recognizing the importance of countermeasures against the risks from sustained ground motion, the
Japanese government has now released a draft of a new technical guideline that revises structural design procedures, safety measures for furnishings and fittings, and a screening method to identify skyscrapers that need to be examined in detail.

**Technical guideline for tsunami evacuation shelters.** Japan’s first technical guideline for tsunami shelters was published in 2004. A revised guideline was released in November 2011, based on detailed surveys of the areas affected by the GEJE. Where the risks from tsunamis pressure are less serious, the tsunami load can be smaller under the revised guideline than under the previous guideline (figure 11).

**LESSONS**

**The importance of retrofitting older buildings.** The importance of retrofitting buildings is demonstrated by the fact that buildings designed under the 1981 building code and retrofitted buildings performed well in the GEJE, whereas most of the damaged buildings were constructed before 1981 and had not undergone any retrofitting. Further efforts to retrofitting are required, including more attractive incentives for those who cannot afford to invest in safety or are reluctant to do so (as are many elderly people). More affordable retrofitting methods should be developed. Partial retrofitting, safety shelters inside the home, and beds covered by safety frames are examples of affordable options.

**Safety of nonstructural building components.** The GEJE demonstrated the importance of considering nonstructural elements when thinking about earthquake safety. The materials, design, and construction of nonstructural components vary greatly. Technical guidelines are needed to ensure that such components are earthquake-resistant.
**Structural safety and functional continuity of buildings.** Even when structures withstood ground shaking and saved the lives of their inhabitants, inhabitants could not reoccupy their dwellings because of deformation of walls and doors. Substantial shear cracks in nonstructural walls made the inhabitants feel that it was dangerous for them to stay. Besides structural safety is achieved, it is recommended that efforts to achieve functional continuity of the buildings—with minimum disruption to everyday lives—are made.

**Liquefaction and landslides.** Countermeasures against liquefaction and landslides need to be enhanced in Japan. Following the GEJE, the Japanese government has reviewed the method of assessing the risk of liquefaction. Developing more effective and affordable anti-liquefaction treatments is needed. The government is considering a requirement that home buyers be notified of the risk from liquefaction. The government is also providing subsidies for projects to stabilize slopes with landslide potential near houses.

**Long-period ground motion.** The GEJE demonstrated the possibility of a gigantic earthquake occurring as a result of three large earthquakes (Tokai, Tonankai, and Nankai) occurring in short succession. Such a series of earthquakes would be likely to produce strong ground motions of long periods. Structural and retrofitting measures should be performed according to the new guideline, lowering the risk from long period ground motion by preventing amplification of shaking motion through increasing buildings’ capacity to absorb energy, and reducing structural deformation.

**Seismic isolation.** Buildings with isolated bases performed well during the GEJE, enabling them to be used without interruption even immediately after the main shock of the earthquake.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

**Seismic resilience of buildings is the most effective risk mitigation measure.** One of the most basic and effective measure to mitigate risks from earthquakes is to build structures that are resilient to ground shaking. Many buildings in developing countries are extremely vulnerable to collapse (figure 12).

**Use of technologies appropriate for developing countries.** Various seismic design guidelines have been developed around the world. Direct application of such guidelines may not be appropriate in developing countries because of their costs, the limited knowledge and skills of builders, and limited tools and facilities on construction sites. What is needed are seismic design guidelines that are suited to local conditions and capable of enhancing the resilience of buildings.

**Knowledge and lessons should be adapted and customized to local conditions.** In Indonesia a simple technical guideline that is consistent with local technical capacities and other conditions was developed and is being disseminated with help from the Japan International Cooperation Agency (box 1). Knowledge based on detailed surveys of construction sites and motivation on the part of engineers, workers, government officials, and owners of buildings can improve safety. may be effective approach,
Implementation of building codes. Another important issue is how best to implement building codes and how to monitor their implementation. Legislation should include provisions related to the issuance of building permits, inspection of construction, and enforcement of building codes. Enforcement requires sufficient numbers of trained and equipped officials and inspectors with access to technical information.

Japan’s Building Standard Law mandates the implementation systems shown in figure 13. Local government officials (or “designated confirmation bodies”) conduct examination/inspections before, during, and after construction. If conformity with building standards is confirmed, the building official (or “designated confirmation body”) issues a “confirmation certificate.” An interim inspection is performed on buildings that have certain structural characteristics or purposes. Multifamily dwellings, multistoried buildings, and public buildings are generally subject to this type of inspection.

Retrofit historical buildings. In countries with many vulnerable historical buildings, retrofitting is a big issue. Retrofitting should be considered in the context of striking a balance between affordable and effective retrofitting methods, a balance that motivates both private owners and government officials and politicians.

Secure safety of nonstructural components. The issue of nonstructural building components is common in developing countries, although the critical elements may be different. Nonstructural walls, roofing materials, and ornamental attachments such as pediments and signs are examples observed in field surveys in affected areas. Complicating this issue are the large variety of materials and designs and the scarcity of engineers. Materials that provide shelter and the curtain walls of outside buildings must be regulated first, given the
BOX 1: Simple technical guideline and its dissemination through the building permit process throughout Indonesia

The Central Java Earthquake in 2006 caused heavy damage and killed some 6,000 people, mostly through collapse of their houses. During reconstruction, the provincial government developed a technical guideline for small, one-story houses. The guideline, simple enough to be illustrated in a poster, has been well accepted by the population. The central government decided to apply it across the country through the building permit system.

Source: Japan International Cooperation Agency (JICA).
BOX 2: Tsunami evacuation shelters applying the Japanese technical guideline

Banda Aceh was severely damaged by the Indian Ocean Tsunami of 2004. Despite the devastation wrought by the tsunami, local people are returning to the coastal areas because their livelihoods are tied to the sea. Because no suitable evacuation areas are found along the coast, evacuation shelters are being constructed. The Japan International Cooperation Agency is supporting the construction of vertical evacuation shelters that embody Japanese technical guidelines. The shelter shown below was used for emergency evacuation in 2012.

Source: JICA.
risks they pose to pedestrians. To resolve the issue of roofing materials, manufacturers and engineers should be involved in improving construction methods and materials. Also, construction workers should be trained to install such materials in safer ways.

**Prevent large deformation of structures.** Japanese experts are examining ways to minimize structural deformation. This could be useful to countries whose seismic design codes allow larger deformation than Japan’s.

**Prepare for tsunamis.** Japan’s experience and knowledge with tsunami evacuation shelters is useful to other countries exposed to tsunamis, such as Indonesia. The tsunami evacuation shelter in Banda Aceh is an example of Japanese technical cooperation (box 2).

**Promote seismic base isolation.** Buildings with seismic base isolation features suffered very little damage from the GEJE. More key public buildings, particularly those that will be used for emergency relief activities and emergency response—that is, evacuation shelters and fire stations—should be built using base isolation. Simple and affordable techniques for base isolation should be developed for use in developing countries.

**KEY REFERENCES**


NILIM (National Institute for Land and Infrastructure Management), and BRI. 2012. Summary of Field Survey and Research on the 2011 Earthquake off the Pacific Coast of Tohoku. September.

KNOWLEDGE NOTE 1-3

CLUSTER 1: Structural Measures

Hydro-meteorological Disasters Associated with Tsunamis and Earthquakes
Hydro-meteorological Disasters Associated with Tsunamis and Earthquakes

Earthquakes and tsunamis increase the risks of hydro-meteorological disasters. After the Great East Japan Earthquake (GEJE), disaster-prevention structures such as coastal and river dikes were quickly rehabilitated. A phased process of rehabilitation work made it possible to address urgent needs for protection against frequently occurring floods and storm surges, while at the same time meeting longer-term targets for protection against mega disasters. The deterioration of levels of protection against hydro-meteorological disasters was quickly assessed after the GEJE in order to identify priority areas for rehabilitation, revise standards for the issuance of warnings, and raise public awareness about the increased risks of hydro-meteorological disasters.

FINDINGS

THE GEJE AND TSUNAMI INCREASED THE RISKS OF HYDRO-METEOROLOGICAL DISASTERS

The Great East Japan Earthquake (GEJE) caused extensive damage to coastal and river infrastructure and diminished the level of protection they provided against floods and storm surges, thereby increasing the risk of hydro-meteorological disasters. Countermeasures against these risks have been successfully put in place (figure 1). According to the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), 426 coastal units (including coastal dikes and revetments extending along 190 kilometers) out of a total of 515 units with a total length of some 300 kilometers sustained damage in the Iwate, Miyagi, and Fukushima prefectures.

The MLIT began on the day of the earthquake to assess the safety of dams and structures in some 30 rivers. Slope failure and subsidence of dikes were observed at 2,115 sites in eight rivers managed by the MLIT, mainly in the Tohoku and Kanto regions (figure 2). Local governments reported damage to a total of 1,627 sites in the rivers they manage. Many river dikes were also damaged by liquefaction caused by earthquakes. The MLIT confirmed
FIGURE 1: Countermeasures taken against hydro-meteorological disasters following the GEJE

<table>
<thead>
<tr>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>August</th>
<th>September</th>
<th>October</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flooding period</td>
<td>Snow melt flood</td>
<td>Rainy season</td>
<td>Typhoon season</td>
<td>Period when spring tide is relatively high</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Assessment and announcement of secondary disaster risks**
- Assessment and announcement of risks
  - Subsidence on the Sendai Plain, Miyagi and Iwate coastal areas has already been announced

**Discharge of water from inundated areas**
- River, coastal, agriculture, and sewerage departments collaborate to implement emergency protection of coastal lowlands and continue necessary measures (water removal by discharge pump vehicles, etc.)

**Measures against storm surges**
- Restoration of coastal dikes, etc.
- Warning/evacuation measures
  - Lowering of standards for call-out of flood fighters, or announcement standards for river flood forecasting, warnings, communication to residents, etc.

**Measures against heavy rains and floods**
- Lowering standards for call-out of flood fighters, or announcement standards for river flood forecasting, warnings, communication to residents, etc.

**Emergency discharge**
- (stacking sandbags to high tide level) (reinforcement of fore side of sandbags, etc.)

**Sediment management facilities**
- Construct sediment control dams as emergency measures in areas where failure occurred
- * Areas where failure was caused by the earthquake
- ** Areas where there are risks of failure

**Source:** MLIT.
that none of the country’s dams suffered structural problems, except for minor leaks and cracks. One irrigation dam failed, killing seven leaving one person missing in Fukushima Prefecture.

INCREASED INUNDATION RISKS FROM SUBSIDENCE

The earthquake caused extensive subsidence in some areas. Rikuzentakata City in Iwate Prefecture, for example, saw subsidence of 84 centimeters, which led to flooding of coastal areas and roads at high tide, often hampering recovery and rehabilitation efforts.

The level of protection against storm surges and flooding was significantly diminished in the Sendai Plain. The area below mean sea level more than tripled (from 3 km² to 16 km²) after the earthquake (figure 3), as revealed in the MLIT’s laser profiling survey. The MLIT produced subsidence maps and revised downward the water levels at which it issues flood warnings. For management of spatial data and their use in mapping, see KN 5-2.
Landslides caused by the earthquake

The earthquake caused 141 landslides, as a result of which 19 people lost their lives (as of February 2012). Immediately after the earthquake, the MLIT began inspecting 1,952 sediment control facilities managed by the ministry, while the prefectural governments inspected 4,324 facilities. The MLIT conducted emergency inspections of about 32,000 sites with potential risks of sediment disasters such as debris flows and landslides in 220 municipalities where the Japan Meteorological Agency (JMA) had observed seismic intensity of 5+ or larger. Significant deformation was found at 66 locations; minor deformation at 1,077. The MLIT shared this information with municipalities so that they could take the necessary measures.

With the higher risk of sediment disaster since the earthquake, triggers for the issuance of sediment disaster warnings were temporarily lowered. Local meteorological observatories and prefectural governments jointly issue warning about such disasters. Prefectural governments and the JMA are reviewing the standards for the issuance of warnings by investigating the relationship between the amount of precipitation after an earthquake and the probability of a sediment disaster.
REHABILITATING COASTAL AND RIVER DIKES TO PREVENT SECONDARY DISASTERS

After the GEJE, emergency measures were implemented to restore coastal dikes to prevent coastal flooding from storm surges. Emergency rehabilitation was first implemented along about 50 of the 190 kilometers of damaged coastline. Those 50 kilometers were selected because of the important facilities and properties in the area, or because of the urgency of restoring livelihoods, industrial activities, transportation, and agricultural activities.

The emergency rehabilitation work was implemented in three phases determined by climatic conditions and the seasonal occurrence of natural disasters (figure 4). The first step was to reinforce and raise the height of the damaged dikes up to the high-tide protection level. This work was done before the June-July flood season. The second step was to raise the dike height to the high-wave protection level, which was completed by September, before the typhoon season.

FIGURE 4: Rehabilitation of coastal dikes

Source: MLIT.
Full-scale restoration, the third step, is scheduled to start in fiscal 2012 in accordance with reconstruction plans and other rehabilitation projects. The works will be carried out over about a five-year period so as not to disrupt community development and industrial activities. On the Iwanuma Coast and in other coastal areas with facilities that are critical to recovery and reconstruction, such as wastewater treatment plants, full restoration will be completed by the end of fiscal 2012, March 2013.

Rehabilitation of river dikes began directly after the earthquake as the first step in preparing for heavy rain and floods. One of the most urgent tasks was to reconstruct the dikes to their predisaster height before the rainy season began in June. Emergency rehabilitation work was conducted at the 53 heavily damaged sites: 29 in the Tohoku Region and 24 in the Kanto Region. These works were completed by July 11, 2011. The standard for flood warnings was lowered during the flood seasons. The MLIT and the prefectoral governments measure rainfall and the water level in rivers, using automatic monitoring equipment and telemeter systems. The ministry and the governments then issue flood forecasts and warnings through the mass media, the Internet, and mobile phones.

Complete restoration of the river dikes to their predisaster condition began after the typhoon season and was completed by the time the 2012 rainy season began in June. Countermeasures against liquefaction also have also been implemented. The final step will be to improve dikes on the major rivers in the Tohoku region—the Abukumagawa, Narusegawa and Kitakamigawa—to protect against floods and tsunamis.

MEASURES TO MITIGATE INUNDATION RISKS IN THE DISASTER-AFFECTED AREAS

Inundation risks from heavy rain have increased in the disaster-affected lowlands of the Sendai Plain, where river dikes and drainage pump stations were damaged or destroyed and where extensive subsidence occurred. Temporary emergency measures were taken to reduce the risk of flood damage. Thirty-three drainage pump vehicles, provided by other regional bureaus of the MLIT around the country, were deployed in the disaster-affected area. A risk map showing inundation levels from daily precipitation of 100 millimeters and 200 millimeters provided information for local residents and municipalities. Inundation sensors were installed in areas with a high risk of flooding, and the information they collect is published to a Web page. Measures have been taken to send timely notifications automatically to relevant municipalities and local residents when there is a high risk of flooding.

LESSONS

Disaster prevention structures such as coastal and river dikes need to be rehabilitated quickly to prevent secondary disasters. Rehabilitation work should ideally be completed before the next rainy season and typhoon season.

In the aftermath of a disaster, it is important to identify the priority areas for rehabilitation and for protection against hydro-meteorological disaster. Priorities can be determined based on the existence of important facilities or commercial production centers and their significance for recovery and reconstruction activities.
Rehabilitation work should take place in phases. This is an effective way of meeting the communities’ most urgent needs for protection against frequently occurring floods and storm surges, while at the same time meeting longer-term targets for protection from mega disasters.

Deterioration in levels of protection against hydro-meteorological disasters needs to be quickly assessed, and the relevant agencies, organizations, and the public should be informed. Damage information should be collected and disseminated as soon as possible (KN 5-2). Warning standards should be revised according to the assessment.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Following any disaster, protective measures against collateral damage and secondary disasters is essential. The following actions are recommended:

Conduct an assessment immediately following the disaster. Damage to disaster prevention facilities and the risk of ensuing disasters should be assessed immediately after a disaster by quickly collecting relevant information. To make the most efficient use of resources, the areas to be rehabilitated should be dealt with in order of priority. Expert emergency teams should be formed during normal times by drawing on national networks (KN 3-1). Advance agreements can be made to allow the organizations concerned to mobilize private sector resources without going through the usual procurement processes (KN 4-1).

Rehabilitate crucial structures before the next disaster. A staged approach is appropriate, taking into account time constraints before the onset of the next season susceptible to hydrometeorological disaster. Rehabilitation works should be prioritized. Practical works, such as temporary structures made of sand bags or gabion boxes, need to be set up quickly.

Consider financial mechanisms. Financial arrangements, in particular the responsibilities of the central and local governments, should be made in advance during normal times (KN 4-1).

Share risk information with the community. “Post-disaster disaster risks” should be shared with local communities that may be affected. Nonstructural measures such as warnings should be strengthened in at-risk areas, since the effectiveness of countermeasures will have been diminished by the disaster.

KEY REFERENCES


Public facilities and infrastructure can be built in such a way as to reduce disaster risks and serve as disaster risk management facilities. Roads, expressways, and other public facilities helped reduce damage and loss in the Great East Japan Earthquake by providing protection against flooding, and by serving as evacuation routes and base stations for emergency operations. Organizations for disaster management and other public sector organizations should coordinate to ensure that their public works are multifunctional whenever possible; and cost-sharing mechanism should be developed to ensure that the financial burden is shared equitably.

**FINDINGS**

**EXPRESSWAYS SERVED AS DISASTER MANAGEMENT FACILITIES**

Expressways and roads mitigated damage resulting from the Great East Japan Earthquake (GEJE). The East Sendai Expressway, a 24.8-kilometer toll road running through the Sendai Plain, about 4 kilometers off the coast and at an elevation of 7 to 10 meters, acted as a secondary barrier or dike and prevented tsunamis from penetrating further inland (figure 1). It also prevented debris from flowing into the inland urban areas. The embankment served as an evacuation shelter for nearby residents, and about 230 people escaped the tsunami by running up to the expressway.

Many expressways were built on high ground, providing routes for evacuation as well as for rescue operations. Many coastal towns and communities were isolated immediately after the disaster because roads were flooded or covered with debris. Expressways built on higher ground served to connect otherwise isolated towns and communities (figure 2).

The Sanriku Expressway, a 224-kilometer expressway that runs along the Pacific coast through the Miyagi and Iwate prefectures, is still under construction. About 51 percent of the expressway was open for public use when the area was hit by the GEJE; it helped save many lives.
FIGURE 1: **East Sendai Expressway**

*Source: MLIT.*
Expressways constructed on higher ground were not damaged by the tsunami. In the aftermath of the GEJE, they provided an evacuation route for residents and enabled the self-defense forces and other emergency relief teams to get to the coastal municipalities that had been heavily affected. It also served as an important emergency route for transporting food, medical supplies, fuel, and other relief materials going to local disaster management bases and evacuation centers.

Miyako Road, a 4.8-kilometer section of the Sanriku Expressway, opened in March 2010. When the tsunami hit the area, about 60 residents managed to escape from the tsunami by climbing up the expressway embankment.

The Kamaishi–Yamada Road, a 23-kilometer section of the Sanriku Expressway that was opened only six days before the GEJE, served as a disaster management road. It was built to ease traffic congestion on Route 45, the main road connecting the coastal communities. Since Route 45 was prone to flooding from typhoons and tsunamis, the new road was expected to provide an alternative route if Route 45 were cut off in an emergency. In the Unosumai District of Kamaichi City, about 570 residents and school children escaped the tsunami. Because the road that led to the evacuation shelter had been destroyed, they climbed up to the Kamaishi-Yamada Road and managed to reach the evacuation shelter safely.

**SERVICE STATIONS AND PARKING AREAS ALONG HIGHWAYS SERVED AS DISASTER MANAGEMENT BASES**

Roadside service stations, service areas, and parking areas along highways also helped in the disaster management effort, providing bases of operation for rescue teams and evacuation shelters for local residents (table 1). The roadside service stations and rest areas along roads and highways, called Michi-no-eki (road stations), are equipped with toilets, restau-
TABLE 1: “Road stations” used in the aftermath of the GEJE

<table>
<thead>
<tr>
<th>Road stations</th>
<th>Location</th>
<th>Services during GEJE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sanbongi</td>
<td>Osaki, Miyagi</td>
<td>Open for 24 hours with power. Supplied food to evacuees.</td>
</tr>
<tr>
<td>Tsuyama</td>
<td>Tome, Miyagi</td>
<td>Used as a base for self-defense forces and rescue teams and as an evacuation center.</td>
</tr>
<tr>
<td>Fukushima-Touwa</td>
<td>Nihonmatsu, Fukushima</td>
<td>Provided food, water, and toilets for evacuees. Used by 1,500 evacuees.</td>
</tr>
<tr>
<td>Kita-no-sato</td>
<td>Kitakata, Fukushima</td>
<td>Provided water and food.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The hot-spring facility was made available to the affected residents.</td>
</tr>
<tr>
<td>Minamisouma</td>
<td>Minamisouma, Fukushima</td>
<td>Used as an evacuation center and emergency support base.</td>
</tr>
<tr>
<td>Hirata</td>
<td>Hirata, Fukushima</td>
<td>Provided power and water to evacuees and food to local hospitals and evacuation centers.</td>
</tr>
</tbody>
</table>

FIGURE 4: Self-defense force at a roadside station

Source: MLIT.

rants, and shops and are also intended to promote local tourism and business. These facilities are developed jointly by the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) in cooperation with local municipalities. In April 2012, there were 987 such stations nationwide. During the GEJE road stations were turned into disaster management bases equipped with electric power. They were available to the public around the clock when the neighboring area experienced power failures (figure 4).
In Minami Sanriku City, sports facilities near a highway exit were used as a disaster management center, evacuation shelter, drop-off site for emergency supplies, and operating base for the local government, medical institutions, police, and volunteer workers. The local government even moved its office to the site, because its official building had been destroyed by the tsunami.

**EVACUATION STAIRS TO EXPRESSWAYS SAVED SCHOOL CHILDREN**

When Iwaizumi Town in the Iwate Prefecture was severely hit by the massive tsunami, an evacuation stairway constructed at the Omoto Elementary School two years before saved the lives of 88 children (figure 5). Because there was no escape route from the school, since it was surrounded by steep cliffs, some of the children, during a tsunami evacuation drill, suggested how improvements might be made. In response to their suggestions and those of local residents, a MLIT field office completed the approximately 30-meter evacuation stairway with 130 steps along Route 45, which runs right behind the school.

**LESSONS**

Embarkment structures used to raise the elevation of highways and expressways can effectively prevent penetration of tsunami water and debris further inland. They can also be used as disaster management facilities (box 1).

Roads, highways, and expressways provided safe evacuation sites and escape routes because they were designed with earthquakes and tsunamis in mind. It pays to take disaster reduction into account when designing transport and other infrastructure.

Public facilities such as roadside stations and highway parking areas were used by various teams and organizations as base stations for rescue and emergency operations. They were
Recognizing that the embankment of the East Sendai Expressway had served as an effective evacuation site for local residents, evacuation stairs were temporarily installed at five locations along the embankment in May 2011. They are intended to facilitate evacuation in case of a tsunami.

Source: MLIT.

also used as evacuation centers because they were equipped with electricity, food, and water supplies.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

Infrastructure and public facilities such as roads, highways, and railways can be used as disaster management facilities in the event of floods, tsunamis, mudflows, and landslides. Facilities that are multifunctional are a particularly cost-effective approach to disaster management.

**Integrate various facilities into planning for disaster risk management.** DRM plans should include a range of public facilities. For example, playgrounds and parking areas can become rescue team bases or spaces for transition shelters. Expressway embankments can become evacuation sites in the event of cyclones, floods, and tsunamis.

**Develop cost-sharing mechanisms.** Cost-sharing mechanisms should be established between DRM organizations and public works organizations. The latter cannot be expected to bear all the DRM-related costs of a project, since those costs affect the project’s financial feasibility. In Japan the cost of adding height to an expressway is shared by the DRM organizations (KN 2-3-1).

**Coordinate with other sectors.** Coordination with other sectors, such as transportation, is required to develop multifunctional facilities. Platforms to coordinate planning, construction, and operation and maintenance should be established. In Japan prefectural governors designate the multifunctional facilities, allowing concerned organizations to initiate coordination under a new tsunami DRM law (KN 1-3).

**Consider negative effects.** High structures such as bridges and highways may have negative effects, such as water logging. They may isolate or separate communities and impose obstacles to the passage of people and animals. These effects should be assessed, and countermeasures or diversion channels and routes developed. In Japan, permission from DRM organizations is required before highways and bridges can be built.
KEY REFERENCES


KNOWLEDGE NOTE 1-5

CLUSTER 1: Structural Measures

Protecting Significant and Sensitive Facilities
KNOWLEDGE NOTE 1-5

CLUSTER 1: Structural Measures

Protecting Significant and Sensitive Facilities

The Great East Japan Earthquake was a multihazard event. A massive quake triggered a series of tsunamis of unprecedented dimension, as well as the subsequent nuclear accident. Sensitive facilities need to be protected against low-probability and complex events because damage to such facilities can have a cascading effect, multiplying the destruction and leading to irreversible human, social, economic, and environmental impacts.

FINDINGS

IMPORTANT FACILITIES WERE SERIOUSLY DAMAGED BY THE COMPLEX DISASTER

The Great East Japan Earthquake (GEJE) was a massive disaster triggered by the largest earthquake ever recorded in the history of Japan. But it was not only an earthquake disaster. The quake triggered a series of hazards and events including tsunamis of unprecedented dimensions, as well as a subsequent nuclear accident. Damages to critical disaster-response facilities, such as public buildings, hospitals and schools, hindered local capacities for response and recovery. Furthermore, destruction of sensitive facilities, such as a nuclear power station and industrial facilities, led to cascading damages and serious social, economic, and environmental impacts. The cascading effects of the GEJE revealed the weakness of Japanese disaster risk management (DRM) systems in the face of low-probability, high-impact events, and highlighted the importance of protecting sensitive facilities against disasters of any scale.

Government buildings. Local municipalities in Japan have the primary responsibility of saving and assisting people in the event of disasters. However, in the GEJE, many coastal towns and villages were devastated by the earthquakes and tsunamis, suffering great damage to their buildings, facilities, and personnel, and losing their capacity to take response measures promptly.
Based on a survey by Japan’s Cabinet Office, of the 237 municipalities that responded and that experienced seismic intensity of 6- or more, about 12 percent had to relocate their buildings either fully or partially (figure 1). In Otsuchi Town in Iwate Prefecture, a massive tsunami swallowed up the municipality building, destroying it and taking the lives of town officials including the mayor, who was at the time directing the disaster-response operations (figure 2). The town was without a mayor for five months.

**Disaster management and evacuation facilities.** Disaster management and evacuation facilities are critical to protecting people in times of disaster. Many of these facilities were devastated by tsunamis (box 1). In the 11 coastal municipalities of Iwate Prefecture, 48 out of 411 emergency evacuation shelters (designated shelters to which people are to...
Protecting Significant and Sensitive Facilities

A woman on the municipal staff in Minami-Sanriku City was urging residents over the radio to evacuate to higher ground. Although tinged with fear and apprehension, her voice gave people courage and helped save countless lives. She continued broadcasting to the very end before being engulfed by the tsunami. She never returned home. She had planned to be married in September 2011. In all, 39 staff members were declared dead or missing. The 12-meter-high building was located in a risk area that was submerged by 2.4 meters of water during the 1960 Chilean Tsunami.

Source: Prime Minister’s Office and Fire and Disaster Management Agency

evacuate immediately after an earthquake, as distinct from evacuation centers) were inundated by tsunamis; and in Rikuzentakata City, one of the cities with the highest casualty rates, more than half the evacuation shelters were inundated. The city’s gymnasium was designated as a primary evacuation shelter, and more than 80 people were there when the tsunami hit (figure 3). Only a few survived.

FIGURE 3: The Rikuzentakata city gymnasium
Health and social welfare facilities. Hospitals and social welfare facilities also need to be protected, because without medical response capabilities the number of casualties will increase and health hazards will spread. According to the Ministry of Health, Labor, and Welfare, almost 80 percent of hospitals were either destroyed or severely damaged by the earthquakes and tsunamis (figure 4). Furthermore, more than 12 percent of social welfare facilities—such as homes for the elderly, children, people with disabilities, and other vulnerable groups—were damaged by the disaster.

Industrial facilities. Six out of nine oil refineries in the Tohoku and Kanto regions had to suspend operations; fire broke out at two of the nine facilities. At an oil refinery in Chiba, the structure holding one of the liquefied petroleum gas (LPG) tanks failed, and the tank collapsed, leading to LPG leakage. The leaked LPG caught fire and caused an explosion, spreading the fire from one tank to another (figure 5). Six people were injured and all 17 LPG tanks were damaged, along with pipelines and roads. The fire and debris from the explosions damaged the surrounding buildings and vehicles. Nearby residential areas also suffered as the blasts damaged windows, shutters, slate roofs, and more. The explosions at the oil refineries are believed to have been one of the factors that accounted for the fuel shortage immediately after the disaster, which disrupted people’s lives and hindered emergency recovery operations in the disaster-affected areas.

The collapsed tanks had met all the requirements for earthquake-proof structures; however, at the time of the earthquake the tank was temporarily filled with water, instead of the lighter weight LPG, in preparation for a regular inspection. The braces supporting the legs that held the tank up could not bear its weight during the earthquake, leading to its collapse (figure 6).
In light of this accident, a government committee that conducted a technical review of LPG facilities recommended:

- Revision of the technical guideline for the tank braces
- Confirmation of the facilities’ safety by private companies, and government monitoring of the confirmation
• Risk assessment and countermeasures against liquefaction to be undertaken by private companies

• Reassessment of earthquake risks following the government review.

Cultural properties. According to the Agency for Cultural Affairs, more than seven hundred nationally designated cultural properties (such as monuments and historic buildings and landscapes) were heavily damaged by the earthquake and tsunami. Many national treasures, important cultural properties, and special historic sites also have been affected. Fortunately, few cultural properties of national importance were damaged. However, several properties will take a long time to recover, and some have been lost forever.

Disasters that result in irreversible damage or losses of important cultural properties can have a severe negative effect on local businesses, such as those that depend on the tourism industry, and can also undermine people’s pride in their communities. A culture-sensitive approach to restoration, in which original or local materials are used, is required to maintain the cultural value of historical buildings (figure 7). Retrofitting work should not be carried out in a way that destroys the historic value of the monument or building. If retrofitting cannot be carried out without compromising the structure’s cultural value, the area should be closed to visitors rather than altered in a way that changes its character. Following the Great Hanshin-Awaji Earthquake in 1995, the Japanese government established guidelines for protecting cultural properties against earthquakes and began implementing seismic assessments and retrofitting structures associated with national treasures and important cultural properties.

FIGURE 7: Retrofitting Jokoji Temple

Source: Agency for Cultural Affairs.
THE CASCADING EFFECT OF THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION

Four nuclear power stations comprising 14 units were located close to the epicenter of the March 11 earthquake. The earthquake caused all operating units to shut down automatically. Large tsunamis hit all sites within an hour of the main shock, damaging several of them. The worst affected sites were Fukushima Daiichi and Fukushima Daini. Fukushima Daini lost some safety-related equipment, but off-site and on-site power remained available, although not at optimal levels. On the other hand, Fukushima Daiichi lost much of its safety-related equipment because of the tsunami and almost all off-site and on-site power. This led to a loss of cooling to the operating reactors, and the ensuing nuclear meltdowns and release of radioactive materials.

The failure of the Fukushima Daiichi nuclear power station has had severe social consequences. About 160,000 people in Fukushima were evacuated, of whom more than 60,000 were taken outside Fukushima Prefecture. Many were unable to return to their homes for a long time because of unsafe levels of radioactivity.

Some agricultural products were found to contain high levels of radiation, resulting in local products being stigmatized as unsafe. There was also an incident in which radioactive gravel from Fukushima was mixed into the concrete used for construction of a new apartment building, exposing the residents to radiation.

FIGURE 8: Nuclear power stations near the epicenter and their emergency shutdown modes

| Source: Office of the Prime Minister. | auto shutdown | cold shutdown |
| Onagawa |
| Unit 1 524 MW, 1984– | ✔️ | ✔️ |
| Unit 2 825 MW, 1995– | ✔️ | ✔️ |
| Unit 3 825 MW, 2002– | ✔️ | ✔️ |
| Fukushima Dai-ichi |
| Unit 1 460 MW, 1971– | ✔️ | ✔️ |
| Unit 2 784 MW, 1974– | ✔️ | ✔️ |
| Unit 3 784 MW, 1976– | ✔️ | ✔️ |
| Unit 4 784 MW, 1978– | ✔️ | ✔️ |
| Unit 5 784 MW, 1978– | ✔️ | ✔️ |
| Unit 6 1,100 MW, 1979– | ✔️ | ✔️ |
| Periodic inspection | ✔️ |
| Fukushima Dai-ni |
| Unit 1 1,100 MW, 1982– | ✔️ | ✔️ |
| Unit 2 1,100 MW, 1984– | ✔️ | ✔️ |
| Unit 3 1,100 MW, 1985– | ✔️ | ✔️ |
| Unit 4 1,100 MW, 1987– | ✔️ | ✔️ |
| Tokai Dai-ni |
| Unit 1 1,100 MW, 1978– | ✔️ | ✔️ |
FIGURE 9: **Cause of the accident at the Fukushima Dai-ichi nuclear power station**

- ➀ Loss of off-site power due to earthquake
- ➁ Emergency diesel generator inoperable due to tsunami
- ➂ Loss of all cooling function

Tsunami (inundation height 14–15 m)

Seawater level

Seawater pump

Source: TEPCO (Tokyo Electric Power Company).

FIGURE 10: **Fukushima Dai-ichi nuclear power station**

Source: TEPCO (Tokyo Electric Power Company).
The Japanese government has taken decisive steps to clean up contaminated areas around Fukushima and to minimize health risks. It has set aside about ¥1.15 trillion for decontamination and disposal of contaminated waste between fiscal years 2011 and 2013. The long-term environmental and health effects of the nuclear incident are unknown; and the Japanese government will be monitoring the health status of residents of Fukushima Prefecture over the next 30 years.

The Government Investigation Committee on the Accident at the Fukushima Nuclear Power Stations stressed that a paradigm shift is required in DRM for catastrophic events. The interim report of the committee pointed out:

“The following three factors contributed greatly to the occurrence and response of the accident:

- Lack of preparedness for serious accidents caused by tsunamis. Neither TEPCO, the operator of the nuclear stations, nor the regulatory authorities had prepared for accidents as serious as those caused by the enormous tsunamis that followed the GEJE. Countermeasures must be put in place to address high-impact events, even those with low-probability. All concerned organizations must recognize these risks.

- Lack of appreciation for the effects of complex disasters. Securing nuclear stations and ensuring the safety of people in the neighboring communities against unforeseen complex disasters is a serious issue. Existing countermeasures for dealing with complex disasters must be reviewed and revised.

- Lack of a holistic understanding of complex disaster scenarios. Existing countermeasures to address nuclear power accidents do not reflect a thorough understanding of the complexity of nuclear power station systems. The excuse that the event was “beyond assumption” is unacceptable. Serious problems existed in the disaster risk management system for nuclear accidents.”

LESSONS

Important facilities were in most cases well protected against large-scale earthquakes thanks to seismic reinforcement and other measures.

Crucial facilities or facilities sensitive to disasters should be designed to withstand extreme events. Although tsunami hazards were taken into account in the site evaluations and design of facilities, the hazard level had been underestimated.

Nuclear power stations and other disaster-sensitive facilities should be carefully evaluated against the risks of all natural hazards, and these assessments should be periodically revised based on the latest knowledge and technologies. The failure of a sensitive facility, such as the case of the Fukushima Daiichi nuclear power station, can cause not only short-term consequences but also long-term social, economic, and environmental problems.
The cascading effects of the GEJE disaster highlight the importance of protecting sensitive facilities against disasters of any scale. The followings are recommended as important steps to lower risks for crucial facilities and to prevent high and irreversible impacts of complex disasters.

Identify critical facilities. Critical facilities need to be identified and well protected against extreme events. These include hospitals, government offices, evacuation shelters, schools, and other facilities to be used for rescue operations, evacuation, and other disaster management activities. Also, facilities, such as nuclear power stations and oil refineries that may cause cascading effects in various sectors should be identified. Disaster management plans should include information on the functions of these facilities and the risks they may pose.

Assess critical facilities. Facilities that are required to function as bases for disaster-response activities should be “stress tested” for disaster resistance. Even simple assessments, such as confirming a facility’s safety against recorded disasters, is useful in preparing for disaster. The risk of all natural hazards, including that of multihazard events, should be carefully evaluated. Risk assessment should incorporate not only statistics on recent hazards but also historical records of past disasters as well as future projections, if possible. Such assessments and assessment methodologies should be periodically updated.

BOX 2: Tsunami impact on the Onagawa nuclear power station

The Tohoku Electric Power Company’s Onagawa Nuclear Power Station is located about 120 km west of the epicenter of the March 11 earthquake. Although the tsunami was about 13 meters high at the Onagawa nuclear power station, the station’s structures and equipment were not severely damaged.

When the first unit was built in the 1970s, the site elevation of the station was set as 14.8 meters above sea level. A literature review and interview surveys revealed that the maximum tsunami height at the Onagawa site was estimated to be about 3 meters, but the 14.8 meter site elevation was considered appropriate.

Since then, the tsunami hazard assessment has been reviewed many times, using up-to-date findings and cutting-edge tsunami simulations and, every time, the safety of the facility against tsunamis has been confirmed. The most recent tsunami design standard was set as 13.6 meters. Even though the Onagawa site experienced a subsidence of 1 meter, the March 11 tsunami did not submerge the main facility.

At the second unit, however, the intake unit for the seawater pump station was built as a pit-structure, and the pump was situated below the rest of the facility. This caused the seawater to enter the pump room through the tide gauge, submerging an emergency generator and rendering it inoperable.

In the aftermath of the disaster, the main building of the nuclear power station was used as an evacuation center for about 400 local residents whose houses had been washed away. These people stayed at the power station for about three months.
Protect critical facilities. Critical facilities should be protected against the risks of all natural hazards. The possibility of multihazards should be considered in their design. Enforcement of building codes should be a high priority for buildings and other important structures.

Prepare for complex disasters. High-risk plants and facilities need to be included in disaster management plans. Plans for quick recovery and rehabilitation after a disaster of unexpected scale should be made. Evacuation drills should be conducted based on various disaster scenarios.

Establish enforcement mechanisms. Regular inspections of critical facilities by firefighters and other disaster management organizations should be established. Responsibility for safety guidelines, monitoring, and enforcement needs to be clearly established in land-use procedures, building codes, fire inspections, and so on. Effective enforcement requires appropriate legislation, organization, and human resources.

KEY REFERENCES


KNOWLEDGE NOTE 2-1

CLUSTER 2: Nonstructural Measures

Community-based Disaster Risk Management
Local communities play a key role in preparing for disastrous events such as the Great East Japan Earthquake (GEJE), and are normally the first responders to take action. On March 11, 2011, community-based organizations (CBOs) were active in the disaster response and saved countless human lives. Recognizing the role of communities and providing them with central and local government support is critical to maintaining and strengthening important community-based functions.

Local communities have been responding to and managing disaster risk for centuries. Before the creation of Japan’s formal state system, local communities carried out disaster-related activities as volunteers; community-based organizations (CBOs) have existed for centuries. They include: *Suibo-dan* for flood risk dating from the 17th century, *Syobo-dan* for firefighting from the 18th century, and *Jisyubo* for earthquake disasters from the 1970s (see table 1).
In addition, various nongovernmental organizations (NGOs) and nonprofit organizations (NPOs) are involved in disaster risk management (DRM) activities at the community level. Many of them collaborate with *jichikai* (neighborhood associations) and local governments, and sometimes with local academic institutions.

How the government and CBOs coordinate around DRM has evolved over two centuries, shaped by major events and trends. These include the Meiji Restoration at the end of the 19th century, which prompted modernization and centralization; democratization following World War II; and the miracle of economic development in the 1960s. Traditional community structures were eroded over time as Japanese society modernized and urbanized. As depicted in figure 1, this has resulted in a decrease in spontaneous and autonomous community-based engagement in DRM with a corresponding increase in government support to these activities. The government’s recognition of and support to community-based DRM has been key to keeping these efforts alive and well.

**FINDINGS**

**THE ROLE OF CBOs IN THE GEJE**

A key factor in reducing the number of lives lost in the GEJE was the long tradition of community organization around risk reduction and preparedness. The tsunami waves brought on by the GEJE overwhelmed coastal defenses, and warning systems underestimated the height of the waves. CBOs played critical roles in responding to the event.
THE VOLUNTEER FIRE CORPS (SYOBO-DAN)

The volunteer fire corps traces its history to the 18th century. Corps members have regular jobs but, when disaster strikes, they take part in disaster management activities in their own communities, such as firefighting, issuing warnings, assisting evacuations, conducting search and rescue operations, and operating facilities. There are currently some 890,000 active volunteers across Japan, which is almost six times the number of career firefighters. The Fire Defense Organization Act and its bylaws stipulate the corps’s roles, organizational structures, members’ status as part-time government staff, and compensation and allowances. The local government has principal responsibility for the corps, while the central government subsidizes their facilities.

The Syobo-dan responded to the GEJE at the risk of their own lives. Some 250 members were killed or are missing, including 51 in Rikuzentakata City. Some examples follow:

- A corps member quickly guided all the people in a community to an evacuation shelter preventing any casualties. Corps members supported the evacuation of 30 handicapped and elderly persons, and persuaded three other people to move who were insisting on staying at home (Shiogama City).
- Members closed the tsunami gates by hand, since they could not be operated automatically because of power failures (Miyako and Ofunato cities).
- Members died closing the tsunami gates in Kamaishi and Isihinomaki cities.
- One member died ringing a fire bell to warn people of the tsunami right up until the tsunami hit (Otsuchi City).
- Six members, on the way back from closing gates, tried to save a bedridden elderly woman from her residence. Five of the six members and the woman died in the tsunami (Otsuchi City).

Based on lessons learned from the GEJE, the Fire and Disaster Management Agency requested local governments to reinforce the volunteer fire corps in October 2011 with equipment, increased allowances up to the level stipulated by law, and the recruitment of new members.

NEIGHBORHOOD ASSOCIATIONS (JICHIKAI)

Communities were generally very well prepared for the GEJE. Most had participated in regular disaster drills and knew what to do when the tsunami warning was issued.

For example, in Kesennuma City, a television program broadcast in 2007 urged neighborhoods to prepare themselves. The program provided a detailed simulation of a tsunami hitting Kesennuma. This simulation was shown to the local residents, and the neighborhood associations (Jichikai) subsequently undertook to identify key evacuation routes. Regular disaster drills were also conducted. These preparations helped local residents to
evacuate safely and quickly to higher ground immediately after the GEJE, thus saving many lives (figure 2).

In the Toni village of Kamaishi City, community members participate in annual disaster evacuation drills conducted by the Jichikais. The drills are conducted every year on March 3 to mark the anniversary of the Meiji-Sanriku tsunami of 1896. Participation rates in the disaster drill vary from neighborhood to neighborhood, with more people participating in the smaller, more cohesive communities. According to the head of the Jichikai, the participation rate in Kojirahama is low, while in Kerobe most people participate in the drill. In Kerobe and Oishi, community members have a strong sense of solidarity, as the population is much smaller than in Kojirahama and they have lived there for years. Toni residents have written books about the effects of past tsunamis, which are used by the communities as an awareness-raising tool. In addition, there are two tsunami maps: one issued by the Kamaishi City government and the other developed by the community members themselves. The former includes the expected flood area, expected height of the tsunami, and expected arrival time. The latter includes local information about which areas were flooded in the Meiji-Sanriku and Syowa-Sanriku-tsunamis, evacuation sites, evacuation routes, and dangerous areas. These maps are distributed to all families in the town of Toni (KN 5-3). Finally, a number of community festivals are used as opportunities to engage local schools in disaster awareness and preparedness activities (figure 3).

In the Wakabayashi ward of Sendai City, the local community forged a very strong relationship with the elementary school to educate people in disaster preparedness. At the initiative of the Jichikai, regular drills were conducted in cooperation with the school. A handbook was prepared on managing the evacuation centers. After the 2010 Chilean earthquake, a tsunami warning was issued for the Tohoku coast, and tsunami waves of up to 1.5 meters reached some areas. This prompted communities in Wakabashi to reexamine their evacuation plans. They found that it would take longer than expected for school children in the coastal school, Arahama Elementary, to evacuate to the designated school, which was 4 kilometers from the coast. The local community therefore decided to take shelter
in Arahama Elementary School, and emergency food supplies were increased to feed 800 instead of 300 people, and were stored on the top floor of the school building. During the GEJE, Arahama Elementary served as the shelter for more than 300 adults from local communities, in addition to 70 school children. They remained in the school overnight, and the food supplies were well protected on the top floor during the emergency (figure 4).

LESSONS

The GEJE experience yielded several important lessons about the need to empower communities: to understand and reduce the risks they face, to be prepared, and to act as first responders to hazard events. It also pointed to important ways that their roles can be strengthened. Specific lessons include:
The volunteer fire corps plays a critical role in DRM for several reasons:

- Since the volunteers come from the community, they have local knowledge of the context and are familiar with those residents who may need special assistance to evacuate, such as the disabled or bedridden.

- The total number of volunteers is some six times that of the professional firefighting staff, providing a cost-effective way of mobilizing large-scale emergency response capacity.

- The members receive regular training and can respond immediately because they are locally based.

Community-based DRM activities are well integrated in the daily lives of the residents, ensuring that awareness of natural hazards is maintained, for example, by marking the anniversary of a large catastrophe with disaster drills, and linking awareness-raising activities with local festivals.

The role of communities in DRM is formally recognized and supported by local and national authorities through linkages with local institutions.
RECOMMENDATIONS FOR DEVELOPING COUNTRIES

• Most people saved from major disasters are rescued by relatives and neighbors within the first 24 hours—before professional responders can get there. Statistics show that in the 1995 Kobe earthquake, 80 percent of those rescued were saved by their neighbors. So, while local and national authorities have key responsibilities for civil protection in hazard events, communities are always the first responders and should be empowered in that role.

• Strong and effective community-based DRM requires grassroots support and linkages to the day-to-day life of the community. Linking disaster risk awareness and preparedness activities to local cultural events can be extremely effective in maintaining a culture of preparedness.

• In addition to grassroots support, building effective and sustainable capacity for community-based DRM requires the formal recognition and support of local and national authorities. In addition to providing financial and technical assistance, local and national governments should develop legislation on and institutionalize the role of CBOs.

KEY REFERENCES


KNOWLEDGE NOTE 2-2

CLUSTER 2: Nonstructural Measures

Disaster Management Plans
Following its devastating experience with recent disasters, Japan has been strengthening or drawing up new disaster management plans at the national and local levels. The Great East Japan Earthquake (GEJE) revealed a number of weaknesses in planning for complex and extraordinary disasters. Central and local governments have been revising their plans to reflect what they learned from the GEJE.

Japan’s disaster management system addresses all phases of disaster prevention, mitigation and preparedness, and emergency response, as well as recovery and rehabilitation. It specifies the roles and responsibilities of national and local governments, and enlists the cooperation of relevant stakeholders in both the public and private sectors. Following the Great East Japan Earthquake (GEJE), assessments have been made of the capacity of existing disaster risk management (DRM) planning systems to prepare for and react to large-scale disasters. Revisions have been proposed, based on the lessons learned on March 11.

**FINDINGS**

**DISASTER MANAGEMENT SYSTEMS IN JAPAN**

**Disaster Countermeasures Basic Act.** In the 1940s and 1950s Japan was repeatedly ravaged by typhoons and earthquakes. In particular, the 1959 Isewan Typhoon in 1959 caused tremendous damage; in 1961 the Disaster Countermeasures Basic Act was passed.

The act established the following:

- The Central Disaster Management Council was to formulate the overall policy for DRM and to function as the national coordinating body for disaster management. The council was chaired by the prime minister, and its members came from line ministries, semipublic organizations (such as Public Broadcasting, the Bank of
Japan, the Japanese Red Cross, and a telecommunications company) and representatives from academia (figure 1).

- Roles and responsibilities regarding disaster reduction were clearly defined at the national, prefectural, and municipal government levels, as well as for community organizations and citizens; and the three levels of governments were required to draw up master plans for DRM. Also, all the ministries and semipublic organizations were asked to prepare disaster management plans for their sectors.

- The cabinet submitted an annual report to the National Diet covering the status of DRM, and specifying the budgetary allocations for DRM programs. The National Diet formed special committees for disaster management in both its lower and the upper houses, which have continued to monitor governmental DRM initiatives.

In 1995 the occurrence of the Hanshin Awaji Earthquake forced a revision of the 1961 Act to focus more on countermeasures and prevention, resulting in a new Disaster Countermeasures Basic Act in 1995.
The Central Disaster Management Council retained its leading role in conducting the following activities:

- Formulating and coordinating the implementation of the Basic Disaster Management Plan.
- Formulating and coordinating the implementation of contingency plans for emergencies.
- Advising the prime minister or the minister of state for disaster management on important issues relevant to disaster management.
- Fostering consultations on important issues surrounding disaster management, in response to inquiries from the prime minister or the minister of state for disaster management.

The cabinet office is the secretariat for this council. The minister of state for disaster management, who is assisted by the staff of the cabinet office, has a mandate to oversee the planning and central coordination of basic DRM policy and large-scale disaster countermeasures. The minister is also responsible for integrated information gathering and other disaster emergency measures.

The Basic Disaster Management Plan is the master plan and the basis for DRM activities in Japan. It is prepared by the Central Disaster Management Council in accordance with the Disaster Countermeasures Basic Act. The plan clarifies the duties of the central government, public corporations, and local governments in implementing measures. The plan also describes the sequence of disaster countermeasures such as preparation, emergency response, recovery, and reconstruction for various types of disasters.

Based on the Basic Disaster Management Plan, every designated government organization and public corporation draws up a Disaster Management Operation Plan; and every prefectural and municipal disaster management council prepares a Local Disaster Management Plan.

The council has the right to establish technical committees to study technical matters. After the GEJE, the council recommended specific evaluations to identify whether any revisions or additions to the 1995 Basic Act were required.

The Expert Committee on Earthquake and Tsunami Disaster Management prepared a report to document facts and findings from the GEJE experience. In response to this report, the Japanese government amended the Basic Disaster Management Plan on December 27, 2011, aiming to enhance countermeasures against multihazard, high-impact events.
Major revisions to the plan included:

- Addition of a new section on tsunami disaster management.

- Fundamental improvements in disaster management for tsunamis and earthquakes in the light of the GEJE:
  - Requirements to prepare for low-probability and large-scale earthquakes and tsunamis.
  - More careful consideration of multihazard and multilocation disasters.
  - Mandatory inclusion of DRM in urban land use.
  - Raising of public awareness about evacuation, DRM measures, and hazard maps.
  - Additional investments nationwide for capacity building of each countermeasure.
  - More resources to be invested in understanding disaster risk, and developing innovative systems for monitoring earthquakes and tsunamis.
  - Communication tools such as tsunami early warning systems to be strengthened.
  - Additional reinforcement and retrofitting of homes and buildings to reduce earthquake damage.

- Revision of countermeasures, such as taking gender into consideration at evacuation shelters, and improvement of warning messages.

**REVISI NG LOCAL DISASTER MANAGEMENT PLANS**

The municipal government plays a fundamental role in disaster management: according to the Disaster Countermeasure Basic Act, it is responsible for establishing a local disaster management plan, emergency operations such as warning systems, issuing evacuation recommendations and orders, and flood fighting and relief activities (figure 2). In cases where a municipality is so widely and heavily devastated that it cannot carry out many of its primary roles, the prefectural government shall issue evacuation recommendations and orders instead of the municipality.

A local disaster management plan shall provide for the following:

- Specification of the roles of government organizations, designated public corporations (such as public utilities and the Red Cross), and other relevant public organizations.
Disaster Management Plans

- Plans by category of activity, including: development or improvement of DRM facilities, investigation and research, education, drills and other preventive measures, collection and dissemination of information, issuing and disseminating of forecasts and warnings, evacuation, fire fighting, flood fighting, rescue, hygiene, and other emergency measures and rehabilitation efforts.

- Plans for coordination, stockpiling of food and supplies, procurement, distribution, shipping, communication, facilities, equipment, materials, funding, and so on.

When a prefectural disaster management council wishes to formulate or revise a local disaster management plan for the prefecture, the council is required to consult the prime minister in advance, who in turn shall consult the Central Disaster Management Council. When the prefectural disaster management council has formulated or revised its local prefectural disaster management plan, the council is required to release and disseminate a summary of the plan or revision.

Source: CAO.
Following the GEJE, local governments across Japan have started reviewing their disaster management and risk reduction systems to strengthen countermeasures for multihazard, high-impact events.

The Fire and Disaster Management Agency set up a Review Committee on Improvement of Earthquake and Tsunami Countermeasures in Local Disaster Management Plans. This committee aimed to (i) assess counter measures taken by local governments in the GEJE, and (ii) support local governments in revising their local disaster management plans, which are the foundation for local disaster management and reduction measures. In particular, emergency measures, including evacuation measures, and emergency training have been emphasized.

The committee made the following key recommendations for revising local disaster management plans:

- Develop action plans with concise descriptions and measurable results by setting quantitative targets.
- Plan the timing of initial actions to be taken in the event of a disaster (manuals and so forth).
- Be sure to specify emergency measures for evacuating local residents (issuing of evacuation orders and other communications with residents).
- Establish procedures in case local disaster management capabilities are lost, for example, prefectures must quickly provide appropriate alternative measures or assistance to municipal governments.
- Clarify the basic principles, including policies and standards, for developing disaster management systems.
- Make full use of emergency disaster management and reduction programs (implemented by individual communities) to further strengthen evacuation measures.

**SPECIFIC ACTIONS TO REVIEW LOCAL DISASTER MANAGEMENT PLANS**

Local governments in the affected areas have started enhancing their disaster management systems. For example, at an informal meeting of municipal mayors in January 2012, the government of Iwate Prefecture proposed amendments to its disaster management plan based on its experience in the GEJE. These amendments aim to improve disaster countermeasures by taking into account scenarios involving the largest possible earthquakes and tsunamis.

The amended plan includes procedures that allow the prefecture to provide support to municipal governments during large-scale disasters before they request it. It also provides for a communications security program for setting up multiple telecommunications systems, including satellite mobile phones, in prefectural and municipal government offices. These amendments were prompted by the experience of damaged or suspended administrative
Disaster Management Plans

functions after March 11 because of power failures and destruction of offices. According to the amended plan, when contact with the affected municipalities cannot be made, the prefecture will automatically dispatch a survey team. The plan also authorizes the governor to provide support to municipalities in the event of a large-scale disaster.

After the GEJE, many local government organizations across Japan, in addition to the Iwate, Miyagi, and Fukushima prefectures, started reviewing their local disaster management plans. For example, Kawasaki City is in the process of adding tsunami countermeasures, which are hardly mentioned in the current plan; and Saitama Prefecture has decided to review measures for dealing with commuters who can’t get home, emergency supply policies, and wide-area radiation contamination.

LESSONS

National and local governments in Japan have distinct and complementary roles in DRM planning. The national level is in charge of defining the overall DRM strategy, coordination and legislation, allocation of funds, and deployment of the government budget. In local-level disaster management plans, governments are focusing on coordination of administrative and operational functions; preventive measures, such as education, safety drills, and issuing and transmitting of information and warnings; evacuation and rescue activities and primary goods supply and distribution in emergency situations; and overall coordination of reconstruction and restoring livelihoods during the recovery phase. The central government provides substantial funding for emergency response and reconstruction.

The lessons learned from the Great Hanshin-Awaji Earthquake in 1995 had already prompted improvements to Japan’s DRM legislation and government policies. In recent years, high priority has been given to developing countermeasures for large-scale earthquake disasters. Legislation has been passed on countering large-scale ocean-trench-type earthquakes, plans for large cities where damage is likely to be wide-ranging have been established, and the overall legislative framework on DRM and disaster countermeasures has been improved. After the GEJE, these kinds of countermeasures have been emphasized even more, and a full revision of the Disaster Countermeasure Basic Act was proposed in December 2011.

The main drivers of the latest revision are: the need to account for low-probability, high-impact multilocation hazards, and to strengthen the local government’s role in providing training and planning emergency measures and evacuations.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

- Plans at the national and local levels should be revised frequently, based on lessons learned from other disasters in and outside the region. It could be helpful to set up a committee at the national level to coordinate the timing and content of revisions at the national and local levels. Consultations between national and local government representatives could assure complementarities and synergies across roles and activities.
• A local disaster management plan is useful in specifying countermeasures against future natural disasters, as long as clear roles and responsibilities are assigned to each tier of government regarding preventive measures, emergency response and rescue, and recovery and reconstruction activities. It is also useful to identify capacities that may need to be strengthened.

• Agreements could be designed and signed at the local level with key sectors, specifying responsibilities for emergency response measures, rescue operations, and evacuation plans. Private companies, as well as community-based organizations entering into those agreements, could develop services (in coordination with local governments) that can be delivered as soon as a disaster strikes, even without a formal request or authorization from the local government (KN 4-1).

KEY REFERENCES


KNOWLEDGE NOTE 2-3

CLUSTER 2: Nonstructural Measures

The Education Sector
Although the education sector sustained considerable damage in the Great East Japan Earthquake (GEJE), it also played a key role in protecting lives. Importantly, it provided both civil protection “hardware” and “software”: school buildings served as evacuation shelters and transition shelters, and the school curricula ensured that children knew how to prepare for and react in emergencies. The performance of schools in responding to the GEJE provided a number of important lessons about the role of the education sector in disaster risk management.

**FINDINGS**

**DAMAGE TO THE EDUCATION SECTOR**

The GEJE caused severe structural damage to schools. In total, 6,284 public schools were damaged. The Ministry of Education, Culture, Sports, Science, and Technology classified the schools into three categories according to the level of damage they sustained: 193 schools were completely destroyed (level 1); 747 schools sustained heavy damage and need structural repairs (level 2); and over 5,000 schools had minor, mostly nonstructural damage (level 3) (figure 1).

Seven hundred and thirty-three students and teachers were killed or are missing. The proximity of the schools to the coastline was a contributing factor. The students and teachers in the Okawa Elementary School building in Ishinomaki City died tragically because they did not evacuate to higher ground. Where students in coastal schools survived, the school structure, disaster risk management (DRM) education, and linkages to community preparedness played critical roles.
THE ROLE OF DRM EDUCATION IN COMMUNITY PREPAREDNESS

DRM education conducted effectively and in cooperation with other local community preparedness efforts saved many lives after the GEJE (KN 2-2).

For example, in Kamaishi, where the number of casualties reached 1,000, there were 5 deaths reported among 2,900 school children, and not a single child present in school that day was killed. The so-called Kamaishi Miracle is attributed to strong DRM education, including a longstanding local tradition of teaching children the culture of *tendenko*, which means to evacuate to higher ground on their own without searching for relatives or friends. This practice resulted from many years of experience with disasters, and is based on a strong mutual understanding and trust that family members will also evacuate to safety.

Kamaishi City has been conducting DRM education programs since 2005 in cooperation with Gunma University. The programs are not mandatory, but are being implemented in selected schools in vulnerable coastal areas. Two such schools are Unosumai Elementary and Kamaishi-Higashi Junior High School (figure 2). The program engages the local community in preparing disaster risk maps, and holds evacuation drills four times a year—one joint drill with the elementary and junior high school, and one annual drill with the local community.

Kesennuma City provides another excellent example of how DRM is integrated into school curricula, where Education for Sustainable Development (ESD) has taught students for years about local environmental issues, and how to value and protect natural resources, the environment, and cultural heritage assets. ESD also includes a strong focus on DRM.

In Kesennuma, students at the Hashikami Junior High School are taught DRM as part of the ESD program. The school served as an evacuation center for more than 1,500 people after
BOX 1: Kamaishi-Higashi Junior High School

On March 9, 2011, the students of Kamaishi-Higashi Junior High School, located 500 meters from the coast, felt an earthquake and evacuated to the 3rd floor of the neighboring elementary school building. When the earthquake hit two days later on March 11, the students evacuated again to the 3rd floor, and were then advised by the local fire volunteer (shobodan) to evacuate to higher ground. The children of the elementary and junior high schools evacuated together, since they had conducted joint evacuation drills. They reached the first evacuation point located 700 meters from the school, where they noticed a cliff had collapsed. An elderly woman stated that she had never seen this happen there before and advised the students to move to a safer place. They moved to another point that was 400 meters higher, where they at first felt safe. However, when they heard the tremendous roar of the tsunami 30 minutes after the earthquake, they decided they should go to an even higher evacuation point.

Not one child or teacher present at school that day lost their lives in the event. Unfortunately, two students who were absent died in their homes, two drivers died in the school building, and one administrative staff is missing.
the GEJE, which occurred just before graduation. A graduation ceremony took place in the gymnasium, and was attended by the evacuees. During the ceremony, a student gave a speech in which he honored two students who had lost their lives in the tsunami:

“People are talking about Hashikami Junior High School as the “School of disaster prevention education,” and we are being praised around the world. We trained ourselves thoroughly and have been doing disaster prevention drills regularly. But our power as human beings was dwarfed by nature’s violence, and nature deprived us mercilessly of some of our most important things. This disaster was too cruel to
simply be called a trial sent from heaven…I feel angry and hardened. But our future lies not in blaming God but in helping each other and persevering, as difficult as that may be.”

His words reflect the anguish of the community, and at the same time the recognition, gained from the ESD curriculum, that the community’s responsibility is not to despair, nor to consider the disaster an “act of God,” but to rely on one another for support and to improve their risk management capacity.

THE ROLE OF EDUCATIONAL FACILITIES IN DISASTER RESPONSE AND RECOVERY

As noted earlier, schools played a critical role in the immediate response to the GEJE (as evacuation shelters) and in the recovery process (as transition shelters) as shown in figures 3. The arrows represent the evacuation routes that people followed. Balancing the need to provide evacuation centers for communities and the need to reconvene classes for students has been a challenge, particularly where limited availability of suitable land has made housing reconstruction difficult, and the move from transitional shelter to permanent housing has been delayed.

Another challenge relates to the future role of school buildings in civil protection as demographics shift. While schools have traditionally been the most important public facilities in local communities, declining birth rates and a rapidly aging population make it difficult to justify rebuilding them in the same numbers and sizes. The following examples illustrate these issues in more detail:

- In the Arahama area, a school building served as an important evacuation shelter because of the flatness of the surrounding terrain and the building’s height. The reconstructed school building should be able to withstand future earthquakes, have a flat rooftop to which people can evacuate, be situated away from the coast, and be kept stocked with emergency supplies. Since the disaster, a large proportion of the local community has relocated elsewhere because of a lack of jobs, adequate housing, and infrastructure. These issues will need to be examined before rebuilding the school (figures 3 [a] and 4 [a]).

- In the Toni area, both the elementary and junior high schools need to be rebuilt. However, it is difficult to justify the construction of new schools of the same size because of the decrease in the number of school-aged children. Therefore, a single building will be developed jointly housing the elementary school, the junior high school, and other public community facilities. The security of school children also needs to be ensured given that the school building will be shared with the general public, and anyone can access it (figure 3 [b] and [d], and figure 4 [b] and [d]).

- Although Shishiori Elementary School is not located on the coast, the tsunami flooded the ground floor as it moved upstream along the river. While it only reached the ground floor, the school was nevertheless evacuated as there was no way of telling whether the upper level would be affected (figures 3 [c] and 4 [c]).
FIGURE 3: Location of schools in various areas
Hashigami Junior High School was used as an evacuation shelter following the disaster, and is still being used for transition shelters. Since the school gymnasium has not been available for more than a year, the quality of educational services is being affected (figure 3 [e] and 4 [e]).

The loss of teachers who died in the tsunami has created a shortage of staff in many schools, posing an additional challenge for the continuity of the education. Finally, counseling services for school children suffering from posttraumatic stress disorder must also be provided.

Considerable resources are required if the education sector is to recover fully. Funds need to be allocated for temporary schools, followed by site selection and construction of new schools, and repairs to buildings that remain structurally sound. An aging population and declining numbers of students presents a special challenge, as communities balance using school facilities for both education and civil protection purposes.

LESSONS

Key lessons from the GEJE experience for the education sector are as follows:

- **Importance of DRM education.** As exemplified by the Kamaishi experience, DRM education played an important role in determining the students’ evacuation behavior. The role of teachers in implementing DRM in schools should be emphasized.

- **Structure, location, and layout of schools.** The location of school buildings is a crucial issue. In most cases, the buildings were located in close proximity (within 100–200 meters) to the coastline. Newer schools have slanted roofs to avoid water logging and structural decay. However, this prohibited people from taking shelter on rooftops. Also, it has been observed that schools that were parallel to the coast sustained greater damage than those set perpendicular to the coastline.

- **Function of schools and educational continuity.** While schools were to be used as evacuation centers, in several cases, people from local communities remained sheltered in schools for more than six months. This has serious implications for the restoration of educational services and children’s educational development. This issue needs to be considered in future school-level contingency planning.

- **Human resources and training.** In the aftermath of the GEJE, schools face a shortage of teachers, which has affected the continuity of education. Students from the education faculties of local universities have tried to fill this gap; however, this also needs to be addressed in planning for educational continuity in postdisaster situations.

- **New role of schools and multistakeholder dialogue.** Given the changing demographic conditions, schools need to play a bigger role as community facilities. Therefore, a broader range of stakeholders, including community members, needs to be included in reconstruction decision making.
FIGURE 4: Schools and locations: (a) Arahama Elementary School, Sendai City; (b) Toni Elementary School, Kamaishi City; (c) Shishiori Elementary School, Kesennuma City; (d) Toni Junior High School, Kamaishi City
RECOMMENDATIONS FOR DEVELOPING COUNTRIES

The education sector plays an important dual role in the provision of civil protection hardware and software: school buildings serve as evacuation shelters and transitional shelters; and school curricula help instill a culture of DRM and preparedness in the community. The recovery of the education sector is directly linked to the recovery of the entire community.

DRM education saves lives. Students save their own lives and the lives of others when they lead evacuations in communities. DRM in the education sector should not be limited to the education curriculum, but should also include related issues such as structural and nonstructural safety measures; legislative measures supporting the integration, implementation, and funding of DRM in the education sector; risk assessments and early warning systems; and DRM training for school staff.

The postdisaster reconstruction process offers an opportunity for communities to reconsider their future needs regarding both the education of their children and their community facilities. A multistakeholder dialogue can help determine the optimal arrangements and design reconstruction plans accordingly.

KEY REFERENCES


A business continuity plan (BCP) identifies the potential effects of disruptions to an organization’s critical operations if a disaster were to occur, and specifies effective response actions and quick recovery measures. In the Great East Japan Earthquake (GEJE), BCPs served their purpose to some extent, but certain weaknesses were identified. While BCPs helped to keep critical operational functions going, and then to rehabilitate general operations, most small- and medium-sized enterprises had, unfortunately, not even prepared BCPs. Since the private sector plays a major role in creating jobs and supporting local economies, it should be required to prepare BCPs, but with support from the government.

INTRODUCTION

WHY IS PRIVATE SECTOR PREPAREDNESS IMPORTANT?

Because social functions and stakeholders in modern developed societies are highly interconnected and interdependent, any disruptive incident can affect an entire region. A single incident can have an extensive impact both domestically and internationally, by undermining supply chains and value chains (KN 6-3).

Examples of direct and indirect negative effects include:

- Loss of human life and injury.
- Damage to physical assets, the environment, and natural resources.
- Disruption of public utilities, such as electricity, water, transport, and telecommunications.
- Disruption of citizens’ daily livelihoods.
• Disruption of local government administrative functions.
• Reduced supplies of daily goods and services.
• Bankruptcy of private companies, lost economic opportunities, and income loss.
• Unemployment and economic downturns.

The private sector plays a major role in creating employment and supporting the local economy, thereby ensuring regional sustainability (KN 4-5). In the event of a disaster, the role of the private sector becomes even more important in this respect. In each phase of disaster risk management, it:

• Provides evacuation shelters and relief goods.
• Ensures employment so that victims can regain their livelihoods quickly.
• Provides labor, services, and products essential to the speedy recovery of social functions, roads, transportation, supermarkets, schools, hospitals, and other functions.

Effective cooperation among disaster-resilient private sector players helps ensure a resilient and sustainable civil society. One lesson learned from past catastrophic events such as the Great Hanshin-Awaji (Kobe) Earthquake, Hurricane Katrina, the GEJE, and the Thailand flood is that the private sector plays an important role in reducing national and regional economic damage when it is well prepared.

WHAT IS A BUSINESS CONTINUITY PLAN?

A BCP identifies the critical operational functions of an organization and the potential impacts of a threat prior to its occurrence. It specifies effective ways of responding and quick recovery measures so that a business can continue to operate at acceptable levels and avoid disruptions for a specified period of time (box 1). The process of developing and deploying a BCP strategically within the organization is referred to as business continuity management (BCM).

BCM is a risk management strategy that focuses on maintaining the continuity of critical operations to ensure the supply of goods and services, and thereby the organization’s survival. Figure 1 shows the concept of business continuity and the recovery curve of an organization’s level of service before, during, and after a disaster. Developing a BCP helps an organization identify what preparations must be made before a disaster strikes to secure its employees, assets, information technology (IT) systems, and information, as well as its reputation.
BOX 1: **Accident at a microchip plant**

In 2000, lighting struck a Philips microchip plant in New Mexico, causing a fire that contaminated millions of mobile phone chips. Nokia and Ericsson, Philips’s biggest customers, reacted differently to their supplier’s plight. Nokia’s supply-chain management strategy allowed it to switch suppliers quickly; it even reengineered some of its phones to accept other types of chips. Ericsson took no action and waited for Philips to resume production. That decision cost Ericsson more than $400 million in annual earnings and, perhaps more significantly, some of its market share. By contrast, Nokia’s profits rose by 42 percent that year.

**FIGURE 1: The business continuity plan concept**

![Diagram showing business continuity plan concept](image)

- **Before**
  - Capacity utilization (supply of products, etc.)
- **After (initial response and BCP response)**
  - Recovery curve
  - Occurrence of disaster
  - Recovery curve after implementation of BCP

1. To continue business at the level over the possible limit
2. To recover capacity utilization within the permissible time
3. Variance between target and recovery time to current condition
4. Variance between target and recovery time to current condition

**Source:** Cabinet Office.
BCPs IN THE ASIA-PACIFIC REGION

The Asia-Pacific Economic Cooperation (APEC) region accounts for approximately 40 percent of the world’s land area, more than 40 percent of the world’s population, and around half of global gross domestic product (GDP). And yet, regrettably, it sustains almost 70 percent of the world’s natural disasters. As the APEC region’s supply chains are closely intertwined, and a single disaster can affect the economic activities of the entire region, it is essential and urgent that efforts be made to strengthen the private sector’s capacity for disaster preparedness and recovery by promoting BCP development among APEC member economies. A survey was conducted in 2011 to better understand the current level of BCP awareness and adoption in the private sector.

Substantial differences were found in the level of BCP development between small and medium enterprises (SMEs) and large companies, listed and unlisted companies, and between companies that have actually experienced disaster-related disruptions and those that have not. The level of BCP development varies greatly by firm size: only 15.9 percent of SME respondents have a written BCP, while 52 percent of large company respondents have one. Also, there are considerable differences among APEC economies.

FINDINGS

BCPs IN JAPAN

The Central Disaster Management Council chaired by the prime minister has carried out damage estimates for the Tokyo metropolitan area in the event of a strong inland earthquake. A magnitude 7.3 earthquake with an epicenter in the northern part of Tokyo Bay has been forecasted and one scenario assumes extensive damage, including a death toll of approximately 11,000 people, the total collapse of 850,000 buildings, and a maximum economic loss of ¥112 trillion. After the GEJE, governments are currently revising this damage estimate to verify if even worse figures are possible or probable.

In 2005 the council established the Policy Framework for Tokyo Inland Earthquakes to ensure the continuity of functions in the capital, and to establish countermeasures for reducing the death toll by 50 percent and economic losses by 40 percent. It also set strategic goals that included increasing the earthquake-proof rating of houses and buildings to 90 percent, increasing the fixed furniture rate to 60 percent, and increasing the BCP adoption rate to 100 percent for large companies and 50 percent for medium-sized companies within a 10-year period. In addition, it published business continuity guidelines to help companies develop their BCPs. Forty-six percent of large companies and 21 percent of medium-sized enterprises have developed BCPs in 2011.

DAMAGE AND RECOVERY AFTER THE GEJE

The GEJE caused 656 private companies, which employed 10,757 workers, to go bankrupt within one year. But only 79 companies of them, 12 percent, were located in the Tohoku
region while the others were located all over Japan. The reason for bankruptcies among the latter group was indirect loss or damage caused by disruptions in their supply chains.

The BCPs functioned to some extent, but with some problems. The ratio of companies without a BCP was still high at the time of the GEJE, and differed according to company size. Among large companies, 40 percent had prepared BCPs before March 11, while only 12 percent of medium-sized enterprises had done so. Approximately 80 to 90 percent of the medium-sized and large companies indicated that their BCPs were effective in the response-and-recovery phase after the March 11 disaster. All SMEs indicated that their BCPs were effective to some degree, while the ratio of SMEs that produced BCPs was low. Workers’ capacities had been developed by formulating BCPs, so they were able to respond to even unexpected events. SMEs were able to start alternative production by collaborating with companies in other prefectures and were willing and able to collaborate in BCPs, because they do not compete with one another on a national scale.

The main reasons that BCPs did not function are as follows:

- The damage was much greater than predicted, because the companies followed government scenarios that underestimated reality.
- Not enough training was conducted. Workers who had not seen the BCP documents could not take the necessary actions.

**PRACTICES AT THE GEJE**

**The case of a large distribution company.** Seven & i Holdings Co., Ltd. operates convenience stores, general merchandise stores, department stores, and supermarkets. The company has revised its BCPs seven times since the Kobe earthquake in 1995. A supermarket in Ishinomaki City, one of the most devastated cities, started selling foods and other goods outside its own buildings starting at 6 p.m. on March 11. On the next day, all 10 supermarkets opened in the Tohoku Region. The decision to reopen in times of disaster was delegated to the individual shops, which could assess the situation quickly. Multiple logistics routes were secured and 400 workers were brought from other areas to support the stores in the devastated areas.

**The case of an SME.** The Suzuki Kogyo Co. is a waste management company with 67 employees in Sendai City, which suffered from the GEJE. The company equipped itself with satellite phones and standby generators, and conducted training and drills based on a BCP formulated in 2008. The emergency center was established at 3:30 p.m., 45 minutes following the earthquake on March 11. Two days later the company resumed the critical operation of treating medical waste from dialysis. Other companies took over the waste management operations.

**HOW PAYMENT AND SETTLEMENT SYSTEMS AND FINANCIAL INSTITUTIONS RESPONDED TO THE GEJE**

Financial services are a basic lifeline in a society, supporting many kinds of economic activities. The failure of payment and settlement systems could prevent customers from making
deposits, cash withdrawals, and payments, thereby intensifying public anxiety in times of disaster. The financial sector was seriously affected by both the physical damages and the indirect effects of the disaster. Nevertheless, even in the aftermath of the earthquake, the nation’s payment and settlement systems and financial institutions, including the Bank of Japan, continued to operate in a stable manner and, on the whole, managed to function normally (box 2).

BOX 2: How the GEJE affected payment and settlement systems and financial institutions

The Bank of Japan (BOJ) responded to the disaster by:

- **Supplying a massive amount of cash to financial institutions.** The cash paid out by BOJ branches and local offices in the Tohoku region of northeastern Japan in the first week after the earthquake amounted to approximately ¥310 billion, about three times the amount paid out over the same period in the previous year.

- **Exchanging damaged banknotes and coins** for clean ones through the Bank’s branches in the Tohoku region and the special window in Morioka City, which amounted to ¥2.42 billion starting after the earthquake up through June 21.

- **Ensuring the stable operation of the BOJ-NET,** which is used for funds transfer and services related to Japanese government bonds as well as the BOJ’s market operations.

- The minister for financial services and the BOJ Governor jointly requested financial measures, such as allowing withdrawals of deposits upon the verification of the depositor’s identity even in cases where deposit certificates or bank passbooks had been lost.

- **Arranging treasury funds services and government bond services** at its head office and branches, where treasury agents were unable to continue those services.

- **Gathering information,** in cooperation with the Financial Services Agency, on damage to and the actions taken by payment and settlement systems as well as the financial institutions, and providing accurate and timely information to domestic and overseas markets on the operational status of the Japanese financial infrastructure.

The private sector responded as follows:

- To meet the needs of depositors and borrowers, the financial institutions opened temporary offices, and opened windows on Saturday, March 12, and Sunday, March 13, 2011, the weekend immediately after the earthquake. Of the total of about 2,700 offices of the 72 financial institutions headquartered in 1 of the 6 prefectures in the Tohoku region or Ibaraki Prefecture in the Kanto region, some 310 offices (11 percent of the total) were closed as of March 16.

- The financial institutions worked in close coordination, such as by delivering cash to other institutions that needed additional cash.
BOX 2, CONTINUED

- Major bill and check clearing houses expanded their areas of coverage, so that participating financial institutions could bring in bills and checks that normally would be processed by the clearing houses that were not operating.

- Payment and settlement systems as well as financial institutions across Japan generally continued to operate stably. There were also procedures and systems in place to address the temporary inability of affected financial institutions to participate in the payment and settlement systems.

- Marketwide business continuity arrangements developed in the money market, and the foreign exchange market and the securities market functioned smoothly.

- The stock market infrastructure was able to provide smooth and uninterrupted processing with a high level of operational capacity despite the surge in trading volume following the earthquake.

Lessons

- Payment and settlement systems and financial institutions need to review the severity and scope of the scenarios used in designing their business continuity arrangements, to see whether they address potential stress events sufficiently in light of the recent disaster.

- It is crucial to enhance business continuity arrangements in line with the identified scenarios. This includes enhancing backup arrangements for computer systems and headquarters functions, increasing in-house power-generating capabilities against potential long-term constraints on the electricity supply, enhancing arrangements for securing necessary staff in the event of prolonged disruption of public transportation services, and securing system-processing capacity to withstand a surge in trading activity.

- Implementing and enhancing “streetwide exercises,” with participation of the overall financial industry, and eventually with the cooperation of nonfinancial firms such as the providers of social infrastructure, would be effective in ensuring consistency of arrangements across institutions.


LESSONS

The private sector in Japan has made substantial efforts to adopt BCPs, which proved to be useful when put into action following the GEJE. At the same time, however, some lessons were learned that could make corporate BCPs even stronger and more effective. Until recently there had been an attitude of tolerance toward business disruptions caused
by disasters of a certain scale, as they were considered to constitute force majeure. Public opinion has shifted since March 11. Now, even if the scale and intensity of a disaster exceeds assumptions and predictions, disruptions are deemed to constitute negligence, and top managers are expected to be able to take appropriate measures to ensure the continuity of critical operations. Companies should:

**Ensure BCP effectiveness through regular drills and continuous education.** These drills and training must target specific departments in the company and should address specific capacities and skills; generic training is of no use. The plan should list specific activities and give detailed directions to be followed in emergencies and to facilitate recovery. These should be explained in detail to those officials and employees who are expected to implement them. Drills and training should be regular and ongoing, and some coordination at the sectoral level is recommended.

**Radically shift from a “disaster-based” to a “consequence-based” perspective in strategy development.** Private companies should formulate their BCPs to reflect the results or outcomes they expect from implementation, rather than specific measures to counter specific disasters. They should identify key services, and examine how long the service will be disrupted and how they can shorten the disruption time.

**Focus more on supply chain disruption risk by knowing more about the situations of stakeholders.** In addition to the company’s own operations, BCPs should address supply chain issues that affect other companies and markets. To facilitate this, meetings should be held regularly with companies in the same sector and with supply chain companies, first to assess the potential risks and then to develop concerted measures to ensure business continuity throughout the supply chain.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

If well prepared for disasters, the private sector can play an important role in reducing local and regional economic damage. BCPs are an effective tool for strengthening the private sector’s disaster resilience.

**Raise public awareness.** Private companies and organizations do not always recognize the importance and usefulness of BCPs. Efforts should be made to raise awareness about BCPs and develop effective BCPs to achieve greater regional resilience. Practices and lessons from disasters should be widely shared with private companies and organizations.

**Start from a small disaster.** Private companies could begin with a small hazard scenario as the first step in formulating BCPs, and then add greater or different kinds of hazards. For example, in Japan, since earthquakes are a very familiar hazard, most companies start by preparing BCPs for earthquakes which are considered easier to produce. They then proceed to develop BCPs for more complicated disasters, such as pandemics.

**Mobilize government support.** Governments may feel that providing support to BCPs for the private sector is not their role. But securing livelihoods and the local economy is certainly a relevant public sector concern. Governments should provide private companies with the necessary information such as risk assessments and guidelines for producing
BCPs. Also, governments should collaborate with chambers of commerce and other industrial associations that provide support to these companies.

**KEY REFERENCES**


KNOWLEDGE NOTE 2-5

CLUSTER 2: Nonstructural Measures

Tsunami and Earthquake Warning Systems
Warning systems can mitigate the damage caused by tsunamis and other natural events, and prevent the loss of human life and properties. Countermeasures, such as evacuations to higher ground and the stopping of trains, depend on getting the right information and disseminating it in a timely manner. Warning systems must also be aligned with community response. While Japan has developed the most sophisticated tsunami-warning system in the world, the system underestimated tsunami height on March 11 and may have misled the evacuees and increased human losses.

FINDINGS

COMMUNITY-BASED TSUNAMI-WARNING SYSTEMS

Before March 11, 2011, Japan had already developed sophisticated high-technology tsunami-warning systems that included satellite communications and hundreds of real-time monitoring stations. But on March 11 the community-level response (and community-based warnings) was the key that saved countless human lives. The volunteer fire corps—which are community-based organizations (CBOs) trained in disaster management (see KN 2-1)—used various tools such as handheld loud speakers, fire bells, sirens, and fire engine loud speakers to warn communities throughout the affected areas. In Katsurashima, Shiogama City, all community members including 30 disabled people were safely evacuated because the fire corps went door to door to every house, helping community members move to higher ground. In Otsuchi and Natori cities some members of the corps kept ringing fire bells or giving directions on their loud speakers right up until the tsunami hit—some at the expense of their own lives.

TSUNAMI WARNINGS ON A NATIONAL SCALE

Japan’s Meteorological Agency (JMA) monitors seismic activity throughout Japan, around the clock. The agency can quickly calculate the hypocenter and magnitude of an earth-
quake, and issue a tsunami warning within three minutes after the earthquake. The information is immediately disseminated to the public by disaster management authorities, local governments, and the mass media (figure 1 and box 1). The JMA has recently invested some ¥2 billion in tsunami and earthquake monitoring and warning systems.

On March 11, 2011, the JMA issued the first tsunami warning at 14:49, three minutes after the earthquake. People started evacuating and organizations concerned started preparing for the tsunami.

Critical problems were found in estimating the tsunami’s height and getting information out to the public. Underestimation of the tsunami’s height likely contributed to the delay in people’s evacuation. The agency at first estimated tsunami heights of three to six meters in Iwate, Miyagi, and Fukushima prefectures, well below the actual heights. This was because the agency underestimated the earthquake magnitude as Mj (JMA magnitude)* 7.9, while the actual magnitude was Mw (Momentum Magnitude) 9.0.1 The agency could not calculate the Mw within 15 minutes, as with a normal operation, because of the scaling-off of most broadband seismographs. Cable-type offshore hydraulic gauges, which provide useful forecasting information, were not installed to revise tsunami information. Also, the

* The JMA magnitude has the advantage of being calculated quickly within three minutes, but tends to underestimate the magnitude of earthquakes over M8. The moment magnitude is utilized worldwide but takes around 10 minutes to calculate.
BOX 1: Tsunami warnings in Japan

The JMA conducted tsunami computer simulations for various earthquake scenarios, and stored the results (which included tsunami arrival times and heights) in a database. Since the simulation takes some time, the agency cannot promptly issue warnings using real-time simulation following an earthquake. When a large earthquake occurs, the operating system quickly calculates the hypocenter and magnitude, searches the tsunami database for this hypocenter and magnitude, and selects the most appropriate simulation results from the database. Based on the estimated height of the tsunami, the JMA issues a tsunami forecast. Tsunami forecasts fall into two categories: tsunami warnings and tsunami advisories. Warnings are further divided into two classes: tsunami and major tsunami.

The JMA improved the warning systems in 1941 following the establishment of a tsunami-warning unit for the Sanriku coast. The agency expanded it into a nationwide service in 1952; and after the 1960 Chilean earthquake tsunami, the system started covering long-distance tsunamis as well. In the Hokkaido Nansei-Oki earthquake of 1993, the tsunami arrived before any warning was issued. The JMA improved the system, and started issuing estimated tsunami heights in 1999.
JMA issued information on a 0.2-meter-height tsunami 13 minutes after the earthquake. The agency revised the estimated height to 6 to 10 meters at Iwate, Miyagi, and Fukushima prefectures 30 minutes after the quake, and then to more than 10 meters in 45 minutes (figure 2). The revised information, however, did not reach everyone, since they were evacuating, and power and communication systems had failed due to the earthquake.

According to interview surveys by the Japanese government, almost half of the population received no tsunami information or evacuation orders in the affected areas; and 60-70 percent did not receive the revised information about tsunami heights.

Based on lessons learned from the GEJE, the JMA plans to take the following approach while issuing a warning (figure 3):

- Issue tsunami information that is useful in making decisions about evacuation; the information should be clear and timely, emphasize crucial messages, and encourage evacuation.
- Issue the first warning quickly, within three minutes following an earthquake, and revise it according to observed data.
- Provide tsunami height predictions qualitatively, instead of numerically in the first warning for possible megatsunamis caused by earthquakes greater than M8, considering the uncertainty of tsunami estimates.

FIGURE 2: Timeline of revised tsunami warnings on March 11, 2011

Source: JMA.
Note: Mj = JMA magnitude
- Raise public awareness of the principle that people should take the initiative on their own to escape from tsunamis when they feel any quakes.

- Improve the accuracy of warnings about frequently occurring tsunamis to better inform people’s evacuation decisions by improving confidence.

NHK, Nippon Hoso Kyokai, and Japan Broadcasting Corporation reviewed programs during the GEJE, and found that the tones of the warning announcers on television were rather

**FIGURE 3: New methods for tsunami warnings**

Source: JMA.
Note: Mj = JMA magnitude; Mw = moment magnitude
The corporation is revising the warning methods issued through television to encourage evacuation by announcements that are persuasive.

THE EARTHQUAKE EARLY WARNING SYSTEM

The Earthquake Early Warning (EEW) System aims at mitigating earthquake damage by providing a lead time to slow down trains, stop elevators, and give people time to take protective measures (figure 4). The JMA quickly determines the hypocenter and magnitude of an earthquake based on real-time monitoring data. The agency estimates the distribution of strong ground tremors, and issues warnings to government officials and the mass media, such as radio, television, and communication companies before the tremors reach them. For example, gas and train companies use this warning to control their operations. Also, warnings are issued to the public through SMS alerts. The JMA launched this EEW service in 2007.

During the GEJE, the JMA issued the first EEW 8.6 seconds after detecting the first primary wave (P-wave) at the nearest seismic station. There were 15 to 20 seconds of lead time after the warning and before the main shock hit Sendai. At Seisho High School, Kanagawa Prefecture, students used this time to get under their desks or leave -at-risk spots before the main ground tremors arrived. Also, at a primary school where teachers and students had conducted practice evacuation drills, they calmly began evacuating as soon as they got the warning.

**FIGURE 4: Earthquake early warning system**

Source: JMA.
According to a JMA survey, over 80 percent of people believe the EEW information helps them protect themselves. Some 60 percent took action, such as taking shelter under desks, upon receiving the EEW. Although some 40 percent of EEWs have been incorrect and underestimated the actual size of quakes, over 80 percent of respondents want to keep using the system. The JMA is improving the accuracy of the EEW by upgrading prediction models.

**BULLET TRAINS’ EARTHQUAKE DETECTION SYSTEM**

On March 11, 19 bullet trains (including two traveling close to the maximum speed of 270 kilometers per hour) were running on the Tohoku Sinkansen Line. All trains were able to stop safely soon after the earthquake occurred without incurring any casualties. The system detected the P-wave and stopped the trains by automatically cutting their electricity supplies (figure 5). The railway companies started using the system in 1992, and have improved it since then. During the Chuetsu Earthquake in 2004, a bullet train derailed because it was traveling right above the epicenter, although no causalities were reported. The companies shortened the lead time between detecting a P-wave and issuing the warning, from three seconds to between one and two seconds. The number of earthquake monitoring and detection stations has also increased to 239 across the country.

**LESSONS**

The following lessons should help inform the development of warning systems:

- The earthquake warning systems were able to reduce economic damages and loss of life by shutting down bullet trains and providing lead time for people to take protective measures. Japan has developed new technologies to improve these systems.

- Using warning systems to trigger timely community response is the key to disaster management. No matter how advanced technology becomes, the guiding
principle is that people should take the initiative to escape from a tsunami on their own as soon as they feel any quakes.

- Inaccurate or inappropriate information in a tsunami warning could mislead or delay evacuation and increase the loss of lives. Warning information should be issued on safer side, considering the possible inaccuracy of estimates and the limitations of the forecasting technology.

- Multiple methods of information sharing must be secured. While warnings must be delivered to everyone at risk, only half of the affected residents actually received the information following the GEJE. It was difficult to provide people with revised information during the evacuation because of power and communication system failures.

- Disaster risk communication must be practiced regularly, so that people are able to better understand the information and messages and agencies can better understand the mechanisms that local people use to cope with disasters (KN 5-3).

### RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Warning systems can save people’s lives and reduce economic damages from natural disasters such as floods, tsunamis, earthquakes, landslides, and other events. People can take countermeasures, such as escaping to higher ground, protecting themselves from falling debris, and stopping trains before they are overtaken by these events.

**Start with low-cost systems.** Warning systems can start with simple methods. Low-cost equipment, such as fire bells and sirens, were widely utilized as warning tools during the GEJE. Observers in communities once monitored water levels in rivers and sent information to concerned organizations by phone until a decade ago in Japan. Warning systems can evolve by replacing equipment, such as automatic monitoring equipment and telemeter systems, based on these basic systems.

**Link with community-based activities.** Actions at the community level are crucial as demonstrated by the volunteer fire corps that issued warnings and saved lives on March 11. Warning systems and other measures organized by communities may be particularly relevant in developing countries where government capacity and resources are limited (box 2).

**Develop technology and understand its limitations.** Although various technologies, such as flood prediction, tsunami simulations, communication systems, and earthquake monitoring are all needed to develop effective warning systems, their limitations must be taken into account. On March 11, underestimating the tsunami height likely caused people to delay their evacuation and led to greater losses.

**Conduct interactive risk communication.** Communities, governments, and experts should exchange information and ideas about potential risks (KN 5-3). Communities should be able to understand the information delivered in the warning, while also being aware of the system’s limitations. Also, government staff must understand communities’ response to disasters to design warning systems.
**Understand communities’ coping mechanisms.** Since warning systems are meant to benefit communities on the ground and to inform their actions, the responsible organizations should understand how local people cope with and respond to disasters. Community members decide on their own when, where, and how to escape. The organizations should tailor the contents of warning messages to the users’ needs and points of view. Such messages need to be simple, timely, and encourage evacuation.

**Establish end-to-end systems** to ensure that warnings reach the communities at risk. Multiple communication channels should be established so that information keeps flowing in case of power and communication failures.

**Ensure services are available 24/7.** Since natural events can happen at any time, the organizations concerned are required to function around the clock—24 hours a day, 7 days a week. Staff rotation should be arranged in the organizations.

**KEY REFERENCES**


KNOWLEDGE NOTE 2-6

CLUSTER 2: Nonstructural Measures

Evacuation

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).
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

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.

BOX 2: Tsunami evacuation routes for schools
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
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

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](image-url)
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.

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.
• **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.
KEY REFERENCES


KNOWLEDGE NOTE 2-7

CLUSTER 2: Nonstructural Measures

Urban Planning, Land Use Regulation, and Relocation

Reconstruction should include a range of measures to enhance safety: disaster prevention facilities, relocation of communities to higher ground, and evacuation facilities. A community should not, however, rely too heavily on any one of these as being sufficient, because the next tsunami could be even larger than the last. Communities also need to rebuild their industries and create jobs to keep their residents from moving away. The challenge is to find enough relocation sites that are on high enough ground and large enough, and to regulate land use in lowland areas.

FINDINGS

RECONSTRUCTION FROM THE GEJE

Reconstruction after the GEJE has been slow compared to the Hanshin-Awaji Great (Kobe) Earthquake that hit the city of Kobe and killed 6,400 people in 1995. The seismic shocks experienced in the GEJE affected a much broader area. A number of characteristics of the GEJE made reconstruction more difficult and lengthy.

First, since tsunamis tend to hit the same areas repeatedly over several decades or even several hundred years, some affected people want to reconstruct their houses at suitable new locations instead of the damaged sites. Although the rubble has been removed, full-scale reconstruction has not yet begun. Planning and local consensus-building for relocating communities to high ground has been attempted. It takes time to find them places to live, and to reach agreement as a community to move together to a safer place. Since it takes several years to rebuild completely, it is unclear whether local employment and population levels can be sustained.

Second, the radiation contamination from the accident at the Fukushima Daiichi Nuclear Power Station will last a long time and prevent the local people from returning to their homes. Reconstruction projects may be delayed since it is still unclear when or if people...
will be able to return to their places of residence. There is also a concern that many people, especially younger families, may choose not to go back to their home towns.

While the nuclear accident in Fukushima was a bit less serious than in Chernobyl, it was ranked the same on the International Nuclear Event Scale. No major emissions of radioactive material from the collapsed nuclear power plants have been observed since April 2011. A ban or restrictions on land use will be introduced to prevent exposure to high levels of radiation. The government plans to reclassify the Warning Zone and Planned Evacuation Zone into three new categories: Long-term Habitation Difficult Zone (more than 50 mSv of Annual Radiation Exposure), Prioritized Decontamination Zone and Decontamination and Possible to Return Zone. All the nuclear power plants in Japan were shut down in May 2012 for maintenance and evaluation.

There are two tiers of local government in Japan, prefectures and local municipalities, which are responsible for disaster response and reconstruction. Municipal governments play the most important role because they are closest to the victims and the stricken areas. The prefectoral governments are grappling with the broad reconstruction issues. For example, they have supported municipal governments in debris management by coordinating solid waste management facilities in the prefectures.

THREE ELEMENTS MUST BE ARRANGED

All reconstruction plans aim at rebuilding towns and communities that are resilient to major disasters. The most important lesson from the GEJE is that there are many disasters we cannot prevent. All we can do is reduce the damages. Sometimes we cannot predict, or even imagine, the severity of future natural hazards and so we will be unprepared. Although many breakwaters and tsunami dykes had been built in the stricken areas, the tsunami, nevertheless, destroyed or overtopped most of them, and poured into the towns and villages behind them. “Reducing damages” means first and foremost preventing the loss of human lives; property damage to houses, infrastructures, and various man-made facilities may be unavoidable.

Disaster risk management (DRM) consists of three components: disaster prevention facilities, community relocation to safer ground, and evacuation facilities. This approach was reflected in the government’s basic policy on reconstruction, after the GEJE Reconstruction Council’s report recommended a shift in DRM from prevention to risk reduction.

Disaster prevention facilities included tsunami breakwaters or dikes. It is important to recognize both their usefulness and their limitations as explained in KN1-1. Damages would have been even worse without them. At the same time, the facilities could not prevent huge tsunami to attack areas behind them. Most of the breakwaters and dikes will be rebuilt to be even stronger and larger. These facilities can only resist tsunamis of limited size.

Community relocation and redesign are also important ways of reducing damage. Clearly, when communities are located on high enough ground, the tsunami can’t reach them. This was well known in areas that had been repeatedly hit. After the Showa Sanriku Tsunami in 1933, which killed about 3,000 people, the government promoted reconstruc-
tion on higher ground; but this policy could not be fully implemented since it was difficult to find suitable locations.

Evacuation facilities consist of escape routes and shelters. Escape routes should be easy to follow and clear of debris. Although evacuation drills and instructions discourage the use of vehicles, escape routes must nevertheless accommodate both pedestrians and cars as discussed in KN2-6. Evacuation shelters should be multilevel structures to accommodate evacuees safely as water levels rise.

All three components must be use together as a holistic system. Using only one or two elements is not enough. While disaster prevention facilities and the location of communities are based on forecasts and estimates, the actual hazard may be larger, and therefore, life-saving evacuation facilities will also be required.

Although these strategies are being applied in the reconstruction of tsunami-stricken areas, experience has shown that relocating communities to higher ground has been difficult to implement. And while relocation of communities and construction of evacuation facilities may be possible in newly reconstructed areas, people are also worried about areas that are under threat of being hit by tsunamis in the near future. In these areas, construction of disaster prevention facilities takes longer and the relocation of communities to higher ground is more difficult than in those areas destroyed by the GEJE: compensation has to be paid for the existing buildings, and consensus for relocation has to be built among the residents.

**LEARNING FROM PAST TSUNAMI RECONSTRUCTION**

The following three examples illustrate the challenges of reconstruction. Dikes alone cannot protect communities, so locating communities at higher elevations is key. However, it is difficult to find suitable locations and to sustain people’s livelihoods.

**LOCATING ON HIGHER GROUND SAVED LIVES AND PROPERTY**

The Yoshihama fishing and farming village in Ohfunato city, in the Iwate Prefecture could successfully mitigate damages at the GEJE. The village could be relocated because of availability of land close to the original residential areas, local leadership and financial assistance from governments. The village began moving to higher land following the Meiji Sanriku Tsunami in 1896, which washed away almost the entire village. The residents found and developed the relocation site themselves, and the relocation was completed with government financial support after the Shouwa Sanriku Tsunami in 1933. Fortunately, there was a hill above the old village that sloped gently to the beach. The villagers moved all their houses onto the hill and turned the lowlands, where they had lived, into farmland. A three-meter high tsunami dike was built in the 1970's. In the GEJE, the tsunami hit the village, flooding most of the farmland, but not the residential zone. Only a couple of houses, located lower down, were washed away, and one person was killed.
PARTIALLY SAVE COMMUNITIES

Another example is the Touni-hongo village in Kamaishi city, in the Iwate Prefecture. This is a well-known village that relocated the entire community after the Shouwa Sanriku Tsunami in 1933 to a newly developed site on hilly ground nearby. One of the community leaders, who owned the land, donated it to the community. The Iwate prefectural government developed the relocation site with financial support from the central government. A hundred houses were moved to the new site and the old location was turned into farmland.

The GEJE tsunami flooded and washed away all 50 houses located on the lower ground, but it didn’t reach the houses relocated to higher ground.

The houses on the lower level were built after the 10 meter-high tsunami dike had been constructed. Residential land use was allowed, because the dike was expected to protect the hinterland. However, the tsunami broke into the village at a point beyond the dike, and another tsunami wave came in through a tunnel on the road behind the village that connects it with the neighboring village. One of the reasons for building houses on lower ground is to make daily life easier for the elderly who have a hard time on steep slopes. Many similar cases exist of communities that were partially damaged because of lax land-use management that allowed building on low ground. Constructing large dikes may even encourage building on lower ground.

COMMUNITIES COMPLETELY DESTROYED

The final example is Taro, Miyako city, Iwate Prefecture. Taro was internationally known because of its huge and long tsunami dykes. Taro was hit by the 1896 tsunami, losing 1,867 people, about 83 percent of its population of 2,248; it was then hit again in 1933 and lost 911 persons, 32 percent of the population. This time about 200 out of 4,400 people perished. After the Shouwa Sanriku Tsunami in 1933, Taro considered following the central government’s recommendation and relocating the entire community to higher ground. They could not, however, find a suitable site where the people could see the fishing port or build their houses facing south, among other important conditions. Because Taro was a large village, the residents finally gave up looking for a new site, and decided to build a dike around the residential area, and paid for it themselves.

After the first year of construction, the central and prefectural governments approved the project as a disaster prevention public work and provided the rest of the funding. A second dike with almost the same dimensions as the first one was built after 1960 Chilean Tsunami, to prepare for larger tsunamis.

But even with these two dikes, Taro, this time, was utterly destroyed. The newer dike closest to the beach was destroyed and the other was overtopped. There were several cases in Sanriku, where previously stricken communities had not moved but had simply added landfill. All of these incurred severe damage.
RECOVERY OF INDUSTRIES AND EMPLOYMENT

Another serious issue came up while planning for reconstruction: out-migration. A survey showed that the population had decreased by 46,000 between 2005 and 2010 before the disaster in the coastal municipalities ranging from the Iwate to the Fukushima prefectures. According residential statistics, the same area lost 57,000 people between March and November 2011 including about 15,000 people who were taken by the disaster. Therefore, if people are not strongly induced to stay in these areas through economic incentives such as industrial recovery and job creation, even more residents may leave in spite of the physical reconstruction (KN5-5).

This urgent need for development requires that part of the huge national reconstruction budget should be used to develop new job-creating industries and to attract entrepreneurs from outside the region.

The first step is to rebuild existing enterprises especially in the fishing and marine product processing industries including shipbuilding, freezing, and warehousing. We cannot, however, rely on these alone, since they have been gradually losing jobs to heavy international competition.

A second important initiative is setting up new industries that may increase future employment. All local government reconstruction plans include activities such as tourism, renewable energy production, and manufacturing of products that respond to local demand.

In Fukushima the outlook is worse. The government announced that certain parts of Fukushima will not be habitable for a long time because of high radiation levels. The government must therefore help people relocate.

TOWARD BUILDING COMMUNITIES RESILIENT TO DISASTER

Local governments have not regulated land use in the affected areas from a perspective of DRM. Lowlands had been developed for residential, commercial, and industrial purposes. But economic development, urbanization, and population growth have increased vulnerability to tsunami damage along the coast. The population in the coastal areas of Iwate prefecture has tripled over the last century: from about 76,000 at the time of the Meiji Sanriku Tsunami in 1896 to some 274,000 in 2011.

The Japanese government is reinforcing DRM systems by introducing land use regulations based on lessons learned from the GEJE. The Act on Building Communities Resilient to Tsunami was legislated in December 2011 to prepare for low-probability, high-impact tsunamis (figure 1). The goal of the act is to protect human lives at all costs. The following approaches have been adopted:

- Multiple lines of defense, combining structural and nonstructural measures (Cluster 1, and KNs 2-1, 2-2, and 2-8),
Shifting from a “single line of defense” based on tsunami dikes to a “zone defense” using roads and other structures such as secondary dikes, and land use regulation,

Practical measures for quick and safe evacuation, and

Assessing tsunami risks based on local conditions, such as industry, commercial activities, history, and culture.

The Ministry of Land, Infrastructure, Transport, and Tourism has formulated basic guidelines on tsunami counter measures for prefectures and municipal governments. The guidelines specify that prefectural governors should categorize risk areas as “yellow zone,” “orange zone,” and “red zone.” In municipalities, mayors formulate counter measure action plans. The governors and mayors designate structures such as highway as disaster management facilities.

In yellow zones, where residents are likely to lose their lives, evacuation measures, such as evacuation shelters, drills and hazard maps, are required. In the orange zone where residents are highly likely to lose their lives, key facilities, such as hospitals, are to be set up in

FIGURE 1: Concept of Act on Building Communities Resilient to Tsunami
tsunami resilient structures. In the red zone where residents cannot escape the tsunami, all buildings including residences must be tsunami resilient, such as having multiple stories that rise high enough to evade the tsunami waters.

Cost sharing and various incentives are used in implementing these measures. Local governments may provide the private sector with incentives to secure evacuation facilities. Additional floor-space ratios for evacuation spaces on high floors are given as bonuses. They may also be exempted from paying 50 percent of the building tax on evacuation space. Participating organizations share the costs of multipurpose structures. For example, DRM organizations will share the additional construction costs for roads used as secondary dikes.

The central government and local governments provide financial assistance for developing safe relocation sites on high ground. Community members must reach a consensus on relocation before it begins. The community bears the cost of building new houses, while local governments are responsible for developing the infrastructure associated with the relocation sites.

LESSONS

Tsunami-prone areas must be ready for recurring disasters. Reconstruction must include three key safety measures: disaster prevention facilities, relocation of communities to higher ground out of reach of the tsunami, and evacuation facilities. The community must not rely too heavily on any single one of these, since the next tsunami may be much larger than the last, and require a broader range of precautions.

Industrial recovery is indispensable for economic sustainability. In the absence of businesses and job opportunities, people will leave their disaster-stricken communities. Simply rebuilding houses will not induce people to stay; industrial recovery policies must also be strengthened.

Public-private partnerships are crucial. Enormous sums of public money are being spent on reconstruction projects and to stimulate the local economy. But this will end in several years. It is important to create as many business activities as possible to promote economic growth and opportunities.

Relocation is effective but implementation is a challenge. Three examples from past tsunamis illustrate that, although relocation measures are effective, they are not easy to implement. In the village of Yoshihama, houses that had already been relocated following a tsunami did not suffer from the GEJE. However, around the mountainous coastal village of Taro, finding suitable relocation sites was difficult, and in the village of Touni-hongo where houses had been relocated to high ground following a tsunami, lowland use could not be properly regulated.
RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Understand and manage disaster risk. The Japanese experience illustrates that improper land use regulation leads to increasing damage from disasters. Urbanization in the lowland areas has made the eastern coast of Japan more vulnerable to tsunamis. Disaster risks must be properly understood and managed in urban planning.

Develop facilities, live in safe place, and prepare evacuation. The approach of integrating three elements: facilities, settling in safe areas, and evacuation can be used to manage disaster risk in developing countries. Since every country has its own geographic, socio-economic, and budgetary characteristics, and also faces hazards of different dimension, practical approaches will differ from country to country. Since most developing countries have limited resources for constructing facilities, they should focus on living in safe areas and putting rigorous evacuation measures in place.

Protect by zone and multi-line. “Zone defense” and “multi-line” approaches can be effective against tsunami, as well as other disasters such as floods, landslides and mud flows. Infrastructure, such as highways and railways, help mitigate disasters risk in both rural and urban areas. In the Philippines, a “MegaDike” constructed to protect against lahars, volcanic mud flows, from Mount Pinatubo, is also used as a highway. Disaster management organizations and infrastructure organizations should coordinate in planning and sharing the costs of multipurpose infrastructure (KN 1-4).

Promote relocation where feasible, acknowledging difficulties. As Japan’s experiences with tsunami disaster recovery illustrates, relocation to safer sites and land use regulation in risk prone areas are effective, but challenging to implement. Even though people may be ready to relocate to higher grounds right after a disaster, they may also change their minds, preferring to live in the lowlands because it is more convenient for daily life. After the Indian Ocean Tsunami in 2004, the Indonesian and Sri Lankan government tried to introduce similar regulatory approaches, but did not succeed because of opposition from the communities and limited enforcement mechanisms.
KNOWLEDGE NOTE 2-8

CLUSTER 2: Nonstructural Measures

Green Belts and Coastal Risk Management
KNOWLEDGE NOTE 2-8

CLUSTER 2: Nonstructural Measures

Green Belts and Coastal Risk Management

For more than four centuries Japan has been developing forested green belts to mitigate coastal hazards such as sandstorms, salty winds, high tides, and tsunamis. Although Japan’s green belts were severely damaged by the March 11 tsunami, they did reduce the impact of waves, and protected houses by capturing floating debris. Local governments are planning to reconstruct the green belts as a countermeasure against tsunamis. While local communities have traditionally taken charge of maintaining green belts, their role has been weakened because of changes in society brought about by economic development and urbanization.

FINDINGS

Japan is surrounded by the sea; its coastline measures approximately 34,000 kilometers, with 1,640 square kilometers (km2) of a forested green belt distributed along its sandy coast. For more than four centuries Japan has been developing this green belt. Composed mainly of Japanese black pine (box 1), it serves various functions. It reduces the impact of coastal hazards such as blown sand, salty winds, high tides, and tsunamis. Japan’s Forest Law stipulates that disaster risk management (DRM) forests should be planted in coastal areas to prevent damages from wind, airborne sand, and tsunamis. Another benefit of the greenbelt is that it is a scenic landscape called hakuza-seisyou in Japanese, which means “beautiful coast with pine trees and sandy beach.” Its role as a tourist attraction has become increasingly important as Japanese society has become more affluent.

In the Sendai Plain, pine forests, 200 to 400 meters wide along Sendai Bay, have for the past four centuries mitigated disasters and provided beautiful scenery consisting of green forests, white sands, and blue ocean. Masamune Date, a distinguished feudal lord, started to plant Japanese black pines along the Teizan Channel on the Sendai Plain in 1600. The people who lived on the dunes along the coast had suffered from sandstorms and tidal disasters that damaged their agricultural products, and the pine forests protected their fields. Masamune allowed the people to sell wood from branches that were trimmed or had fallen to cover the expense of maintaining the green belt.
In the late 19th century, the Japanese government designated Reserved Forests, maintaining their DRM function. In 1933 the green belt mitigated damages from the Syowa Sanriku tsunami. In 1935 the government started an afforestation program to mitigate tsunami damage; and again promoted afforestation following the Chilean earthquake tsunami in 1960.

The green belt became less important after the rapid economic growth of the 1970s, as other more effective DRM measures were developed, and electricity and gas replaced wood as energy sources for people. The community’s role in managing the green belt diminished, and governments took over its maintenance.

**DAMAGE TO THE GREEN BELT**

In the Great East Japan Earthquake (GEJE) of 2011, 3,660 hectares (ha) of the green belt were damaged by the tsunami, at a cost of ¥55 billion. In the four affected prefectures, 2,825 ha of the green belt were flooded; and 1,069 ha of the green belt were damaged more than 75 percent (figure 1). The green belt of the Miyagi Prefecture was severely damaged—trees were uprooted or bent, or their trunks were broken.

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**BOX 1: Takatamatsubara and the hope of recovery**

In the disaster-affected areas of Tohoku, there were several famous coastal forests. Takatamatsubara of Rikuzen Takata City was a 21-hectare coastal forest, 2 kilometers long and 200 meters wide, consisting of some 70,000 pine trees. In the 17th century, a wealthy merchant started planting pine trees in the barren coastal areas to protect agricultural lands from heavy winds and salt water. Another merchant began planting in the 18th century. The local communities developed and maintained the forests for some 350 years, conducting annual festivals to commemorate the two merchants. These coastal forests had also been a tourist attraction where a million or so people came to bathe or enjoy nature every year. After the GEJE disaster only a single pine tree remained—a meager symbol of hope of recovery.

*Source: Ministry of Environment.*
The green belt reduced the impact of the tsunami, delayed its arrival time, and protected houses by capturing drifting debris. Several ways in which the green belt reduced damages have been reported. In Hachinohe City, Aomori Prefecture, a forest caught 20 ships washed inland by a 6-meter tsunami, thereby protecting the houses located behind the trees (figure
2). Although these houses were inundated by over 3 meters of water, they were not washed away. In past tsunami disasters, the following benefits have been confirmed:

- The energy and speeds of the tsunamis decreased.
- Floating wreckage was blocked.
- People washed away by the tsunami were able to save their lives by clinging to trees.
- The trees helped preserve sand dunes, which in turn mitigated the force of the tsunami.

Natori City was hit by a tsunami of 8.5 meters. Almost all of the green belt was flooded and 106 ha (more than 80 percent) was damaged. Figure 3 shows the condition of the green belt in Natori City before and after the tsunami. The extent of the damage differed by location depending on the geographic conditions on the ocean side. In the northern part, which had sand embankments from port construction, the green belt was preserved; in the middle portion, which had no barrier, the green belt was washed away or knocked down; and in the southern part, the presence of a tidal embankment preserved the green belt.

Local governments are planning to restore DRM coastal forests as one of their structural countermeasures, along with dikes and mounds. The Forest Agency suggests that the forests should be at least 50 meters wide, and preferably 200 meters, for effective DRM in...
coastal areas. DRM effects can be increased with building mounds; and debris, which is a serious obstacle to rehabilitation, can be used for building mounds.

The Miyagi prefectural government recommended the following actions to help the recovery of DRM forests:

- Coordinating with other rehabilitation works, such as coastal dikes and debris management.
- Selecting tree species that conform to local conditions and support biodiversity.
- Collaborating with nonprofit organizations, volunteers, and the private sector.

**MAINTENANCE**

Community action is essential to maintaining the coastal green belt. Local communities had historically developed and maintained the green belt to protect their houses and agricultural
lands from coastal hazards. Proper maintenance is required to preserve the forest’s DRM function: trees should be planted with moderate density, and frequent thinning is required otherwise the trees will not develop to their full size.

Since the late 1960s, the community’s role in managing the green belt diminished as Japan experienced rapid economic growth; as previously noted, governments took over their management (figure 4). Growth led to the development of infrastructure such as dikes and new energy installations, while the fishing and agriculture industries lagged behind. Dikes replaced the green belt in coastal hazard prevention; and communities started using coal instead of pine trees as a fuel source. Community-based organizations (CBOs) that had managed the green belt broke up as communities lost interest and the government was unable to manage and maintain such vast forested areas. Moreover, damage caused by the pine weevil became a serious problem from the 1990s.

**LESSONS**

- Green belts can be effective against small tsunamis, sea winds, or sands, but not against a huge tsunami like that of March 11. Combining green belts with dikes and embankments can strengthen their effectiveness (KN 2-3-1).

- Green belts reduce tsunami damage by reducing wave energy, delaying water arrival time, and protecting houses by capturing floating debris.
• Green belts also provide other important benefits recognized by communities, such as protection from coastal storms, salt damage, and sand and provide spaces for recreation and wildlife. Forests may also provide psychological safety and augment well-being.

• Green belts require several decades to develop properly. Japan has had over four centuries of experience in their development.

• Local communities can play important roles in green belt maintenance. Maintenance mechanisms should be modified as society changes. In Japan the government expanded its roles as the economy grew.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Forest projects can be effective countermeasures against tsunamis, floods, and other water-related disasters. Forested green belts can decrease disaster risks by reducing the force of natural hazards. During the Indian Ocean tsunami in 2004, mangroves and other coastal green belts mitigated potential damages due to the disaster.

Understand the DRM function of the green belt. Public awareness of the DRM function of the green belt should be raised. Also, information should be shared with decision makers to promote green belts.

Utilize the forest as a means of livelihood. In Japan forests have been used along rivers to mitigate floods, and farmers use bamboo from the green belts to produce handicrafts that provide them with additional income. Farmers can also earn from fuel woods and nontimber products, such as fruits, flowers, and medicinal plants.

Foster participatory maintenance. Restoring the green belts includes two major activities: cultivation and sustainable management which should involve several stakeholders. Plantations can be jointly implemented by the government and civil society, including the community. Community participation in cultivation leads to a sense of ownership. Communities can continue using the green belt as a space to learn skills and as a way of maintaining relationships with external organizations.

Support community. Local governments and civil society organizations play an important role in increasing awareness and engaging the local community. DRM education in schools will also raise awareness and encourage participation.

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KNOWLEDGE NOTE 3-1

CLUSTER 3: Emergency Response

Mobilizing and Coordinating Expert Teams, Nongovernmental Organizations, Nonprofit Organizations, and Volunteers
In response to the Great East Japan Earthquake (GEJE), domestic and international assistance initiatives were launched by a large number of public and private sectors organizations; and various emergency teams were mobilized through national and international networks. The GEJE reminded us that civil society organizations play an indispensable role in disaster management. These organizations have the advantage of flexibility and speed in reaching and caring for affected communities. However, there were no coordination mechanisms in place that functioned properly on the ground. Because of the complexity of disaster response operations and the large numbers of actors involved, coordination mechanisms must be established in advance during normal times.

**FINDINGS**

**Mobilizing the Government’s Expert Teams**

Municipality and prefecture governments play a leading role in disaster response in Japan. However, because of the catastrophic consequences of the March 11 earthquake and tsunamis many of the local governments were unable to respond, so national agencies as well as prefectures and municipalities outside the affected region were quickly deployed (KN3-4). Organizations concerned had formed a variety of expert teams in light of the lessons learned from past disasters, in particular the Great Hanshin-Awaji (Kobe) Earthquake in 1995. The national government took action immediately by setting up a response office 4 minutes after the earthquake, and an Emergency Disaster Response Headquarters headed by the Prime Minister, within 30 minutes. Its mandate was to oversee and coordinate all response activities.

**Self-Defense Forces** The total number of personnel in operation reached some 107,000 with about 540 aircraft and nearly 60 vessels. SDF rescued approximately 19,000 disaster victims, or nearly 70 percent of those rescued in the GEJE event. The SDF provided transportation assistance to medical teams, patients and rescue units dispatched from various
The SDF also responded to the nuclear accident, engaging mainly in pumping water for cooling used fuel pools, decontaminating personnel and vehicles, and monitoring amounts of airborne radiation (figure 1).

**Emergency fire response teams** Following its experience with the Kobe Earthquake, the Fire and Disaster Management Agency created fire response teams to mobilize firefighting departments across Japan. At the GEJE, the emergency teams dispatched more than 30,000 firefighters from 712 fire departments in 44 prefectures nationwide over a period of 88 days ending on June 6. In cooperation with local fire departments, the emergency teams had rescued 5,064 people as of June 30, 2011. Most fire department in devastated areas had lost their radio equipment or base of communications. In light of this experience, the Fire and Disaster Management Agency has decided to provide the teams with additional mobile communications equipment and a larger supply of fuel so that they can operate effectively even over a wide areas and for a longer period of time.

### TABLE 1: Expert teams organized by the government

<table>
<thead>
<tr>
<th>Ministry/agency</th>
<th>Expert teams</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ministry of Defense</td>
<td>Self-Defense Forces</td>
</tr>
<tr>
<td>Ministry of Health, Labor and Welfare</td>
<td>Disaster Medical Assistance Team</td>
</tr>
<tr>
<td>Ministry of Land, Infrastructure, Transport and Tourism</td>
<td>Technical Emergency Control Force, Coast Guard</td>
</tr>
<tr>
<td>Fire and Disaster Management Agency and prefectoral fire departments</td>
<td>Emergency fire response teams</td>
</tr>
<tr>
<td>National Police Agency and prefectural police agencies</td>
<td>Interprefectural emergency rescue units</td>
</tr>
</tbody>
</table>

**Source:** Ministry of Defense.

![Figure 1: The SDF in action](image)
Interprefectural emergency police rescue units

Interprefectural emergency rescue units are police units that have been set up in prefectures nationwide, based on the experience with the 1995 Kobe Earthquake. In response to the GEJE, these rescue units conducted such activities as search and rescue and securing emergency transportation routes. A total of 750,000 person-days were spent working on site, with as many as 4,800 personnel working per day (figure 2). A review of their operations during the GEJE revealed that the scale was so large that some units could not manage their operations on their own, while others had difficulty securing enough personnel. The Police Agency will enhance its response capacity by setting up emergency quick response teams and long-term response teams numbering 10,000 personnel.

Crimes such as theft were a major concern since many houses had been left vacant after residents fled to evacuation centers away from home. According to the National Police Agency, the number of crimes committed in the disaster-affected areas in the year after the disaster had decreased significantly compared to the previous year, while the number of burglaries had risen (table 2). Many ATM machines were also destroyed. Police teams were deployed to ensure safety in the disaster-affected areas.

Disaster Medical Assistance Team (DMAT)

DMAT is a specialized team of medical doctors, nurses, and operational coordinators trained to conduct emergency operations during the critical period, normally within 48 hours, after a large-scale disaster or accident. DMAT was established in 1995 after the Kobe Earthquake, when it was learned that 500 more people could have been saved if medical support had been provided more promptly.
TABLE 2: Crime in the disaster-affected areas

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Crimes</td>
<td>42,102</td>
<td>51,305</td>
<td>-18</td>
</tr>
<tr>
<td>Felonious</td>
<td>187</td>
<td>245</td>
<td>-24</td>
</tr>
<tr>
<td>Violent</td>
<td>1,804</td>
<td>2,008</td>
<td>-10</td>
</tr>
<tr>
<td>Larceny</td>
<td>31,894</td>
<td>38,484</td>
<td>-17</td>
</tr>
<tr>
<td>Burglary</td>
<td>5,729</td>
<td>5,690</td>
<td>0.7</td>
</tr>
<tr>
<td>Vehicle</td>
<td>9,992</td>
<td>12,440</td>
<td>-20</td>
</tr>
<tr>
<td>Non-burglary</td>
<td>16,173</td>
<td>20,354</td>
<td>-21</td>
</tr>
<tr>
<td>Intellectual, white collar</td>
<td>1,150</td>
<td>1,905</td>
<td>-40</td>
</tr>
<tr>
<td>Moral, sexual</td>
<td>375</td>
<td>404</td>
<td>-7</td>
</tr>
<tr>
<td>Others</td>
<td>6,692</td>
<td>8,259</td>
<td>-19</td>
</tr>
</tbody>
</table>

Source: National Police Agency.

In response to the GEJE, DMAT sent about 380 teams, 1,800 staff, from 47 prefectures for 12 days to provide support to hospitals and to rescue and transport patients. Because the tsunami damage was so extensive and local medical centers had been washed out by tsunamis, DMAT also had to provide care for people with chronic illnesses. Although DMAT’s operations usually take place within 48 hours after a disaster, they had to operate for a much longer time.

Technical Emergency Control Force (TEC-FORCE) The Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established TEC-FORCE in 2008. The TEC-FORCE is a specialized group made up of ministry staff that helps disaster-affected municipalities to quickly assess damages, identify measures to prevent additional damage, and provide technical assistance for rehabilitation and emergency response activities. In response to the GEJE, more than 18,000 person-days of personnel were dispatched, together with disaster management equipment and machinery (figures 3 and 4). TEC-FORCE provided satellite communication vehicles, enabling them to connect to public lines and establish communications with other organizations concerned.

The Japanese Red Cross Society (JRCS) JRCS has mobilized relief resources to the affected area from the onset of the disaster. JRCS is designated as one of the public relief organizations by the disaster response law and the biggest humanitarian organization in Japan. Within 24 hours from the disaster 55 medical teams (out of which 22 teams as DMAT) were dispatched and subsequently 935 teams, or 6,700 personnel, in total were deployed during 6 months, treating 87,445 persons, along with provision of psychosocial support to affected population.
Mobilizing and Coordinating Expert Teams, Nongovernmental Organizations, Nonprofit Organizations, and Volunteers

Mobilization of Japanese NGOs and NPOs

Domestic nongovernmental organizations (NGOs) and nonprofit organizations (NPOs) have played a significant role in carrying out disaster management activities. As of January 20, 2012, there were 712 organizations participating in the Japan Civil Network for Disaster Relief in East Japan. There is no limitation either on the type of organization that can join the network, such as nonprofit, public-interest, or religious, or on budget size.

In a disaster, the role of NGOs and NPOs is to complement the government’s role. Since in Japan the government is indeed the primary agent obligated to initiate action in response to a natural disaster, NGOs and NPOs are responsible for filling in where governmental
The early responders can be categorized into two groups: Japan-based (mainly Tokyo-based) NGOs specializing in international relief operations even before GEJE, and Japanese NGOs and NPOs based in different parts of Japan that address domestic needs. The Japan Platform, a platform for international emergency humanitarian aid organizations, mobilized funding for relief operations within 3 hours after the earthquake. Seven registered organizations carried out initial needs assessments with JPY15 million in funding, 5 organizations provided support to education with JPY450 million, 2 organizations provided health care and hygiene promotion with JPY210 million, 8 organizations engaged in rehabilitation work, 12 organizations provided food and nonfood support with JPY3.12 billion. These organizations, experienced in providing emergency humanitarian aid overseas, were able to leverage international standards and expertise. They played a pivotal role in mobilizing experts in specialized fields.

The Japanese NGOs and NPOs had been mainly involved in domestic emergency relief activities. Organizations based and operating in the disaster-affected areas made long-term commitments to sustaining activities such as assessing people-centered needs, and facilitating a seamless transition from emergency to recovery support.

The JRCS has been pulling together JPY307 billion in donations as of January 19, 2012, and its counterpart, the Central Community Chest of Japan, Red Feather Campaign, had garnered JPY38.8 billion in donations as of October 2011. A Central Grant Disbursement Committee was set up to ensure a fair allocation of the funds collected by the JRCS and the other designated fundraising organizations, to the affected prefectures. Each prefecture has established a prefectural-level grant disbursement committee that sets criteria for eligible recipients as well as for the amounts to be distributed by the municipal authorities who are responsible for identifying individual beneficiaries and distributing the cash.

The Japan Platform, an organization that manages funding from various sources for international emergency humanitarian aid projects, had received JPY6.7 billion from private companies as of July 2011, the Japan Foundation received JPY2.4 billion, the Central Community Chest of Japan received JPY2 billion, and the Japan National Committees for UNICEF received JPY3.6 billion as of January 16. The line separating fundraising organizations from private companies has narrowed as private companies actively collect funds and work in parallel with emerging NGOs like Just Giving Japan, which uses the Internet to solicit donations.

Another important responsibility of NGOs and NPOs is coordination of relief efforts. A designated agency, in most cases a UN agency, would function as the cluster lead international relief operations. However, no central agency was assigned for overall coordination in Japan. The prefectural offices or the disaster response headquarters at the prefecture levels were the first bodies to be assigned to disaster response, but they did not function as a coordinating body for all NGO and NPO relief operations. The newly established
prefectural cooperation recovery centers functioned as networking hubs, and grew into a spontaneous coalition for coordination. The Tokyo-based NGO—the Japan NGO Center for International Cooperation (JANIC), which had already created a network of NGOs, functioned as a provider of pooled information.

The third role of NGOs and NPOs in disaster response is enrollment and management of volunteers. The Ministry of Health, Labor and Welfare named the Japan National Council of Social Welfare, Tasukeai Japan, the 3.11 Reconstruction Aid Information Portal in cooperation with the Reconstruction Agency and Japan Civil Network, as the main contact points for people to apply for volunteering. Over 280,000 people joined in the disaster response as volunteers in the two months after the earthquake.

**SUPPORT IN FUKUSHIMA**

Apart from the national budget, Fukushima prefecture received JPY7.2 billion in donations, which were used for activities such as school reconstruction, support for children, and improvement of temporary shelters. JPY1.3 billion was received and used to provide for disaster orphans. In collaboration with the governmental funds, the Japan Platform supported 8 projects in Fukushima, funding 5 organizations with JPY1.8 billion. Apart from the Japan Platform there are several other organizations working separately on relief activities. However, the number of NGOs working in Fukushima is much smaller than in the Miyagi and Iwate prefectures. According to JANIC, between March and June 2011, the number of NGOs working in the Fukushima Prefecture was 17, whereas in Miyagi it was 40 and in Iwate it was 33. The contrast is made clearer by the number of projects provided by NGOs: In the Miyagi prefecture there were 292 projects, 179 in Iwate, and 60 in Fukushima. In the early stages, those concentrated on delivering emergency kits including food and nonfood items. Following emergency activities, these organizations faced difficulties in supporting rehabilitation program, which is completely new and unknown operation for them. The experiences and lessons learned in Fukushima should be passed on and shared with the broader international aid community. The Japanese NGO community should conduct timely and objective evaluations and studies of their 3.11 operations.

**VOLUNTEERS**

The Japan National Council of Social Welfare set up volunteer centers in the affected municipalities. The social welfare councils in municipalities nationwide sent more than 30,000 person-days of staff to operate the volunteer centers.

As of January 2012 more than 900,000 person-days have been used in doing volunteer work through the volunteer centers in the 3 prefectures of Tohoku (figure 5). Considering that more than 1 million volunteers were mobilized in the first month after the Kobe Earthquake in 1995, the number of volunteers mobilized during GEJE was relatively small. Some reasons for this are that the affected areas were far from large cities, and were rural coastal communities dispersed over a wide area, making it difficult for the volunteers to gain access.
INTERNATIONAL ASSISTANCE

As of November 1, 2011, 163 countries and regions and 43 international organizations had offered aid and relief. Emergency assistance squads, medical teams, and reconstruction teams had been dispatched from 24 countries and regions along with expert teams from 5 international organizations. In regards to material and monetary support, the Japanese government accepted relief supplies and donations totaling over JPY17.5 billion, from 126 countries and regions. By May 17, 43 overseas NGOs from 16 countries had arrived in Japan. The scale of assistance has been larger than for the Kobe Earthquake in 1995, when 67 countries and regions provided aid and relief; and the U.K., Switzerland, and France dispatched emergency teams.

The JRCS received financial support from 95 sister Red Cross and Red Crescent national societies from all over the world, which amounted some 700 million USD, plus additional 400 million USD from the State of Kuwait and EURO 10 million from the European Commission's ECHO. According to a survey conducted by the Brookings Institute, Japan received US$720 million from other countries, which accounts for almost half of the global humanitarian disaster funding in 2011 and some 0.4 percent of the planned reconstruction budget of the Japanese Government.

The U.S. dispatched approximately 16,000 military personnel under “Operation Tomodachi (Friends).” They provided a variety of assistance, including search and rescue efforts, the transport of supplies and people, and the recovery and reconstruction of the devastated

![FIGURE 5: Number of volunteers](image-url)
areas. At the peak of the action, approximately 140 aircraft and 15 vessels took part in the operation along with the Japanese SDF.

COORDINATION

There was no functioning coordinating mechanism among the various government organizations, civil society, and the private sector, to help avoid duplication and confusion in relief and response activities. Coordination was required at all levels and all phases. On the ground, these organizations must coordinate with community-based organizations, and with each other, to assess victims’ needs and to carry out activities smoothly and effectively. The SDF and NGOs did coordinate emergency food distribution to the evacuation shelters.

Coordination with municipal governments is crucial, since the municipalities have the primary responsibility for disaster management. Since the municipal governments have quite limited experience in working with CSOs, linkages between the municipalities and CSOs could not be easily established. Municipalities can provide support to evacuees in transition shelters, but not in their homes. This function was instead carried out by CSOs. Coordination was also lacking between the private sector and local governments outside the affected areas; and the overall coordination of international assistance was a challenge.

Coordination is required at all phases of recovery since victims’ needs change as recovery progresses. While water and foods delivery are key at the emergency phase, needs become more diverse including sustaining livelihoods, education, and improving the living conditions at evacuation shelters or in transition housing.

Good practices could be found at specific sectors at some sites. Ishinomaki Red Cross Hospital coordinated all medical teams from JRCS and other agencies at the 330 evacuation centers throughout the Ishinomaki city. The hospital organized survey teams to gather medical and non medical conditions, including water and sanitation over a one month. These formed the basis for planning and implementing response activities by various organizations including local governments.

LESSONS

- National networks should be used to mobilize experts, including search and rescue teams, medical teams, and engineers. Organizations should prepare these teams during normal times, such as compiling rosters and conducting training.

- The teams came from outside need to independently engage in activities in the disaster field without support, often for long-term. Communication and transport equipment, fuel, food and water should be stocked.

- At megadisaster, like GEJE, expert teams are expected to engage in activities for longer terms than frequent disasters that require response activities for a few days. Since enormous number of various public facilities are damaged, expert teams are required to develop capacities for long-term activities, one month or more.
• Since enormous numbers of different types of organizations are involved in disaster management, coordination mechanisms are essential. There was no functional coordination mechanism in the GEJE. This is why megadisasters overstretch capacities of local governments, and damage government staff and facilities at devastated areas. In developing countries, UN cluster systems serve as coordinating mechanisms. Considering the difficulties faced by the local governments in the GEJE, similar mechanisms should be established in the central government or under some umbrella organization of civil society organizations.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Prepare response teams. Specialized agencies, such as the police, fire departments, public works, and hospitals should prepare during normal times for the mobilization or response teams. The following activities are required:

• Clarify the chain of command
• Designate a secretariat function
• Prepare a roster of emergency team members
• Conduct emergency drills
• Keep the necessary equipment in stock

Develop capacity. Expert teams are required to develop capacities for working independently for long-term. Stand-by or rotating teams, communication and transportation should be arranged.

Establish coordinating mechanism. Various types of organizations from inside and outside the country engaged in response and recovery activities. Government agencies often have problems coordinating the enormous numbers of organizations carrying out a broad range of activities. Megadisasters stretch the capacities of local governments; and local government staff and facilities suffer. Once disaster happens specific teams came from outside the devastated areas and start coordination among all organizations. The following actions are required:

• Preparedness: establishing face-to-face relationships during normal times facilitates coordination in times of disaster.
• Networking: information, experts and private sector personnel should be networked to share information, to effectively collaborate each other, and to mobilize diversified resources.
• Consideration of vulnerable groups: special care is required for vulnerable groups, such as the disabled, the elderly, and children. These groups are easily marginalized (KN3-6).
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Huma, NICCO, JPF HP. http://w3.japanplatform.org/area_works/tohoku/action/03.html.

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KNOWLEDGE NOTE 3-2

CLUSTER 3: Emergency Response

Emergency Communication
Emergency Communication

The Great East Japan Earthquake (GEJE) caused immense damage and congestion in telephone infrastructure, including 1.9 million fixed-line services and 29,000 mobile phone base stations. Government radio communication infrastructure was also seriously damaged. Voice messages were widely used to confirm whether family members and relatives were safe, and satellite phones played a crucial role in emergency communication during the response stage. Social media was extensively used for search and rescue, as well as for fundraising. Social media and community radio reach two distinct age groups: social media for the younger generation and community radio for the older generation.

FINDINGS

Communication infrastructure is indispensable in securing government functions and protecting lives and property during disasters. Communication systems are used to disseminate warnings to the public, to enable search and rescue organizations to communicate among themselves, and to confirm the safety of family members and relatives. Social media was extensively used for search and rescue, as well as fundraising. Community radios can provide local information such as times and locations where emergency water and food supplies or relief goods will be delivered.

TELEPHONE

Damage and subsequent restoration of fixed-line, mobile, and broadband services. The Great East Japan Earthquake (GEJE) caused immense damage to both fixed-line and mobile phone infrastructure, including flooding of exchange facilities, damage to underground cables and conduits, destruction of telephone poles and overhead cables, destruction and loss of mobile phone base stations, and draining of backup batteries during the long power outages. In the Tohoku and Kanto regions, an estimated 1.9 million fixed-line services from NTT East Japan, KDDI and SoftBank Telecom were rendered inoperable,
including subscriber lines, ISDN and FTTH, while 29,000 mobile phone and PHS base stations also stopped functioning.

Telecommunications carriers initially deployed mobile power supply vehicles and mobile base stations to those areas with no commercial power supplies, and set about re-building damaged facilities as quickly as possible. The rapid response effort saw full service restored to almost all affected areas, with some exceptions, by the end of April 2011 (Figures 1, 2, and 3).

**Voice messaging and other services.** The sharp increase in voice call traffic immediately after the earthquake caused significant congestion. Carriers restricted fixed-line traffic by as much as 80-90 percent and mobile services by as much as 70-95 percent in order to allow emergency calls and other critical communications to go through. Mobile phone packet communication services such as email were generally not restricted.* Even when carriers did impose restrictions, they were generally no more than about 30 percent and were only temporary. Thus, packet communications provided considerably easier access than voice services.

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* A data stream is divided into packets, or units, that are separately routed to a destination where the original message is then reconstituted.
Telecommunications carriers set up emergency messaging services so that people could check on the safety and whereabouts of their families, relatives, and other relevant people (figure 4). These services were used some 14 million times following the GEJE. Because of these emergency messaging services, traffic congestion was cleared up on the same day the earthquake struck, in contrast to the Hanshin-Awaji Earthquake in 1995 when congestion continued for five days.

Some mobile phone carriers introduced an emergency messaging service whereby the terminal device converted voice recordings into voice files that could then be sent via packet transmission. Other mobile phone carriers are planning to follow suit.

**DISASTER MANAGEMENT RADIO COMMUNICATIONS**

The disaster management radio communications networks of national and local governments are generally considered to be more robust and resilient than public fixed networks. In the GEJE, however, many towns and villages, particularly those located along the Pacific coastline, suffered various levels of damage to their radio communications systems, including both community announcement systems with loud speakers and mobile systems...
FIGURE 3: Damage of NTT East and NTT Docomo

FIGURE 4: Disaster emergency message traffic and comparison with Kobe Earthquake
on emergency vehicles. The main causes were damage to or loss of radio transmission equipment from the earthquake and tsunami as well as loss of electric power during sustained blackouts.

In the aftermath of a megadisaster like the GEJE, a key issue is how to deliver relevant information such as public warnings and evacuation instructions across wider areas in a timely and reliable manner. Local governments are looking at advancing and multiplying ways to deliver emergency information to residents, and improving their disaster resilience.

**SATELLITE COMMUNICATIONS**

Compared to terrestrial communication infrastructures, satellite phones and satellite communication systems were less vulnerable. These systems had the advantage of being available for quick deployment in any region including regions with no land-based communication infrastructure, as well as in marine areas. Satellite phones, in particular, played a vital role in emergency communication among local governments and rescue organizations.

**Satellite mobile phones.** This system provided voice and internet communication capabilities for disaster management organizations, evacuation shelters, and staff working on infrastructure rehabilitation, among others. This was also the case for local governments and communities isolated by typhoons and heavy snowfall. In preparing for disasters, batteries and equipment should be stored for rapid deployment.

**VSAT (Very Small Aperture Terminals).** VSAT provides voice and internet communication capability by enabling accesses from multiple mobile terminals via wireless LAN technology. They were also used to provide connection through portable and truck-mounted mobile phone base stations for rapid restoration of communication infrastructure, and to provide a temporary communication network for disaster relief organizations.

**Portable and truck-mounted satellite earth stations.** These were used by disaster relief organizations and media entities to transmit video images from disaster sites. The Heli-Sat system, which enables video transmission through satellite, will be introduced in the future.

**Marine earth stations.** This provided communication for rescue and recovery activities by seagoing vessels in cases where land routes were disrupted.

**RESPONSES IN DISASTER INFORMATION BROADCASTING**

After the earthquake occurred, broadcasting companies including NHK (Japan’s public broadcasting corporation) and local operators interrupted regular programming to provide disaster-related information. For example, NHK delivered emergency earthquake warnings, followed by news reports on a continuing basis starting 2 minutes after the earthquake occurred. These were carried on the company’s 8 channels including its general programming channel, the educational channel, and its radio channels. The general programming channel continued to provide news reports and programs related to the earthquake and tsunami for 12 days up until March 22; and the total time devoted to disaster-related news and reports was about 254 hours. People were able to watch many of those programs on
their mobile phones in areas where the electricity supply had failed. The programs were delivered by one-segment broadcasting.†

As many as 120 television relay stations stopped functioning because of the loss of commercial electricity during the initial period of the disaster, and as many as 4 radio relay stations shut down. Master stations continued broadcasting by generating their own power. All the stations within the area had been restored by the end of May 2011 except for one radio station within the evacuation zone around Fukushima Daiichi nuclear power station. This station was restored by March 2012. After the March 11 events, the Ministry of Internal Affairs and Communications (MIC) requested the NHK, the National Association of Commercial Broadcasters (NAB) in Japan, and the radio stations in the affected areas to increase broadcasting disaster information; and on April 1, 2011 MIC requested that NHK and NAB be able to provide accurate and detailed information as quickly as possible to the public.

**SOCIAL MEDIA**

Social media are a set of applications and services that use the Internet to connect people. They combine dynamic, collaborative Internet-based tools, social networks, computers and, increasingly, mobile devices. Social media consist of social networks such as Twitter and Facebook that connect users, as well as websites and computer applications that enable users to collaborate and create content, such as the Wikipedia and YouTube websites.

Social media were used extensively during the GEJE for various purposes, such as search, rescue, and fundraising. Table 1 summarizes how they were used to meet different types

<table>
<thead>
<tr>
<th>TABLE 1: Dominant information types and how they were used</th>
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<tbody>
<tr>
<td><strong>Twitter</strong></td>
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<tr>
<td>General disaster information</td>
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<tr>
<td>Safety confirmation</td>
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<tr>
<td>Fundraising</td>
</tr>
<tr>
<td>Infrastructure status notification/ regional facility status</td>
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<td>Housing provision</td>
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<td>Goods provision</td>
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<td>Moral support</td>
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<td>Volunteer recruitment</td>
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<td>Special needs support</td>
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† A mobile terrestrial digital audio video and data broadcasting service in Japan. People can watch TV programs on mobile phone.
of information-sharing needs during the disaster. A questionnaire survey was carried out to learn about the uses of social media by 250 different types of responders: information senders, volunteers, managers of media groups, and so forth (figure 4).

Social media and the Internet were found to be highly reliable regardless of the users’ role, location, or the extent to which they were affected by the disaster. Users found social media to be extremely beneficial in general to an overwhelming degree. For directly affected individuals and people in the affected areas, the strongest reasons for using social media were convenience and their mass dissemination capacity. The Google Person Finder let people enter an inquiry about a missing person or provide information for interested parties. In total over 600,000 person names were registered.

All users experienced problems with the trustworthiness of information to a high degree. Users feel, to a particularly high degree, that the information shared through social media needs to be more accurate and reliable, especially information about infrastructure. Support for government use of social media in disasters is extremely high and was highest among directly affected individuals, individuals in disaster-stricken areas, and those involved in disseminating information to groups.

The higher the level of participation in sharing information through social media, the more likely an individual is to receive and share large amounts of information, and believe that the information comes from credible sources.

**EMERGENCY FM RADIO**

Emergency FM radio also played a crucial role in providing information to local residents. In the Tohoku area, 25 emergency broadcasting stations specializing in disaster information were set up. Immediately after the disaster, the communication systems developed by
local governments did not work because of power failures and a lack of emergency backup power supply. MIC distributed 10,000 portable radio receivers to evacuation shelters, and requested equipment manufacturers such as Panasonic and Sony, to distribute over 40,000 portable radio receivers.

FM radio provided locally customized information, such as information about aftershocks, or the availability of local services and activities related to people’s everyday needs. This kind of information was beneficial immediately after the disaster, while different information was required as reconstruction progressed. Some entertainment programs were presented 6 to 9 months after the disaster (box 1).

Several problems were identified. Ensuring sufficient human resources is a key issue. Immediately after the disaster, a significant number of volunteers provided the radio stations with different kinds of help, but over time the number decreased. A sustainable funding source is needed to continue radio broadcasting either in the form of emergency radio or community radio. FM radio users in Natori city are keen on having local residents continue to participate in broadcasting activities, and on gradually changing over to community FM with funding from communities and subsidies from local governments.

**BOX 1: Ringo (Apple) Radio of Yamamoto Town, Miyagi Prefecture**

FM Radio was used as a temporary emergency station in Yamamoto. It is located inside the Yamamoto town hall and was set up with the help of FM Nagaoka of Nagaoka city, Niigata prefecture. Ringo FM started broadcasting on March 21, and is on the air from 7:00 am to 7:00 pm. At first, it only announced information such as bathing times and food rationing information for those living in the town. Later the content became less about daily life than about supporting and comforting the residents. According to the coordinator, “We will never be able to completely eliminate the sadness of the victims, but we would like to provide them with encouragement from the bottom of our heart.”
LESSONS

- To reduce telephone network congestion, packet communications and emergency message services should be expanded. MIC is raising public awareness about using these services in times of disaster.

- The GEJE reminded us that resilient and redundant communication systems should be established. Backup systems are needed and batteries and generators with enough fuel should be acquired and stored in higher locations to avoid flooding.

- Social media and FM radio have played a crucial role in providing information to local communities; they reached two distinct age groups: while the former was used more by the younger generation, the latter is used mainly by the older generation.

- The way in which social media and FM radio are used changes over time—from sharing information about the safety of family and friends, to disseminating information about relief goods and services, and gradually to livelihood-related information.

- To enhance the use and effectiveness of social media in emergencies, city and local governments should use them for regular communications related to city news and events. In Japan, the Prime Minister’s Office launched a new Twitter site after the disaster.

- For FM radio, sustainability is a key issue. Off-air activities, in which communities participate in producing radio programs, should be strengthened, so that communities will be invested in supporting the continuation of FM radio.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

When disasters strike, communications infrastructure should be used to disseminate warnings to the public, to enable communication among search and rescue organizations, and to confirm the safety of family members and relatives. Immediately after the disaster, however, communications systems often break down because of power failures, damage to infrastructure, and congestion.

Improve the reliability of communication networks. The following actions are required:

- Reducing damage by developing backup systems, such as batteries, generators, and backup trunk lines.

- Mitigating congestion by increasing the capacity of facilities such as switching equipment.

- Restoring service by deploying emergency facilities, such as portable switching equipment and portable satellite stations.
Utilize social media. The increasingly higher levels of mobile phone penetration in developing countries can allow for the effective use of social media during disasters, provided they are also used during normal times. Social media can also provide information to communities outside the disaster-stricken area, and facilitate the acquisition and appropriate allocation of aid and assistance. Starting with the Haiti Earthquake of 2010, the use of social media during disasters has significantly increased in other countries. There is a strong potential for cultivating the use of social media among different groups and for developing a social media-based platform designed for emergency situations.

Improve accessibility. Local accessibility is a key issue in many developing countries. Using mobile networks and social media can help in collecting and disseminating local information before and during disasters.

Enhance reliability of social media. The trustworthiness of information is extremely important for social media. Local government or relevant national government agencies should consider using social media in their public relations activities during normal times. When disasters occur, those social media channels can be used to share disaster-related information with the public.

Utilize radio to share information in communities. FM radio is commonly used in developing countries to share information in communities. Community radio is a rather low-cost and effective means of reaching small groups that are usually not served by the national and international media. Radios can provide information such as times and locations for provision of emergency water and food supplies or distribution of relief goods in the immediate aftermath of a disaster, and then gradually shift to providing different information for daily living or to help lift the spirits of people in the local communities. Radio is also appreciated by the elderly who may not have access to internet-based information.

Enlist community participation to ensure sustainability. For FM radio to be effective, there needs to be a balance between on-air and off-air activities. Community participation is the key to the long-term survival of FM radio, and therefore, off-air community activities, such as workshops, are very important. These activities can also be linked to local schools and educational system for greater sustainability.

KEY REFERENCES


KNOWLEDGE NOTE 3-3

CLUSTER 3: Emergency Response

Logistics Chain Management for Emergency Supplies
In response to the Great East Japan Earthquake (GEJE) disaster, relief goods were distributed and delivered through prefectural- and municipal-level depots. This delivery system faced several problems including fuel shortages, interruption of telecommunication services, and supply and demand mismatches, resulting in stockpiling of the goods in depots and delayed delivery to the people in need. Several measures can be taken to address these issues, including prior surveys of depot facilities, estimating in advance the quantities of emergency goods that will be required, enlisting the support of professional logistics specialists, and promoting logistics information management in unaffected areas, among others.

FINDINGS

The damage from the earthquake and tsunami was enormous; over 120,000 houses were totally damaged, and more than 470,000 people had to leave their home and evacuate to over 2,400 shelters.

Delivery of relief goods was planned to be executed through depots at two levels—prefectural and municipal. Especially in the first two weeks, fuel shortages made downstream deliveries from prefectural depots very difficult. Also, manpower shortages and the inconvenient building specifications of depots were the main causes of unnecessary stockpiling in depots. Telecommunications disruptions furthered mismatches between real needs and supplies. But the professional support of logistics specialists was effective in relieving the bottlenecks in depots.

THE RELIEF GOODS DELIVERY SYSTEM IN JAPAN

In Japan delivery of relief goods is the responsibility of the prefectural governor, who responds to requests from the municipalities. According to the postdisaster plan, delivery of relief goods was to be executed using depots at two levels: prefectural and municipal, as shown in figure 1. As illustrated in green in the figure, the national government
FIGURE 1: Information and transportation flows in the official relief goods delivery system

Companies, public bodies, inhabitants in other areas

- Request
- Shipping information
- Independent offer by goodwill

Cabinet Office, etc.

- Shipping order request
- Shipping information

Collection points in shipping prefectures

- Transportation
- Order, arrival schedule

Prefectural (first level) depot in affected area

- Transportation
- Inventory check
- Order, arrival schedule

Municipal (second level) depot in affected area

- Transportation
- Inventory check
- Order, arrival schedule

Evacuation shelters, hospitals

- Supply
- Request
- Transport information

Prefectural disaster responding office

- Request
- Shipping information

Municipal disaster responding office

- Request
- Transport information

Companies, public bodies, inhabitants in other areas

- Information flow
- Transportation flow

Reported information, Internet information

Transportation

Shipping order request

Inventory check

Shipping information

Order, arrival schedule

Prefectural (first level)

Prefectural (second level)

Shipping order request

Shipping information

Inventory check
Delivering several kinds of goods, such as food, drinking water, clothing, and bedding, either to people’s homes or to more than 2,000 shelters, was a challenge, especially in the first several weeks when fuel was in short supply. This was especially true for the smaller local transport companies that did not have their own storage facilities. By the end of June, 1,800, 1,400, and 2,400 trucks were dedicated to transporting goods from prefectural depots to municipal depots in Iwate, Miyagi, and Fukushima, respectively. Fuel shortages combined with power outages and telecommunications failures hampered local government efforts to meet emergency needs.

Although many believe that transportation problems were the critical factor, several other forces were at play. The workload spiked at the same time that many staff were being lost to the disaster. Moreover, while the disaster countermeasure manuals state that the economic or industrial support branch of the local government is responsible for the delivery
system, workers in that section did not have enough knowledge or experience with logistics and supply chain management. They simply stored the goods in public buildings, with no logistics management plan, so the space was quickly filled (as shown in figure 2).

The building specifications and design of the depots was also a contributing factor. The depots require large storage and handling capacity as well as easy access to expressways, especially prefectural depots. Privately owned warehouses would have been ideal if they had not been damaged. The space under viewing stands in athletic fields, race courses, and indoor gymnasia also served well as depots (figure 3). In Miyagi Prefecture, large warehouses located near Sendai Port were severely damaged by the tsunami.

Neither Yume Messe Miyagi, the convention complex at Sendai Port, nor the Miyagi Prefectural Sports Park could be used as depots since they had already been designated as mortuaries.

**TELECOMMUNICATIONS DISRUPTIONS AND INFORMATION BOTTLENECKS**

The disaster disrupted business operations such as information aggregation; meanwhile, the failure of some communications systems hampered the evacuation of people to safe areas. Very little of the real-time information that was needed to ensure timely and accurate procurement of goods was available: including the location of the shelters, the correct addresses of the recipients of goods, or information about the type and amount of assistance that communities needed. Information about whether relief goods had actually been received could not be easily communicated among depots for several weeks after the earthquake.

**BOX 1: The negative effect of goods sent with goodwill**

The demand for different kinds of emergency supplies continued to change over time. There were many instances where in a certain area emergency goods were in high demand one day, and no longer needed after a few days.

Relief goods resulting from a spontaneous outpouring of goodwill but sent without making any prior arrangements with the recipient municipal bodies and without clearly marked declarations of contents did not meet people’s needs and further burdened an already strained distribution network with dead stock and inventory.

Unpacking and sorting the emergency supplies sent by goodwill alone was an enormous amount of work. As these kinds of donations mounted, they clogged and undermined the efficiency of the distribution depots.

Many such goods arrived in Onagawa City, in Miyagi Prefecture. Used clothing was sent to the temporary shelters; however, 80 percent of the clothes, or 200 cartons, were returned to the gymnasium of the junior high school, which was the distribution center. About 7.7 tonnes of donated goods had to be recycled.
LESSONS

• Suitably designed depots with cargo-handling equipment such as forklifts are needed, along with the support of logistics professionals.

• Information on arrival times at each depot is crucial for planning storage and location management.

• Prior quantitative estimates of urgently needed goods should be carried out based on regional demographic statistics. This helps arrange “push delivery”, supply-driven deliveries, in the first few days after the disaster.

• Emergency delivery systems should be closed down as soon as feasible to allow normal commercial distribution systems to take over. They are capable of serving a variety of consumers, and are more flexible and demand driven.

• At the intermediate stage, logistics management is best delegated to designated municipal authorities in unaffected areas.

THE NEED FOR SPECIALIZED SUPPORT

As stated earlier, local government officials without sufficient knowledge, training, or experience in logistics management performed the specialized functions of receiving, sorting,
and dispatching emergency supplies at distribution depots. This resulted in confusion and massive congestion of the delivery networks.

In large-scale disasters, local government staff are called upon to discharge a variety of functions related to emergency management. The government should enlist business logistics professionals and draw on the capacity of the private sector as much as possible, to ensure properly integrated management of the distribution depots. Many local public bodies hesitated to hire private companies for relief goods distribution and management because they were not sure that they would be able to pay them under the Disaster Assistance Law. In future, a case can be made for putting in place agreements and contracts with the private sector for specialized logistics management services.

**GETTING INFORMATION FROM UPSTREAM**

For distribution depots to operate smoothly, local decision makers need to have real-time information about the kinds of goods being transported and the timing of shipments. This information enables them to arrange for the personnel and space needed to accommodate consignments. In normal times, this information can be obtained from, for example, point of sales (POS) systems.

In the aftermath of the disaster, this kind of information about the emergency goods ordered by the national government was not available to prefectures and municipalities in time. In addition, relief goods often arrived unexpectedly from various private companies, nonprofit organizations, and individuals with no prior information, which seriously reduced the processing capacity of distribution depots.

**PREPARING A “PUSH” LOGISTICS PLAN**

Since it is impossible immediately after disaster to collect information about affected populations and the extent of damages and loss, it is helpful to design simulations of different scenarios to generate data on the expected number of victims, including data on vulnerable groups such as the elderly, disabled, women, children, and so on. Based on these simulations, contingent emergency stocks of basic goods—packages of water, food, household goods (such as tableware, kitchen wrap, tissues, towels, toothbrushes, masks, and blankets) and emergency medicines for the first three days following the disaster should be stored locally, typically at community-level schools and centers.

Since the initial disaster response is invariably carried out rapidly without geographical or population information from the affected areas, data need to be gathered or forecast in advance and stored in databases to implement “push delivery” of first-response aid.

**SWITCHING BACK TO COMMERCIAL SYSTEMS**

National and local governments should use supply chain and logistics management as they respond to victims’ changing needs. As many victims move from shelters into temporary housing, and as normal distributors such as shops, supermarkets, and convenience stores
gradually recover, national and local governments should facilitate the return to normal commercial supply.

More specifically, the early restoration of commercial demand and supply chains, the rapid restoration of market dynamics, and the speedy distribution of donations to increase local purchasing power and liquidity should be a priority for municipal and local authorities. Job creation and conditional or unconditional cash transfers are highly effective short-term post-disaster measures, and are often more important than continuing the supply and distribution of relief goods by public agencies.

The speed and manner of the transition from public to private supply logistics should be determined by how dependent the affected population is on relief supplies, and on the robustness and speed with which the private sector networks can restore commercial operations. In the case of the GEJE, delivery of relief goods lasted for 40 to 50 days after the disaster. Commercial businesses reappeared in about a month.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- Public facilities, such as gymnasiums and community halls, can be used as logistics depots as they are well designed with strong enough floors, wide enough entrances and exits, and good accessibility for cargo handling.

- Prior agreements can be put in place between the government and logistics companies specifying the terms and conditions and payment methods for hiring logistics professionals, machinery, and depot facilities.

- There should be prior identification and training of local government staff who will be tasked with responding to large-scale disasters.

- There should be prior formulation of a list of goods and a standard format for shipments and orders for smooth and seamless activation of the disaster response.

**PLANNING PUBLIC FACILITIES**

Building specifications for new public facilities, such as gymnasiums and meeting halls, should take into account their possible use as relief goods distribution depots. Floor strength, entry and exit widths, accessibility for cargo handling, as well their geographical locations should be assessed. If private sector warehouses already exist in the region, agreements for diverting their use in case of disaster, as well as for the provision of labor and for allocating costs, should be signed in advance.

**BUILDING A RESILIENT INFORMATION SYSTEM**

Information on the needs of affected populations must guide procurement agents in purchasing the right goods and quantities to be delivered to distribution depots. In the wake of a disaster, communication must be maintained between municipal offices, prefectural
offices, and the national government. Communication networks can be made more resilient by using satellite communication systems and on-site power generation equipment. Communication networks also need to support two-way connectivity between distribution depots and those facilities that can be used as evacuation shelters.

With respect to reliable road transportation, road status information gathered by probe cars linked to a global positioning system (GPS) is very helpful in determining delivery routes. To provide real-time information for emergency administrative and service-truck drivers, a system should be designed to integrate road status information from probe vehicles, road opening status from each road management authority, and traffic regulations from the police.

MULTIPLE EXECUTION SYSTEMS AND PAIRED ADMINISTRATIONS

In the aftermath of the GEJE, the national government formed a special team to take charge of the logistics of relief supplies. Ideally, every disaster response unit—at the national, prefectural, and municipal levels—should do the same.

Since the affected regions cannot be expected to provide sufficient information after large-scale disasters, municipalities outside the disaster area should initiate the information management functions for relief logistics. When municipalities are matched up in predetermined pairs based on their disaster profiles and spatial distribution, there are more chances of success.

THE NEED FOR INFORMATION SHARING AND COORDINATION

Information about goods, such as the volume, size, and weight of unit packages; number of individual items packed in a unit package; and the need for temperature control is indispensable for logistics managers to calculate the type and number of trucks required and to determine where and how to store the cargo in the distribution depots. Thus, it is important to create a mechanism for responsible parties to properly collect and share this essential information.

There is an equal case to be made for adopting universal definitions of various items and ensuring accurate and smooth information exchange about logistics by determining corresponding units among national and local government agencies, logistics operators, providers of goods, and so forth. As the first step, standard order forms, transportation request forms, and cargo transportation certifications should be prepared and adopted across the board.

In each region, the division of roles, cost-sharing arrangements among the related organizations, as well as appropriate workflow should be discussed in an interdepartmental council. In addition, training in logistics management should be conducted regularly to make sure that the workflow is smoothly implemented in the wake of disaster.
**KEY REFERENCES**

Supporting and Empowering Municipal Functions and Staff

KNOWLEDGE NOTE 3-4

CLUSTER 3: Emergency Response
Prepared by Toshiaki Keicho, the World Bank, and International Recovery Platform (The Union of Kansai Government)
A megadisaster can destroy government offices and kill public officials. In the Great East Japan Earthquake, many municipalities in Tohoku suffered serious damage to their office buildings and incurred considerable staff losses, which hampered their disaster response timing and effectiveness. To compensate for this, many kinds of partnership arrangement were formed between localities in the affected areas and their counterparts in unaffected areas. Formalizing these partnership arrangements and building local government capacities to deal with emergency situations are key success factors for developed and developing countries alike.

**FINDINGS**

**OFFICE DAMAGES AND STAFF LOSSES**

A disaster can destroy government offices and undermine government functions. Local governments are expected to play a critical leading role in disaster response and relief activities. In the case of the Great East Japan Earthquake (GEJE), many affected municipalities suffered serious damage to their offices and lost many of their public officials, which initially prevented them from undertaking relief activities in a timely manner.

A total of 62 municipalities in six prefectures (Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Chiba) in northeastern Japan were affected by the GEJE tsunami. Among them, 28 municipalities in the three worst-affected prefectures (Iwate, Miyagi, and Fukushima) suffered at least partial damage to their office facilities. Sixteen of them had to relocate their administrative functions to other buildings or temporary offices. Furthermore, computer servers in some of these municipalities were seriously damaged or destroyed, resulting in a loss of information on residents, and other data critical to providing municipal services.

Fukushima’s case was slightly different. Nine municipalities near the crippled Fukushima Daiichi nuclear power plant had to relocate their offices relatively far from the plant (mostly within the same prefecture), because of concerns about radiation levels in their jurisdic-
tions, even in cases where the physical damages from the earthquake and the tsunami were very limited.

To make matters worse, many municipalities in the hardest-hit areas lost their public officials: a total of 221 officials are dead or missing from 17 municipalities in the three hardest-hit prefectures. In particular, the town of Otsuchi in the Iwate prefecture lost its mayor and 32 officials including seven managers, out of a total of 139 staff (figure 1). The town was left without a mayor for 5 months. Rikuzentakata city, also in Iwate prefecture, lost 68 officials out of a total staff of 295; while the town of Minami-Sanriku in the Miyagi prefecture lost 39 officials out of 240 staffs.

**Evolving Partnerships among Localities**

One of the most interesting developments after March 11 was that a variety of partnership arrangements evolved between local governments affected by the disaster and those that were unaffected. Many prefectures and municipalities outside Tohoku took the initiative to quickly send a large number of their own public officials to the disaster-affected areas to help them with post-disaster relief activities and other emergency operations.
According to Japan’s Internal Affairs and Communications Ministry, some 79,000 local government officials were dispatched to the affected prefectures and municipalities from all over Japan between March 11, 2011 and January 4, 2012. After a year, many are still serving there in every possible field, from civil engineering and urban planning to social work and finance. In FY 2012, at least 1,200 officials from local governments around Japan will spend a significant period working in the three hardest-hit prefectures as part of the reconstruction effort.

Most of the local governments outside Tohoku did this out of altruism, but they also considered it an opportunity for their officials to gain experience in dealing with post-disaster situations. So it is a win-win arrangement. The following sections describe the different kinds of partnership arrangements.

**RIKUZENTAKATA WAS ADOPTED BY NAGOYA**

Rikuzentakata city lost about one fourth of its officials in the disaster. This was a huge loss. Then, Nagoya city, one of the biggest cities in central Japan, came to the rescue and "adopted" Rikuzentakata. Soon after March 11, Nagoya started exploring how it could best help the disaster-affected areas of Tohoku, and decided to target primarily one of the most affected cities, Rikuzentakata.

Nagoya has so far sent 143 officials to Rikuzentakata, for a maximum term of one year, and about 30 officials from Nagoya are still working there. Nagoya sent a variety of experts such as urban planners, public health specialists, and statisticians. Rikuzentakata plans to gradually recruit more staff and to become self-sufficient by 2014. Until then, Nagoya will continue to help and to send officials to Rikuzentakata but on a declining basis.

**TONO AS A HUB FOR TSUNAMI RELIEF**

The inland city of Tono, in the Iwate prefecture, is located within 50 kilometers of many of the hardest-hit coastal cities and towns in Iwate, such as Miyako city, Yamada town, Otsuchi town, Kamaishi city, Ofunato city and Rikuzentakata city. Tono is about an hour by car from any one of these, and only 15 minutes by helicopter. Taking advantage of its strategic location, Tono established itself rapidly and effectively as a hub for tsunami relief by making the city’s 144 facilities (schools, community centers, public parks, and so forth) available for logistics supply and other relief activities. As a result, 3,500 emergency relief workers from the Japan Self-Defense Force (JSDF), police, and fire departments based themselves in Tono within ten days of the disaster and started their relief operations from there. Furthermore, about 250 organizations and agencies used Tono as a base for their relief activities, coordinated and supported by Tono city. Tono’s initiative was possible because the city had been discussing this kind of support mechanism with the tsunami-prone coastal cities since 2007, and Tono’s officials were trained and well prepared for disasters.
DISASTER RELIEF AGREEMENTS

During the past couple of decades, more and more local governments in Japan have signed disaster relief agreements with one another. A typical agreement involves two localities, located far enough apart so that both are not affected by the same disaster; and if either party is affected by a disaster, the other is supposed to help. As of April 2010, 1,571, or 89.8 percent of all municipalities, had signed such an agreement, of which 820 signed with a municipality outside their own prefectures. Various kinds of support were provided to the municipalities affected by the GEJE based on these agreements.

THE UNION OF KANSAI GOVERNMENTS

In the wake of a megadisaster like the GEJE, mutual support among local governments within the same region may not work out if the entire region is severely affected, and therefore local governments in unaffected regions may play a bigger role.

A coalition of prefectural governments in western Japan called The Union of Kansai Governments (UKG) quickly stepped in after the GEJE to help the three most affected prefectures in Tohoku in an organized fashion. To distribute UKG’s support equitably, each UKG member prefecture was assigned to assist only one of the hardest-hit prefectures (table 1). After being assigned a prefecture to support, the UKG prefecture dispatches its personnel to gather information, identify needs, and coordinate relief activities.

This is a Japanese version of the Twinning Arrangement that was used in China during the recovery from the Sichuan Earthquake of 2008. This type of partnership is efficient and effective because it is facilitated by local governments that have a better grasp of the needs of their disaster-affected counterparts.

Among the advantages of this Twinning Arrangement are that it avoids overlapping of support, clarifies responsibilities, and is likely to achieve efficiency, speed, continuity, and accountability.

Under this arrangement by the UKG, the Hyogo prefecture has been assigned to assist the Miyagi prefecture. The Hyogo prefecture extended the following support:

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<tr>
<th>Beneficiary prefectures</th>
<th>Supporting prefectures</th>
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<tr>
<td>Iwate</td>
<td>Osaka, Wakayama</td>
</tr>
<tr>
<td>Miyagi</td>
<td>Hyogo, Tottori, Tokushima</td>
</tr>
<tr>
<td>Fukushima</td>
<td>Shiga, Kyoto</td>
</tr>
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</table>
• Provision of relief supplies (clothes, food, water, and so forth),

• Dispatch of its own officials (54,589 as of December 1, 2001) and

• Acceptance of evacuees. Recognizing that continuing support is needed in the affected areas, the Hyogo prefecture is now developing a mid- to long-term support plan. This plan includes assigning technical officials such as urban development specialists, as well as those who can share lessons from the experience of the Great Hanshin-Awaji Earthquake of 1995.

STAFF IN FUKUSHIMA

While municipalities in the Iwate and Miyagi prefectures mainly receive as many officials as they ask for from the unaffected areas, municipalities in the Fukushima prefecture had difficulty filling their staffing needs because of concerns about the radiation risks. According to the Fukushima Prefectural Government, the number of additional staff requested by its 21 disaster-hit municipalities was 178 for FY 2012, but only about 40 percent of that demand has been met.

MUNICIPAL DATA PROTECTION

In addition to the office damage and staff losses, some of the Tohoku municipalities lost residential information and other critical data because their computer servers were damaged. One of these municipalities, the town of Otsuchi, which lost its on-site computer server, considered adopting cloud backup solutions for storing vital information and other key data. Cloud server backup solutions allow data to be transferred to an offsite location for secure storage, reducing the risk of losing data in times of disaster.

LESSONS

• City halls and municipal offices should be focal points for disaster response initiatives; and they play a critical leading role in relief activities. Therefore, they must be located in safer areas, or built or retrofitted to be disaster-resistant.

• Japan’s experience shows that partnership arrangements between localities in disaster-affected areas and their counterparts in unaffected areas are effective. Some of these arrangements were based on formal agreements, but others were based on good will. It is advisable, before disasters strike, to formalize these mechanisms among local governments, obtaining the necessary legal backing and clarifying cost-sharing arrangements. Right after the GEJE, the Japanese Central Government decided to shoulder the cost of dispatching local officials to disaster-affected areas, which was believed to be instrumental in promoting the emerging partnerships among localities.

• When it comes to disaster relief agreements, it is essential that partnering prefectures and municipalities be geographically distant or in different regions.
Agreements within the same region may not be effective, for example, in a large-scale disaster like the GEJE that damaged virtually the entire region.

- In a large-scale disaster, it is important to allocate the support fairly and equitably to the affected areas. The UKG’s initiative to assign its member prefectures to each support different individual localities was exemplary in this regard.

- Disaster preparedness by local governments should include a plan to minimize the damage to their information systems and to protect critical databases so that they can continue to function and provide emergency services to disaster victims and residents.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- The roles that local governments must play in the aftermath of a disaster can be critical. But clear roles and responsibilities must first be assigned to each tier of government, specifying what needs to be done by which level in case of a disaster, and to strengthen their capacities accordingly.

- In disaster-prone developing countries, the locations of municipal offices should be reviewed along with their vulnerability to disasters. Consider relocating or retrofitting them if necessary so that municipalities can continue to perform their roles in the wake of a disaster.

- Partnerships among localities for emergency relief activities could work in many developing countries, particularly in relatively large countries. However, they are unlikely to work effectively if carried out in an ad-hoc manner. Formalizing these agreements and building the emergency response capacities of local officials are the keys to successful partnerships. Cost sharing under the partnership also needs to be clarified upfront.

- Municipalities in developing countries should be aware of the risk of losing their digital information and databases in a disaster, and need to come up with a cost-effective solution to minimize that risk.

**KEY REFERENCES**


Evacuation Center Management
Evacuation Center Management

A megadisaster will result in an enormous number of evacuees staying in evacuation center for a significantly long time. This note describes how Japan managed its evacuation centers after the Great East Japan Earthquake. It highlights important management issues, including: shortages of essential supplies and services, successful self-management practices initiated by the affected people themselves, good management practices by local governments, and the sensitivity required to accommodate diverse groups of evacuees with special needs.

FINDINGS

After the Great East Japan Earthquake (GEJE), nearly 2,500 evacuation centers were established in the disaster-affected Tohoku region; additional centers were also located outside of Tohoku. At peak occupancy, more than 470,000 people were staying at these centers. Most facilities, such as schools and community centers, were publicly owned and had been designated as evacuation centers even before the GEJE. Right after the GEJE, however, a number of private facilities such as hotels and temples were also enlisted as the need for centers far exceeded expectations; and a number of evacuees stayed with their relatives or friends. Evacuees gradually moved out of the centers as the construction of transition shelter progressed. Within four months after the disaster, about 75 percent of evacuation centers were closed, although some centers in Tohoku stayed open as long as nine months.

The evacuation pattern in Fukushima, where the nuclear accident occurred after the GEJE, was very different from other disaster-affected areas in Tohoku. In Fukushima, many people had to relocate from one center to another, moving farther from the crippled nuclear power plant as information became available on the risk of radiation exposure. More than 10,000 people had to change evacuation centers three or more times, with some people moving as many as ten times.

This knowledge note will focus mainly on management of publicly owned centers, since collecting information on the private centers has been difficult.
FIGURE 1: **Number of evacuees after the GEJE**

![Graph showing the number of evacuees after the GEJE over time.]

FIGURE 2: **Number of evacuation centers**

![Graph showing the number of evacuation centers over time.]

**NOT ENOUGH SUPPLIES**

Given the magnitude of the disaster and the number of evacuees, most evacuation facilities lacked sufficient supplies of food, water, clothes, and blankets. In the first days and weeks following the disaster, transporting these essentials to the centers was hampered by damaged roads and the shortage of vehicles and fuel. This problem was exacerbated by the fact that the many temporary facilities were not formally designated centers and therefore had not been stocked with essentials.
LACK OF WATER AND POWER

Furthermore, water and power supply systems were damaged in most of the disaster-affected areas, and in some places had not been restored even after one month. These problems made life miserable for the evacuees. For example, they had difficulty using the toilets without water for flushing. It has also been reported that the cold weather in northeastern Japan, and no electric heating in the facilities, made many evacuees sick, especially the elderly. As the evacuation period became prolonged, the inability to bathe was also a serious issue.

People could not stay in their high-rise apartments because of water and power failures. Since they could not continue to carry water and food upstairs to the higher stories, they moved to evacuation centers until public services were restored.

SELF-MANAGING BY EVACUEES

Although managing evacuation centers is a municipal responsibility, most municipalities in the disaster-affected areas suffered badly from the loss of staff, seriously weakening their capacity to cope with the emergency. At the beginning, most facilities were supported by local teachers, volunteers, and other civil society groups. As the evacuation period became extended, evacuees themselves started taking a number of initiatives. At many shelters, a self-governing body emerged, with leaders and members of various committees selected by the evacuees themselves.

For example, evacuees at the Ofunato Junior High School in the Iwate prefecture organized themselves into eight groups: for nursing, sanitation, food, facilities, supplies, and heating. At one school in Minami-Sanriku in the Miyagi prefecture, evacuees divided themselves into 20 groups, based on the communities they came from before the disaster, and assigned themselves roles and responsibilities for day-to-day activities.
An event hall called the Big Palette in Koriyama, Fukushima prefecture, admitted more than 2,000 evacuees mainly from Tomioka town and Kawauchi village, both affected by the nuclear disaster. These evacuees established a volunteer center at the hall, where volunteers and the evacuees themselves helped organize activities such as opening three cafes, starting an FM radio station, organizing a gardening event, and undertaking a summer festival. The volunteer center provided opportunities for the evacuees to help themselves and to engage in productive activities in an otherwise depressing life at the evacuation center.

**GENDER SENSITIVITY**

One of the problems cited at many of the centers was the lack of gender sensitivity (KN 3-6). There simply wasn’t enough privacy for anyone, but particularly not for female evacuees, many of whom did not have private spaces where they could change their clothes or breast-feed their babies. Many centers eventually installed partitions, but it was often too late. It has also been reported that relief goods delivered to these centers were biased in...
fear of male evacuees. The main reason for the lack of gender sensitivity was that mostly men were responsible for managing the centers, both in centers managed by municipalities and in those managed by the evacuees themselves.

**WELFARE SHELTERS FOR THOSE WITH SPECIAL NEEDS**

Many experts have pointed out that evacuees tended to suffer from tremendous stress, and would therefore need special mental healthcare and counseling services as the evacuation period grew longer. This was especially true for children. However, the availability of such services varied from center to center.

Taking care of the elderly and those who needed special attention was another big challenge. At many centers, all the special needs groups had to share the facilities with the other evacuees. However, Sendai City in Miyagi prefecture had about 30 special centers called “welfare shelters” that provided nursing and other care for the elderly, the disabled, and other groups. About 250 people and their families were transferred to these from other centers.

**MANAGING WITH A HUMAN FACE**

A close relationship should be established early on between evacuees and the local officials who are responsible for managing the centers. A good practice in this regard came from Hachinohe city in the Aomori prefecture. Right after the GEJE, there were about 120 families at eight evacuation centers in Hachinohe. The city government assigned two officials to every seven or eight evacuated families with whom they could consult on any issue. For example, they had questions about subsidies for future housing and livelihood recovery.
The relationship established with the officials at the evacuation centers continued even after the evacuees had resettled in private or public rental houses. Although this arrangement was possible because of the relatively small number of evacuees in a relatively big city with more than 2,000 officials, the city should nevertheless be commended for its initiative.

DISASTER RELIEF AGREEMENT

In 2006, two cities in the Fukushima prefecture entered into a Disaster Relief Agreement: Naraha city, which was affected by the nuclear disaster, and Aizu-Misato city, located relatively far from the crippled plant, which was not. When the nuclear disaster happened, most evacuees from Naraha city went to evacuation centers in Aizu-Misato city that were managed by local officials. This was a rare example of successful cooperation between two municipalities because of their long-standing friendly relationship. In Fukushima, most evacuees had to go beyond the prefecture’s jurisdictional boundaries because of radiation risks. In most cases, however, the evacuation centers were managed by the evacuees’ municipalities rather than by the host’s.

LESSONS

• While it may not be possible to be perfectly prepared for a megadisaster like the GEJE, it is nonetheless essential to designate evacuation centers in safe locations and equip them with as many emergency supplies as possible. Many prefectures and municipalities all over Japan are conducting ex-post evaluations to assess the locations and number of evacuation centers and the adequacy of supplies at these centers.

• Since a megadisaster is likely to interrupt essential services such as water and power, it is critical to install alternatives such as portable toilets and power generators. Sendai City is planning to equip its designated facilities with renewable energies, such as solar panels, as a back-up power source.

• Evacuees should take part in managing activities and services at evacuation centers. They are not guests who are simply receiving foods and materials, but enough capable in managing evacuation centers.

• Evacuees consist of diverse groups of people who have different needs and wants: women and children, the elderly, the disabled, and sometimes even foreigners. Those in charge of managing evacuation centers should be sensitive to this diversity; and it is critical to include women in management and leadership positions at these facilities.

• Some local governments have come up with innovative arrangements for managing evacuation centers and supporting evacuees. These governments should share their experiences and learn from each other so that good practices may be replicated in the future.
• Providing the information that disaster victims need is not only critical to their well-being but also comforting. It is important to listen to evacuees to understand what kinds of information they need and want, and to continue listening since their needs may change over time.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

Most of the lessons described above are applicable to developing countries. Evacuation centers are needed after most natural and industrial disasters, including not only earthquakes and tsunamis but also floods, landslides, and volcano eruptions, and so forth.

In disaster-prone developing countries, evacuation centers should be safely located. Schools and community centers should be designed and built to also serve as evacuation centers; and they should also be stocked with essential supplies such as food and drinking water, and equipped with emergency power generators. In developing countries, rainwater harvesting systems in schools and other public facilities, and renewable energies such as solar panels may also serve well in emergency situations. Political and financial support for pre-disaster investment in evacuation centers and supplies should be mobilized.

One of the biggest challenges in managing evacuation centers in developing countries is weak local government capacity. Evacuees should, therefore, get organized to help themselves as illustrated by the Japanese experiences. In many developing countries this effort could perhaps be supported by NGOs.

Gender sensitivity and serving diverse groups of evacuees are required in any country. Communication among these groups and governments should be established at the evacuation centers. Developing countries should plan to manage this issue better than it was dealt with in Japan, especially with respect to gender.

**KEY REFERENCES**


KNOWLEDGE NOTE 3-6

CLUSTER 3: Emergency Response

 Ensuring Protection in Response and Equity in Recovery
Prepared by Yoko Saito, Disaster Reduction and Human Renovation Institution; International Recovery Platform; Hironobu Shibuya, Save the Children Japan; and Margaret Arnold and Mikio Ishiwatari, World Bank.

Valuable contributions were also provided by Emi Kiyota, Ibasho; and Akiko Domoto and Hiroko Sue Hara, Japan Women’s Network for Disaster Reconstruction and Gender.
As in every disaster, certain groups were more vulnerable than others to the effects of the Great East Japan Earthquake (GEJE). Two-thirds of those who lost their lives were over 60 years old. Response efforts to the catastrophe also affected social groups differently and reflected existing inequities, particularly with respect to women. Children, the elderly, and the disabled also have special needs, which were not always met. These “vulnerable” groups should also be engaged in the planning, design, and implementation of relief and recovery activities to ensure a more effective and efficient recovery, and contribute to more sustainable and resilient communities in the longer-term.

**IMMEDIATE IMPACT OF THE DISASTER**

Vulnerability to the impacts of natural hazards normally varies by social and demographic group, and the GEJE was no exception, with the elderly proving to be the most vulnerable. Two thirds of the deaths occurred among the elderly—people over 60 years old—who accounted for some 30 percent of the total population in the affected areas. They are physically weaker than other groups, and could not run fast enough to reach higher ground.

Seven hundred and twenty-seven children and young people (0-19 years old) lost their lives in the GEJE. As of October 31, 2011, 1,327 children had lost one parent and 240 children had lost both their mother and father. Of these, 160 were adopted by relatives. A survey conducted by Ashinaga, (“Daddy-Long-Legs,” a scholarship organization for orphaned students) revealed that households with disaster-affected children, in particular female-headed ones, face difficulties in livelihood. The details are as follows:

- Half of affected children are in female-headed households.
- Forty-five percent of the heads of households have permanent full-time jobs, while 30 percent are unemployed or looking for work.
Among female-headed households, 24 percent are employed full-time, while 47 percent are unemployed or looking for work.

Seventy percent of their houses were damaged; 30 percent are living in their own homes, with the remainder living with relatives (29 percent) or in evacuation centers or transition centers.

**RESPONSE AND EARLY RECOVERY**

**GENDER**

Women in Japan do not have the same socioeconomic status as men, participate less in decision making, and have less access to social and economic opportunities. The relative poverty rate of women is higher than that of men (28.1 percent vs. 22.9 percent in 2007). The average hourly wage rate in 2008 for female full-time workers was 69 percent of the rate for male workers, and the proportion of women in positions equivalent to or higher than section manager in private corporations is 6.5 percent. The prefectures affected by the event belong to a medium range of gender equality in Japan: The ranks of gender equality index of Iwate, Miyagi, and Fukushima prefectures are 11th, 27th, and 17th, respectively out of 47. The GEJE relief and response efforts reflected and reinforced these preexisting inequalities. Most evacuation centers were managed by men. In fact, throughout Japan, 96 percent of the leaders of residents’ associations, who also served as the leaders of evacuation centers, are men.
Privacy and security. Privacy for women was rarely available at evacuation centers, which added greatly to their stress. A survey conducted by the Cabinet Office in April 2011 revealed that only 26 percent of the centers had private spaces for women; at many centers women had to change their clothes under blankets or in a toilet.

Women were hesitant to voice their needs to the male leadership of the centers. Basic needs related to hygiene were overlooked or handled in an insensitive manner. For example, in one center, male staff distributed a sanitary napkin to each woman and said: “If you need another one, please let me know.” In centers where women were engaged in management, those items were made readily available in bathrooms. Male leaders at evacuation centers considered skin lotions and other cosmetic items to be luxury goods, while for women they contributed to a sense of normality. When a cosmetic company sent make-up kits to several centers, women were able to put on make-up for the first time since the disaster, which raised their spirits and encouraged them to be more active.

In May 2011, there were two reported cases of rape confirmed in the three affected prefectures after the disaster, compared to nine reported incidents at the same time in 2010. There were thirteen reported cases of forcible indecency compared to thirty-two cases in the previous year. The Minister of State said these incidents did not occur in the affected areas. It is difficult, however, to obtain verifiable numbers of sexual harassment incidents since they can take many forms—from sexual taunting to physical harassment—and often go unreported. At evacuation centers, personal alarms were distributed to protect women and children, and they were cautioned to avoid going to the outdoor toilets alone, especially at night.

FIGURE 2: An evacuation center, one month after the earthquake
In one center, a grievance desk was set up; however, since there were no partitions in the facility, everyone could see and hear who was registering a complaint. This made women reluctant to report any concerns or incidents. In another center, a private, soundproof space was set up where women felt more confident about reporting grievances.

Domestic violence is also difficult to track, as it is typically considered a family matter and seldom discussed or reported. Of the cases that police responded to in the three affected prefectures from March 11 to December 31, 2011, 98 were recognized as having a clear linkage to the disaster. Many of these involved violent acts by husbands who had increased their alcohol consumption after the disaster.

The Gender Equality Bureau of the Cabinet Office recognized that gender perspectives were not sufficiently considered in managing evacuation centers, and on March 16, 2011 issued an ordinance on “Disaster response based on the needs of women and women with children” to provide guidance to relevant agencies. They also initiated consultation services for women dealing with distress or violence. However, conditions on the ground made it difficult to reach the evacuees and people managing the centers.

At the Fukushima Big Pallet, a major evacuation center accommodating more than 2,000 evacuees, spaces for women were set up in collaboration with local women’s organizations. The organizations provided advice to women and referred them to experts when necessary. They provided a safe space for women to gather and share their thoughts and concerns with others, and also held events such as cooking and handicraft classes. Women said that they felt relaxed and comfortable in these spaces.

**Maternal care.** Many nursing mothers did not have privacy for breastfeeding. Some went outside in the cold in search of privacy and others gave up nursing and changed to powdered milk. A number of maternal care clinics and hospitals offered temporary evacuation facilities free of charge for families with pregnant women and infants. However, the Japan Primary Care Association reported that many pregnant women refused to move to these places because they were concerned that their neighbors would no longer consider them to be community members if they moved to a separate place.

The Japan Primary Care Association set up several programs to support pregnant women and families with infants, and sent an obstetrician and gynecologist to the affected area.

**Workload and livelihoods.** Women in many evacuation centers were requested to prepare meals for the evacuees three times a day, in addition to taking care of the elderly and children while the men were out looking for work. This placed a heavy burden on them. In some centers, a rotation system was established to alleviate the pressure on any specific person or group. Moreover, while men were engaged in cash-for-work programs cleaning up debris from the disaster, women were not compensated for their work in the centers.

**Men’s needs.** Integrating a gender-sensitive approach in relief and recovery efforts means understanding and addressing the needs of men and boys in addition to those of women and girls. While data still needs to be collected in the affected area, there are indications of a need for counseling for men to deal with alcoholism and domestic violence. Moreover, men may need special counseling for child rearing if they have become single parents or if they have lost their livelihood.
BOX 1: Single Father Japan

Single Father Japan was established before the GEJE to support single fathers. The organization requested the Japanese Government to extend bereavement pensions for men who had lost their wives in the event. Their main activities are providing counseling and open lectures, awareness raising, and research on single-parent families. See http://zenfushiren.jp.

CHILDREN

The GEJE left children feeling frightened, confused, and insecure. The number of incoming calls to “Childline,” a free counseling service for children, increased fourfold in the Fukushima, Miyagi, and Iwate prefectures following the event. The government made plans to deploy some 1,300 mental health counselors to all public schools in affected areas.

The government expanded its support to foster parents caring for relative’s orphans; and recommended that the child’s previous connections with friends and with the child’s home region should be maintained. Governments and various organizations, such as Ashinaga and the Fund for the Future of Children affected by the GEJE, started providing financial support or scholarships to orphans.

Because of the accident at the Fukushima Daiichi Nuclear Plant, children in the Fukushima prefecture have stopped playing outside or swimming in pools, and have suffered from the stress of remaining indoors. In 74 percent of Fukushima households, children have decreased the time they play outdoors to 13 minutes per day to avoid the effects of radiation. These children demonstrate signs of increased stress through acting-out twice as often as other children. The government organized a few days of “refresh camp” where children can play sports and engage safely in outdoor activities. Some 6,000 children participated in the program.

OLDER PEOPLE AND THE DISABLED

A lesson learned from the Great Hanshin-Awaji (Kobe) Earthquake in 1995 was that special centers should be established for older people and the disabled. In 2008, the Ministry of Health and Welfare issued guidelines stating that Welfare Evacuation Centers for special care needs should be established within seven days of a disaster emergency. However, only 20 percent of municipal governments in the three affected prefectures prepared special evacuation centers in response to the GEJE. Many disabled people faced challenges accessing evacuation centers; and there were some reports of mentally ill and autistic people leaving centers because they were not properly cared for.

People over 60 make up 30 percent of the population in the affected area, but local authorities were unprepared to respond to their needs. Evacuation for elderly people with dementia and their family members was challenging. While long-term care facilities organize regular
evacuation drills, local government had limited knowledge about the elderly with dementia who lived in their communities and were not well prepared to support them. Older people also faced accessibility issues at evacuation sites and temporary housing sites. A number of older people in need of soft food and diapers went with their needs unmet. Older people are prone to withdrawal when disconnected from friends and family; this is an issue for many people in temporary housing who have lost their social networks.

The elderly residents in care facilities that were damaged in the GEJE were relocated to evacuation centers such as school gymnasias, where they faced difficulties living without nursing care. Finding nursing care staff was a challenge because many of them had suffered from the GEJE: 52 out of 1,165 eldercare facilities in the Iwate, Miyagi, and Fukushima prefectures were damaged by the event, and 173 staff members are dead or missing. In April 2012, the Ministry of Health, Labor and Welfare (MHLW) issued an ordinance to local governments to prepare for large disasters by: arranging for evacuation of the elderly living in care facilities; support for staff who are sent to devastated areas; and support for the elderly who need care at home.

One eldercare facility became an evacuation site by default. Designed as a group home for 20 people, the building was equipped with an accessible kitchen, bathrooms, bedrooms, and a living room for individuals with physical and cognitive impairment. While large-scale multilevel eldercare facilities could not function without electricity and running water because of the GEJE, this small-scale group home was able to provide basic services and an accessible environment for over 100 people of all ages from the community.

Coordination challenges among agencies may have hindered the collection of data and the provision of support to disabled people affected by the GEJE. For example, DRM staff at a local government’s could not have access to information on the disabled in the affected area because of privacy policies; and a housing facility that provided income-generation activities for disabled people did not fall under the purview of MHLW so did not receive assistance. Such “bureaucratic mismatches” resulted in certain groups falling through the cracks.

In an effort to ease the burden on vulnerable groups, MHLW temporarily suspended the collection of national insurance system premiums for long-term nursing care. They also simplified procedures for claims; and allowed affected people to receive services without showing their insurance identifications cards, and reduced or waived service fees.

EMPOWERING MARGINALIZED GROUPS FOR LONG-TERM RECOVERY

Recognizing its importance, a number of groups have acted to enable marginalized groups to participate meaningfully in medium and longer-term recovery efforts.

The first meeting of the Government’s Reconstruction Design Council was held on April 11, 2011. No mention was made of gender or of issues related to the disabled in the Council’s reconstruction principles, and only one woman was appointed to the 15-member Council. This is a nationwide problem, reflected in the following figures:
In the National Disaster Prevention Council, only 1 out of the 25 committee members is a woman.

At disaster prevention councils at the prefectural and municipal levels, the participation rate of women is only 4 percent.

In response to the GEJE, there was an appeal led by several women leaders, including Akiko Domoto, former governor of the Chiba prefecture, and Hiroko Sue Hara of Josai International University, to establish the Japan Women’s Network for Disaster Reconstruction and Gender. In June 2011, on the three-month anniversary of the disaster, the network held a symposium on gender equality in the GEJE reconstruction process. The network’s advocacy efforts have been successful, and have contributed to the inclusion of the following text in the Basic Act on Reconstruction in response to the GEJE which was passed on June 20, 2011: “…opinions of the residents in the disaster-affected regions shall be respected and opinions of a wide range of people including women, children and disabled persons shall be taken into account.” There were also accompanying guidelines issued on promoting the participation of women, children, and the disabled in all aspects of the reconstruction process. The real challenge in the coming months will be the implementation of the law and guidelines, as so far the capacity and will to engage and address the needs of vulnerable groups and women has been quite limited.

A number of UN and civil society organizations are also supporting children. Four organizations: UNICEF, Save the Children, General Research Institute of the Convention on the Rights of the Child, and Childline have established a Network for Supporting Children at the GEJE, with the objective of coordinating among governments, CSOs, experts, and the private sector. Through the network, information is shared on support activities, damages incurred, and the progress of recovery; children’s messages are issued to the public.

**BOX 2: Save the Children**

One key lesson Save the Children has learned over many years of responding to emergencies is that while children are more adversely affected by disasters, they also have a great capacity to recover quickly, provided they are given the proper support and directly engaged in supportive dialogues. Children can inform families, school officials and local officials of their needs, and of how they can help their communities recover. When asked about what would be of most support to them, children generally expressed their desire to return to normal routines and living situations—and to help their communities recover. Save the Children surveyed more than 11,000 children in the affected area on what type of role they would like to play in the recovery process, and how they would like to see their towns rebuilt. Close to 90 percent said they wanted to contribute in some way to rebuilding their communities. Save the Children is strengthening children’s participation in the recovery process by ensuring their views are part of the planning for rebuilding their towns and communities, and assisting children to convey their thoughts and ideas to their communities and to local and national government officials.
and recovery policies are recommended. As of November 2011, 29 organizations were participating in the network.

UNICEF is providing assistance to the children of Japan for the first time in nearly half a century with a budget of JPY4 billion. The assistance covers emergency support supplies; health and nutritional support; educational support; psychosocial support (psychological care); protecting children in harsh environments, such as being orphaned, in need, or in impoverished families; and child-friendly reconstruction plans.

Older people are more often thought of as a vulnerable group in need of care rather than as a resource to support younger generations. When marginalized, elders lose opportunities for interaction and the ability to contribute to society, and young people lose the wisdom and talents that elders can offer. After the GEJE, an NGO, called Ibasho, focusing on issues of aging societies, visited the affected area and heard many stories about elders who saved younger people’s lives by instructing them on where to escape to or by teaching them how to survive with extremely limited resources. Older people also expressed a great deal of gratitude for all the foreign aid they had received, and wanted to give back. “I want to be useful to others but I do not know how,” was heard numerous times.

To empower elderly survivors of the GEJE, Ibasho is building a café adjacent to a large temporary housing site in Ofunato Iwate, which is expected to open before the end of 2012. The Ibasho café is being designed in partnership with the community as a place where people of all ages can gather and share conversation and refreshments in an informal setting. It is envisioned that elders will plan, manage, and operate the café. Everyone—including people with physical disabilities or cognitive illnesses such as dementia—will be encouraged to participate to their fullest ability. It is hoped that this intergenerational exchange and interaction will create stronger social capital in the community, resulting in strengthened resilience to natural hazards and the risks associated with the rapid growth of an aging population.

**LESSONS**

Lessons learned from the GEJE include:

- Data collection disaggregated by gender and age, and including the disabled is needed to understand the relief and recovery needs of all affected people, and particularly those groups that have special needs. It would be worth looking into arrangements and agreements that can be made between agencies for accessing data in case of an emergency.

- Once an emergency occurs it is already too late to start advocating for gender-sensitive perspectives. A gender perspective must be included in center management at normal times to ensure women’s privacy and safety. It is crucial to involve women in center management.

- The livelihoods of women also need to be supported; opportunities for income generation during relief and recovery should be provided to them as they are to men.
• Children are in particular need of support that will provide them with a certain sense of security and normality; they can also be meaningfully engaged in rebuilding their communities.

• When planning evacuation sites, it may be beneficial to reexamine how care facilities for the elderly and disabled are designed and integrated into neighborhood and city planning.

• Engaging marginalized groups actively in the design and implementation of recovery efforts contributes to their recovery and to the future resilience of the community.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

• The needs and impacts of different groups can be quite varied. Assess and understand the different needs of women, girls, boys, men, the elderly, disabled, ethnic groups, the very poor, and other marginalized groups in order to respond effectively. Those working in the informal economy may face particular difficulties, for example, where the loss of housing also means the loss of workplace, tools, and supplies. It is important to formally recognize and compensate those working in informal economy.

• Rights-based approaches should be adopted. Women should be encouraged to participate in disaster management committees, camp management, and risk assessment. National and local disaster management policies and strategies should be reviewed from a gender perspective.

• Establish specific monitoring mechanisms (for example, Continuous Social Impact Assessments) to ensure that women and children can access recovery resources, participate publicly in planning and decision making, and organize to sustain their involvement throughout the recovery process.

• Sexual harassment and domestic violence comes in various forms. It is necessary to create safe and secure spaces for women, children, and other marginalized groups. Protection shelters and consultation services for victims should be established in collaboration with NGOs, governments, and the police.

• For longer-term recovery, support can be designed to help upgrade the living standards of the poor, to enable the most marginalized to participate, and to establish mechanisms that promote an inclusive, more resilient society. Supporting marginalized groups requires a solid understanding of the broader societal and policy context (e.g., labor market practices).

KEY REFERENCES


Social infrastructure and public utilities are critical for quick and effective disaster response and recovery. Japan’s rigorous seismic reinforcement of infrastructure has greatly reduced the effort required to restore essential facilities. Identification of priority infrastructure, legislation of financial arrangements for rehabilitation, and establishment of predisaster plans alongside the private sector have enabled prompt emergency response operations and facilitated a quick rehabilitation.

FINDINGS

The Great East Japan Earthquake (GEJE) caused tremendous damage to infrastructure and public utilities in the eastern region of Japan. According to the Cabinet Office, damages to public utilities and social infrastructure were estimated to be about ¥1.3 trillion ($16 billion) and ¥2.2 trillion ($27 billion), respectively (KN 6-3).

Since damage to the road network was limited, and rehabilitation work was efficient, (figure 1) the main highways and roads to the affected areas were repaired within one week. Bullet train service was resumed within 49 days of the event. These developments, in turn, facilitated full-scale relief activities in the devastated areas. All of this was a huge improvement compared to the aftermath of the Hanshin-Awaji (Kobe) earthquake in 1995, when it took over one-and-a-half years for highway reconstruction and 82 days for the bullet train line to be repaired.

Roads. Some 15 expressway routes and 69 sections of the national highway system, mainly in the Tohoku region, were closed immediately after the earthquake. Many prefectural and municipal roads were also closed. Because they had been retrofitted, bridges on national roads or expressways were not damaged, but 20 bridges on prefectural and municipal roads collapsed or were severely damaged (KN 1-2).

The subsequent tsunami flooded approximately 100 kilometers (km) of national highway, and submerged three expressway interchanges and junctions. The tsunami also washed
away five national road bridges. Massive amounts of debris brought in by the waves left many of the coastal roads unusable (figure 2).

**Railways.** Railway facilities were also severely damaged, but various earthquake countermeasures, including the seismic reinforcement of railway facilities, prevented most of them from breaking down and causing fatalities. Some 325 km of railway were damaged, mostly by the tsunami. Damage included the displacement or washing away of railroad tracks, power poles, bridges, and stations; the collapsing of earthen embankments; and damage to platforms.

**Airports.** The Sendai Airport, the major airport in the Tohoku region, is located about 1 km from the Pacific coast at an elevation of 4 meters above sea level. The tsunami hit the airport and flooded the runway, the first floor of the terminal building, and the airport access railways (figure 3).

**Ports.** Fourteen international and other major ports and 18 local ports were severely damaged by the tsunami and unable to function. Numerous ports that support the region’s fishing industry were also destroyed. The tsunami and the earthquake together destroyed much of the port infrastructure. Debris from the tsunami washed into the port area, preventing ships from entering.

**Damages to public utilities.** Public utilities were severely damaged by the earthquake and tsunami. About 2.3 million houses were left without water supply after the earthquake, and the sewerage systems were destroyed in the coastal cities and towns in an area spanning some 550 km.
FIGURE 2: Status of expressways and national highways immediately after the earthquake

Source: MLIT.

FIGURE 3 (left): Sendai Airport after the tsunami
FIGURE 4 (right): Manhole raised by liquefaction in Urayasu City.

Source: MLIT and Urayasu City.
Wastewater treatment plants were damaged at 63 locations, 48 of which had to stop operating because of tsunami inundation. The condition of six wastewater treatment plants near the Fukushima Daiichi Nuclear Power Station is still unknown because of access restrictions. In Urayasu city, Chiba, sewerage systems were severely damaged by liquefaction (figure 4).

The number of houses left without electricity reached 8.5 million. Several nuclear and conventional power plants, including the Fukushima Daiichi Nuclear Power Station, went offline after the earthquake, reducing the region’s total power generation and supply capacity. The capacity of the Tokyo Electric Power Company (TEPCO) was reduced by about 40 percent from 50 gigawatts (GW) to about 30 GW, not enough to meet the typical 40 GW peak-time demand for that season.

**INFRASTRUCTURE REHABILITATION PLANNING AND IMPLEMENTATION**

Concerned organizations were able to start rehabilitation work immediately after the earthquake and tsunami, to a large extent subsidized by the national government under the National Government Defrayment Act for Reconstruction of Disaster Stricken Public Facilities (enacted in 1951). This act applies to a variety of transport systems and other infrastruc-

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**FIGURE 5: Steps in infrastructure rehabilitation**

![Steps in infrastructure rehabilitation](source: MLIT)
ture such as rivers, coastal facilities, sabo facilities, roads, ports and harbors, parks, and sewerage systems. The typical course of rehabilitation project implementation is illustrated in figure 5. In the aftermath of a disaster, local governments report their infrastructure damage to the national government, usually within 10 days of occurrence, with a request for a national subsidy. Upon receipt of the application, the national government conducts a disaster assessment within 2 months of the disaster and approves the subsidy. To ensure quick rehabilitation, local governments can begin implementing their projects immediately after the disaster occurs, even before applying for the subsidy.

The national government subsidizes two-thirds of the project costs, and much of the local government’s share is covered by national tax revenues. Thus, local governments actually cover only 1.7 percent of the costs at most. This local government share decreases as the severity of the disaster increases. In the case of the GEJE, the costs were so large that the local government share was minimal.

To ensure the quick rehabilitation of infrastructure, the national government enters into predisaster agreements with the private sector, ensuring that in the event of a disaster, the needed workforce will be mobilized quickly, without burdensome contracts and paperwork. Such arrangements are made between government field offices and private companies or private sector associations, and they cover such postdisaster activities as construction, engineering consulting, surveying, telecommunications, and broadcasting.

**Roads: Operation Toothcomb.** Transportation infrastructure is critical for delivering relief supplies. After the GEJE, roads were recovered early on to secure an emergency transportation network. Immediately after the earthquake on March 11, the Ministry of Land, Infrastructure, and Transport (MLIT) deployed a strategic initiative to make sure that the entire length of the Tohoku Expressway and National Route 4 was passable to traffic. This major artery runs south to north from Tokyo to Aomori along the inland part of the region, which suffered relatively little damage. Next, 16 routes were opened up, stretching out from various points on this major north-south artery and reaching east to the coastal areas that were worst hit by the tsunami. The plan was called Kushinoha Sakusen, or Operation Toothcomb, because of the shape of the road network (figure 6 and 7). From the next day, the operation began clearing debris from the emergency roads that run eastward from the inland arterial highway—national route 4 (running north-south)—connecting them to the Pacific coast. By March 15, four days after the earthquake, 15 eastward access roads were usable, and by March 18, 97 percent of the national coastal highways were accessible.

Furthermore, 13 days after the earthquake the entire Tohoku Expressway, the main expressway connecting the Tohoku region to central Japan, was open to general traffic.

The quick rehabilitation of roads was possible for a number of reasons:

- The seismic reinforcement of road structures had helped minimize damage.
- There was a clear focus on opening up the 16 eastward routes by concentrating the workforce on them first.
- The authorities used their predisaster agreements to mobilize contractors immediately after the disaster.
FIGURE 6: Operation Toothcomb

Source: MLIT.
Ports and navigation passages. The MLIT requested contractors to begin clearing navigation passages so that disaster relief vessels could enter ports. The operations began in 14 principal ports on March 14, the day after the lifting of the tsunami warnings. This included removing debris as well as ensuring the safe passage of emergency relief vessels (figure 8). By March 15, 4 days after the earthquake, all 14 ports were either entirely or partially usable, and began accepting vessels delivering emergency supplies and fuel. At Sendai’s Shiogama Port in Miyagi Prefecture, the first oil tanker entered 10 days after the earthquake, reducing the fuel shortage in the disaster-affected areas.

Railways. The Tohoku Shinkansen (bullet train) resumed operations between Tokyo and Nasushiobara (the southern section) on March 15, and between Shinaomori and Morioka (the northern section) on March 22. By April 29, the entire Tohoku Shinkansen line was in operation, as were most of the other railways except for those along the coast. The rehabilitation of the coastal railways, especially the Joban Line that runs through an area 20 kilometers from the Fukushima Daiichi Nuclear Power Station, has still not happened.
Many are currently being evaluated for possible rehabilitation along with the reconstruction of the towns and cities. The Sanriku Railway, which runs along the coast, is expected to resume its operation in April 2014.

**Sendai Airport.** The Sendai Airport rehabilitation operation began two days after the earthquake, and by March 15, four days after the earthquake, the airport was being used by rescue and emergency supply rotorcraft. Fixed-wing aircraft were able to use it by the following day, allowing the US Army to bring in emergency supplies. The airport was available for commercial services on April 13.

**Water supply systems.** Although water supply services were resumed for about 90 percent of residents within 1 month of the disaster, the aftershocks on April 7 and 11 temporarily increased the number of households without water (figure 9). The Japan Water Works Association (JWWA) set up emergency headquarters to arrange for relief teams. The Ministry of Health, Labor and Welfare, JWWA, and 400 water utilities nationwide provided assistance to the affected areas by dispatching emergency teams with water supply trucks and machinery. They also helped conduct investigations for the restoration and reconstruction of water works.
Sewerage systems. Of the 120 disaster-affected wastewater treatment plants, those with minor damage (95 facilities) were rehabilitated and have recovered their predisaster capacities. Sixteen treatment plants are still inoperable because the tsunami destroyed their infrastructure and equipment. The 13 facilities that are accepting influent sewage have been providing primary treatment only, consisting of settlement and disinfection.

The reconstruction planning for the sewerage systems is the responsibility of the local municipalities. However, some 6,575 personnel have been dispatched from national or local municipalities in other regions to support their rehabilitation efforts. Sanitation is a major challenge in a disaster. Higashimatsushima City in Miyagi Prefecture did not have enough toilets for the people staying at evacuation centers. The city installed “manhole” toilets, paid for by a national subsidy system for promoting earthquake proofing of sewerage systems across the country. These toilets, which can be easily and quickly installed, were well received, especially by the elderly.

Electricity services. About 90 percent of the power services were recovered within one week of the disaster; however, the aftershocks on April 7 and April 11 temporarily increased the outages (figure 10). Because of its reduced power supply capacity, the TEPCO implemented rolling blackouts in its service areas, including Tokyo, between March 14 and 28.
**BOX 1: Rapid rehabilitation of sewerage system in Rikuzentakata City**

In Rikuzentakata City in Iwate Prefecture, the wastewater treatment plant was severely damaged by the tsunami. But within its service area 400 houses located on higher ground had survived the tsunami. When water supply services resumed, the sewage generated by these 400 houses had nowhere to go. Following a proposal by a private company, the city decided to introduce a movable membrane bioreactor unit, which was quickly installed and began operating within a month.

*Source: MLIT.*

**FIGURE 10: Electricity rehabilitation**

*Source: Cabinet Office (based on data from Tokyo Electric Power Company).*
LESSONS

• Quick emergency response initiatives, such as Operation Toothcomb, contributed greatly to the prompt rehabilitation of transportation networks and the starting of relief activities.

• Identifying the routes to be recovered first and prioritizing resources and manpower accordingly, was an effective approach to rehabilitating transportation networks.

• Agreements, made with the private sector before the disaster, to provide emergency response operations were effective in quickly mobilizing the needed workforce.

• Experts and equipment dispatched from national and local governments contributed to prompt rehabilitation.

• Rigorous implementation of the seismic reinforcement of infrastructure prevented excessive damage to structures, minimizing the effort required to restore their functions.

• At the time of a disaster, sanitation can be a major challenge. Resumption of water supply services without adequate sanitation led to sanitation and hygiene problems.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Effective emergency and rehabilitation operations depend on social infrastructure and public utilities. The following arrangements are required if rehabilitation works are to be started and completed promptly.

Establish financial arrangement mechanisms. Budget-sharing mechanisms between local governments and the central government should be established in advance. Negotiating between governments only after a disaster has occurred will delay rehabilitation work. Such negotiations should cover:

• Procedures for applying for a subsidy to the central government.

• The cost-sharing ratio of rehabilitation works, shared between national and local governments.

• Criteria for which types of disasters—and at what scale—require which mechanisms.

• Establishment of a body of experts and responsible organizations at the central government level.

• Team formulation and procedures for damage assessment.

Arrange predisaster agreements with the private sector. Prearranged agreements with the private sector allow for quick mobilization of the needed rehabilitation workforce.
Government agencies can skip the procurement process and start work immediately. These agreements should include (i) the designated responsibilities of governments and private companies for rehabilitation work, (ii) a government guarantee of payment for the work involved, and (iii) procedures for project requests from the government.

**Arrange support teams.** Emergency support teams should be established during normal times (KN 3-1). Rehabilitation requires enormous additional resources from local governments, which are already burdened by the aftermath of disaster. Emergency teams from other government agencies can assist those local governments affected by disaster.

**Develop disaster-resilient infrastructure.** If infrastructure and utilities are planned and developed to mitigate potential disaster damage, the effort and time required for rehabilitation can be minimized. Retrofitting bridges can reduce both damage and rehabilitation efforts (KN 1-2).

**Identify key infrastructure.** Transportation or communication networks that are critical to emergency operations should be identified before the disaster and given priority during the rehabilitation efforts.

**KEY REFERENCES**


KNOWLEDGE NOTE 4-2

CLUSTER 4: Recovery Planning

Reconstruction Policy and Planning
KNOWLEDGE NOTE 4-2

CLUSTER 4: Recovery Planning

Reconstruction Policy and Planning

The unprecedented damage caused by the Great East Japan Earthquake (GEJE) affected multiple locations, posing severe challenges for local governments. Based on advice from an independent council, the government acted quickly and issued a basic policy and regulation framework within four months, laying the foundation for an inclusive process of recovery and reconstruction. This note documents the interactive process of reconstruction planning, as conducted by various levels of government with the active engagement of affected people, experts, volunteers, and the private sector.

FINDINGS

The GEJE was Japan’s first major multilocation disaster in recent history. With over 200 municipalities affected, it required both a national-level response as well as inclusive and participatory local planning. By adopting early policy and regulatory guidance and releasing several budgetary supplements, the government supported the evolution of effective recovery and reconstruction plans, including coordination at the prefecture and municipal levels. Overall, the policy and planning process involved three stages:

- **Stage I (0 to 4 months):** The government established a disaster headquarters, chaired by the prime minister and an independent reconstruction design council (RDC). Basic guidelines and an act were issued within 4 months, based on the council’s recommendations. The first supplementary budget was passed within 1.5 months of the disaster.

- **Stage II (4 to 11 months):** The provisional reconstruction headquarters was established. Prefectures and municipalities prepared basic recovery plans in close consultation with disaster-affected people. Two other supplementary budgets were adopted to fund the recovery.

- **Stage III (11 months to 10 years):** A reconstruction agency and special zone for reconstruction were formed, and a fourth supplementary budget was passed. The
reconstruction was envisaged to last 10 years, and to be implemented through flexible grants and policies in support of the municipalities.

Although challenges remain—particularly with respect to the role of the new reconstruction agency—the GEJE reconstruction planning process can be seen as a model for other megadisasters. Prior to the GEJE, Japan already had a sound institutional and policy framework for disaster response and mitigation, based on lessons learned from past disasters. Building on this foundation, Japan acted rapidly to establish a reconstruction planning framework based on mutual trust, respect, and collaboration among stakeholders. At the same time, the fact that the GEJE required a new agency and reconstruction act shows that megadisasters, by their very nature, tend to overwhelm existing institutional arrangements. The chronology of policy and planning followed during the GEJE is summarized in figure 1 and explained in further detail below.

**BASIC PRINCIPLES, GUIDELINES, AND LEGAL FRAMEWORK FOR RECONSTRUCTION (MARCH TO JUNE 2011)**

The government set up a headquarters for emergency disaster control less than an hour after the disaster. At the same time, building on lessons learned from the Great Hanshin-Awaji Earthquake in 1995, the government sought to broaden the recovery strategy by setting up an RDC. This advisory panel was composed of a team of highly respected intellectuals, academics, religious figures, and elected officials. Within two months of the disaster, the council issued “Seven Principles for the Reconstruction Framework,” a consultative vision for the reconstruction. By the end of June 2011, a final report was given to the prime minister, which in turn became the basis for the government’s *Basic Guidelines and Basic Act on Reconstruction* (GOJ 2011a and 2011b), issued 3.5 months after the disaster. Thus, the initial process of national consultation set the stage for the entire recovery and reconstruction effort.

The *Basic Guidelines* set in place several innovative policies (box 1). It placed municipalities and residents at the center of the reconstruction; it promoted the concept of multiple defenses and people-oriented measures in disaster reduction (departing from past reliance on defensive structures); and it encouraged land-use planning as a way to balance safety considerations with the need to preserve links between communities and infrastructure.

The recovery and reconstruction period was estimated to last 10 years and cost ¥23 trillion ($290 billion), with the bulk of the effort focused on the first 5 years. The financial resources were to be secured through reconstruction bonds, reduction of public expenditures, increase in nontax revenues, and temporary taxation. As of early February 2012, the government had passed four supplementary budgets, worth a total of ¥21.9 trillion ($274 billion). The budgets were issued over a period of several months, and served to support different stages of recovery and reconstruction.

The *Basic Guidelines* also provided for the establishment of a special zone for reconstruction containing financial and regulatory incentives, and a central one-stop reconstruction agency to respond to, and help coordinate, the needs of local governments (see section on Reconstruction).
FIGURE 1: Chronology of key policy and planning measures after the GEJE

Great East Japan Earthquake

11 March

Reconstruction Design Council

Seven Principles for Reconstruction
Basic Guidelines for Reconstruction
Basic Reconstruction Act
Reconstruction Headquarters

1 month

Law for Special Zone for Reconstruction

2 months

Prefecture and Municipality Recovery Plans

3 months

Reconstruction Agency and Reconstruction Fund

10 months

11 months

1 year

Reconstruction Grant Projects

10 years
BOX 1: **Basic guidelines for reconstruction after the GEJE**

**Key policies**

- Recognize the challenges of an aging and declining population by promoting adequate public transportation and support services.
- Promote a strategy of multiple defenses through both soft and hard (structural) measures, putting people at the center of disaster reduction.
- Promote a “new public commons” through social inclusion of a wide range of stakeholders in the reconstruction.
- Make municipalities in disaster areas the main actors accountable for reconstruction, aided by financial and technical support from the central government and prefectures.
- Promote rapid reorganization of land use, to stimulate investment and prevent speculation.
- Prioritize providing stable residences for the affected, through favorable housing loans and low-rent public housing.
- Assist municipalities with reconstruction planning through external experts.
- Promote employment of affected people through recovery and reconstruction investments under the “Japan as One” project.
- Prioritize rehabilitation of key transport and logistics infrastructure and revival of local economic activities.
- Open reconstruction to the world through active international cooperation and lesson sharing.
- Create a special zone for reconstruction to support local projects through flexible procedures and financing.

*Source: GOJ 2011a.*

**RECOVERY PLANNING PROCESS (JULY 2011 TO MARCH 2012)**

**PREFECTURE-LEVEL PLANNING**

Based on the national guidelines, the most affected prefectures and municipalities—Iwate, Miyagi, and Fukushima, with more than 120 affected municipalities among them—developed their own recovery plans. These plans were not intended to be comprehensive, but rather to reach consensus among residents on the vision and key principles to be followed,
the proposed land-use planning (including potential relocation of communities), and the implementation program (figure 2). It was understood that the plans would evolve over time through further consultations with ministries and elected officials, and eventually result in more detailed (and costed) reconstruction plans.

The three most affected prefectures benefited substantially from a partnership arrangement supported by the Union of Kansai Governments (a grouping of prefectural governments in Western Japan), which provided expert personnel to assist with the emergency and relief efforts. This twinning experience, which also proved beneficial after the 2008 Sichuan earthquake, is outlined further in KN 3-4.

To formulate the prefecture recovery plans, task force meetings were held with experts and citizens to collect public comments. In general, prefectural-level plans allowed local stakeholders to make decisions on infrastructure and other issues (such as debris disposal) that required intermunicipal coordination.

Fukushima, for example, faced a special problem due to the nuclear plant accident, which restricted access to contaminated areas and led to the evacuation of large numbers of residents. The Miyagi Prefecture recovery plan, in turn, developed a detailed tsunami
protection plan, including structures resistant to a 100-year tsunami, elevated structures, population relocation to higher altitudes, an accessible evacuation plan, and the promotion of a culture of disaster prevention.

**MUNICIPAL-LEVEL PLANNING**

Planning processes at the municipal level tackled such issues as risk assessment, financing, land tenure and land use, transportation infrastructure, and the role of the government in building consensus and providing relevant information to communities. Recovery plans had a positive tone, reflecting the municipalities’ confidence in the nation’s ability to assist affected people in improving their lives.

Similar to the prefectural recovery planning process, municipalities established recovery planning committees involving experts, residents, and community representatives. Generally, they used surveys and workshops to incorporate residents’ opinions into the plans. For instance, in Minami-sanriku (in Miyagi), a resident’s committee played a key role in proposing “symbolic projects” that were then integrated into the municipal plan (figure 3).

**FIGURE 3: Community involvement in recovery planning in Minami-Sanriku Town (Miyagi Prefecture)**

Source: IRP.
Similarly, Ofunato Municipality (in Iwate), held residents’ workshops and students’ reconstruction meetings involving more than 3,000 residents. In Sendai (in Miyagi), the largest city in the Tohoku region, the mayor herself visited residents’ workshops and talked directly with victims. About 80 workshops were held to share information between residents and the city government, and residents submitted more than 2,000 comments on the draft recovery plan.

The central government supported municipal efforts by deploying two professional private sector consultants per municipality to provide technical services linked to damage assessment and engineering analysis. Experts such as university faculty members, architects, engineers, lawyers, and members of nongovernmental organizations (NGOs) also participated actively and voluntarily in the municipal planning process, according to their field of expertise. Thus, the process of participatory planning was widely supported by governmental and nongovernmental actors across all administrative levels in Japan.

Two issues were particularly challenging in recovery planning: land-use planning and demographic trends.

**LAND-USE PLANNING**

Municipalities used land-use planning as a tool to reach consensus on the strategy for reconstruction. This was based on a tsunami simulation conducted by the prefectural governments.

The simulation assumed two different levels of a tsunami (figure 4): a maximum-level tsunami such as the GEJE (a 1,000-year event) and a frequently occurring tsunami (a 100-year event). The height of the coastal seawall is usually planned to protect from a frequently occurring tsunami. If a maximum-level tsunami hit the area, water may overtop the seawall and inundate the town. However, because of land-use planning—such as relocation of residential areas, land elevation, and multifaceted protection using forests and/or roads—the water level is projected to be less than 2 meters high in residential areas (making it unlikely for houses to be washed away). Low-lying areas would be reserved for parks, commerce, and industry (figure 5). In case of a maximum-level tsunami, people would have to evacuate, and early warning systems and evacuation routes would become crucial.

In the ria coastal areas of Iwate and the northern part of Miyagi, there was not enough land space available for relocation since steep mountains line the coast. In Minami-sanriku Municipality, for example, many fishing villages that were located adjacent to the coast were severely affected by the tsunami and had to be relocated. However, residents wanted to live close to their original location and to the fishing port to maintain their livelihoods. A policy of separate relocation was therefore proposed, whereby each village would move to a small hillside space close to its original location (see box 2). Residents plan to establish community development associations to facilitate relocation planning.

**POPULATION MOVEMENTS**

According to government statistics, a large number of people moved out of the affected municipalities following the disaster. The gap between out-migrants and in-migrants relative to the total population in 2011 was particularly high for coastal municipalities—9.4
BOX 2: **Land use and population relocation strategies**

There are generally three land-use strategies to address tsunami events (see upper figure): (i) avoiding risk, (ii) separating risk, and (iii) controlling risk. In the risk avoidance strategy, residential uses are prohibited or restricted in high-risk areas, although nonresidential purposes (for example, recreational) may be allowed. This strategy is being considered in several municipalities in Tohoku, and has been adopted within 20 kilometers (km) of the nuclear power facility in Fukushima. It requires a relocation plan, and identification and planning for the relocated infrastructure and population at the new site.

In a *risk separation strategy*, some areas are restricted, some are elevated, and others used to divert the tsunami to controlled directions. The *controlling risk strategy* uses multiple defenses (such as elevated areas/infrastructure, sea walls, and levees). This type of strategy was adopted in the Otsuchi Municipality in Iwate and is proposed for parts of Sendai. It requires knowing the optimal height and location of multiple defenses.

Population relocation can also follow different strategies (lower figure). In a *separate relocation plan*, each community is relocated separately to a higher location. In a *collective relocation*, separate (original) communities are relocated to a common (safer) area. A third *combination strategy* uses variants of the above.

In the wide coastal plains, such as near Sendai, the city government adopted a *controlled risk strategy*, whereby house rebuilding would be restricted in areas where water levels could rise above 2 meters. The government also intends to raise the height of the roads to act as breakwaters, as well as use vegetative defenses.
FIGURE 4: Tsunami simulations

Source: Ofunato City.

FIGURE 5: Recovery concept of Minami-Sanriku Town
FIGURE 6: **Population decrease in disaster areas, and survey of population and businesses in Minami-sanriku (December 2011)**

**Households**
- Not affected: 24%
- Planning to relocate to higher ground: 23%
- Planning to move in public housing: 20%
- Planning to leave town: 16%
- Undecided: 33%
- Don’t know: 16%

**Companies**
- Not affected: 16%
- Already recovered: 46%
- Preparing to recover: 23%
- Closed business: 16%
- Don’t know: 23%
- Undecided: 23%
- Went out of town: 16%
- Already recovered: 16%

Total 3,159 households  Total 552 companies

FIGURE 7: **Gap between people moving in and people moving out as a share of population**

*Source: Statistics Bureau, Ministry of Internal Affairs and Communications, and Minami-sanriku Town*
percent in Minami-sanriku, 8.9 percent in Yamamoto, and 8.5 percent in Ostuchi. That gap was also large among young people (less than 15 years old) —up to 14.6 percent in Minami-sanriku and 13.2 percent in Onagawa, further raising concerns about the aging population. In Minami-sanriku, some residents gave up rebuilding altogether due to lack of funds, and planned to either leave town or move to public housing (figure 7).

By contrast, Sendai City experienced a net population inflow (6,633 in 2011). Urbanization in Sendai has therefore accelerated and the population gaps between urban and rural areas are widening. Thus, preexisting trends of aging and declining populations in rural areas and small towns have been exacerbated since the disaster, and must be taken into account in the reconstruction planning.

**RECONSTRUCTION (2012 –2020)**

On February 10, 2012, 11 months after the tsunami, the Japanese cabinet established a national reconstruction agency for a period of 10 years. The agency—headed by the prime minister—aims to promote and coordinate reconstruction policies and measures, and support affected local governments in the Tohoku region (figure 8). It will serve as a “one-stop shop” for local authorities. Although it is based in Tokyo, it includes three regional branches in the most-affected prefectures (Iwate, Miyagi, and Fukushima).

As envisaged under the Basic Guidelines, the government also created a Special Zone for Reconstruction, benefiting 222 municipalities in the disaster-afflicted zones. These munici-

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**FIGURE 8:** *Coordination framework for the reconstruction agency in Japan*

Reconstruction Agency

- **Planning based on local demands**
- **Budget request**
- **Earmark budget**
- **Implementation plan**
- **Distribute budget**

Branches (prefectural level)

- **Receive demands**
- **Special Zone for Reconstruction**
  - Authorize programs
  - Add special measures
- **Reconstruction grant budget based on approved plans**

Affected municipalities

- **Formulate reconstruction plan**
- **Apply for special zone and reconstruction grant**
- **Propose additional special arrangements**

Relevant ministries

- **Coordination, control and supervision**
- **Budget**

Regional offices of ministries

- **Projects under direct control of central government**
Palities were allowed to submit specific reconstruction plans and apply to the government for funding, as well as a package of special arrangements—such as concessions for land-use planning, creation of new systems related to land use, tax incentives, and special deregulation and facilitated procedures for housing, industry, and services. This strategy supports flexible implementation over time. Reconstruction grants and plans for special measures are submitted to the prime minister, whereas special arrangements for land use are subject to public hearings and inspections.

The process of reaching an agreement on detailed project plans has just begun in most municipalities. In Minami-sanriku, for example, total reconstruction costs are estimated at a few hundred billion yen, a vast sum compared to the annual budget of the town (¥8 billion a year). Two projects are being proposed: a land readjustment project for recovery and a group relocation project (figure 9). An application for a special zone for reconstruction will also be submitted to the central government to relax regulations and attract businesses. Implementation capacity remains a worry, however, as 40 out of the 170 town officials (administrative posts) died or went missing during the disaster.

The creation of the reconstruction agency and the special zone for reconstruction are designed to respond to reconstruction timelines and facilitate a high number of reconstruction projects at increased speed. They represent a major step forward compared to
the Great Hanshin-Awaji Earthquake in 1995, where Reconstruction Agency and Special Zone were not put in place, but it remains to be seen how these new systems will be able to coordinate the various recovery plans, turn them into effective projects, and—significantly—overcome a highly sectoral government structure. Already, there are indications that prefectures and municipalities are finding ways to bypass the structures and access funds directly. To succeed, the system must be able to adapt and adjust.

Similarly, it remains to be seen whether the innovative policy of the special zones for reconstruction will be able to help slow or reverse preexisting economic and demographic trends, such as struggling industries and declining and aging rural populations in the affected areas.

**LESSONS**

- To be effective, recovery planning and policies must be based upon local conditions and culture. As such, the highly participatory recovery-planning process followed in Tohoku has proven to be a solid model for megadisaster recovery.

- In disasters of this magnitude, a well-respected and independent advisory council can play a key role in setting the blueprint for the recovery.

- Even though municipalities were responsible for disaster response, they became effectively dysfunctional in the aftermath of the disaster due to the destruction of their offices and the large numbers of dead or missing (a situation that also happened in Haiti). Such destruction is one of the main factors slowing recovery. Furthermore, the implementation of a large number of projects and the outpouring of volunteer support posed a significant burden for smaller municipalities, where financial and human resources are constrained, even at the best of times. This has been one of the principal justifications for the establishment of the reconstruction agency.

- The large scale and diversity of the recovery make information and communication management more challenging and more critical to a successful recovery. Systematic information on victims, for example, was a challenge for many smaller municipalities who lost both records and staff. As a result, prefectures have begun to centralize such information for use by local governments.

- The affected municipalities also benefited from the support of expert consultants contracted by the central government, who had the expertise to quickly carry out damage and needs assessments and provide logistical support. Damage assessments were completed quickly, as the central government relied on private engineering companies who had readily available information on infrastructure replacement costs.

- Similar to the provincial pairing system employed in China after the Great Sichuan Earthquake, and to staff secondments following the Nargis cyclone in Myanmar, twinning arrangements with local governments outside the disaster-affected areas proved very effective for prefectures and municipalities facing a shortage of expertise and manpower.
• While recovery projects may secure the safety of residents’ lives, they will be costly. The population of most disaster-affected areas is sharply decreasing, and it will be a challenge to balance the needs of aging survivors with long-term financial efficiency.

• The design of new residential areas could have been facilitated had a predisaster recovery plan been in place to preselect suitable areas. Taking into consideration the likelihood of large-scale disasters in Japan, enactment of new legislation should be considered to not only facilitate postdisaster response, but also predisaster recovery planning.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

• Megadisasters in developing countries often involve a multiplicity of humanitarian agencies, donors, and NGOs. As such, it is even more critical to develop, early on, a shared vision for recovery and reconstruction that recognizes local cultural and life values and is perceived as legitimate by key stakeholders. Failure to do so can result in a proliferation of external-driven plans and strategies, as seen recently in Haiti.

• Predisaster planning can help promote a more resilient recovery. This was the case following the 1995 Bangladesh floods, where the response benefited considerably from the level of disaster preparedness introduced after the 1985 floods. In Gujarat, by contrast, a lack of proactive planning despite past disasters hampered recovery efforts following the 2001 earthquake.

• Every megadisaster is different, and the necessity for a dedicated reconstruction agency depends on postdisaster governance and coordination capacity. The Agency for the Rehabilitation and Reconstruction of Aceh and Nias (BRR), established 3.5 months after the tsunami, was generally effective largely due to a strong mandate, national commitment, and external financial support. Concerns about slow recovery, however, led the BRR to take over implementation responsibilities, posing a potential conflict of interest with its oversight function. In later years, the BRR progressively devolved implementation to local governments. Another example of an agency with both coordination and operational functions (albeit not in a developing country) was the Victorian Brushfire Recovery and Reconstruction Authority established after the 2009 brushfires in Australia. Using a successful model based on people, economy, environment, and reconstruction, the authority completed its mandate in 30 months. In other disaster contexts, however, a hybrid model may be more appropriate, where a centralized agency coordinates reconstruction, but implementation capacity continues to be delegated to government agencies.

• In general, recovery planning is most effective when it uses participatory methods and directly integrates the views of experts with those of affected people. Response to numerous megadisasters (for example, the GEJE, 2006 Yogyakarta earthquake, and 2010 Pakistan floods) attest to the merits of this approach. Community members’ participation in planning workshops should be arranged. Also, community leaders should be assigned as members of planning committees. The 2008 Wenchuan earthquake provides an alternative model, where centralized, top-down
planning led to rapid reconstruction. At the same time, there was a weak focus on local capacity building and community preparedness, issues that could hamper future disaster response.

- Governments in developing countries have a very narrow window of opportunity to decide whether to rebuild in situ or relocate populations to safer areas. The government of Thailand, for example, considered seriously whether to relocate parts of the capital to higher grounds following the 2011 floods, but this opportunity was quickly lost due to social and political pressures. While moving entire cities has proven historically difficult to achieve, megadisasters can still provide opportunities to improve spatial planning—as demonstrated after the 2011 tsunami in Samoa, when affected coastal communities agreed to relocate further inland.

- Relocation may be needed to preserve public safety, but it often removes people from their sources of livelihood. In a disaster response, both safety and livelihood have to be well balanced, and nowhere is this delicate balance more difficult than in developing countries. In such countries, affected people are often poor and marginalized, having settled in unsafe areas often because they offer the only land available. When disaster strikes, land speculation and security problems are often rampant; residents quickly rebuild in their original neighborhoods out of fear someone else may move in. As house insurance markets tend to be nonexistent, governments are left with very few instruments to promote relocation: they can resettle people involuntarily (which is seldom successful), or they can promote voluntary relocation by investing in alternative “growth centers” (for example, by building social infrastructure in safer areas). Often, relocating people as close as possible to their original homes and livelihood sources proves to be the most sustainable solution.

- Open and transparent information sharing is a key prerequisite to successful planning. This can be a major constraint in developing countries, where information on key issues such as land tenure and historical exposure tends to be scarce or inaccessible. Since Haiti, development partners working in megadisasters have promoted the use of crowdsourcing and other open data platforms, often with great success. The challenge now is to mainstream such processes effectively into local planning, so that they can provide vulnerable people with a greater voice in mitigating future disasters. The processes should be formulated considering local conditions, since relationships between governments and civil societies vary from country to country.

**KEY REFERENCES**


GFDRR (Global Facility for Disaster Reduction and Recovery). 2010. “Haiti Earthquake
Reconstruction—Knowledge Notes from the DRM Global Expert Team for the Government of Haiti.”


Transitional shelter can play a crucial role in housing reconstruction following a megadisaster. Reconstruction of permanent housing cannot move forward until a number of complex issues are settled, such as relocation planning and removal of debris. Even after plans are agreed on and reconstruction begins, it may take several years for permanent housing to be completed. In this context, affected people may need to rely on transitional shelter for extended periods of time, and this will have a significant effect not only on housing, but also on their overall recovery including livelihood rehabilitation.

**FINDINGS**

The Great Eastern Japan Earthquake (GEJE) led to the total collapse of some 108,000 residential houses. An additional 117,000 houses suffered damage to more than half of their structure (KN 1-2). As a result, more than 450,000 people had to be evacuated to evacuation centers. Within four months of the disaster, 75 percent of the centers had closed, as people were moved gradually to transitional shelters (KN 3-5).

Lessons learned from the Great Hanshin-Awaji (Kobe) Earthquake of 1995 and other disasters led the Japanese government to promote the concept of networked relocation following the GEJE, when an attempt was made to preserve, to the extent possible, existing social networks. The government also offered multiple options for transitional shelter, depending on geography, reconstruction planning, and local preferences. These included temporary housing, mostly prefabricated; government-owned accommodation and public housing; and private rental apartments, which proved popular due to lower prices, higher comfort, and greater versatility. Local governments, volunteers, and nongovernmental organizations (NGOs) provided complementary support, including counseling. As relocation into transitional shelters proceeded, several innovations were introduced, including physical upgrades to improve comfort, wooden housing (easier to convert into permanent use), and multiple-story accommodation. Key challenges have been the lack of sufficient land due to the volume of remaining debris, as well as logistical difficulties in keeping track of disaster survivors to ensure ongoing support. This note discusses the GEJE experience and offers lessons learned with application to developing countries.
JAPANESE FRAMEWORK FOR TRANSITIONAL SHELTER

Prefectural governments are responsible for transitional shelter according to the provisions of the Japanese Disaster Relief Act (1947), with funds allocated from the central government. The prefecture, outside of exceptional cases, can choose the type and form of housing as well as hire private construction companies. Municipal governments coordinate with prefectures for the selection of sites, distribution of affected people, and maintenance of shelters. Affected people are expected to move into permanent accommodation within a period of 2 years (the time normally allowed by Japanese law), and at their own cost, although they receive up to ¥3 million ($37,500) in compensation from the government, depending on the housing damage. Alternatively, they can rent public housing at subsidized rates. The usual flow of the housing reconstruction process is shown in figure 1.

FIGURE 1: The housing recovery process in Japan

Disaster → Evacuation Center → Transitional Shelter → Permanent Housing

BASIC TYPES OF TRANSITIONAL SHELTERS USED AFTER THE GEJE

The government adopted three main programs of transitional shelters in the aftermath of the GEJE (figure 2):

- Newly constructed temporary housing (mostly prefabricated by private contractors)
- Private rental apartments
- Existing public housing and government-owned accommodations (previously built to house government officials)

The type of transitional shelter was influenced by geographic and demographic considerations (figure 3):

- Temporary housing were commonly used in the ria coastal areas north of Sendai (including part of the Miyagi Prefecture and most of the Iwate Prefecture), where most of the resident houses suffered major destruction. This area is characterized by steep and fjord like topography, and both small fishing villages and larger towns located near the ocean; there is little available land near the ocean fit for building.
• Private rental apartments predominated in Sendai City and urban areas in the coastal plains, much of it undamaged.

• The towns in Fukushima Prefecture presented a unique case: due to the radiation hazard residents had to be evacuated for an uncertain length of time. Facing the prospect of having to provide long-term transitional shelter (possibly for many years), the Fukushima Prefecture decided to construct more than 4,000 units of wooden temporary housing, including larger-sized units for larger families. As of March 2012, about 60,000 residents had evacuated the Fukushima Prefecture to other prefectures.

### FIGURE 2: Characteristics of transitional shelters used after the GEJE (as of December 27, 2011)

<table>
<thead>
<tr>
<th>Shelter type</th>
<th>Number of houses allocated or chosen</th>
<th>Number of houses supplied</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary housing (mostly prefabricated)</td>
<td>52,182</td>
<td>52,620</td>
</tr>
<tr>
<td>Government-owned accommodations</td>
<td>9,832</td>
<td>38,464</td>
</tr>
<tr>
<td>Public housing</td>
<td>8,238</td>
<td>24,505</td>
</tr>
<tr>
<td>Private rental housing</td>
<td>65,692</td>
<td>—</td>
</tr>
<tr>
<td>Total</td>
<td>135,944</td>
<td>115,589</td>
</tr>
</tbody>
</table>

Source: Disaster Management Headquarters.
Temporary housing, typically one-story prefabricated row houses built by private companies (29 square meters), is the most common type of transitional shelter used in Japan (figure 4). Typical construction costs have ranged from $5.7 to $6.6 million ($71,000-$80,500 per unit), slightly more than double the price of the 1995 Kobe earthquake. As of early 2012, some 52,000 housing units have been built.

Many prefectures have preexisting agreements with construction companies to build prefabricated temporary housing during emergencies. But even with these agreements in place, it was not possible for construction companies to build all the units needed immedi-
ately, due to shortages of construction materials and workers. Because of such shortages and a lack of coordination across companies, the quality and level of construction of temporary houses varies across the disaster area.

Government policy requires that temporary housing be built on publicly owned land, outside high-risk areas. This posed a significant challenge for much of the disaster area, particularly along the ria coastline north of Sendai, where there was almost no available land—a major reason for the initial delays in the construction of temporary housing. The first residents moved only in April/May, one to two months after the disaster (figure 5).

In many towns, however, a high percentage of temporary housing remained empty, as prospective residents found them inconvenient (too distant from their original villages), uncomfortable, and much smaller than their original houses. The houses were constructed using low-quality, bare-minimum standards, and were not suited to the cold climate of the Tohoku region. Problems included gaps between walls and roofs, drafts, and the absence of noise or temperature insulation, shelves or storage areas, places to sit outside, an awning or enclosure around the front door, and a veranda outside the sliding door (which made it dangerous for the elderly hanging laundry, or small children). Moreover, as allocations were
determined by lottery, residents complained that they did not know their neighbors and lost their community connections. Some people preferred to stay in evacuation shelters as long as possible because food and utilities were provided for (a trend also observed following other megadisasters).

PRIVATE RENTAL APARTMENTS

Although not widely used during the Kobe earthquake, privately owned rental housing became the preferred form of transitional shelter after the GEJE, with about 66,000 units used by disaster victims. Rents were paid directly by the government. Such apartments were widely used in the urban areas of Tohoku, including Sendai City.

As also observed in Haiti, private rental units offer many advantages over conventional temporary houses: they are considerably cheaper—about ¥0.7 million-¥1.5 million ($9,000-$18,000) per year per unit or for a two-year average stay, which makes them two to three times less costly than temporary housing. They also allow affected people to move into...

FIGURE 5: Number of temporary houses completed

Source: MLIT.
transitional shelters quickly (people started moving in less than a month after the disaster, compared to one to two months for the prefabricated units). In addition, regular apartments are considered more comfortable and livable for residents.

Nonetheless, private rental apartments are not a viable option for areas that suffer extensive destruction of existing housing stock. In addition, the fact that affected residents are scattered across existing housing units makes it difficult for government and relief workers to track them to provide the necessary information and support. It also makes disaster survivors more prone to losing social connections than when they are grouped together in conventional temporary housing.

**PUBLIC HOUSING AND GOVERNMENT-OWNED ACCOMMODATIONS**

Some disaster survivors moved into public housing managed by government entities, as well as into other government-owned residential facilities. Public housing shares many of the positive features of private rental housing, although it can also lead to residents’ isolation, with limited access to the information and social networks found in the more aggregated temporary housing.

**SUPPORT SYSTEMS**

**COMMUNITY BUILDING AND EMOTIONAL CARE**

Throughout the disaster region, local governments, volunteers, and NGOs started numerous support initiatives to help disaster victims at transitional shelters. These included both physical (provision of furniture, building of additions or improvements, provision of community spaces, buses) and nonphysical support (social events, counseling, health checks, visits, shopping and support for elderly and children).

One example is the Disaster Victims Support Center, started by the town government of Minami-sanriku (Miyagi Prefecture) through the National Government Emergency Employment Fund. The center hired about 100 disaster victims to visit other affected people in temporary shelters, counsel them, and provide support to the most vulnerable. It also established one satellite location in each of the four regions of the town to be closer to the temporary housing residents. This initiative built upon the earlier example of the community centers established in the aftermath of the Kobe earthquake (box 1).

The Japanese Red Cross provided six electric household appliances (televisions, refrigerators, washing machines, cooking pots, microwave ovens, and hot water pots) to those families who moved to new but empty prefabricated houses and apartments. By June 2012 the number of beneficiary families reached over 130,000 throughout Japan, from Okinawa to Hokkaido, including those families displaced by the Fukushima nuclear accident.

**TRANSPORTATION**

One of the key difficulties faced by residents of transitional shelter is the distance from work, schools, hospitals, and shopping. Providing adequate transportation to support these residents is therefore an important challenge.
LIVELIHOOD SUPPORT

Many support groups have started projects to assist residents of transitional shelters in generating side incomes. Examples include the friendship bracelet "Tamaki" produced by wives of fishermen, and hammocks produced by fishermen (both from fishing nets). Other women’s groups have started making and selling products such as key chains, fabric bags, and slippers. The link between transitional shelter and livelihoods has proven important not only to help improve the socioeconomic status of affected people, but also their psychological recovery (see KN 4-5).

THE EVOLUTION OF TRANSITIONAL SHELTERS IN THE GEJE

NETWORKED (GROUP) RELOCATION

Given the shortage of publicly available land in disaster-stricken areas, the government allowed some temporary housing units to be built on privately owned land.

BOX 1: The case of community centers at transitional shelter siters after the Kobe earthquake

A total of 232 community centers were opened as bases to support residents, established by an association of local organizations:

- Volunteers and nonprofit organizations manage the centers.
- Life support advisors visit each house to confirm safety and provide advice.
- Events and gatherings are held by volunteers to promote communication among residents.
- Establishment of community-based organizations is supported.
Lessons were also learned from Kobe. Many elderly residents had died a solitary death after being separated from their social networks by lottery systems that dispersed them into transitional shelters. In the GEJE, a lottery system was also used during the initial stages of the recovery as the number of temporary houses were much fewer than the number of affected people wanting to move out of the emergency shelters. In Minamisanriku (Miyagi), for example, some 62 percent of the temporary shelters followed the lottery system.

As more temporary houses became available, municipalities made an effort to support community building and design group housing units that encouraged interaction between neighbors. In Minami-sanriku, therefore, two models of temporary group housing were adopted: large group sites built on public land (schools or athletic facilities) and smaller group sites built on private land. On the larger group sites (built earlier), prospective residents were chosen by lottery, which prioritized senior citizens, families with small children, and other vulnerable residents. Affected people were also given the choice to go to a large group site sooner, or wait a little longer and be relocated collectively into one of the smaller group sites, closer to their former neighborhoods. Smaller group sites were built specifically to support collective group relocation from nearby neighborhoods, to keep affected communities relatively intact.

**PHYSICAL IMPROVEMENTS**

The close network of support to affected people enabled local governments and NGOs to do some improvements to the poor physical condition of the temporary housing units by adding awnings, balconies or verandas, and insulation or soundproof materials, and by providing benches, shelves, and other indoor furniture (figure 6). But problems of basic construction persisted over the entire disaster area, and it was very difficult to improve the situation for all residents.

FIGURE 6 (left): *Improvements to temporary housing—adding insulation to the walls and double-pane windows*

FIGURE 7 (right): *Multiple-story temporary housing made with stacked containers*
Multiple-story temporary housing made from stacked containers was introduced in Onagawa town to compensate for the scarcity of available land. Stacking the containers to form two- and three-story group temporary housing also helped reduce overall construction time (figure 7).

Wooden temporary housing has been used extensively in Fukushima Prefecture, where long-term, temporary residency is required, as well as in Sumita, Rikuzentakata, and Tono towns. The main advantage is that it can be used for longer periods than the prefabricated houses, and can potentially be converted and/or reused for the construction of permanent housing. It is also more comfortable and warmer, and has the advantages of being disposable. But it is not as standardized as the prefabricated type, and cannot easily be produced in large quantities offsite. In addition, in megadisasters such as Aceh, the extensive use of wood resources has contributed to deforestation of already fragile environments.

TEMPORARY TO PERMANENT HOUSING

In common with other megadisasters (for example, Haiti, Aceh and Yogyakarta in Indonesia, and Chuetsu and Kobe in Japan), it is expected that owner-built transitional shelter will start to emerge. Like wooden temporary housing, it can be reusable and converted to permanent use.

In the 2006 Central Java earthquake in Yogyakarta, the government promoted a “roof first” concept to transitional shelter, allowing residents to incrementally finish the structure. The 2001 Gujarat earthquake in India and the “Katrina Cottages” built following the 2005 Hurricane Katrina (United States) provide further examples where materials and/or semi-permanent structures were provided to residents to gradually rebuild their homes (box 2). This process, however, needs to be carefully monitored to ensure that residents rebuild according to safer standards and do not settle on disputed land.

A relatively unanticipated challenge to the general recovery and reconstruction has been the vast quantity of debris left by the tsunami. Collecting and disposing of such a large amount of debris requires time, large spaces, and resources—impeding other aspects of recovery.

LESSONS

- As discussed in this note, the GEJE experience demonstrates the importance of providing multiple options for transitional shelter. It also shows the importance of allowing local governments and affected communities to have a voice in the location, type, and services provided. This leads to flexible housing solutions that better match the needs of residents. Table 1 summarizes some of the advantages and disadvantages of the various types of transitional shelter, based on the GEJE as well as international experience.

- The design of the transitional shelter was built upon experiences with past disaster recovery in Japan. In Kobe a great deal of temporary housing was constructed far from the city center and former neighborhoods, with residency determined by a lottery system. These conditions exacerbated the feeling of loss for affected...
### Box 2: International examples of creative, temporary-to-permanent housing

The “roof first” concept of temporary shelter was adopted in Yogyakarta following the Central Java Earthquake (2006). It prioritized putting a roof over the heads of residents, who could then incrementally finish the structure. For permanent housing recovery, a core house was used to provide a structurally safe permanent shelter as soon as possible for a large number of beneficiaries, who could then expand their housing incrementally over time.

*Source: IFRC*

### Table 1: Transitional shelter options compared

<table>
<thead>
<tr>
<th>Type</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temporary housing (prefabricated)</td>
<td>• Standard specifications</td>
<td>• Requires available, safe, and undisputed land</td>
</tr>
<tr>
<td></td>
<td>• Can be built in large quantities offsite</td>
<td>• Slower relocation than rental units (needs to be constructed)</td>
</tr>
<tr>
<td></td>
<td>• Easy to keep track of relocated people</td>
<td>• Low quality and lack of comfort</td>
</tr>
<tr>
<td></td>
<td>• Can be used for collective relocation (preserving social networks)</td>
<td>• Often built in inconvenient locations, far from original homes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• If use is prolonged, risks degrading to a slum</td>
</tr>
<tr>
<td>Temporary housing (owner built)</td>
<td>• Can evolve to permanent housing</td>
<td>• Requires available, safe, and undisputed land</td>
</tr>
<tr>
<td></td>
<td>• Flexibility in location, materials, style</td>
<td>• Principles of building back better (or in nonrisk areas) may not be followed</td>
</tr>
<tr>
<td>Private rental housing</td>
<td>• Cheaper</td>
<td>• May not exist in affected areas</td>
</tr>
<tr>
<td></td>
<td>• Fast relocation (already constructed)</td>
<td>• Relocated people are scattered difficult to keep track and provide services</td>
</tr>
<tr>
<td></td>
<td>• Flexibility and comfort</td>
<td>• Can reinforce social isolation</td>
</tr>
<tr>
<td>Public and government-owned housing</td>
<td>• Cheaper</td>
<td>• Can reinforce social isolation</td>
</tr>
<tr>
<td></td>
<td>• Fast relocation</td>
<td>• More difficult to preserve social networks and provide services than temporary housing</td>
</tr>
<tr>
<td></td>
<td>• Comfort</td>
<td></td>
</tr>
</tbody>
</table>
people, and there were many cases of “solitary deaths” (kodokushi), where no one even knew that the individual had passed away. The GEJE model tried to prevent this to a certain extent by promoting group relocation and preservation of improved social networks.

- **Community-based organizations** (such as *jichikai*) and **support groups** can play important roles in assisting affected people to understand and resolve issues by themselves during their stay at transitional shelters.

- The design of transitional shelters should be better from the start to promote efficient recovery—for example, by taking into consideration climate conditions and transportation and livelihood needs. It is also important to consider the **special needs of vulnerable groups**—including the elderly, children, and disabled. Transitional shelters need to be accessible to them, and complementary care services planned and provided. To facilitate this, local governments in highly vulnerable areas should **select a suitable construction site for temporary housing and coordinate the works and services needed before a disaster occurs**. Neighborhood groups should also be trained in network relocation.

- A better **information database of disaster survivors** is necessary in order to provide suitable support to the affected population. For example, such data can help in the planning of how many houses to build as affected people move out of the area into surrounding cities, as well as help forecast demographic changes over the long term. This information is also critical for more efficient and economic reconstruction planning.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- The **timeline** and **costs** of transitional shelter must be considered carefully. In developing countries, affected people often start rebuilding their homes immediately after a disaster, and often according to poor safety standards. As such, transitional shelters may not be needed for long periods (as was the case during the 2010 Pakistan floods), and resources should be shifted toward permanent reconstruction.

- Long periods in transitional shelters may also make it more difficult for beneficiaries to move to permanent housing (such as in the Marmara earthquake, Turkey) and encourage the growth of slums or ghettos.

- In general, megadisasters in developing countries require transitional shelters that are **upgradeable**, **reusable**, and **recyclable**, allowing shelter materials to be gradually used for permanent housing. Salvageable materials from debris can often be used to build or complement shelters, and their salvage can be temporary a boost to local livelihoods.

- Owner-built shelters or units built with strong beneficiary participation are often best (for example, 2001 Gujarat, 2006 and 2008 Yogyakarta, and 2010 Haiti) but care must be taken to oversee the quality of the construction or provide incentives for better standards (such as conditional cash transfers). Cash or voucher programs,
such as used in Haiti (2010) and Wenchuan (2008), can promote flexible solutions and allow families to pool resources and rebuild together.

- Transitional shelters must be planned together with strategies supporting daily life (shopping, health care, social life, schools, infrastructure, psychosocial support) as well as livelihoods. To the extent possible, affected people themselves should participate actively in these services, helping rebuild a sense of community and a quick return to normalcy.

- The location of temporary housing is particularly important, especially where land is scarce. Sites with uncertain tenure should be consistently avoided. The preparation of a “land bank”—preselected areas that can be quickly converted to be used as transitional shelters or permanent relocation—should therefore be a critical component of any predisaster contingency plan in highly vulnerable areas. In places where public land is scarce, this may require that the government prenegotiate the use of the land with private landowners to prevent subsequent land speculation.

- To the extent possible, the distance between transitional shelters and former homes should be minimized to allow displaced people to maintain social networks and livelihoods, and protect their land and property.

- Community cohesiveness should be ensured by providing timing and site options for temporary shelter. This, however, requires high levels of government capacity and costs, and could slow down shelter transitions. Community members should provide one another mutual help.

- A systematic communication and monitoring strategy is critical to avoid harmful rumors, keep affected people informed, and allow for beneficiary feedback.

- Civil society and the private sector may not be robust and resilient enough to face the disaster, and may not have the necessary relations with their governments in some countries. In these countries, government initiatives are crucial.

**KEY REFERENCES**


IRP Guidance Notes on Recovery: Shelter http://www.recoveryplatform.org/resources/guidance_notes_on_recovery

Shelter Center, Shelter After Disaster http://www.sheltercentre.org/library/shelter-after-disaster

Shelter Center, Transitional Shelter http://www.sheltercentre.org/transitional-shelter


Some 20 million tonnes of waste resulted from the Great East Japan Earthquake (GEJE). The amount of debris in Iwate Prefecture was 11 times greater than in a normal year, and in Miyagi 19 times greater. Appropriate treatment and disposal depends on the type of debris or waste, while recycling should also be considered. Authorities should prepare for disasters by designating temporary storage sites and routes for transporting waste. Japan’s existing debris management plans are being revised to include methods for estimating the amount of disaster waste generated by tsunamis and appropriate measures for dealing with it.

FINDINGS

THE MANY CAUSES OF DISASTER

Disasters have a variety of causes including earthquakes, tsunamis, typhoons, floods, and fires. Over the past decade, several major disasters have destroyed social infrastructure all over the world: Sumatra’s Andaman earthquake in 2004, Hurricane Katrina in 2005, the Great Sichuan Earthquake in 2008, and the earthquakes in New Zealand and Turkey in 2011. Differences in the nature and geographical extent of the environmental effects, and other waste-related problems that may arise, are dictated by many variables including: the cause of the disaster, types of local industry, building densities, and so forth. In other words, big differences exist and it is extremely difficult to generalize.

THE AMOUNT OF DISASTER WASTE AND ITS CLASSIFICATION

The GEJE generated large amounts of disaster waste. Japan’s Environment Ministry estimated 20 million tonnes as on May 21, 2012. This number is very large even when compared with the 15 million tonnes from the Great Hanshin-Awaji (Kobe) Earthquake, the 20 million tonnes from the 2008 Sichuan earthquake, or the 10 million m³ found in Indonesia alone following the 2004 Indian Ocean tsunami (Brown, Milke, and Seville 2011).
Estimates for the Kobe earthquake in 1995, based on the unit waste generation intensity for totally destroyed structures, were 61.9 tonnes/household and 113 tonnes/building. Although there are few reports on the per-unit-floor-space amount, one value reported for the Kobe earthquake was 0.62–0.85 tonnes/square meter (m²), and a contemporary review put it in the range of 0.20–1.44 tonnes/m² (Takatsuki, Sakai, and Mizutani 1995).

**TSUNAMI SEDIMENT DEPOSITS AND THEIR PROPERTIES**

Tsunami sediment deposits consist mainly of sand, mud, and other bottom material, but their properties and compositions vary widely. Some examples of deposits causing concern are those mixed with the ruins of homes crushed by tsunamis, those containing oils, and those that release offensive odors or dust due to putrefaction or drying. Deposits may also be mixed with substances such as pesticides, acids, alkalis, and other hazardous chemicals from industries in the disaster-stricken areas. Doing nothing about such substances raises public health concerns. The tsunami from this earthquake left heavy deposits. To estimate the amount, we multiplied the tsunami-inundated area by the average thickness of the deposits and a volume-to-weight conversion factor, and obtained a total estimated 11,990,000–19,200,000 m³ and 13,190,000–28,020,000 tonnes for the six disaster-stricken prefectures of Aomori, Iwate, Miyagi, Fukushima, Ibaraki, and Chiba (JSMCWM 2011). The deposit height is between 2.5 and 4 centimeters.

The gist of the chemical analysis results is as follows. Ignition loss (600°C, 3 hours) had a spread of 1.2 percent to 16.3 percent, and there were some samples influenced by the organic matter and oils in the seabed mud. Hexane extracts exceeded 0.1 percent in a number of samples, and on the high end oily mud was at 9.8 percent. While tests for heavy metals did not detect much, lead was detected in many samples in the mg/kg range. Leaching amounts of heavy metals (using a method based on Environment Ministry Notification No. 46) were found in some instances to exceed environmental quality standards for soil contamination from lead, arsenic, fluorine, and boron. In the cases of lead and arsenic, it is conceivable that natural sources were responsible for exceeding leaching standards. Because concentrations of fluorine and boron are high in the seawater of this area, the influence of seawater is a possibility. There were no samples in which the content of persistent organic pollutants (POPs) such as dioxins, PCBs, or pesticides exceeded the standards (for example, for PCBs the standard is the destruction target of 0.5 parts per million [ppm] for PCB treatment, for dioxins it is the environmental quality standard for soil and for sediment in bodies of water, and for other substances it is the established reference guidelines). The levels found were generally the same as the results of environmental monitoring surveys of sediment and soil that were performed in recent years by the Environment Ministry in nearby water and land areas. Because our investigation is based on 62 samples and a limited study, a more detailed study may be carried out in the future, but it is safe to say that at this point no serious contamination in particular has been found.

Essentially, the guidelines for disposing of tsunami deposits call for removing pieces of wood and other materials, detoxifying them, and then using them as fill in landfills or for embankments. In urban areas, where hydraulic excavators are hard to use, removal is performed by people with shovels or other tools. After being gathered, deposits are carried away by heavy machinery, while septic tank pumper trucks can be used for sludge, which has a high water content. After removal, the deposits are put in temporary storage sites; pieces of wood and concrete, which can be used as civil engineering materials, are sepa-
rated out. If the deposits contain hazardous substances, they are detoxified by washing and/or physical/chemical treatment, and then either likewise used as material, or taken to a municipal solid waste disposal site if they cannot be effectively used. It was decided that if tsunami deposits contain no pieces of wood or other matter and are not contaminated with hazardous substances, they could be left in place after making arrangements with landowners.

HAZARDOUS WASTE SEPARATION AND DISPOSAL

The types of waste that present dangers, and the methods of handling them, require various cautions, particularly if operations are on-site. There are hazardous wastes such as gas cylinders, building materials containing asbestos, and transformers and capacitors containing PCBs. The Japan Society of Material Cycles and Waste Management (JSMCWM) has prepared a disaster-waste quick reference chart, and it is desirable that personnel performing waste removal should use this (or others like it) to learn about hazardous wastes.

Here is an example from Sendai City of how to treat hazardous waste: such waste, ranging from household cleaners, paints, lead-acid automobile batteries, and emergency power supply systems used by industries, are all being stored separately in a space about the size of a baseball field. Of these types of waste, a decision has been made only about gas cylinders and fire extinguishers—which should be treated by the related industries—while the treatment and disposal of other materials is still undecided. A high level of caution is needed in daily dealings with household hazardous waste, and further detailed measures are required to tackle this issue when establishing plans to deal with disasters.

LESSONS

BASIC FRAMEWORK FOR DEALING WITH DISASTER WASTE

On April 5, 2011, the Science Council of Japan issued the “Urgent Proposal Related to Measures for Earthquake Disaster Waste and Prevention of Environmental Impact.” The proposal’s overall framework was drafted by the JSMCWM, and then issued in collaboration with the Japan Society of Civil Engineers and the Japan Society on Water Environment. The medium- and long-term response was also taken into consideration in formulating a basic policy for the disposal of earthquake waste and the minimizing of environmental impacts. The essential points are given below:

- Waste is to be treated and disposed of quickly, while keeping in mind the securing of public health and the handling of hazardous waste. Priority is to be given to dealing with putrefied organic matter and quickly removing it from cities and streets, or—while taking measures such as spreading lime to delay putrefaction—to determining locations of hazardous wastes such as medical waste, asbestos, and PCBs, and trying to process each waste type in the proper manner.

- Temporary storage sites are to be created (which take the water environment into consideration) and waste is to be uniformly separated. Waste collection locations
are to be decided on immediately, and putrefied materials including sludge-type items, flammable materials, and hazardous wastes should not be mixed. Care is to be taken not to create huge piles, to prevent fires and other such events, and not to cause contamination of water, soil, or groundwater.

- Recycling should be considered, to help put resources to use in recovery and reconstruction. Concrete debris might be recycled in the recovery and rebuilding phases, wood scraps could substitute for fossil fuels in power generation and other applications, and various other types of recycling could be conceived.

- Local employment and wide-area cooperation should be facilitated in disaster-waste recycling. It was determined that in this case what is promoted internationally as “cash for work” could be effective. On dealing with disaster waste in the Tohoku region, even if wastes were to be recycled, the region would not have sufficient treatment and disposal capacity, which raises the possibility of wide-area cooperation. A case can be made for taking a nationwide response: integrating industry, government, academia, and the citizenry.

Figure 1 shows the basic flow involved in operating temporary storage sites and preliminary waste storage sites to facilitate the local management of municipal solid waste. These storage sites play a major part in the smooth removal of debris from disaster areas.
For instance, it was known that since much of the disaster-stricken area in the Tohoku region comprises narrow coastal zones and also because of the urgent need for land for temporary housing and other purposes, it was not easy to secure land for temporary storage sites. In all geographical areas, authorities should prepare for disasters beforehand by designating places for temporary storage sites, traffic routes for waste transport, and other related needs.

In situations such as when a tsunami has scattered individuals’ private possessions and mixed them with disaster waste, removal and processing must proceed while also determining who owns what. At the end of March 2011, the government issued “Guidelines on the Removal and Other Treatment of Collapsed Homes and Other Property after the Tohoku Region Pacific Coast Earthquake” (Ministry of the Environment 2011), which contained the following three points:

- Make sure everyone knows in advance the plans for where operations will be conducted, schedules, and other particulars.
- Before removal, take photographs and make other records of buildings, automobiles, motor scooters, and boats.
- For ancestral tablets, photo albums, and other items that are valuable to owners and other persons, as well as chattels, provide opportunities to return them to the respective owners and other persons.

Valuables such as precious metals and safe boxes should be put into temporary safe-keeping. Efforts should be made to contact the owners or relevant parties in the event they are identified, and the valuables should be returned when the owners or relevant parties so request. When the owners or other relevant parties are unknown, the guidelines call for the valuables to be processed as directed by the Lost Property Act.

**SEPARATION AND RECYCLING: THE SENDAI CITY MODEL**

Following is one conceivable classification scheme for the composition of disaster wastes from earthquakes and tsunamis:

- Waste consumer electric appliances and electronics, and various household effects
- Waste wood, concrete rubble, tiles, and so on
- Plants, trees, and other natural items
- Large structures and so on
- Deposits (silt, bottom sediment, and so on)
- Wrecked vehicles and boats
- Hazardous wastes (asbestos, pesticides, PCBs, and so on)
• Evacuation center waste

• Infectious waste, human corpses, and animal carcasses

Depending on the composition of each type, it is necessary to identify and carry out the appropriate treatment and disposal methods, while keeping in mind the possibilities for recycling. Table 1 lists the specific types of waste that fall under the above categories, and their recycling and disposal methods. Although people tend to concern themselves with removing disaster waste quickly, they should from the outset consider how wastes could be recycled to reuse valuable resources and prevent wasting landfill space.

Disaster waste and tsunami deposits generated in Sendai City were estimated to be around 1.35 million tonnes and 1.3 million tonnes, respectively. As of April 2012, these could be treated as follows:

• Concrete, which accounts for about half of the 1.35 million tonnes of disaster waste, can possibly be reused as material for reconstruction.

• Strategies for waste other than tsunami deposits are near completion.

The city had already estimated the amount of disaster waste only three weeks after the March 2011 earthquake, and set up a target of disposing of it within three years. Realizing that it was impossible to treat the waste using only existing facilities, the city decided to set up additional temporary incinerators, which were constructed in the autumn of 2011. Three temporary incinerators (one stoker furnace and two rotary kilns; 480 tonnes/day of total disposal capacity) were installed in three designated temporary storage sites along the coastal area. The following items were separate and recycled: wood lumber (for fuel use), metals, tires, four items designated in the Home Appliance Recycling Law, automobiles, and motorcycles. These items were carried out in turn to each place to be recycled.

Including wastes that are supposed to be landfilled, the amount of waste collected and moved to temporary storage sites is measured by a king-size weighing scale, and in some cases the results are recorded in a manifesto sheet.

**FINANCIAL SUPPORT**

To facilitate disposal of disaster waste, half the cost is covered by government subsidies, and a tax-exemption system is applied to 80 percent of the remaining cost (that is, a local government has to pay only 10 percent of the total cost). Additional measures are being taken this time to reduce the burden on local governments considering the size of the enormous damage caused by the GEJE.
### TABLE 1: Classification and treatment of earthquake waste

<table>
<thead>
<tr>
<th>Category</th>
<th>Outline</th>
<th>Type of waste</th>
<th>Recycling and disposal method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste from household goods</td>
<td>Household goods destroyed by earthquake and tsunami</td>
<td>• Valuables and mementoes</td>
<td>• Each item stored for return to owner</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Home appliances (TVs, refrigerators, air conditioners, washing machines)</td>
<td>• Home appliance recycling system</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Other home appliances</td>
<td>• Metal recycled after dismantling and crushing; organic material incinerated, inorganic matter disposed of in landfill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Tatami mats, mattresses</td>
<td>• Tatami mats, mattresses</td>
</tr>
<tr>
<td>Waste from collapsed houses</td>
<td>Collapsed houses and buildings (including furniture) destroyed by the earthquake and tsunami</td>
<td>• Timber from houses, furniture</td>
<td>• Desalted if necessary. Potential usages include: 1) particle board, charcoal, and reuse of material; 2) use as fuel in cement kilns; 3) energy recovery from incineration</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Concrete, asphalt, waste tiles</td>
<td>• Crushed and used as aggregate for roadbed material and in construction</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Asbestos-containing building materials</td>
<td>• Controlled management: disposed of in landfill, melted</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Plasterboard</td>
<td>• Controlled management: disposed of in landfill</td>
</tr>
<tr>
<td>Wood</td>
<td>Scattered and accumulated garden trees, pine wood, and other trees</td>
<td>• Garden trees, live trees, etc.</td>
<td>• Desalted if necessary. Potential usages include: 1) particle board, charcoal, and reuse of material; 2) use as fuel in cement kilns; 3) energy recovery from incineration</td>
</tr>
<tr>
<td>Bulky waste</td>
<td>Large-sized and unusual waste from factories and infrastructure</td>
<td>• Tanks, power poles, feedstuffs, fertilizer, and fishing nets that each require a specific disposal method</td>
<td>• Crushed and separated and then recycled, incinerated, or disposed of in landfill. Caution is required for hazardous substances such as asbestos.</td>
</tr>
<tr>
<td>Deposits generated by the tsunami</td>
<td>Gravel and mud left in disaster area after the tsunami. Most is bottom sediment from water bodies, but sometimes organic materials and contaminants are included.</td>
<td>• Sediments mixed by the tsunami with the debris of collapsed houses and other debris. Some include oil. Odor and dust could arise on putrefaction and drying. Hazardous chemicals such as acids, alkalis, and pesticides from the disaster area could be included.</td>
<td>• Used as fill for landfills or embankments after removing woody debris and detoxifying. Detoxified by washing or incineration when material contains hazardous substances. Non-recyclable items are taken to final disposal site and disposed of as general waste. Where there is no wood debris and no contamination with a hazardous substance, they could be left in place after making arrangements with landowners.</td>
</tr>
<tr>
<td>Vehicles/ships</td>
<td>Automobiles/ships</td>
<td>• Automobiles, motorbikes, tires, ships, etc.</td>
<td>• Automobile recycling system. Tires chipped and used as a supplemental fuel. Ships are dismantled, recycled, and disposed of. Caution required for asbestos materials.</td>
</tr>
<tr>
<td>Hazardous waste</td>
<td>Asbestos, PCBs, etc.</td>
<td>• Batteries, fluorescent lamps, fire extinguishers, gas cylinders, waste oil, waste liquids, transformer oil, etc.</td>
<td>• Controlled management undertaken as necessary for each type of waste.</td>
</tr>
</tbody>
</table>
RECOMMENDATIONS FOR DEVELOPING COUNTRIES

PREPARING A DISASTER WASTE MANAGEMENT PLAN IN ADVANCE

It is essential to make disaster waste disposal plans beforehand to help reduce the need for decision making with insufficient information in the wake of a disaster. Guidelines on measures to manage disaster waste and on measures to treat waste from flooding were established in Japan in 1998 and 2005. Both sets of guidelines require that any plan should specify how to:

- Establish basic policies for waste management.
- Construct and manage the system that deals with waste management.
- Classify disaster waste and secure necessary equipment and temporary storage sites for disaster waste.

In 2010, 72 percent of municipalities across the country (a rather high rate), had disaster waste management plans in place. But they are now being revised to include the following:

- Estimation method for the amount of disaster waste generated by tsunamis, and countermeasures for dealing with the waste.
- Multiple predictions for disasters of different scales.

Accordingly, periodical review of disaster waste management plans is indispensable.

BUILDING COOPERATIVE STRUCTURES WITH VARIOUS ORGANIZATIONS AND INSTITUTIONS

When disasters occur, cooperative ties with various organizations and institutions are key to the smooth management of disaster waste. This is because many problems and administrative needs arise, while the number of appropriate policy experts is limited and the waste disposal sites in the affected areas are often damaged. Above all, much more waste is generated in these circumstances. Developing cooperative relations between local governments in the surrounding affected areas and with communities far from the stricken areas should be considered. Sendai City, for example, which was affected by the GEJE, over the course of a year received 58 staff from 8 organizations to help promote its waste management plans. For waste collection, the city received help from 7,510 staff from 10 organizations, as well as 88 vehicles.

In addition to cooperating with industries and local municipalities, building and making effective use of cooperative relationships with academic organizations, other expert groups, and nonprofit organizations are also recommended.
BOX 1: Preliminary findings of the United Nations Environment Programme’s (UNEP’S) expert mission on Japan’s earthquake waste

- The contingency plans put in place by some prefectures before the earthquake allowed them to respond more quickly to the waste management challenge (for example, in Sendai City, which had contingency plans, three incinerators were already in place processing 460 tonnes of waste a day).

- While Japan has done much to advance global best practices on handling disaster debris, there is still scope for substantial optimization so as to lower the costs of postdisaster debris management and reduce its environmental impacts.

- Commendable emphasis has been placed on waste segregation and recycling. Waste is divided into several categories such as wood, metals, electrical items, tatami mats, fishing nets, vehicles, plastics, and so on. Some segregated materials are already being reused: for instance, tree trunks are being sent to a paper mill, shredded wood is being sent to a cement company for use as fuel in the manufacturing process, and building rubble is being recycled as building material, landfill, or in road construction.

- Maximizing the possibilities for waste recovery and recycling while minimizing the need for transportation are priorities for effective debris management.

- Under Japanese law, the manufacturers of cars and white goods (refrigerators, washing machines, and so on) are responsible for the final disposal of their products. But the volume of disaster debris generated is likely to overwhelm their intake capacity, which may need to be expanded.

- Despite the magnitude of the challenges, and their own personal tragedies, the officials in the various Japanese cities are doing systematic and dedicated work to manage the debris in a time-bound fashion.

- Opportunities exist for learning from best practices in various cities, and a systematic approach to capturing them and disseminating them would be beneficial.

- The national guidelines produced for disaster debris management could be locally adapted, with input from academic experts to reflect local circumstances. This will lead to more environmentally optimal outcomes.

- There is scope for improved monitoring and communication of the waste management activities in the disaster-impacted areas, which will enable everybody to appreciate the challenges faced and the efforts made.

CUSTOMIZING THE REMOVAL PROCESS TO LOCAL CONTEXTS

Each country has its own environmental safeguards, technology, and recycling practices. Utilizing these local practices are crucial in effective debris management.

KEY REFERENCES


KNOWLEDGE NOTE 4-5
CLUSTER 4: Recovery Planning
Livelihood and Job Creation
Livelihood and job creation have long been critical challenges to disaster recovery. Following the Great East Japan Earthquake (GEJE), the Japanese government launched an innovative cash-for-work (CFW) project, hiring more than 31,700 jobless people to work not only on reconstruction, but also on clerical and support work for affected people. This allowed it to reach out to women and the elderly, vulnerable groups that were traditionally excluded from schemes focusing primarily on manual work.

**FINDINGS**

The GEJE caused some 140,000–160,000 people to lose their livelihoods and jobs. By February 2012, in part as a consequence of an innovative emergency job-creation project initiated by the government, 143,820 people had found employment in the three most affected prefectures. Of these, 22 percent (31,700) were jobs directly created by the emergency job-creation project. Despite gaps between sectors, regions, and types of employment available, the government-initiated job-creation policy has generally been effective in sustaining employment in disaster-affected areas.

**RECORD OF LIVELIHOOD AND JOB CREATION IN JAPAN FOLLOWING CATASTROPHIC DISASTERS**

Livelihood and job creation has long been a critical issue in disaster response and recovery, both in Japan as well as worldwide. Fundamentally, it plays three critical roles:

- **Economic.** It serves as a key—and in some cases only—source of income for the population affected by disaster.

- **Social.** It encourages affected people to participate in the recovery process, thus strengthening their social ties.

- **Psychological.** It helps those who lose their jobs regain their self-esteem and look forward to a future.
Historically, job-creation policies benefiting those affected by disasters have not been particularly successful in Japan, despite their recognized importance and long record—even dating back to the 1854 Ansei Nankai earthquake disaster. After the 1923 Kanto earthquake, the Ministry of the Interior encouraged local governments and private firms to hire affected people for disaster response and recovery work; however, this attempt was unsuccessful, as the work provided was mainly manual while affected people aspired to nonmanual, “white collar” labor. The national government instead encouraged jobless people to move to suburban areas of the cities from which they originated.

Livelihood- and job-creation attempts were also unsuccessful following the Great Hanshin-Awaji (Kobe) Earthquake of 1995. As a result of the disaster, some 40,000–100,000 people were left jobless. The national government issued a law in March 1995 forcing public projects in affected areas to reserve up to 40 percent of their workforce for affected people rendered jobless by the earthquake. A year later, however, only 30 people had been hired under the policy. Contractors continued to make employment decisions based on profitability and efficiency, and there were no penalties for noncompliance. As a result, employment for affected people was limited to simple and unskilled public work tasks. During the recovery process, 254 people died in transition shelters without the care of family members or neighbors. Some study reports point out that most of the people who died alone were jobless, suggesting that they were isolated from society and had no contact with others.

**DAMAGE CAUSED BY THE GEJE AND ITS IMPACT ON LIVELIHOODS AND JOBS**

The GEJE could be the most severe of recent disasters in Japan. The Japan Research Institute (JRI) estimates that 140,000–160,000 people lost their livelihoods and jobs in May 2011 due to earthquake and tsunami damage. Moreover, most of the tsunami-hit cities lost the bulk of their infrastructure.

Ishinomaki City, for instance, was one of the largest cities hit by the tsunami (population 160,000). The Ishinomaki fishery port is the third-largest in Japan in terms of total landings. Fishery and seafood processing were the main industries of the city, engaging hundreds of companies and employing several thousand people.

The tsunami washed out nearly the entire central business district of the city. Aside from damage to buildings and facilities, the earthquake lowered soil levels by approximately 1.4 meters, allowing seawater to penetrate the area at full tide. To restart the industry it will be necessary to first elevate the soil, something very few companies can afford to do given the burden of existing loans. Over a year has passed since the earthquake and tsunami, and the national government has included the elevation costs under its third supplementary budget (FY2011). But it will take several years to complete such a large reconstruction project and, therefore, job recovery in Ishinomaki City is expected to be slower than during the 1995 Kobe earthquake.

In Fukushima, the national government designated the area within a 20-kilometer (km) radius of the Fukushima Daiichi Nuclear Power Plant accident as a restricted area, affecting some 78,000 people. Areas with relatively high radiation levels, even outside the 20-km
radius, were designated as Deliberate Evacuation Areas, affecting an additional 10,000 people (most of whom lost their jobs).

Although the national government is planning to remove restrictions in areas with relatively low radiation levels, the recovery of livelihoods and jobs in these areas will be difficult to address. A recent questionnaire of evacuees from these areas conducted by Fukushima University indicates that only 4 percent intend to return to their homes immediately after the lifting of the restrictions. Of the respondents, 25 percent have already decided not to return at all, citing lack of jobs as one of the major reasons. Close to 46 percent of respondents under the age of 35 say they will not return. Since the power plant was the main source of economic activity in the area, there are now very few job opportunities left. Thus, livelihood and job creation will also be critical to recovery in these areas. The survey results further indicate that 16 percent of the respondents say that recovery of the infrastructure will be necessary, while 21 percent argue for a concrete plan for radium decontamination.

**LIVELIHOOD AND JOB CREATION UNDER THE GEJE**

**GOVERNMENT INITIATIVES**

Following the GEJE, the Japanese government’s response involved both cash transfers to the most vulnerable, as well as an emergency job-creation project.

To help secure livelihoods to the most vulnerable people (such as the elderly those handicapped who are not regarded as employable), the government provided cash transfers through the regular social security system based on the Public Assistance Act, amounting to around ¥50,000 to ¥250,000 per month. In addition, the Japanese disaster management system provided up to ¥3 million ($37,500) to households that lost their houses to assist them with reconstruction efforts. Cash was also individually distributed to the most vulnerable people in the form of donations received from all over Japan.

To promote job creation, the Ministry of Health, Labor and Welfare (MHLW) launched the “Japan as One” Work Project immediately after the earthquake. The project had three major policy objectives:

- Steadily create jobs through reconstruction projects.
- Develop a system to match disaster victims with jobs,
- Secure and maintain securing employment among disaster victims.

The first policy objective built upon an earlier emergency job-creation fund created in 2008 after the global financial crisis. Following the GEJE, the government spent ¥50 billion ($625 million) to enlarge the fund, expanding its eligibility to disaster-related job losses.

Examples of activities supported by the project included:

- Evacuation center management and administration, such as food distribution, cleaning, procurement, and the delivery of food and other materials.
• Safety management and life-support services such as patrolling, caring for the elderly and disadvantaged, babysitting, supplementary lessons for students, and bus driving.

• Office-work support for local governments such as issuing resident cards, operating the call center, guiding visitors, distributing donations, and monitoring and performing needs assessments at evacuation centers.

• Reconstruction and recovery work such as debris removal, the cleanup of houses of the elderly, parks and public building maintenance, planting of flowers in parks, and public relations activities for sightseeing promotions.

The basic thrust of this policy was very similar to that of a CFW program (see box 1), but it differed substantially from typical CFW programs in developing countries. The range of work created by this project was so diverse that women and elderly could also work, whereas other CFW programs have tended to provide mostly manual labor (for example, infrastructure reconstruction).

One of the constraints faced by the job-creation project was that employers had to comply fully with domestic labor laws. For example, employers had to compel workers to take compensation, employment, and social insurance. Paperwork accompanying employment procedures proved a bottleneck during job creation. Although many of the government agencies, nongovernmental organizations (NGOs), and private contractors were major sources of job opportunities, they were reluctant to hire the jobless since they were otherwise occupied with the emergency response.

Public-private partnerships were an effective solution to this problem. The Fukushima Prefecture government, for example, requested private staffing agencies to hire affected people for the work of disaster-response organizations (including municipal governments). This scheme was very effective since the organizations involved did not have the burden of paperwork or personnel management.

Public-public partnerships were also used. The CFW activity in Ofunato City was partially undertaken by the Kitakami City government. Kitakami City received emergency job-creation funding from the Iwate Prefecture government, and entrusted a private staffing agency to hire affected people to care for affected peoples in transition shelters in Ofunato City.

For the second policy objective of the “Japan as One” project—matching disaster victims with jobs—the government intended to fully activate and empower public employment exchanges in the affected areas. This was effective to some degree but not enough to manage the significant burden of job matching. This was why (as mentioned above) private staffing agencies played a significant role in job creation.

The third objective—to secure and maintain employment among disaster victims—was supported by two activities. Some ¥727 billion ($9 billion) was distributed as an employment adjustment subsidy to affected industries, as an incentive for them to secure employment. In addition, the government provided ¥294 billion ($3.7 billion) to extend benefit terms of unemployment insurance. This helped protect workers in the formal sectors. Without this assistance, the burden of the job-creation project would have been much higher.
NGOS AND THE PRIVATE SECTOR

Nongovernmental organizations (NGOs) and the private sector also played important roles in the aftermath of the GEJE. The International Volunteer Center Yamagata, for example, launched a CFW project where jobless affected people were hired for debris removal and cleaning activities. Their salaries were financed by donations from all over Japan as well as overseas. The work was eventually expanded to community-support activities. The project ended on March 31, 2012, having hired 112 jobless people. Although it was a typical CFW scheme, it was not as large as programs seen in developing countries.

Another example was the Sanriku-ni Shigoto-wo Project in the Sanriku area, driven by a nonprofit alliance of Iwate Hakuhodo Co. Ltd., Iwate Menkoi TV, and Sendai Television Inc. This project provided livelihoods to fishermen’s wives previously engaged in seafood processing. While affected fishermen had benefited from an emergency job-creation project promoted by the Fishery Agency for debris removal and fishing port clean-up efforts, their wives had been left jobless.

Thirty new shops were opened in the Minamisanriku shopping village, inaugurated on February 25, 2011, for temporary job creation following the disaster (figure 1). The Ministry of Economy, Trade, and Industry through its “Small Medium Enterprise Support, JAPAN Program” facilitated the establishment of this temporary shopping village. Souvenir items produced by local residents, particularly women, were sold in some shops to support livelihoods.

FIGURE 1: Minami-Sanriku shopping village
The project generated a new handicraft made by women: a friendship bracelet called *tamaki* ("ring") made of fishing-net materials (figure 2). Approximately 50 percent of the sales went to the women producers. This project was covered extensively by television and the social media, and for several months production could not keep abreast of sales. As of February 29, 2012, 298 producers had received as much as ¥83 million ($1 million), according to the project Web site. The success of this project triggered many other kinds of handicraft production.

The Security Support Fund, operated by Music Securities Inc., was an e-commerce citizen aid initiative that matched prospective investors with small businesses affected by the GEJE to help restart them. Those who needed financial support submitted proposals via the fund’s Web site. In turn, prospective donors could visit the Web site and find projects for their potential investment. Thus, it worked as a microfinance project where prospective donors were matched directly to the recipients.
Livelihood and Job Creation

This fund has two important features: (i) one unit of investment can be as small as ¥10,500 ($131) and (ii) investors do not expect an economic return from their investment. About half (¥5,000) of the single unit of investment is considered a donation. Most of the investors enjoy communicating through the Web site with the businesses they are supporting. The fund has now grown to ¥700 million ($8.8 million), attracting more than 20,000 investors.

Policy results and outstanding challenges

Partially as a result of the government policy, the labor market has recovered rapidly in the affected areas. The number of beneficiaries of employment insurance leapt to 81,179 in June 2011 from 29,931 the previous March. Since June 2011, moreover, job offers have exceeded the number of new applicants, and this gap has been growing (figure 3).

Although the job situation is surely improving in general terms, recovery is not yet complete, and there are gaps in four major areas: (i) differences between job offers and applicants (mentioned above), (ii) gaps among regions, (iii) gaps among sectors, and (iv) gaps in employment patterns.

BOX 1: Livelihood options in humanitarian assistance

International humanitarian assistance has typically used two instruments to promote livelihood recovery after disasters: cash transfer and public works programs (cash for works).

Cash transfers are typically used to provide short-term assistance to the most vulnerable affected people. To be effective, cash grant programs must be well targeted (for example, aimed at the elderly, widows, refugees), be transparent, have sound mechanisms for monitoring and evaluation, and have a clear exit strategy. Typical programs implemented during the 2005 Pakistan earthquake and 2004 Sri Lanka Tsunami involved a transfer of $50 per month per target household for a period of four to six months. Often, cash transfer programs coexist with, or graduate, to become CFW programs.

Cash-for-work (CFW) programs have been common tools for humanitarian assistance. These programs provide cash to affected people in return for their work on various recovery projects, such as debris removal and the repair or reconstruction of damaged infrastructure. They have been used in many disaster situations, including the 2004 Indian Ocean Tsunami, the 2008 Myanmar Cyclone, and the 2010 Haiti earthquake.

CFW programs were developed as an alternative to food-for-work (FFW) programs, in which affected peoples could receive food in return for their disaster-recovery and mitigation work (during droughts and famine). Cash has several advantages over food as a worker incentive: (i) related logistics are less complex and management costs are lower; (ii) workers can choose what they buy, thus empowering them; and (iii) cash has a large market impact when it is spent locally. At the same time, CFW programs must avoid crowding out the normal job market and, like cash transfers, require close monitoring.

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POLICY RESULTS AND OUTSTANDING CHALLENGES

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FIGURE 3: **Recovery process of labor markets of the three major affected prefectures**

Source: MHLW.

FIGURE 4: **New-job-opening ratios of the affected prefectures**

Source: MHLW.
In common with other disasters, job opportunities have disproportionately been concentrated in urban areas. Figure 4 illustrates trends in new-job-opening ratios by prefecture. Miyagi Prefecture—where Sendai City, the capital of the Tohoku region, is located—has been attracting more jobs than the other two prefectures. Even within the Miyagi Prefecture, job opportunities are concentrated in the Sendai metropolitan area (a new-job-opening ratio of 1.17 in February 2012), while Ishinomaki and Kesennuma, both of which are located on the coastal areas severely affected by the tsunami, offer relatively scarcer job opportunities (ratios of 0.77 and 0.55, respectively).

Additional gaps are seen among job sectors. With rising reconstruction demand, many new job offers come from construction and related industries, with relatively fewer offers in the manufacturing and distribution industries. Job applicants, on the other hand, appear to be seeking occupations more focused on food processing and clerical work.

A final gap is seen in employment patterns. In spite of an increase in job offers, most involve part-time or short-term employment. The job-opening ratio for full-time, regular workers in Miyagi Prefecture in February 2012 was only 0.49. The situation for those who are looking for regular, full-time work is therefore not as favorable as the general statistics suggest.

Part of the reason why a large proportion of job openings involve so much short-term employment relates to the government-supported emergency job-creation project. Between March 2011 and February 2012, 31,700 workers—or 22 percent of all job offers in the Iwate, Miyage, and Fukushima prefectures—stemmed from the emergency job-creation project (figure 5).
This finding has key two implications. First, the government-initiated job-creation policy has been effective in sustaining the job market in disaster-affected areas. In its absence, unemployment issues would have been far more severe. At the same time, the transition from CFW jobs to regular jobs has been a difficult challenge for the economic recovery process.

CFW programs in developing countries typically assist in the process of economic recovery and even economic growth: this is plausible since disasters in developing countries tend to affect growth rates positively. As such, CFW programs fill an important employment gap immediately following a disaster, after which economic growth creates sufficient permanent jobs to take over.

But economic recovery in developed countries does not necessarily follow this trend: the populations of the three prefectures affected by the GEJE had been declining since before the earthquake. As an economy shrinks, it does not necessarily generate sufficient permanent jobs to take over the role of emergency job-creation programs. Japan could well be facing this problem.

**LESSONS**

- Dedicated emergency job-creation programs, complemented by cash transfers to the most vulnerable, can be effective ways to assist disaster-affected people during a recovery. At the same time, they need to be adjusted progressively to emerging job markets, and avoid cluttering them in the process. More prolonged assistance may be needed when local economies are contracting.

- The livelihood needs of disaster-affected people are diverse, and thus require diverse solutions. The most vulnerable may need cash transfers, whereas those already benefiting from pensions (for example, the elderly) may need primarily an occupation to make them feel needed. Others—such as widows with young children—require regular employment with insurance benefits.

- The experience of the GEJE shows how learning from past disasters has been used effectively to design the emergency job-creation project. Regulatory measures and market forces alone did not succeed in creating jobs following the Kobe disaster. The GEJE helped launch a more proactive government project, which promoted diverse employment and partnerships with NGOs and the private sector, while retaining the means to monitor its overall progress.

- The GEJE job-creation program has been innovative in facilitating public-private and public-public partnerships. In particular, hiring staffing agencies helped reduce the administrative burden, which would otherwise have prevented many employers from engaging the victims of the disaster.

- Matching jobs with the needs of the jobless is a very important but difficult task. Most of the affected areas have seen excess labor demand and labor supply simultaneously, but in different sectors, and urban areas have clearly benefited over rural areas. Interventions such as continuous monitoring of job supply and demand, job retraining, and further integration with municipal plans are necessary to effectively complete the recovery.
Unemployment insurance can be effective in securing the incomes of those affected. But there are several limitations: (i) unemployment insurance does not cover self-employed workers and those who run private enterprises and (ii) the national government has twice had to extend the beneficiary period of insurance, allowing even those covered for the shortest period to benefit from the program until January 2012. Unemployment insurance therefore needs to be seen as part of a broader livelihood recovery program following a disaster.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- To the extent feasible, CFW and employment programs following a disaster should expand the range of work opportunities, from simple manual labor for infrastructure reconstruction to nonmanual work. While in developing countries most of those affected are poor and unskilled, megadisasters such as the Haiti earthquake of 2010 also affected skilled workers. It is important that all be given opportunities to contribute meaningfully to the recovery and reconstruction of their neighborhoods, although priority for external assistance must naturally be given to the poorest and most vulnerable. In particular, the jobs created should be:
  - Appropriate to the workers’ skills and abilities.
  - Help boost the morale and self-esteem of those affected.
  - Build upon the workers’ skills, to help them secure their next occupation.

- The balance between quality and quantity needs to be planned carefully in developing countries, where the primarily goal is often to provide rapid cash relief to the poorest and most vulnerable of the disaster victims. As a rule, the proportion of labor to the total costs of the activity should therefore remain high (for example, 50-80 percent). CFW schemes need also to be designed with a view to providing a smooth transition to long-term jobs, and avoid attracting people back to vulnerable urban areas. As such, prevailing wages should be set just below the market rate for unskilled manual labor, thus ensuring that programs attract only those without other alternative means to earn income, and do not crowd out more permanent job creation.

- In the above context, CFW schemes in developing countries differ from those promoted under the GEJE. Under the GEJE, the beneficiaries of the job-creation project were paid market wages, as there was no possibility of circumventing minimum wage regulations. In addition, as they had the option of claiming unemployment insurance, it was important to set the wages at levels sufficiently attractive to motivate them to work. Statistics in the GEJE prefectures do not show that this approach—at least in Japan—caused wage inflation. Thus, it was not supposed to prevent a transition to normal employment.

- Similar to the experience of Japan, CFW programs in developing countries need to be part of a broader social protection program which can include cash transfers to the most vulnerable, such as was done in the aftermath of the Pakistan earthquake.
or Sri Lanka tsunami. If so, the eligibility, amount, and duration of payments, and cash-delivery mechanisms must follow transparent procedures.

- Periodic evaluations are essential to determine whether livelihood programs are reaching their goals, and allow for corrections among program partners. In the case of Haiti, for example, preliminary evaluations pointed to the need to better target the most vulnerable, while avoiding prolonged aid dependency. A particularly neglected aspect tends to be seasonal competition between CFW and agriculture or fishing occupations, as well as assistance to people who, while not direct victims of the disaster, may be under traditional obligations of sheltering family members, with consequent strains on food supplies.

- Job-creation programs in Japan tend to be smaller than those in developing countries—most hire fewer than 100 people each. Although this model is not necessarily an efficient way to maximizing employment, it helps integrate CFW programs with long-term job opportunities, as employers are directly responsible for supervising and caring for employees.

- The case of the Securite Supporting Fund in Japan proves the effectiveness of e-commerce in directly linking affected people with potential benefactors. This has also been observed in other recent megadisasters (for example, the Pakistan and Bangkok floods), where the social media increasingly played an important role in disaster recovery (see also KN 4-2).

- While CFW programs are effective schemes for the short term, the transition from CFW jobs to regular jobs is a difficult challenge. Job opportunities for construction works will complete within a few years. Government support for creating regular jobs is essential in devastated areas—such as arranging jobs, building factories, rehabilitating facilities of irrigation and fishery harbors, and resolving double debt (KN 6-4).

**KEY REFERENCES**


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Prepared by Junko Sagara, CTI Engineering, and Keiko Saito, World Bank
Hazard and risk assessments are the crucial first step in disaster risk management (DRM) and the basis for formulating DRM policies. They must take into account worst-case scenarios in the event of the largest possible hazard, while recognizing that hazard assessments of earthquakes and tsunamis will always have their limitations and associated uncertainties. In Japan so-called hazard maps, that combine hazard information with evacuation routes and locations of evacuation centers, are effective tools for promoting evacuation procedures and risk awareness among the public. However, in the case of the Great East Japan Earthquake (GEJE), these hazard maps, created before the event, may have given people a false sense of security by underestimating the disaster’s potential impact. Hazard maps should be designed to guide and facilitate prompt evacuation. They should be easy to understand and readily available.

Risk assessment involves estimating the hazard levels of possible earthquakes and tsunamis to be considered when formulating disaster management policies. It is the first step in developing disaster risk management (DRM) plans and countermeasures. In Japan, the responsibility for risk assessment rests with government agencies at multiple levels. Implementing agencies at the national, prefectural, and municipal levels normally conduct risk assessment to inform their planning and the design of preventive measures. The national government is responsible for providing information and technical assistance to help prefectural and municipal entities assess risks properly and to reflect these risks in DRM measures.

**FINDINGS**

**MEGADISASTER HAZARDS CONSIDERED IN RISK ASSESSMENT**

In Japan, countermeasures against earthquakes and tsunamis have been based on the risks associated with five large earthquakes that have occurred over the past several hundred years (figure 1 and box 1). The Central Disaster Management Council has set up a committee to investigate and assess the potential hazard levels and expected damages.
from each of these scenarios. The committee also developed DRM strategies and a master plan for preventive actions as well as postdisaster response and recovery measures. DRM measures implemented at the national, prefectural, and municipal levels have traditionally been based on these strategies and plans.

The March 11 disaster occurred in the vicinity of the Japan and Chishima trenches—the region where the Central Disaster Management Council’s committee had investigated trench-type earthquakes. From the list of past earthquakes in the region (figure 2), eight were selected for consideration, based mainly on their intensity, frequency, and the possibility of recurrence in the same area. The selected historic earthquake scenarios included the Meiji-Sanriku Earthquake Tsunami of 1896, which generated a giant 20-meter-high tsunami, and Miyagi-ken-oki (Miyagi Prefecture) earthquakes that have been occurring at 40-year intervals. On the other hand, earthquakes such as those off the coast of Fukushima Prefecture were not selected because their probability of occurrence was estimated to be low, at 7 percent (figure 3). Furthermore, the Jogan Earthquake of 869, believed to have caused massive tsunamis in the east Japan region, was excluded because the available modeling techniques were unable to replicate its seismic intensity and tsunami height, and the probability of recurrence in the same area was considered to be very low.
Risk Assessment and Hazard Mapping

As illustrated in figure 2, the March 11 earthquake had a very large epicentral and tsunami source area, larger than any earthquake recorded in Japan’s history. Furthermore, its magnitude of Mw9.0 exceeded the hazard level of any earthquake in the country ever considered for purposes of disaster management. Thus, the extent of the high seismic intensity area of the actual earthquake was much larger than expected, and the area that experienced Japanese seismic intensity of 5+ or larger was about 10 times the estimate (figure 4). Furthermore, the actual tsunami height was twice the height used in the predisaster tsunami hazard predictions (figure 5).

Because the magnitude of the GEJE and tsunami far exceeded the predisaster estimates, the Japanese government has been revising its methods of assessing earthquakes and

BOX 1: Principles for selecting large-scale earthquake scenarios and the actual earthquakes selected

- Repeated occurrence
- High probability of future occurrence
- Possibility of occurring within the next 100 years
- Not considered if an active fault earthquake has occurred in the last 500 years
- A significant number of occurrences can be identified in historical records
- Magnitude is between M7 to M8
- Consider the economic and social activities and central administrative functions to be protected

Earthquakes meeting the above criteria:

- Tokai earthquake (M8.0)
- Tonankai/Nankai earthquake (M8.6)
- Japan and Chishima trenches earthquake (M7.6-8.6)
- Tokyo Metropolitan inland earthquake (M6.9-7.5)
- Chubu and Kinki inland earthquake (M6.9-8.0)
FIGURE 2: Historical occurrence of trench-type earthquakes in the vicinity of Japan and the Chishima trenches

Source: CAO.
FIGURE 3: The probability of occurrence, magnitude, and location of potential earthquakes in Japan

Source: Headquarters of Earthquake Research Promotion.
FIGURE 4: Actual versus predicted seismic intensity

Source: CAO.

FIGURE 5: Actual versus predicted tsunami height

Source: MLIT.
tsunami hazards. The Basic Disaster Management Plan, revised after the GEJE, provides the following guidelines for estimating earthquakes and tsunamis.

- Earthquake and tsunami countermeasures should be based on scenarios that take into account the largest-possible earthquakes and tsunamis, which should be considered from every possible angle using all scientific means.

- Earthquake and tsunami scenarios should be based on the most accurate earthquake records available, going as far back in history as possible, and in combination with an analysis of historical literature, topographical and geological studies, as well as other scientific findings.

ESTIMATING DAMAGE

Because of the underestimation of the earthquake and tsunami hazards, the damage caused by the GEJE far exceeded the predisaster damage estimates. The number of completely destroyed buildings was about six times the estimated amount, and the number of human lives lost was more than seven times the estimation (table 1). The conventional methodology for estimating damages can be characterized as follows.

- Quantitative estimation including direct physical damage, human loss, damages to lifeline and transportation infrastructure, economic losses (direct and indirect).

- Qualitative estimation including fires induced by tsunami; critical lifeline infrastructure facilities such as power plants, gas production plants, water and wastewater treatment plants, and so forth.

- Three scenarios reflecting different seasons and times of day (winter 5 am, summer 12 pm, winter 6 pm), which are likely to affect fire scale and incidence.

<table>
<thead>
<tr>
<th>TABLE 1: Comparison of estimated and actual damage</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Estimation</strong></td>
</tr>
<tr>
<td>Area with seismic intensity of 5+ or larger (km²)</td>
</tr>
<tr>
<td>Inundation area (km²)</td>
</tr>
<tr>
<td>Buildings completely destroyed</td>
</tr>
<tr>
<td>Disaster waste (tons)</td>
</tr>
<tr>
<td>Deaths (includes missing)</td>
</tr>
</tbody>
</table>

*Note: The figures for estimation reflect the larger of the damage estimates for the Miyagi-ken-oki and Meiji-Sanriku earthquakes.
ᵃ. Estimation of deaths uses the case of the Meiji-Sanriku earthquake case with a low disaster awareness level.
ᵇ. Deaths from the GEJE as of January 31, 2012.*
A facility is considered to have received no damage if it is equipped with enough mitigation measures against ground motion and fire.

A quantitative estimation of the impact was carried out using the relationship between the magnitude of the hazard (seismic intensity, maximum ground velocity, tsunami inundation depth, and so on) and the actual damage (number of destroyed houses, human loss, and so on), which was established based on historical earthquakes. For example, tsunami damage to buildings was estimated using the assumption that a building is completely destroyed if the inundation depth is 2.0 meters or more based on empirical evidence. Human losses caused by tsunamis were estimated based on the tsunami-affected population and historical records of death by tsunami inundation depth and estimated evacuation rates (percentage of people who can obtain warning information and the time it takes for people to evacuate). These were calculated for 50-meter-by-50-meter grid cells, and overlaid on exposure data, such as spatial socio-demographic data, available nationwide from the Geospatial Information Authority of Japan (GSI). Furthermore, infrastructure damage was estimated on the basis of the estimated number of destroyed buildings, lifeline failure rates and the number of days required for restoration, for which empirical relationships have been established based on previous disasters.

The underestimation of damage in the case of the GEJE was largely due to an underestimation of the magnitude of the hazards involved. Also, it has been pointed out that some factors—such as evacuation rates—used for damage estimation purposes were higher than actual rates, which could have further contributed to an underestimate of human losses. At the time of this writing, the damage estimation methodology is being revised.

**EARTHQUAKE AND TSUNAMI SIMULATION AND HAZARD MAPPING**

Hazard maps provide important information to help people understand the risks of natural hazards and to help mitigate disasters. Hazard maps indicate the extent of expected risk areas, and can be combined with disaster management information such as evacuation sites, evacuation routes, and so forth. In Japan, hazard maps are prepared and made available for various hazards such as earthquakes, tsunamis, floods, landslides, liquefaction, and volcanic eruption (KN 5-2 and 5-3).

Japan’s prefectural governments conduct hazard mapping, and the hazard data they prepare, for example, expected inundation depth and extent, is in turn used by the municipalities to prepare disaster management maps called hazard maps, that indicate not only the expected hazard but also information such as evacuation routes and evacuation sites (figure 6). The Act on Special Measures for Earthquake Disaster Countermeasures, passed in 1995, mandates the prefectural governments and local municipalities to prepare these maps to promote awareness of earthquake and tsunami risks in their respective jurisdictions. As of 2010, more than 80 percent of the prefectures had prepared tsunami inundation maps and 50 percent of coastal municipalities were equipped with tsunami hazard maps.

The national government provides technical assistance and guidelines to promote hazard mapping by local governments. In 2004, the central government prepared *Tsunami and Storm Surge Hazard Map Guidelines* to help the municipalities in creating hazard maps and to promote the use of hazard maps throughout the country. The guidelines provide infor-
FIGURE 6: An example of a tsunami hazard map, Miyako City, Iwate Prefecture

Source: Miyako City.

TABLE 2: Methods for defining inundation risk areas

<table>
<thead>
<tr>
<th>Method</th>
<th>Procedure</th>
<th>Advantages/disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Numerical simulation in time series</td>
<td>Use numerical models to estimate inundation area as well as inundation depth and flow velocity, inundation time.</td>
<td>Precise assessment is possible and can take into account the effects of the disaster mitigation structures. Resource intensive.</td>
</tr>
<tr>
<td>Level-filling method</td>
<td>Calculate the inundation based on the height and width of the tsunami and estimate the extent of inundation based on the topographical data.</td>
<td>Not so resource intensive. Ignores the effects of structures and buildings and the momentum of water flow (tsunami run-up).</td>
</tr>
<tr>
<td>Prediction based on past inundation</td>
<td>Define the risk area based on the inundation area of historical tsunami events.</td>
<td>Simple and low cost. Cannot be used for areas with no historical records. Cannot reflect changes such as construction of disaster reduction facilities.</td>
</tr>
<tr>
<td>Estimation based on ground elevation</td>
<td>Define high-risk areas as those areas lying lower than the expected tsunami height.</td>
<td>Simple and low cost. Cannot take into account the effects of structures and buildings and the momentum of water flow (tsunami run-up).</td>
</tr>
</tbody>
</table>
Information on the basic concepts of tsunami and storm surge hazard maps, and the standard methodology for preparing them. The guidelines explain in depth the numerical simulation methodology for identifying inundation risk areas, which is the principal means of tsunami hazard mapping. Alternative methodologies, as shown in table 2, are also explained so that the best method can be selected according to the resources and data available. Numerical simulation of tsunamis generally requires the following steps.

**FIGURE 7: Hazard map usage patterns**

Source: CAO.

**FIGURE 8: Inundation area: hazard map versus actual**

Source: CAO.
• Development of a fault model
• Topographic data
• Setting of initial water level conditions (typically uses the vertical displacement calculated by the fault model)
• Calibration and verification of the model
• Predictive simulation

Hazard maps in Japan have been used by the municipalities to design evacuation procedures. But they have not been utilized for land use or development planning. The lessons learned from the GEJE have prompted the Japanese government to implement a new act to create tsunami-resilient cities. The new legislative framework calls for the prefectural governments to prepare an inundation risk map, which is to be used for regulating land use and mitigating the effects of a tsunami (KN 2-7).

HAZARD MAPS IN THE DISASTER-AFFECTED AREAS

All municipalities hit by tsunamis during the GEJE had prepared hazard maps before the earthquake and tsunami. But surveys show that only 20 percent of the people knew about these hazard maps (figure 7); and the extent of flooding indicated on the hazard maps was in many cases underestimated compared to the actual inundation area (figure 8). It is likely that these maps provided residents with a false sense of safety, and prevented people from evacuating, resulting in greater human losses.

LESSONS

• Hazard assessment is critical since it serves as the basis for DRM policies. Earthquake and tsunami hazard assessment is conducted extensively in Japan to raise public awareness and to prepare for disasters.

• Predisaster damage estimation was low due to the underestimation of hazard levels. Past assessments did not adequately consider certain kinds of damage, including from long-period seismic waves, tsunami-induced fires, and nuclear accidents.

• Recognizing the uncertainties associated with hazard assessment, the largest-possible hazard scenario should have been used, drawing on all available information including not only seismological but also geological, archaeological, and historical studies looking at tsunami deposits, ancient documentation, and so on.

• Hazard maps were developed by all municipalities in the disaster-hit areas, and served as important tools for designing evacuation procedures.

• Hazard maps should facilitate and guide people’s evacuation efforts and should not contribute to a false sense of safety. Providing information on inundation risk zones
for multiple levels of hazards including low-frequency events, or information directly linked with tsunami warnings would be effective. The meaning of the information provided on the maps needs to be clear and adequately explained to the users.

- Risk information must be communicated to the public effectively. In the GEJE, only 20 percent of the people made use of hazard maps.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- Understanding hazard and risk is a vital component of DRM. Quantitative estimation of potential damage is important as it informs the appropriate strategies and measures to be taken. Risk exposure data should be collected, mapped, and shared as they are vital components of risk assessment.

- While bearing in mind that the hazard assessment of earthquakes and tsunamis has limitations and uncertainties, the largest possible hazard should be investigated and considered in formulating DRM policies. Hazard assessment should not rely solely on statistical analysis based on historically recorded earthquakes and tsunamis, because historical records may not account for the maximum-possible hazard levels that may occur in the future. Also, disasters have occurred for which there are no records available. The level of hazard to be used in designing structural measures should be selected based on local conditions. Hazard and risk assessment should be revised and updated periodically with the latest findings and in light of more recently experienced disasters.

- Hazard maps are effective tools for promoting risk awareness, for designing evacuation procedures, and for deciding the locations of evacuation facilities and shelters. Hazard maps should be easy to understand and easy to use for purposes of prompt evacuation, and users should be aware of the limitations and uncertainties of the information they contain. Considering budget and technical constrains, risk estimation methods can be selected as explained in table 2.

- Sharing hazard and risk data and information is crucial. Data can be shared through central depositories that are open to the public, among other means (see KN 5-2).

**REFERENCES**


KNOWLEDGE NOTE 5-2

CLUSTER 5: Hazard and Risk Information and Decision Making

Risk and Damage Information Management
Prepared by Keiko Saito, World Bank. Special thanks to the Earthquake Engineering Field Investigation Team (EEFIT), United Kingdom.
In Japan, municipalities are mandated to produce hazard maps for floods, storm surges, volcanic eruptions, tsunamis, stagnant water, and landslides to which the municipality may be exposed. By combining exposure data with satellite images and aerial photographs, post-event damage assessments can be carried out with reasonable accuracy. Japan’s experience with the disaster of March 2011 demonstrates that having exhaustive data on exposure expedites the damage assessment process, thereby reducing the time required for compensation payments and insurance payouts.

Japan is known for its disaster preparedness. Less well known but no less important for disaster response is the country’s “data preparedness.”

Communities need to understand the risks they face, and to have access to early warnings. In Japan, maps that illustrate the likely extent of hazards and the location of evacuation centers and routes are distributed to households and public institutions, such as schools and hospitals, in an effort to raise public awareness of disaster risk. Immediately after the Great East Japan Earthquake (GEJE) and tsunami, information on the damage caused by the disaster was collected rapidly and shared among responding agencies using a variety of top-down and bottom-up tools, including remotely sensed data, public and private datasets, and online tools such as the Ushahidi-based sinsai.info Web site. The data-collection and dissemination effort underpinned assistance to the affected population, timely allocation of resources to areas in need, and effective reconstruction planning.

**FINDINGS**

**EX ANTE PUBLIC INFORMATION CONCERNING RISKS FROM NATURAL DISASTERS THROUGH THE MLIT HAZARD MAP WEB PORTAL**

In Japan, municipalities are mandated to produce maps related to the following hazards: floods, storm surges, volcanic eruptions, tsunamis, stagnant water, and geological hazards (landslides). These hazard maps include not only information on the expected intensity and...
extent of the hazard but also the location of evacuation centers and designated evacuation routes (KN 5-1). The hazard map Web portal prepared by the Ministry of Land, Infrastructure, Transportation, and Tourism (MLIT) includes a link to all available hazard maps, providing a one-stop shop where information on risks from natural hazards can be accessed (figure 1).

**EX POST COLLECTION OF DAMAGE DATA**

Learning from their experiences with past events, the Japanese Self-Defense Force (JSDF) has been upgrading its emergency response plans. One of the JSDF’s tasks is to capture video footage of the affected region immediately following a major disaster event. In the case of the GEJE, a helicopter was dispatched immediately after the main shock. It trans-
TABLE 1: Excerpts from survey of end users on the use of satellite-based remotely sensed data carried out by JAXA (2011)

<table>
<thead>
<tr>
<th>End user</th>
<th>Use of data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cabinet Secretariat</td>
<td>Spot checks of areas of interest, for example, Sendai airport, Fukushima nuclear power plant. Pre- and post-event images. Maps of maximum inundation.</td>
</tr>
<tr>
<td>Ministry of Land, Infrastructure, Transportation, and Tourism</td>
<td>Maps of maximum extent of inundation. Data based on interpretation of PALSAR and AVNIR-2 taken on March 21, 25, and 30, 2011. Information on areas with stagnant water also continuously provided. Request to monitor 40,000 areas designated as being at high risk from landslide. Wildfire monitoring.</td>
</tr>
<tr>
<td>Ministry of Agriculture, Forestry, and Fishery (MAFF)</td>
<td>Request for information on inundation and presence of stagnant water in agricultural areas. MAFF estimates inundated agricultural area to be 24,000 hectares in six prefectures. Information on inundation in the northern parts of Chiba and Ibaragi prefectures also requested. Data to be used by MAFF to validate ground surveys and for recovery planning.</td>
</tr>
<tr>
<td>Fisheries Agency</td>
<td>Collaboration sought to assist in offshore search for lost ships.</td>
</tr>
<tr>
<td>Ministry of Environment</td>
<td>Request to assist in mapping debris floating off the coast of Sanriku. 560,000 m² of debris already identified in vicinity of Rikuzentakata alone.</td>
</tr>
<tr>
<td>Ministry of Education, Culture, Sports, Science, and Technology</td>
<td>Images of Fukushima nuclear power plant.</td>
</tr>
<tr>
<td>Geospatial Information Authority of Japan</td>
<td>Providing all available imagery. Using electronic control points provided by GSI and InSAR data analyzed by JAXA, crustal deformation of 3.5 meters was identified in Oshika peninsula.</td>
</tr>
<tr>
<td>Miyagi Prefecture</td>
<td>Sighting of an SOS sign in a park in Miyagi Prefecture was reported by the International Charter.</td>
</tr>
<tr>
<td>Iwate Prefecture/University</td>
<td>Monitoring of road accessibility.</td>
</tr>
<tr>
<td>Kanto Regional Development Bureau</td>
<td>Mapping of liquefaction areas provided through International Charter.</td>
</tr>
</tbody>
</table>

In the immediate aftermath of a natural disaster, the collection of information on the damage allows appropriate resources to be allocated for response activities. Traditionally, data have been collected by sending people to the affected areas. During the past decade, however, the use of remotely sensed data has become viable for damage data collection thanks to improvements in the spatial resolution of such data (less than one meter with optical satellite images) and reductions in acquisition costs.
Following a disaster, satellite data are the first to become available, followed by aerial photographs, which provide more detailed images. Aerial surveys are subject to logistical delays, whereas satellites are already in orbit and can generally deliver data within 24 hours to a few days, depending on the satellite. With aerial surveys, by contrast, weather conditions must be good, and the area that a single image can cover is smaller than the area covered by a satellite image, prolonging the time required to photograph a given area.

The International Charter organization provides member states with a unified system of space data acquisition and delivery. Member states can request satellite data at no cost in the event of emergencies following natural or manmade disasters. Remotely sensed data are analyzed by predesignated value-adding vendors to derive and deliver the information requested by the affected country. After the GEJE, the International Charter was activated through the Cabinet Office of Japan, the designated authorized user in Japan. Products produced through the Charter ranged from maps of the extent of inundation from the tsunami to areas of liquefaction, spot checks in areas of interest, and estimates of the volume of debris (table 1).

PUBLIC-PRIVATE PARTNERSHIP BETWEEN AERIAL SURVEY FIRMS AND THE GEOSPATIAL INFORMATION AUTHORITY OF JAPAN (GSI)

Japan has been using remotely sensed data following major natural hazard events for some time. In 1995, following the Hanshin-Awaji earthquake, the National Broadcasting Corporation (NHK) flew helicopters with high-definition video cameras over Kobe city to capture the damage. Private aerial survey firms deploy aircraft to take aerial photographs and other types of remotely sensed data (for example, LiDAR data, in the case of landslides or volcanic eruptions) following every natural disaster event in Japan. Currently the major aerial survey companies have a public-private partnership with GSI under which they jointly capture damage information, thus avoiding duplication of effort. The agreement has been in effect for some years, resulting in an archive of records documenting the changes caused by natural disasters in Japan.

Following the GEJE and tsunami, the partnership spent a month taking aerial photographs of the coastline of the entire Tohoku region coastline (approximately 500 kilometers).

TSUNAMI INUNDATION MAPPING USING REMOTELY SENSED DATA

As early as five days after the tsunami, the GSI announced the first estimate of the total inundation area as 400 km², based on manual interpretation of aerial photographs taken on March 12 and 13. One month after the event, on the April 18, the government officially announced the total inundation extent to be 561 km². The increase reflected the availability of additional aerial photographs and high-resolution optical satellite images of areas previously not covered.

Although GSI’s inundation mapping was considered the official information, other organizations used various methodologies and data sources to map the extent of inundation. A list of these can be found in EEFIT (2011).
TABLE 2: Examples of the difference between estimates of affected population in municipalities in Miyagi Prefecture using two different estimates of extent of inundation

<table>
<thead>
<tr>
<th>Municipality</th>
<th>Population total (2007 census)</th>
<th>Population within inundated area</th>
<th>Difference between GSI and private company</th>
<th>Difference as percentage of total population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Miyagino-ku</td>
<td>182,678</td>
<td>17,375</td>
<td>5,517</td>
<td>3.0</td>
</tr>
<tr>
<td>Wakabayashi-ku</td>
<td>129,942</td>
<td>9,386</td>
<td>686</td>
<td>0.5</td>
</tr>
<tr>
<td>Taihaku-ku</td>
<td>222,447</td>
<td>3,201</td>
<td>682</td>
<td>0.3</td>
</tr>
<tr>
<td>Ishinomaki</td>
<td>167,324</td>
<td>112,276</td>
<td>9,606</td>
<td>5.7</td>
</tr>
<tr>
<td>Shiogama</td>
<td>59,357</td>
<td>18,718</td>
<td>18,545</td>
<td>31.2</td>
</tr>
</tbody>
</table>

For 30 municipalities the Statistics Bureau of Japan compared the difference between the estimate of the population affected by inundation derived using GSI’s aerial photographs with that produced by a private company. Some of the differences are shown in table 2. In most cases, the differences between the two estimates are negligible in relation to the total population in the respective municipalities. In a few cases, however, the difference amounted to more than 20 percent of the total population of that municipality. In Shiogama the difference between the estimates was more than 30 percent of the total population. The full comparison results can be found on the Statistics Bureau’s Web site.

In an independent validation of the mapping performed using JAXA’s ALOS satellite image and GSI’s aerial photographs, Sawada and his team (2011) found a substantial difference in the area shown as inundated: interpretations based on aerial photographs reported twice as much inundated area as interpretations based on satellite images.

Spatial data preparedness in Japan

Decision makers need spatial data to make informed decisions about disaster preparedness, post-event responses, and recovery planning. Spatial data provide information on the location of key infrastructure, populations, agriculture, industrial facilities, education and health facilities, and so on. In Japan these datasets are freely available from the GSI Web site in both raster and vector formats. Building-specific data on exposure levels are also commercially available for the entire country. Overlaying these datasets with the mapped hazard (for example, the extent of tsunami inundation) permits a rapid damage assessment. Commercial building-specific datasets were made available at no cost to enable response agencies to assist in the relief and recovery activities (figure 2).
Quick determination of government compensation and insurance payments through the use of aerial photographs

Aerial photographs were used in an innovative way to determine compensation payments from local governments and insurance payouts by the General Insurance Association of Japan. Because the area of inundation was clearly visible from aerial photographs, and because the tsunami was so powerful, it was deemed that structures located within the coastal inundation zones were 100 percent destroyed. The owners, therefore, were eligible for full compensation.

The innovation in these cases lies in the fact that payouts were made without sending an inspector or a loss adjuster to the address—that is, the aerial photographs were the sole source of claim verification. This system expedited the claim-payment process, resulting in an average payout by the earthquake insurance schemes of $250 million per day during the last week of April 2011—1.5 months after the earthquake (see KN 6-2).

Although data preparedness is advanced in Japan, some of the information is available only in Japanese, and navigating the Web sites where data are available can be difficult. Open Street Map (OSM) is an international volunteer technical community dedicated to producing freely available, detailed topographic data for the entire globe. Local volunteers donate their time to trace satellite images made available for the purpose. To accommodate the international community’s need for topographic maps and English annotation, OSM volunteers created detailed maps of the entire Tohoku coastal region and began publishing the resulting topographic maps online just a few hours after the main shock.

Source: All311 website.
Risk and Damage Information Management

When hazard information is combined with geocoded data on key infrastructure and mechanisms to analyze “big data” (for example, crowd-sourcing), it has the potential to provide damage information rapidly and with reasonable accuracy. In the case of the tsunami damage assessment following the GEJE, a binary damage-assessment system was used, in which building-level data on structures that had been geocoded before the event was overlaid on data on the extent of the disaster, permitting a high-confidence assessment of whether a building was destroyed.

Similar methodologies have been used and continue to be tested for earthquake damage assessment in Haiti and in Christchurch, New Zealand. Large-scale crowd-sourced earthquake damage assessments have been carried out with a view to operationalizing the methodology. Accuracy assessments are being performed to ascertain the level of accuracy that is achievable using these tools. Remotely sensed data has also been used for flood damage assessment. In all cases, it is clear that the accuracy of the damage assessment increases where pertinent data on key infrastructure are available, making a strong case for data preparedness.

Source: gdms.jp.

FIGURE 3: Online interface of Geospatial Disaster Management Mashup Service Study (GDMS)

Source: gdms.jp.
The OSM maps are open, that is, the data can be used across different platforms and without any restrictions. Another characteristic of the maps is that all annotations are available in the local language as well as in English. Moreover, the styles used in the maps are standardized, providing a consistent feel. In some countries, the OSM platform is being used as a tool to raise awareness in communities at risk from natural disasters by involving them in collecting data on their own communities.

**ONLINE PLATFORMS TO STORE AND DISTRIBUTE SPATIAL DATA FOLLOWING THE EARTHQUAKE AND TSUNAMI**

Much of the spatial data created following the GEJE is open data. Several online platforms have been created to host and distribute these open datasets to assist in damage assessment, to facilitate response and relief activities on the ground, and to help local communities. Two such platforms are the Emergency Mapping Team (EMT) and the Geospatial Disaster-management Mashup Service Study (GDMS, figure 3). Most of these platforms use a map interface, against which the data hosted on the system are visualized spatially.

**USE OF SOCIAL MEDIA FOR BOTTOM-UP INFORMATION SHARING**

In recent years, the use of social media in postdisaster settings has spread around the world. Even after the tsunami, when the entire phone network and Internet were down, information from the affected areas came through on social media such as Twitter and Facebook (KN 3-2). Many families stayed in touch using these media in the immediate aftermath. Japanese mobile networks and telecommunication companies have well-established systems that allow subscribers to leave messages for their loved ones. Google set up an online person finder after the GEJE.

Twitter, Facebook, and new types of social media such as Ushahidi are establishing themselves as a global standard for collecting information on needs in local communities. Ushahidi is an open source online interface that allows bottom-up information sharing. Developed to ensure a fair election in Kenya in 2008, the platform is designed to allow anyone to upload information or requests for help, using Twitter or emails, which are visualized on a map interface (figure 4), thus making them actionable items. Sinsai.info, a combination of Ushahidi and OSM Japan, was launched in the immediate aftermath of the GEJE, when OSM data was being used as the base map to display requests for help coming in from communities in the Tohoku region.

All311 is another site that was launched immediately after the event. Hosted by the National Research Institute for Earth Science and Disaster Prevention (NIED) and built using an e-community platform developed by NIED, the site is a one-stop shop for information on ongoing activities, both top-down and bottom-up, in the recovery process. Information is provided in Japanese only. E-community is an open source tool for developing information-sharing platforms with spatial content.
LESSONS

- Satellite images are available before aerial photographs, but they do not reveal as much detail. After the GEJE, a standing public-private partnership between the major aerial survey companies and GSI captured aerial photographs of the areas affected by the GEJE. GSI published an estimate of the inundated area five days after the event, based on manual interpretation of the aerial photographs then available.

- The limits of technology for response activities should be recognized. In the GEJE, the inundation area mapped from aerial photographs was much larger than that mapped from satellite images.

- By overlaying the tsunami inundation estimates with commercially available building-level datasets, it was possible, for insurance purposes, to designate structures that had been completely destroyed by the tsunami.

- Crowd-sourced methods for collecting damage information have great potential. After the GEJE, Open Street Map volunteers were mobilized to create topographical maps of the region with annotations in English and Japanese.
Online platforms were created to host and distribute spatial data useful for response and recovery. Sinsai.info and All311 are two examples.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

- A one-stop online portal is a good way of disseminating hazard maps for a given country. However, in countries where Internet access is not readily available, an online portal may not necessarily be optimal. Conventional methods, such as paper maps and booklets, should be utilized as well.

- Data preparedness is a key ingredient for both pre-event disaster risk management and post-event damage assessment and reconstruction planning. Data collection on key infrastructure should be carried out during normal times and kept up to date. The data can be used for other purposes such as town planning.

- Satellite images and aerial photographs are now routinely used for post-event damage assessment. Damage assessment can be carried out with reasonable accuracy by combining data on infrastructure with exposure data. Collected data should have a specific, well-managed repository and be paired with appropriate tools to analyze the data for risk-assessment purposes.

- New ICT tools are increasingly being used in emergency situations. Open source portals, such as the Ushahidi-based sinsai.info, are important tools that allow requests for help from local people to be logged and acted upon. Creating protocols for how these volunteer-based communities can work with official government entities is increasingly important.

**REFERENCES**


KNOWLEDGE NOTE 5-3

CLUSTER 5: Hazard and Risk Information and Decision Making

Risk Communication
Risk communication is an important component of disaster risk management (DRM) because it shapes people’s perceptions of risk and influences their actions with respect to disaster preparedness and disaster response. It also influences the intervention decisions that are made throughout the disaster management cycle. The credibility of the information source takes a long time to build and needs to be well established before a disaster strikes. In Japan, the level of trust in government and other official communications was sorely tested following the nuclear accident at the Fukushima Daiichi nuclear power station.

Disaster preparedness is often perceived as being mainly a governmental responsibility, with information and directives traveling from the top down. That is the case to some extent, since local communities generally lack the tools and skills needed to conduct scientific risk assessments and fully understand the underlying risk in their localities without expert assistance. The problem with the top-down approach is that policies may be imposed on communities without taking local conditions into account, and communities may become overly dependent on information coming from the government. Recent experiences from the Great East Japan Earthquake (GEJE) showed that when the local community was involved in planning for disaster preparedness, and people took ownership of their own safety plans, they were better prepared and better able to take the necessary actions to protect themselves.

Successful risk communication occurs when there is holistic learning, facilitation, and trust. In holistic learning, the gap in knowledge between the information sender and receiver is minimal (figure 1). Hazard maps, booklets, and videos can all help narrow that gap when it comes to disaster education and risk communication.

Normally, the information generators or senders are government agencies, universities, or research institutions that have the capacity to assess risk and the political mandate to implement DRM measures. The information receivers are the communities, businesses, and individuals who have knowledge of the local area and are the ultimate users of the risk information (figure 2).
FINDINGS

THE IMPORTANCE OF TRUSTING THE INFORMATION PROVIDER

Early warnings greatly influence how people perceive and evaluate the risks from the imminent hazard and their subsequent decision to evacuate. In this respect, the level of trust in and the credibility of the person, institution, or medium issuing the warning is of crucial importance.
importance. Furthermore, factors such as fatalism can affect evacuation decisions. People who have responded to too many false alarms may not take the warnings seriously.

In some cases, the underestimation of the height of the tsunami in the warnings that went out on March 11 likely delayed evacuation and possibly increased fatalities (KN 2-5). Japan’s proposed new early warning scheme will not include any numerical values for tsunami height in the first warning but will use more descriptive expressions, such as “massive” or “very high” waves, in the event of earthquakes larger than magnitude 8. These terms will be further qualified by expressions such as a “tsunami height equivalent to the GEJE is expected.”

OFFICIAL RISK COMMUNICATION TOOLS: HAZARD MAPS

In Japan, hazard maps indicate expected hazard levels and locations as well as the location of evacuation centers and routes (KN 5-1). The map shown in figure 3 was prepared by the village of Toni (Kamaishi City, Iwate Prefecture) in a local workshop with community members. It includes predicted inundation depths indicated by colors, historical records of inundated areas, lead times, evacuation shelters, and telephone numbers for warnings. The hazard map was printed and distributed to all families in Toni before the GEJE.

Developing this type of disaster map through a participatory process is an effective way of communicating risk to the community at large. A post-disaster survey in the Toni area identified citizens’ motivations for participating in the mapmaking process (figure 4).

PROBLEMS WITH THE HAZARD MAPS IN USE

Mapping schemes differ in the colors and symbols used to convey hazard information. In the United States, efforts are being made to ensure the consistency of the content of hazard maps, as well as their design.

While hazard maps are useful tools to help communities understand the risks they face, there are, nevertheless, uncertainties associated with the assessment of the hazard risk itself—future disasters may exceed the levels indicated on the maps. In addition to producing and delivering the maps, their content should be presented to local communities, as was done in Toni Village. In the course of such presentations, governments and experts must explain the limitations of prediction technology. In the GEJE, the maps provided residents with a false sense of safety. Only 20 percent of residents utilized hazard maps for their evacuation in the GEJE (KN 5-1).

Another way of raising awareness of risk is through evacuation drills carried out under as many different scenarios as possible, for example, at night or in rainy weather (KN 2-6). Education at school is also effective to prepare for disasters (KN 2-3).

Although risks from tsunamis are now well understood in the wake of the March 11 event, communities must also become aware of the risks from other possible disasters, such as landslides or cyclones. A Web portal maintained by the Ministry of Land, Infrastructure,
Transport, and Tourism provides access to all hazard maps created throughout the country. See KN 5-2 for details.

INFORMAL TOOL: LOCAL KNOWLEDGE ALONG THE SANRIKU COAST

The Tohoku region has two contrasting topographic characteristics: the Sendai plain, south of Sendai City, which is relatively flat and offers little access to higher ground close to the coast. The other is the Sanriku-rias coast north of Sendai, where the mountains are near the coast. These topographical characteristics influence the kinds of informal evacuation strategies used in the respective areas.
**FIGURE 4:** Reasons given by people in Toni Village for participating in the hazard mapping exercise before the GEJE

- I suffered from disaster in the past: 42%
- I felt danger in the past: 35%
- I want information about potential disasters: 59%
- I want to go along with my neighbors: 29%
- I am a *jichikai* administrator: 9%
- I am a firefighter: 7%
- I am interested: 40%
- Other: 2%

*Tendenko* is a term used in the Sanriku coastal area, referring to self-evacuation without stopping to look for family members, neighbors, or relatives. The assumption is that everyone will be self-evacuating, and therefore there is no need to be concerned about others. Depending on the location of an earthquake’s epicenter, the lead time between the main shock and the arrival of the tsunami can be short. In these cases it is imperative that people self-evacuate without delay. This is practical in the coastal area of Sanriku because of the proximity of higher ground (figure 5).

But the *tendenko* concept does not apply in the Sendai plain because there is no higher ground nearby (figure 6). There, public buildings such as schools or community centers are used as evacuation centers.

**RISK COMMUNICATION FOLLOWING THE ACCIDENT AT THE FUKUSHIMA DAIICHI NUCLEAR POWER STATION**

The accident at the Fukushima Daiichi nuclear power station highlighted the issue of risk communication in nuclear emergencies. The Investigation Committee on the Accident at the Fukushima Nuclear Power Stations (2011) reported that “Communication from the government had been far from ideal. The government delayed providing urgent information, withheld press releases, and was unclear in its explanations. Neither those directly affected by the accident at the Fukushima station nor the public at large believed that the government was providing truthful and accurate information in a timely manner. Examples include the government’s information about the status of the reactor cores—core melt-downs in particular—and the critical condition of unit 3, as well as the unclear statement, repeated several times, that the radiation ‘will not immediately affect human bodies.’”
Nuclear and Industrial Safety Agency (2012) reported that “Seventy-four percent of people at the affected areas were dissatisfied with the information provided because:

- The background and the reasoning behind the reports and recommendations coming from the official sources were not well explained and therefore could not be trusted.
- The briefings did not include enough detail.”

Also, the government committee pointed out that “water contaminated by radiation was discharged into the ocean without notifying neighboring countries. Although this did not violate any relevant international conventions, it may have led the international community to question Japan’s competence in responding to nuclear disasters.”
LESSONS

EARTHQUAKE AND TSUNAMI RISK COMMUNICATION

Risk communication is meant to help people save their own lives. For communication to be effective, people must be able to trust the information and its source, and it takes a long time to build that trust.

There are formal and informal tools for communicating risk. Hazard maps and early warnings systems are the formal tools that Japan has used, both of which are being revised in light of the GEJE, since both underestimated the actual risk. Hazard risk information should be continuously updated.

Informal communication tools include local knowledge such as tendneko practiced on the Sanriku coast, where self-evacuation without waiting for family members and others is encouraged as soon as a large ground shaking is felt. These types of approaches and local knowledge based on experiences with large tsunamis should be preserved and passed from generation to generation.

Participatory DRM planning by the local community is an effective way of communicating risk. Different forms of communication may have to be used for different age groups. The local social structure can be leveraged to facilitate emergency planning, for example, by enlisting local leaders in their various roles and functions.

Regular drills and education also have an important role in shaping the perception of risk in local communities.

Complacency is a constant problem. Even people who have already experienced disasters need to be reminded of the importance of being prepared. People can also become overly reliant on early warning systems.

NUCLEAR ACCIDENT

Japan’s Nuclear and Industrial Safety Agency, a government regulatory body, has proposed the following actions to improve risk communication in the event of nuclear accidents:

**Develop technical capacity.** The technical capacity of staff to analyze information on accidents and to implement countermeasures should be enhanced through specialist training programs.

**Develop communication capacity.** Communication officers should be trained in disaster risk communications. Preparing manuals, communication materials, and answers to frequently asked questions is also necessary. Communication channels should be established with the mass media, the public, embassies, and local agencies.

**Develop coordination capacity.** Mechanisms for information sharing should be established among relevant agencies such as the Office of the Prime Minister and the Ministry of Foreign Affairs. Communication equipment and manuals are also necessary.
RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Establish trust between information senders (for example, the government) and receivers (local communities). Trust is a big part of effective risk communication. If the information source cannot be trusted, real communication is impossible—and it takes a long time to establish trust. Complacency is also an issue: Overreliance on early warnings, hazard maps, and incoming information should be discouraged.

Use a variety of tools to communicate risk. Risk communication tools range from sophisticated communication systems to participatory emergency planning, including community hazard mapping, disaster evacuation drills, neighborhood watches, instruction in schools, and the passing of experience from generation to generation based on previous events.

The way in which risk is communicated in the early warning system is also important. Although sophisticated early warning systems and technologies are important during a disaster, the public should understand limitations of prediction technology.

Leverage the interest that local leaders may have in community preparedness and be aware of social structures, which vary from country to country and place to place. Work with local change agents to provide training and to develop an appropriate risk communication strategy.

Take a multihazard approach. The difference in Japan’s preparedness for the earthquake and tsunami versus its preparedness for the nuclear accident following the GEJE demonstrates the importance of considering all hazards, not just those that are most likely to happen. A good communication strategy is one piece of an overall response plan, which was lacking for the nuclear accident at Fukushima Daiichi.

Update and monitor. Risks are dynamic and change over time depending on population increases or decreases, the development of new industrial facilities and commercial properties, the availability of new hazard information, and scientific innovations (KN 2-8). Risk information should be updated regularly and reflected in risk communication strategies.

REFERENCES


KNOWLEDGE NOTE 6-1

CLUSTER 6: The economics of disaster risk, risk management, and risk financing

Measuring the Cost-effectiveness of Various DRM Measures
Measuring the Cost-effectiveness of Various DRM Measures

The Japanese experience shows that—if done right—preventive investments pay. The Japanese government invested about 7 to 8 percent of the total budget for disaster risk management (DRM) in the 1960s, a move that most probably decreased disaster deaths. Cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) of DRM projects have been widely implemented both at national and local levels in Japan. Different procedures for such analysis have been followed according to the type of project, the funds, and the governing entity responsible. The Japanese experience shows that CBA is applicable to DRM-related projects and is a useful tool in choosing among different options and understanding the effectiveness of a project.

INTRODUCTION

The Great East Japan Earthquake (GEJE) and other recent disasters remind us of the importance of early actions to implement adequate prevention measures, mitigate risks, and establish sound postdisaster financing mechanisms to reduce human, economic, and financial impacts. Even if documented evidence is still lacking, there is a growing consensus that investing in disaster risk management (DRM) is cost-effective, though measuring cost savings is difficult. Several lessons can be derived from the CBA and CEA conducted in Japan.

FINDINGS

NATIONAL BUDGET FOR DRM

Every year many people lose their lives and property in Japan due to natural disasters. Up until the 1950s, numerous large-scale typhoons and earthquakes caused extensive damage and thousands of casualties (figure 1). In the 1960s DRM spending represented 7 to 8 percent of the national budget (figure 2). As mechanisms to cope with disasters and mitigate vulnerability to them have progressed (by developing DRM systems, promoting national land conservation, improving weather forecasting technologies, and
upgrading disaster information communications systems), the number of disaster-related casualties, especially from floods, has been decreasing over the years with the exception of a few outliers.

**COMPARISON OF DAMAGE WITH OTHER TSUNAMI DISASTERS**

The GEJE is the strongest earthquake to ever hit Japan; the destruction it caused is staggering. But it is clear that if Japan were not so well prepared, things could have been much worse.

A longstanding tradition of effective disaster prevention paid off. While almost 20,000 people lost their lives on March 11, the mortality ratio of the GEJE—which hit during the...
MEASURING COST-EFFECTIVENESS

It is essential to make sure that limited financial resources are used in a cost-effective way. Effective spending has high rates of return but is difficult in practice. There are varieties of criteria being used for evaluating the cost-effectiveness of projects, such as CBA, CEA, multicriteria analysis (MCA), and so on. CBA is a well-known tool, particularly useful for governments seeking to compare alternatives. CBA is used to organize and present costs and benefits of measures and projects and to evaluate cost efficiency. CBA was originally developed as a rate-of-return assessment and financial appraisal method to assess business investments. The main purpose was to compare all the costs and benefits of an
investment (even if accruing across different sectors, in different locations, and in different time periods) from the perspective of society. But for most DRM projects there is a lack of information, especially regarding benefits and profits, making it difficult to accurately estimate the cost-effectiveness of measures (Mechler 2005).

**CBA IN JAPAN**

In Japan project appraisals, including CBA, are conducted for public works projects before they are adopted, and every three to five years after adoption to evaluate project efficiency (figure 4). Committees for project appraisal (consisting of academic, business, or legal experts) are established for national and local entities responsible for project implementation, who evaluate the project efficiency of adopted projects. The committees assess the need, cost benefits, progress, possibilities for cost reduction, and the continuity of projects. The appraisal results and associated documents are made open to the public to ensure the transparency of decision making.

**FIGURE 4: MLIT public works project evaluation process, based on Government Policy Evaluation Act (2002)**

- **Evaluation to adopt a new project**
  - Evaluate necessity and validity of the project including cost/benefit analysis.

- **Reevaluation of the project**
  - Make a decision to continue or not from the following 3 viewpoints:
    1. Necessity of the project:
       - Change of social and economic situation
       - Cost effectiveness (cost/benefit analysis)
       - Progress
    2. Expected progress in future
    3. Possibility of cost reduction or alternatives

- **Evaluation after the project**
  - Evaluate the effects, environmental impacts, and social and economic changes, and examine appropriate measures to improve if necessary. The results will be reflected in future projects.

*Source: MLIT.*
A system for evaluating government policies was first introduced in Japan at the prefectural government level to reassess or conduct interim evaluations of ongoing projects. The first attempt at such evaluation was done by the Hokkaido prefectural government in 1997.

The central government, recognizing the importance of such a system, established the Government Policy Evaluations Act (GPEA) in 2001, to provide a legal framework for evaluating government policies. The GPEA aims to promote accountability; provide efficient, high-quality government services and projects; and ensure that the outcomes of these services and projects meet the needs of the nation.

The GPEA calls for all government policies, programs, and projects to be assessed before their inception, to be evaluated after their completion, and to be reassessed or subjected to interim evaluation when necessary.

**CBA FOR COASTAL PROJECTS**

Under the GPEA (2001), the Ministry of Land Infrastructure Transport and Tourism (MLIT) conducts CBA on every project based on the Technical Guidelines of Cost-Benefit Analysis for Public Works Projects (2004). These guidelines set out the overarching principles to be followed by each individual department (such as river, road, or urban development) of the MLIT. Maintenance and management of existing infrastructure and disaster-rehabilitation works are excluded. The Reconstruction Authority has confirmed that post-GEJE rehabilitation efforts will not be subject to CBA evaluation.

In 1987 the MLIT and Ministry of Agriculture, Forestry and Fisheries published the “Guidelines for Cost Benefit Analysis for Coastal Works.” The guidelines were revised in 2004 following the inclusion of disaster prevention, environmental conservation, and sea-coast utilization considerations into the objectives of the Seacoast Act (figure 5). The guidelines recommend that benefits from sea-coast works projects should be quantified into monetary values as much as possible based on probabilities and risks relevant to the following issues:

- Protection of inland properties from flooding by tsunamis and storm surge (expected losses are estimated by multiplying the damage ratio to the value of properties such as buildings, crops, public infrastructure, and so on).

- Prevention or mitigation of damage to land and properties from erosion (the same methodology of protection of properties from flooding).

- Prevention or mitigation of damage by blown sands and sea spray on inland properties and crops, and negative effects on daily life such as through additional labor (expected losses are estimated by evaluating the depreciated value of buildings, damaged crops, and labor loads for cleaning).

- Protection of natural environments such as ecosystems and water quality, and the development of better landscape planning (the values of natural landscapes and ecosystems along the sea line are estimated, as are the benefits of implementing projects; the seawater purification function of the beach is also valued).
• Utilization of seacoast for activities such as recreation and sea bathing (the values of the expansion of recreation activities, fatigue recovery effects, land development, and so on are estimated)

Specific costs to implement a project—including major initial outlays for the investment effort and maintenance expenses—are estimated. The costs and benefits identified have to be discounted to ensure that current and future effects are comparable. Finally, costs and benefits are compared under the economic efficiency decision criteria, such as net present value (NPV), B/C, or the economic internal rate of return (EIRR).
The breakwater construction project in Kuji Port, Iwate Prefecture—started in 1990 and to be completed in 2028—is a good example of the CBA application to a DRM project. The efficiency of the project was last reevaluated in 2010, when the costs were estimated at ¥108.5 billion and the benefits at ¥136.5 billion. The EIRR was calculated at 4.8 percent, and B/C at 1.3. In this evaluation, prevention of inland flooding and sea disasters were considered as monetized benefits, while a decrease in the affected population, improvement of moored vessels security, and stability and development of local industry were considered as qualitative benefits. The project is estimated to reduce the potentially inundated area from 377 to 50 hectares, and reduce the damage to housing from 2,618 to 330 houses (figure 6). Annual estimated benefits are:

- Protection from inundation: ¥4.2 billion
- Protection from marine accident by storm: ¥5.6 billion
- Residual value: ¥11.4 billion

**REGULATORY IMPACT ANALYSIS ASSESSING NONSTRUCTURAL MEASURES IN JAPAN**

Assessing the cost-effectiveness of nonstructural measures presents specific challenges. In Japan, a regulatory impact analysis (RIA) is legally mandatory since 2007 to improve objectiveness and transparency in the process of regulatory establishment. RIAs are applied to nonstructural countermeasures such as changes in land-use regulations. They are designed to objectively assess the potential impacts arising from the introduction of a new regulation or the amendment or abolishment of an existing regulation. Each ministry publishes guidelines to conduct RIAs, which include CBA requirements.
For example, an RIA was undertaken before the adoption of the Act on Building Communities Resilient to Tsunami in December 2011. The changes in regulations outlined in the act—including new land-use regulations and changes of floor-area-ratios for tsunami-evacuation buildings in the designated zone—were assessed through the RIA. It was estimated that the benefits from these changes could outweigh the costs of implementation, as they develop more resilient urban areas through increased safety of housing and public facilities in tsunami-exposed areas and construction restrictions for potentially dangerous buildings. For more information on the act, please consult KN 2-7.

The costs considered in the RIA include the costs associated with the approval processes for structures that contribute to tsunami evacuation; the costs of preparing evacuation plans or evacuation drills; and various administrative costs for approval, inspection, or monitoring of buildings or land use. The benefits, on the other hand, include prevention of inappropriate development, facilitation of prompt evacuation in case of tsunami disasters, and promotion of adequate maintenance of tsunami-disaster-mitigation facilities—all of which contribute to the protection of lives and the mitigation of damage in tsunami-risk areas. These costs and benefits were considered qualitatively in the RIA.

The MLIT has conducted approximately 50 RIAs since 2007. One was conducted, for example, when the Act on Promotion of Seismic Retrofitting of Buildings was revised in 2005 to add schools, welfare facilities, and buildings for storage or treatment of hazardous objects to those facilities under the guidance of administrative offices, and to establish “retrofitting support centers” nominated by the government.

NEW APPROACH TO EVALUATING THE EFFECTIVENESS OF DUAL-PURPOSE INFRASTRUCTURE

The Sanriku Expressway being constructed along the sea shore in the tsunami-affected Iwate and Miyagi prefectures contributed to the recovery of this area (KN 1-2-1). But the evaluation of the cost-effectiveness of such redundant infrastructure (that is, a road used as part of a DRM facility) has never been taken into account before in Japan. The Japanese government is now trying to modify its evaluation methodology to include the potential benefits of road projects from the perspective of disaster management and DRM.

Evaluation methodology is used when the MLIT adopts a new road construction project that is expected to be a key route for rescue and relief supplies, materials, and resources for emergency response, and to form a wide range of road networks for DRM. The evaluation of the disaster mitigation function involves:

- **Necessity evaluation.** Clarify why the project is needed based on DRM considerations (for example, for transportation of rescue and relief supplies, transportation to emergency medical facilities, and reaching core cities in and around the stricken area).

- **Efficiency evaluation.** Numerically estimate the level of improvement and evaluate its priority (for example, improvement of the disaster management function by securing transportation between core cities or within the regional network, like shortening of travel time, dissolution of isolated areas, and so on).
Measuring the Cost-effectiveness of Various DRM Measures

- Effectiveness evaluation. Compare effectiveness among several alternative plans and similar projects.

LESSONS

CEA and, more in particular, CBA, has several limitations, including the difficulty of accounting for nonmarket values, the lack of accounting for the distribution of benefits and costs, and the issue of choosing the correct discount rate. In addition, CBA of DRM presents additional challenges related to the fact that the planning horizon of DRM measures is typically longer than that of policy makers, and that the occurrence of natural hazards needs to be captured with stochastic methods (Mechler 2005). Conducting probabilistic CBA often proves difficult because of the absence of reliable hazard and vulnerability data. This is perhaps the greatest challenge faced by the DRM community in conducting comprehensive economic studies of proposed DRM measures in developing countries. Despite limitations, CBA remains the most commonly used tool to analyze the benefits and costs of DRM measures. In a review of the existing literature on CBA of DRM measures in developing countries, a Global Facility for Disaster Reduction and Recovery (GFDRR) study finds a wide variation in methodologies, assumptions, discount rates, and sensitivity analyses, suggesting that DRM analyses are highly context sensitive (GFDRR 2007).

CBA on infrastructure projects has been widely implemented both at national and local levels in Japan. Different procedures have been identified according to the type of project, the funds, and the governing entity responsible. Different type of costs are included in the analysis, such as operational, maintenance, and fiscal costs; also, different types of benefits are accounted for, such as the protection of inland properties and the natural environment or recreational utilization. The Japanese experience shows that CBA is applicable to DRM structural projects and is a useful tool to help choose among different options (higher B/C is one of the variables to be taken into account when making decisions) and to understand the effectiveness of a project/measure. Nonstructural measures, such as land-use regulations and building codes, can be evaluated as well. For example, administration costs and other necessary costs can be compared when deciding among alternative measures.

The use of CBA must be adapted to the type of measure that is being evaluated. Infrastructure and soft measures require different approaches—not only different procedures and calculations, but also different objectives and bottom-line evaluations. It is also important to introduce clear guidelines about how, when, and where to implement CBA. The Japanese experience also proves that sectoral guidelines released by specific ministries are very helpful, as they describe in practical terms each step to be taken when implementing CBA.

While saving lives is the top priority, valuing such lives when assessing the potential benefits of different measures is extremely challenging and poses complex ethical and political questions. But ignoring the value of life implicitly considers people “useless”—and it would be unethical if property is protected but lives are not. For example, background work done for the joint United Nations–World Bank (UN-WB) report Natural Hazards, UnNatural Disasters shows how, if the value of lives saved were ignored, retrofitting buildings in the Turkish district of Atakoy would not be cost-effective, with a B/C lower than 1. Background work done for the report finds that including a value of life of $750,000 in the benefits, however, tips the scale toward retrofitting. And only by including the value of lives saved
(at $400,000 each) did earthquake-strengthening measures for apartment buildings and schools in Turkey pass the cost-benefit test (UN-WB 2010). This example shows the limitations of CBA. Other techniques such as MCA have been explored and could be more acceptable from an ethical perspective. MCAs do not at present offer much help for practical decision making in Japan.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

Despite its limitations the CBA can be a powerful tool when deciding on and prioritizing DRM measures. It is useful when the issues are complex and there are several competing proposals, and particularly so when comparing alternatives. Nevertheless, considering multiple variables and different objectives at the same time, its use has declined over the years (even at the World Bank).

It is important to set clear rules about when, how, and on what CBA should be performed. Regulatory frameworks, policy procedures, and specific guidelines (possibly at sectoral levels), overseen by specific ministries, can certainly improve the implementation of CBA for DRM.

Connections between decision making and CBA must be clear. CBA can be one informative input, or one of the main variables in decision making. Any decisions should be transparent and reviewed regularly. In the Japanese context, project appraisal committees consisting of external experts and academics evaluate the projects before their adoption, and then reassess their effectiveness to secure transparency and accountability in decision making.

**KEY REFERENCES**


Mechler, R. 2005. “Cost-Benefit Analysis of Natural Disaster Risk Management in Developing Countries.” GTZ.


KNOWLEDGE NOTE 6-2

CLUSTER 6: The economics of disaster risk, risk management, and risk financing

Earthquake Risk Insurance
Earthquake Risk Insurance

The March 2011 earthquake that hit East Japan was the fourth-largest ever recorded. It was not only a human tragedy but an economic shock with losses estimated in excess of ¥16,900 billion, making it the costliest disaster in history. Despite this, the Japanese insurance industry is expected to emerge without significant financial impairment, thanks to a well-developed residential earthquake risk insurance dual program (with private nonlife insurers and cooperative mutual insurers) based on conservative control of insurers’ liabilities (through insurance policy structures and reinsurance). Meanwhile, more than half of Japanese homeowners are still uninsured, creating a significant fiscal burden for the government.

FINDINGS

RESIDENTIAL EARTHQUAKE INSURANCE: A DUAL PROGRAM WITH CAREFULLY CONTROLLED LIABILITIES

Residential earthquake insurance coverage in Japan relies on two major actors: nonlife private insurers and cooperative mutual insurers. Despite major differences in their financial management of earthquake risk, these two insurance systems demonstrated their efficiency in claims settlements and their financial viability after the Great East Japan Earthquake (GEJE). Table 1 compares the residential earthquake insurance scheme offered by the private nonlife insurance companies with the scheme offered by the largest cooperative mutual insurer, the National Mutual Insurance Federation of Agricultural Cooperatives (also known as JA Kyosai*). While the perils covered, assets covered, and extent of coverage are similar across the two programs, earthquake coverage is offered on a voluntary basis with risk-based premium rates by private insurers, and on an automatic basis with flat rates by cooperative mutual insurers.

Both programs are based on conservative control of insurers’ liabilities. In both programs, the claims payments are not intended to provide complete coverage: the maximum

* Also known as Zenkyoren.
coverage is limited at 50 percent of the fire insurance amount (subject to upper limits). Likewise, both programs rely on sophisticated reinsurance strategies. The reinsurance protection of the private insurance scheme relies on a catastrophe insurance pooling mechanism, the Japanese Earthquake Reinsurance Co. (JER), backed by the government of Japan. In contrast, reinsurance protection for cooperative mutual insurers is provided by the international reinsurance and capital markets, with no government intervention. In both cases, the use of reinsurance serves to limit the liability of the private or cooperative risk carriers.

Penetration under the private nonlife insurance program is estimated at about 25 percent of Japanese households, with just under 13 million residential earthquake insurance policies in force: an estimated 48 percent of all fire insurance policies in force include earthquake coverage. Cooperative mutual insurance programs cover about 14 percent of Japanese households, so that total penetration is estimated at 39 percent.† JA Kyosai holds a very large share of the cooperative mutual insurer market, with 5.4 million households holding building endowment policies covering residential earthquake risk (11 percent of total Japanese households). The cooperative mutual insurer Zenrosai has an additional 1.7 million

natural disaster policies covering residential earthquake risk, accounting for a further 3 percent of total Japanese households.

**PRIVATE NONLIFE INSURANCE COMPANIES AND THE JAPANESE EARTHQUAKE REINSURANCE COMPANY**

Earthquake insurance offered by private nonlife insurance companies is available as an optional endorsement to fire insurance policies. Earthquake coverage is available at policy limits of 30 percent to 50 percent of the fire insurance limit, with maximum limits of ¥50 million per dwelling and ¥10 million for personal property.

A three-step claims settlement allows for rapid damage assessment and claims settlement. Payouts are not proportional to damage, but based on a three-step system: total loss, half loss, and partial loss—which allow for 100 percent, 50 percent, and 5 percent of the earthquake insurance policy limit, respectively.

The premium rates are risk based, and vary according to the prefecture where the dwelling is located (divided into eight risk zones) and type of construction (wooden or nonwooden). For an insured amount of ¥10 million, the annual premium varies between ¥5,000 for a nonwooden structure in Nagasaki Prefecture, and ¥31,300 for a wooden structure in Tokyo. Discount rates of up to 30 percent apply when the building is earthquake resistant, according to the Japanese Housing Performance Designation Standards, including a 10 percent discount for buildings constructed after 1981. The premium rates, calculated by the Non-Life Insurance Rating Organization, consist of the pure premium rate and a loading

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**FIGURE 1: Japanese earthquake reinsurance program (as of May 2011)**

Source: JER 2011a.
factor. It should be noted that the rates do not include any loading for profit since the program is not for profit. Despite this rating and because of Japan’s considerable earthquake exposure, rates are still considered high.

The 1966 Earthquake Insurance Law (enacted after the Niigata earthquake of 1964) established the JER, to whom private nonlife insurers were obliged to offer earthquake insurance and cede 100 percent of the earthquake premium and liabilities. The JER thus acts as the sole earthquake reinsurer for the private insurance market. The JER can be seen as an earthquake reinsurance pool, retaining a portion of the liability and ceding the rest back to private insurers (based on their market share) and to the Japanese government through reinsurance treaties. The reinsurance program is designed such that the liability of private insurers and the JER itself does not exceed the accumulated reserves from earthquake insurance premiums. Figure 1 describes the Japanese earthquake reinsurance program as revised in May 2011 after the GEJE. The total claims-paying capacity of the program is currently ¥5,500 billion, which is estimated to correspond to the scenario of the 1923 Great Kanto earthquake with a return period of 220 years.‡ Should insured earthquake losses exceed this amount, claims would be prorated.

The role of the Japanese government is central to the program. The maximum liability of the government of Japan, JER, and private insurers is 87 percent, 10 percent, and 3 percent, respectively. It should be noted that under the previous reinsurance program (before May 2011), the government’s liability was only 78 percent, and the rest was shared equally between the JER and private insurers. The revision of the reinsurance program, leading to an increase of the government’s liability share, is the direct consequence of a depletion of the earthquake reserves of both the JER and private insurers after the GEJE.

Japanese accounting standards allow the insurers to build up pre-event catastrophe reserves (by accumulating the earthquake insurance premiums received, less expenses and any underwriting gains and investment income) over time with separate resources to pay claims, the size of which is based on the probable maximum loss of the insurer’s portfolio. Likewise, the government of Japan has set up a special account to accumulate its reserves. Table 2 shows the amount of reserves at end of fiscal years 2010—that is, before the GEJE. The GEJE wiped out about half of the program’s earthquake reserves.

<table>
<thead>
<tr>
<th>¥ billion</th>
<th>End of fiscal year 2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>1,343</td>
</tr>
<tr>
<td>JER</td>
<td>424</td>
</tr>
<tr>
<td>Private insurers</td>
<td>489</td>
</tr>
<tr>
<td>Total</td>
<td>2,256</td>
</tr>
</tbody>
</table>

Source: JER 2011a.

‡ The total claims-paying capacity of the program will increase to ¥6.2 billion in 2012 (Ministry of Finance 2012).
It is noteworthy that the total reserves supporting the Japanese Earthquake Reinsurance Program, even before the GEJE, represent only a fraction of the liability of all stakeholders. The size of this potential gap is largely due to the government’s reserve-to-liability ratio under the program, which appears low. In case of a major earthquake exceeding the reserves available, it would be critical to immediately mobilize additional resources to ensure the financial solvability of the program.

**COOPERATIVE MUTUAL INSURERS**

Residential earthquake insurance is also available through cooperative mutual insurers. These insurers conduct insurance operations on behalf of Japan’s cooperative societies. The largest of these cooperatives is JA Kyosai, which holds an estimated 85 percent market share of all the homeowners insurance written through cooperative mutual insurers. Like any cooperative, JA Kyosai operates on a nonprofit basis. Its insurance products are different from those of private insurers. Cooperative mutual insurers offer building endowment policies: these policies offer more comprehensive coverage than the policies available through the private insurers and can therefore be seen as a savings mechanism that provides funding for home repairs, whether caused by natural disasters or other adverse events. The five-year (or longer) term policy automatically covers residential dwellings and personal property from damage caused by fire, flood, earthquakes, and other natural disasters. If the policy expires and the policyholder has not claimed a total loss, he or she is entitled to a partial refund of the premium. At the start of 2011, JA Kyosai’s client base comprised more than 11 million building endowment policies.

Earthquake insurance is automatically included in the building endowment policies offered by JA Kyosai. The policy limit is 50 percent of the fire insurance limit, up to ¥250 million. The average fire insurance amount is ¥30 million, hence the average earthquake insurance limit is ¥15 million.

Under the building endowment policy available through JA Kyosai, the claims settlement process in case of an earthquake is proportional: a loss assessor estimates the damage percentage of the house, and this rate is applied to the earthquake policy limit.

The premium rate is flat, that is, the same wherever the dwelling is located. It only differs according to whether the building is a wooden or nonwooden structure.

Cooperative mutual insurers are not subject to the Earthquake Insurance Law and do not participate in the JER. They work outside the nonlife insurance regulatory framework and are instead accountable to their respective ministries; for example, JA Kyosai reports to the Ministry of Agriculture, Forestry, and Fisheries. In contrast to private nonlife insurers, cooperative mutual insurers cede a significant portion of their liabilities to the international reinsurance market. JA Kyosai is known to have one of the largest reinsurance programs in the world, with reinsurance capacity in excess of ¥75 billion. Its large and well-diversified asset base also allows it to retain a significant portion of its liability. In addition to traditional reinsurance, JA Kyosai has issued catastrophe (Cat) bonds to better spread its risk (see box 1).
Industrial and commercial earthquake insurance

Traditionally, industrial and commercial earthquake insurance has been issued as a reduced indemnity policy, which provides limited coverage on a proportional basis. The extent of the coverage depends on the location of the asset, for which the country has been divided into 12 risk zones. The indemnity limit varies from 15 percent in Tokyo up to 100 percent in Niigata. Following the enactment of the Insurance Business Law in 1996, which largely deregulated the insurance market in Japan, insurance policies on a first-loss basis were also offered, which generated a significant increase in the sum insured (the maximum amount that could be paid out). Loss of revenue and business interruptions caused by earthquakes have not traditionally been marketed and have low penetration rates.

Other classes include earthquake fire expense insurance. This is a limited amount for fire following an earthquake, which is provided automatically with some insurance policies, such as the storekeepers’ comprehensive policy. The coverage is limited to 5 percent of the fire sum insured, up to certain fixed limits. Other insurance policies that generally include earthquake coverage are cargo insurance, motor insurance, and engineering insurance.

BOX 1: Innovative catastrophe risk financing: Capital markets protect Japanese farmers against earthquake

In 2008, Munich Re, a reinsurance company based in Germany, issued JA Kyosai’s second catastrophe (Cat) bond, a $300 million issue, through the special-purpose vehicle, Muteki Ltd.

Cat bonds are index-linked securities that secure financial resources on the capital markets, to be disbursed in case of the occurrence of a predefined natural disaster. Cat bonds generally cover the highest level of risk and are mainly issued for specific perils with an annual probability of occurrence of 2 percent or less (that is, a return period of 50 years or more). Unlike traditional reinsurance, Cat bonds are fully collateralized and offer multiyear coverage (usually 3 to 5 years).

The three-year Muteki Cat bond provided fully collateralized protection for Japanese earthquake exposure indirectly to JA Kyosai/Zenkayoren, through a reinsurance agreement with Munich Re, which served as counterparty on the transaction. Like other Cat bonds in Japan, the Muteki Cat bond was parametric, triggered by the location and magnitude of an earthquake rather than the actual losses. Following the GEJE disaster, the Muteki Cat Bond became the first Cat Bond to pay out on the occurrence of an earthquake event. The instrument released the full coverage limit of $300 million in response to the event.

In February 2012 Guy Carpenter and Company announced the placement of a $300 million Cat bond, through the SPV Kibou Ltd, which would ultimately benefit JA Kyosai. It provided protection on a parametric basis, using earthquake data gathered from various recording stations from the Kyoshin-Net network of seismographs.

INDUSTRIAL AND COMMERCIAL EARTHQUAKE INSURANCE

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ECONOMIC AND INSURED LOSSES

The GEJE caused major direct economic losses, with current estimates of ¥16,900 billion (KN 6-1). Private (residential, commercial, and industrial) buildings represented 62 percent, and public infrastructure represented 13 percent of the (direct) economic losses (see annex 1). Insured losses were estimated at ¥2,750 billion, or 16 percent of total economic losses. Residential assets represented 78 percent of insured losses. Fifty-six percent of the residential insured losses were covered by private insurers and the JER, and 44 percent were covered by cooperative mutual insurers (see annex 1).

Despite significant differences, both private and mutual residential earthquake insurance programs had adequate capacity to meet their claims obligations, thanks to efficient management of exposure to losses through a combination of policy limits and reinsurance protection. The earthquake insurance program managed by the private nonlife insurance companies faced an estimated total loss of ¥1,200 billion, with 42 percent retained by private insurers, 13 percent retained by the JER, and 45 percent retained by the government. This event, however, severely depleted the earthquake reserves of both the private insurers and JER, leading to an increase in government liability in the revised reinsurance program of 2012. Earthquake losses incurred by JA Kyosai were estimated at ¥830 billion, 90 percent of which were residential losses. It is estimated that about 58 percent of those losses were reinsured.

The three-step earthquake claims settlement system implemented by the private insurance companies allowed claims to be settled rapidly. Satellite images were also used to identify total losses on buildings, which helped further speed up claims settlements. In the aftermath of the disaster, the General Insurance Association of Japan designated specific total loss zones, based on satellite imagery (KN 5-2). Any total loss claims filed within these areas did not require additional confirmation of incurred losses, thereby speeding up the payout process. Out of ¥1,200 billion generated by the 741,000 claim payments made after the GEJE, 60 percent were paid within two months and 90 percent within five months.

COMPARATIVE ANALYSIS OF THE GEJE WITH OTHER RECENT EARTHQUAKES

It is interesting to compare the economic and fiscal impact of the GEJE with the impact of other recent earthquakes: the 2010 earthquake in Chile and the 2011 earthquakes in Canterbury, New Zealand. All three earthquakes were very large in magnitude and caused severe economic losses in their countries. Table 3 summarizes this comparative analysis. While the GEJE caused the largest economic losses in absolute terms, losses as a percentage of gross domestic products (GDP) are lower than those in Chile and New Zealand given the size of the Japanese economy. The government’s portion of direct losses (that is, additional expenditures), expressed as a percentage of total government expenditures, were estimated at 8 percent for the GEJE and 11 percent for the Canterbury earthquake in New Zealand. Finally, the fraction of the insured losses covered by international reinsurance was estimated at 95 percent in Chile, 29 percent in New Zealand (where the Earthquake Commission EQC retained a large fraction of the losses), and 23 percent in Japan. This last figure hides a large difference between the JER, which relies on public reinsurance and cooperative mutual insurers, such JA Kyosai, that purchase most of their reinsurance capacity abroad.
Lessons

Some key lessons can be drawn from the review of Japan’s earthquake insurance programs in the light of the GEJE:

- **No one-size-fits-all.** The dual earthquake insurance programs in Japan illustrate that there is no one-size-fits-all catastrophe insurance program. Two very different schemes can coexist successfully within a country significantly exposed to earthquakes, offering earthquake coverage to about four households out of ten in Japan.

- **Resilience is critical for earthquake insurance programs.** Both programs managed to fulfill their obligations after the GEJE without difficulties, because of the sound management of policy limits and conservative reinsurance coverage. The apparent resilience of the current setup does not mean, however, that there is no room for these schemes to improve without compromising sustainability. For example, the earthquake insurance limit offered by JA Kyosai started at 10 percent and has increased progressively to 50 percent currently.

### TABLE 2: Comparative analysis of the Tohoku (GEJE), Canterbury, and Maule earthquakes

<table>
<thead>
<tr>
<th></th>
<th>Tohoku, Japan</th>
<th>Canterbury, New Zealand</th>
<th>Maule, Chile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year</td>
<td>2011</td>
<td>2011</td>
<td>2010</td>
</tr>
<tr>
<td>Magnitude</td>
<td>9.0</td>
<td>6.3</td>
<td>8.8</td>
</tr>
<tr>
<td>Estimated direct economic losses ($ billion)</td>
<td>225</td>
<td>15</td>
<td>20</td>
</tr>
<tr>
<td>Estimated direct economic losses (% GDP)</td>
<td>4</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>Estimated direct losses borne by government (as % of government expenditures)</td>
<td>8</td>
<td>11</td>
<td>n/a</td>
</tr>
<tr>
<td>Estimated insured losses (% of direct economic losses)</td>
<td>16</td>
<td>80</td>
<td>40</td>
</tr>
<tr>
<td>Estimated insured losses covered by international reinsurance</td>
<td>23</td>
<td>73</td>
<td>95</td>
</tr>
</tbody>
</table>


*Note*: Direct economic losses are defined as damage to physical assets (including infrastructure).
• **Rapid claims settlement can be achieved, even after a major disaster.** The three-step claims adjustment system implemented by the private insurers allows for rapid damage assessment and claims settlement. It also takes into account that, immediately after a major disaster, large numbers of loss assessors have to be deployed at the same time. The simplicity of the three-step system allows this to happen.

• **Insurance penetration in Japan is high, but there is still considerable room for expansion.** About 40 percent of Japanese households have earthquake insurance coverage, leaving 60 percent of households without coverage. International experience shows that it is very difficult, if not impossible, to increase the penetration rate beyond a certain level on a voluntary basis. Compulsory earthquake insurance could therefore be considered.

The GEJE also highlighted certain challenges of earthquake insurance programs run by private insurance companies:

• **The JER claims-paying capacity is limited in the aggregate.** The aggregate limit is currently set at ¥5,500 billion (to be increased to ¥6,200 billion in 2012), which would be sufficient for a major earthquake such as the Great Kanto earthquake in 1923. But this does not take into account the occurrence of consecutive major earthquakes, which could jeopardize the solvency of the program.

• **The government’s liability under the JER exceeds its ex-ante financing arrangements.** The government’s maximum liability is adjusted based on the balance of earthquake reserves of the private insurers and the JER and the maximum defined liability under the program. The government currently holds 87 percent of the total liability of the program. Its current special account would not be sufficient to cover this level of liability and would require an immediate budget appropriation or reallocation in case of a major disaster.

• **Limited policy coverage may not meet the needs of the insured.** The program is designed to provide partial coverage (up to 50 percent of the fire insurance coverage limit) to “stabilize the livelihood of the earthquake victims” (article 1 of the 1966 Earthquake Insurance Law). There seems to be a growing demand for higher coverage, but such an increase in coverage should be carefully evaluated to maintain the financial sustainability of the system.

• **The claims settlement process introduces significant basis risk and could be revised.** Although the three-step claims adjustment process allows for rapid settlement of claims, there is a big gap between payouts for partial loss (5 percent) and half loss (50 percent). This increases the risk that payments will not match the needs of the insured party following the occurrence of damage (basis risk). A fourth intermediate step could be introduced to reduce this risk.

• **Catastrophe risk modeling for Japan is sophisticated, but could be improved.** State-of-the-art catastrophe risk models have been developed for Japan, but need to be further refined as secondary loss perils such as tsunamis (which caused about 30 percent of the total losses from the GEJE) and liquefaction are not included.
as standard in all models. These models could also be used to further assess the catastrophe risk exposure of public buildings and infrastructures.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

**DEVELOPING Viable AND AFFORDABLE CATASTROPHE RISK INSURANCE PROGRAMS**

Japanese earthquake insurance programs demonstrated considerable resilience after the GEJE. From this experience, recommendations can be made to disaster-prone developing countries willing to promote catastrophe risk insurance to help them promote viable and affordable programs and clearly define the role of the government in public-private partnerships (PPPs).

**Structure policies to allow for sustainable and affordable programs.** Catastrophe risk insurance policies should be designed to enable insurance companies control their liabilities and offer affordable coverage. The policy structure can be revised over time to better respond to the needs of the policyholders, while also ensuring the system’s resilience to major disasters. The partial coverage produced by both Japanese earthquake insurance programs and the simplified loss adjustment process of the private insurer system help to keep costs down.

**Price insurance premiums based on the underlying risks.** Insurance premiums should reflect the underlying risks with respect to the various risk zones and types of construction. Risk-based insurance premiums make policyholders aware of the underlying cost of risk, thereby providing financial incentives to engage in disaster risk mitigation. Even in cases where the full cost of cover is not passed onto the policyholder, it is still possible to signal the underlying cost of risk by making subsidies transparent.

**Provide incentives to invest in disaster risk mitigation.** Additional financial incentives, such as discounts on premium rates or lower deductibles, can be offered to the policyholders who invest in risk reduction.

**Consider mechanisms for enforcing insurance purchase.** Voluntary catastrophe risk insurance does not typically generate high penetration rates, even in highly developed insurance markets. Some type of compulsory mechanism, such as an automatic catastrophe guarantee in fire insurance policies, may be necessary to ensure that a large proportion of the population is insured against natural disasters.

**Promote multiple-catastrophe risk insurance delivery channels.** Catastrophe risk insurance should leverage existing nonlife insurance delivery channels, such as private insurers or mutual insurers. The Japanese system demonstrates that different segments of the population may be best served by different delivery channels, even for very similar products. Multiple distribution channels for catastrophe risk insurance should therefore be explored.
Develop detailed catastrophe risk models. Detailed catastrophe risk models and databases are essential for detailed risk assessment, premium rate calculation, and efficient management of catastrophe risk insurance liabilities. In addition to a strong hazard model, such assessments also require detailed exposure databases of at-risk assets (buildings and infrastructure) and detailed vulnerability functions to translate hazard values into dollar losses. These models are typically developed by private risk modeling firms and licensed to the insurance industry. But for some less-developed insurance markets, governments and donors have funded or partially funded the development of such models as public goods to support market development.

Develop catastrophe risk insurance market infrastructure. Catastrophe risk insurance markets require major investments in basic infrastructure, such as catastrophe risk models, exposure databases, product design and pricing, and the like. Governments can play a major role in developing this kind of infrastructure to help the private insurance industry can offer cost-effective and affordable insurance solutions.

Promote enabling legal and regulatory environments. Unlike traditional lines of insurance business such as automobile insurance, catastrophe risk insurance can generate large correlated losses for insurers. The legal and regulatory framework should enforce adequate pricing, reserving, and reinsurance buying to ensure that insurers will meet their claims in full in the event of a disaster.

Promote PPPs for catastrophe insurance programs. Governments can play an important role in building an affordable and sustainable earthquake insurance program. As the private insurance sector brings its technical expertise and financial capacity to the table, governments can support the development of public goods and risk-market infrastructure to foster sustainable market-based insurance solutions.

Governments can play a role as the financier of last resort. Governments may want to act as financiers of last resort when private reinsurance capacity is unavailable or too expensive to allow domestic insurers to offer cost-effective insurance solutions. Governments should not compete with the private reinsurance market but rather complement it. When needed, governments should make financial capacity available to domestic insurers through public reinsurance or (contingent) credit.
Insurance schemes in agriculture and fishing helped farmers and fishermen stabilize their businesses by compensating them for losses and damages caused by the GEJE. Insurance paid for some level of damage sustained by almost all fishing boats. In Japan, these schemes began as cooperative activities by local farmers and fishermen. They were subsequently turned into voluntary mutual aid programs established by the government, which subsidizes the premiums paid by farmers and fishermen, covers part of the administrative costs, and reinsures the insurance associations.

**Fishery insurance**

The earthquake and tsunami damaged some 25,000 fishing vessels, at a cost of ¥170 billion. Ninety percent of the vessels in Iwate, Miyagi, and Fukushima prefectures were damaged, which had an enormous effect on the fishing industry since these vessels were used for aquaculture as well as fishing. Before the tsunami, the three prefectures accounted for 10 percent of the total catch in Japan (excluding aquaculture). Aquaculture industries were also severely damaged, particularly in the Iwate and Miyagi prefectures, where production of oysters and wakame seaweed is widespread. Damage to aquaculture amounted to ¥131 billion: 57 billion for production and 74 billion for facilities.

**Policies in force for agricultural, fishing boat, and fisheries insurance in 2009**

<table>
<thead>
<tr>
<th></th>
<th>Number of households underwritten (thousands)</th>
<th>Area underwritten (thousands of hectares)</th>
<th>Value covered (¥ million)</th>
<th>Penetration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farm products</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paddy rice</td>
<td>1,752</td>
<td>1,479</td>
<td>1,223,157</td>
<td>91% (area)</td>
</tr>
<tr>
<td>Field rice</td>
<td>0.4</td>
<td>0.2</td>
<td>46</td>
<td>5% (area)</td>
</tr>
<tr>
<td>Wheat and barley</td>
<td>49</td>
<td>252</td>
<td>83,277</td>
<td>95% (area)</td>
</tr>
<tr>
<td>Fruit trees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Harvest mutual relief</td>
<td>76</td>
<td>45 (number of boxes)</td>
<td>107,200</td>
<td>26% (number)</td>
</tr>
<tr>
<td>Tree mutual relief</td>
<td>4</td>
<td>1</td>
<td>7,000</td>
<td>2% (number)</td>
</tr>
<tr>
<td>Livestock</td>
<td>89</td>
<td>6,665 (Number of livestock)</td>
<td>724,586</td>
<td>42% (number)</td>
</tr>
<tr>
<td>Field crops</td>
<td>82</td>
<td>259</td>
<td>140,400</td>
<td>62%</td>
</tr>
<tr>
<td>Fishing boats</td>
<td>192 (boats)</td>
<td>n.a.</td>
<td>1,028,517</td>
<td>&gt;100% (number of boats)</td>
</tr>
<tr>
<td>Fisheries</td>
<td>61</td>
<td>n.a.</td>
<td>394,155</td>
<td>52% (households)</td>
</tr>
</tbody>
</table>

n.a. = Not applicable.
The fisheries insurance system in Japan is well organized, providing essential insurance services at a reasonable cost to all fishermen including small-scale producers. The fishing vessel insurance system, which was established in 1952 under the Fishing Vessel Damage Compensation Law, aims at stabilizing fishing businesses by covering the loss of and damages to their fishing vessels. The system includes the following insurances:

- **Fishing vessel insurance** covering basic damage caused by accidents and disasters, and including special insurance for damage caused by war and seizure.
- **Protection and indemnity insurance** covering compensation for the crew and damages incurred during navigation.
- **Owner-operator insurance** covering the death of owner-operators.
- **Cargo insurance** covering the loss of catches or cargo.
- **Pleasure boat insurance** covering compensation, rescue costs, and damages.
- **Transshipped catches insurance.**
- **Crew salary insurance** covering crew salaries if vessels are seized.

The fisheries mutual insurance scheme, which was established in 1964 under the Fisheries Disaster Compensation Law, aims at stabilizing small- and medium-size fishing and aquaculture operations by covering losses from poor catches caused by natural disasters. The system insures fish harvests, aquaculture, special aquaculture, and fishing gear.

The government subsidizes one-third to one-half of the premium. While fishing vessel insurance enjoyed a surplus of ¥16.5 billion in 2010, the Fisheries Mutual Insurance Scheme suffered a deficit of ¥28.9 billion.

<table>
<thead>
<tr>
<th></th>
<th>Fishing vessel insurance system</th>
<th>Fisheries mutual insurance scheme</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government</td>
<td>72.7 (78%)</td>
<td>21.3 (77%)</td>
<td>94.0 (78%)</td>
</tr>
<tr>
<td>Reserve of government special account</td>
<td>11.0 (12%)</td>
<td>—</td>
<td>11.0 (9%)</td>
</tr>
<tr>
<td>Associations at national level</td>
<td>1.4 (2%)</td>
<td>3.0 (11%)</td>
<td>4.4 (4%)</td>
</tr>
<tr>
<td>Associations</td>
<td>7.8 (8%)</td>
<td>3.2 (12%)</td>
<td>11.0 (9%)</td>
</tr>
<tr>
<td>Total</td>
<td>92.9 (100%)</td>
<td>27.5 (100%)</td>
<td>120.4 (100%)</td>
</tr>
</tbody>
</table>
The Ministry of Agriculture, Fishery, and Forests estimates that total claims would amount to ¥120.4 billion, of which the central government will cover ¥94 billion, or 78 percent for the GEJE. As of March 13, 2012, ¥63.4 billion in claims have been paid out: ¥47.5 billion under the fishing vessel insurance system, and ¥15.9 billion under the fisheries mutual insurance scheme. Sixty percent of vessels were insured under the vessel insurance scheme, of which some 80 percent of boats were over 20 tones. Some 80 percent of the insured vessels were more than 15 years old. Since the schemes cover the residual value of the vessels, the claims paid out may not cover the replacement costs.

Agriculture insurance

Damage to agricultural production and facilities from the GEJE event amounted to ¥63 billion. Rice is an important crop in Japan, but because the GEJE happened before the rice-growing season, insurance almost did not cover rice production losses. Since compensation related to the accident at the Fukushima Nuclear Power Plant has not yet been decided, the total payout on agricultural insurance is uncertain. In Miyagi Prefecture, the agricultural insurance scheme has covered damages to greenhouses in the amount of ¥1 billion.

The Farm Losses Compensation Law introduced the agricultural insurance scheme in 1947 to help farmers stabilize their businesses by covering damages caused by natural disasters; the scheme offers insurance coverage for almost all major agricultural products. It was started by local farmers as a cooperative initiative to set up a reserve fund...
to pay for insurance premiums, which evolved into agricultural mutual relief associations. The insurance scheme includes: rice, wheat, and barley insurance (mandatory for paddy fields of more than 20 hectares); livestock insurance; fruit and fruit tree insurance; field crop and horticultural insurance; greenhouse insurance; and houses and properties. The government subsidizes half of farmers’ premiums.

Prepared by Mikio Ishiwatari, World Bank.

REFERENCES


ANNEX 1. ECONOMIC AND INSURED LOSSES OF THE GREAT EAST JAPAN EARTHQUAKE (GEJE)

GEJE: Economic losses by sector, as percent of total loss (¥16,900 billion)

GEJE: Insured losses by sector, as percent of total insured losses (¥2,750 billion)

GEJE: Insured residential losses by scheme, as percent of total insured residential losses (¥2,137 billion)
ANNEX 2. ESTIMATED GEJE INSURED RESIDENTIAL LOSSES, BY EARTHQUAKE INSURANCE PROGRAM

GEJE: JER earthquake insurance claims (¥1,200 billion)

- Government: 45.2%
- Insurers: 42.0%
- JER: 12.8%
- Retention: 42%
- Reinsurance: 58%

GEJE: JA Kyosai earthquake insurance claims (¥830 billion)

- Retention: 42%
- Reinsurance: 58%
KNOWLEDGE NOTE 6-3

CLUSTER 6: The economics of disaster risk, risk management, and risk financing

Economic Impacts
Prepared by Masafumi Fujita, Research Institute of Economy, Trade and Industry; and Hamaguchi Nobuaki, Kobe University (on global supply chain); Financial Service Agency (on the double debt problem); and Junko Sagara, CTI Engineering; with contributions from Bianca Adam, World Bank.
Following the Great East Japan Earthquake (GEJE), the government of Japan responded promptly to stabilize markets and ensure a swift recovery. Economic activity has since started picking up, thanks in part to domestic demand driven by the massive reconstruction effort. Uncertainties remain, however, surrounding the restructuring of power supply and both national and global economic prospects. The year 2011 will be remembered for the severe challenges to the global supply chain posed by the GEJE and the Thai flood. As an important part of the networked production system, developing countries must share responsibility in making the supply chain more resilient under international cooperation.

**FINDINGS**

Following the GEJE, the government of Japan initially estimated the direct damages between ¥16 trillion and ¥25 trillion (see box 1). The Cabinet Office (CAO) later put estimated damages at ¥16.9 trillion ($210 billion), or about 4 percent of Japan’s gross domestic product (GDP). Before the disasters, approximately two-thirds of nonfinancial assets were held by the private sector. This is in line with the breakdown of the direct damage figures released by the CAO (table 1).

Most of the damages were concentrated in three prefectures of the Tohoku region: Fukushima, Iwate, and Miyagi. The sparsely populated pacific coast of the Tohoku region, where agriculture and fishery are the main activities, accounts for only 2.5 percent of the total Japanese economy in terms of industrial production (figure 1).

Despite the relatively small extent of economic activities in the affected region, the GEJE had severe and widespread economic impacts, partly due to the Accident at Fukushima Daiichi Nuclear Power Station and ensuing energy supply disruptions, and the supply chain disruptions (compounded by widespread flooding in Thailand a few months later).

In the first quarter of 2011, Japan’s GDP contracted by 3.5 percent. According to the International Monetary Fund (IMF), GDP contracted by 0.7 percent in all of 2011, and the estimates for 2012 put GDP growth at 2 percent, stimulated by reconstruction work.
The CAO released two different sets of estimated economic damages (damage on capital stocks) of the GEJE (table A).

Table A. Estimated economic damages of the GEJE by the CAO (¥ trillion)

<table>
<thead>
<tr>
<th>Disaster Reduction Section</th>
<th>Economic and Financial Analysis Section</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Case 1</td>
</tr>
<tr>
<td>Buildings and houses</td>
<td>10.4</td>
</tr>
<tr>
<td>Utilities</td>
<td>1.3</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>2.2</td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Agriculture</td>
<td>1.9</td>
</tr>
<tr>
<td>Others</td>
<td>1.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>16.9</strong></td>
</tr>
</tbody>
</table>

*Note: Case 1 uses damage rates twice as high as the Kobe earthquake, while Case 2 employs the even higher damage rates against buildings and houses for the tsunami-affected areas.*

The economic impacts are estimated separately for damages (on capital stocks) and losses (on flow). The estimation results for damages in table A are calculated by multiplying the existing predisaster capital stock data (based on the CAO’s macroeconomic database), by damage rates twice as high as the ones observed for the Hanshin-Awaji (Kobe) earthquake for Case 1 and by even higher damage rates against buildings and houses for Case 2 to take into account the damages from the tsunami. In this estimation the damaged areas include the prefectures of Iwate, Miyagi, and Fukushima (the above-mentioned damage rates are applied to the tsunami-affected areas in these prefectures, while damage rates equivalent to the Kobe earthquake’s are used for the non-tsunami-affected areas) and the surrounding prefectures of Hokkaido, Aomori, Ibaraki, and Chiba, for which damages are calculated by multiplying the capital stock data by damage rates modified based on the seismic intensity of each prefecture (details unknown).

The estimation of the economic impact from the GEJE (not included in table A) covers the same prefectures and is carried out for three fiscal years (table B).

The estimated production losses due to damages (first-order loss) by the GEJE are calculated based on the damages listed in table A using the production function of each sector. The production loss due to supply chain disruption (roughly equivalent to a higher-order loss) is estimated with the calculated production loss (the above first-order loss) and an interregional input-output table (between Tohoku and the rest of Japan). While the production losses due to limited (electric) power supply were considered, they were not estimated due to the uncertainty of effects on production (resiliency, conservation, or use of other adaptive measures). The production gains
BOX 1, continued

Table B. Estimated economic impact of the GEJE (¥ trillion)

<table>
<thead>
<tr>
<th>Categories</th>
<th>FY2011</th>
<th>FY2012</th>
<th>FY2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production loss due to damages</td>
<td>–1.25 to –0.5</td>
<td>–2.25 to –1.25</td>
<td>–2.25 to –1.25</td>
</tr>
<tr>
<td>Production loss due to supply chain disruption</td>
<td>–0.25</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Production loss due to limited power supply</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Production gain from recovery and reconstruction</td>
<td>2 to 3, 3 to 5</td>
<td>6 to 9.5</td>
<td>5 to 7.75</td>
</tr>
<tr>
<td>Total</td>
<td>0.5 to 2.25</td>
<td>2 to 4.25</td>
<td>3.75 to 8.25</td>
</tr>
</tbody>
</table>

— Not available.

from recovery and reconstruction activities are derived by distributing the amount of estimated damages in table A over three years (meaning it is assumed that all the damaged capital stocks will be restored).

TABLE 1: Direct economic impact of the GEJE

<table>
<thead>
<tr>
<th>Categories</th>
<th>Damage (¥ trillion)</th>
<th>Percentage of total damage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings (housing, offices, plants, machinery, and so on)</td>
<td>10.4</td>
<td>62</td>
</tr>
<tr>
<td>Lifeline utilities (electricity, gas, water, communication, and so on)</td>
<td>1.3</td>
<td>8</td>
</tr>
<tr>
<td>Social infrastructure (waterways, roads, harbors, drainage, airports, and so on)</td>
<td>2.2</td>
<td>13</td>
</tr>
<tr>
<td>Others (including agriculture and fisheries, and so on)</td>
<td>3.0</td>
<td>17</td>
</tr>
<tr>
<td>Total</td>
<td>16.9</td>
<td></td>
</tr>
</tbody>
</table>

Source: CAO.
There are approximately 80,000 businesses in the tsunami-affected areas, 740,000 businesses in the earthquake-affected areas, 8,000 businesses in the evacuation zones of the Fukushima nuclear accident, and 1.45 million businesses in the prefectures covered by the Tokyo Electric Power Company (TEPCO).

**IMPACTS ON AGRICULTURE, FORESTRY, AND FISHERIES**

The amount of damage to agriculture, forests, and fisheries by the GEJE was estimated as ¥2.34 trillion (table 2).

Around 24,000 hectares of agricultural land (approximately 80 percent of paddy fields and 20 percent of farmland) were flooded by the tsunami. Over 95 percent of the damaged agricultural land is located in the three prefectures most severely affected: Iwate, Miyagi, and Fukushima.

FIGURE 1: The extent of economic activity in the municipalities along the Pacific Ocean coast

Source: Ministry of Economy, Trade and Industry.
TABLE 2: **Damage caused by the GEJE**

<table>
<thead>
<tr>
<th>Sector</th>
<th>Direct damage (¥)</th>
<th>Monetary damage (¥100 million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fisheries</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fish vessels</td>
<td>25,014</td>
<td>1,701</td>
</tr>
<tr>
<td>Fishery harbor facilities</td>
<td>319</td>
<td>8,230</td>
</tr>
<tr>
<td>Aquaculture facilities</td>
<td>—</td>
<td>738</td>
</tr>
<tr>
<td>Aquaculture products</td>
<td>—</td>
<td>575</td>
</tr>
<tr>
<td>Common use facilities</td>
<td>1,725</td>
<td>1,249</td>
</tr>
<tr>
<td>Subtotal, fisheries</td>
<td></td>
<td>12,493</td>
</tr>
<tr>
<td><strong>Agricultural land, facilities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Damaged agricultural land</td>
<td>17,456 areas</td>
<td>4,012</td>
</tr>
<tr>
<td>Damaged agricultural facilities</td>
<td>21,866 points</td>
<td>4,290</td>
</tr>
<tr>
<td>Subtotal, agricultural land, and facilities</td>
<td>39,322 points</td>
<td>8,302</td>
</tr>
<tr>
<td><strong>Agricultural crops and so on</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Agricultural crops and livestock, and so on</td>
<td>—</td>
<td>140</td>
</tr>
<tr>
<td>Agricultural livestock production facilities, and so on (mainly country elevators, agricultural warehouses, PVC greenhouses, livestock barns, compost depots, and so on)</td>
<td>—</td>
<td>487</td>
</tr>
<tr>
<td>Subtotal, agricultural crops and so on</td>
<td></td>
<td>626</td>
</tr>
<tr>
<td><strong>Forestry</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Desolation of forest land</td>
<td>429 points</td>
<td>238</td>
</tr>
<tr>
<td>Damage of facilities for maintaining forest</td>
<td>255 points</td>
<td>1,167</td>
</tr>
<tr>
<td>Damage of forest road</td>
<td>2,632 points</td>
<td>42</td>
</tr>
<tr>
<td>Damage of forests</td>
<td>(1,065 ha)</td>
<td>10</td>
</tr>
<tr>
<td>Processing and marketing facilities and so on</td>
<td>112 points</td>
<td>508</td>
</tr>
<tr>
<td>Cultivating facilities for forest products</td>
<td>473 points</td>
<td>25</td>
</tr>
<tr>
<td>Subtotal, forestry</td>
<td>3,903 points</td>
<td>1,989</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td>23,410</td>
</tr>
</tbody>
</table>

It is estimated that the area of agricultural land that will be restored and cultivated again by 2012 could be less than 50 percent in Iwate and Miyagi prefectures, and only up to 20 percent in Fukushima Prefecture as a result of the nuclear accident.

Many plywood-processing factories in Iwate and Miyagi, where about one-third of plywood products are produced, were damaged.

The Fukushima nuclear accident further impacted the agriculture, forestry, and fisheries sectors. Based on the provisional regulation on radiation instated on March 17, 2011, shipping of food products containing radioactive iodine above a certain threshold has been restricted. In addition to the national regulation, some prefectures and local associations set additional restrictions on the shipping of food products.

The accident also affected trade flows of food products with other countries. Import controls for Japanese food products were intensified in 43 countries, and Japanese exports have declined.

**IMPACTS ON THE TOURISM INDUSTRY**

The GEJE have severely affected the tourism industry in Japan, but, according to a report by the World Travel and Tourism Council (WTCC), recovery has been more rapid than previously expected for both domestic and international tourism.

Foreign visitor arrivals in the month immediately following the GEJE were 62 percent lower than the previous year. But recovery was swift and, by the fall of 2011, arrivals were only 15 percent down compared to the previous year. Inbound international travel was more severely affected compared to outbound international travel and domestic travel (figure 2). This trend reflects fears generated by the nuclear power plant accident and loss of competitiveness as a result of the appreciation of the yen in the months following the disaster.

The WTCC estimates that the negative impact of the GEJE on the tourism industry amounts to approximately ¥0.7 trillion.

**IMPACTS ON FINANCIAL AND CURRENCY MARKETS**

Financial and currency markets stabilized quickly after the earthquake. Equity markets fell by over 15 percent in the first weeks after the earthquake, but recouped roughly one-third of their losses by mid-June 2011.

Figure 3 shows the Nikkei Index from January 2011 to June 2012. The Nikkei Index is a stock market index for the Tokyo Stock Exchange (TSE). It is a price-weighted average (the unit is yen), which indexes 225 companies in the TSE (components are reviewed once a year).

The figure clearly shows the fall after March 11 and the recovery till summer 2011. High volatility followed, but those values cannot be strictly connected to the recovery process, as the international financial crisis impacted the TSE.
FIGURE 2: Japanese tourism demand, 2011–12

Source: WTCC 2012.

FIGURE 3: Nikkei Index, January 2011–Jun 2012

Source: Nikkei 2012.
Individual debtor guidelines for out-of-court workouts

Guidelines for individuals on out-of-court debt restructuring: Individual Debtor Guidelines for Out-of-Court Workouts were released on July 15, 2011, and took effect on August 22, 2011.

The Guidelines aimed at individual debtors who are unable, or deemed certain to soon become unable, to repay their existing loans—in other words, those who would in principle qualify to initiate bankruptcy or civil rehabilitation procedures. The creditors subject to the Guidelines consist primarily of private sector banks, cooperative financial institutions, government-affiliated financial institutions, money lenders, and leasing companies.

As of March 30, 2012, the accumulated total number of cases consulted was 1,850, of which 538 cases were in the process of restructuring loans. This system is the first of its kind in Japan and is unprecedented even in the world.

Clearer application of financial inspection manuals

In the case of a company resuming or continuing its operations while repairing damage sustained from the earthquake and tsunami, there is a risk that its capital has been impaired due to the impact of the disaster. Capital augmentation is therefore urgently needed.

The Financial Services Agency introduced measures to apply its financial inspection manuals in a clearer manner, aiming to promote more active use of capital-eligible debt and thereby enable undercapitalized companies to improve their balance sheets and management.

These measures are expected to yield a number of positive effects. For example, even if a company’s capital has been impaired due to the impact of the disaster, the company is able to exchange its existing loans for new ones that satisfy the requirements for capital-eligible debt (that is, a debt-debt swap). As a result, its balance sheet will become healthier, which will in turn lead to greater chances of obtaining new loans from financial institutions.

Measures for financial institutions

Some financial institutions located in the disaster-stricken area sustained significant damage; some institutions operational bases were almost entirely destroyed by the disaster. It is imperative to maintain and strengthen the financial functions of banks
In the immediate aftermath of the earthquake, the yen appreciated sharply because of speculation around sizeable repatriation flows by insurance companies, corporations, and households. The value of the yen touched a record ¥76.25 per dollar on March 17, before retreating to the 80-yen level. After concerted intervention in coordination with the G-7, the yen/dollar rate has traded in a band of 80 to 84. Approximately a quarter of developing East Asia’s long-term debt is denominated in yen. For China, 8 percent of its external government debt is in yen. The figure for Thailand is about 60 percent, for Vietnam about 35 percent, for the Philippines about 32 percent, and for Indonesia about 30 percent. A 1 percent appreciation in the value of the yen translates into a $250 million increase in annual debt servicing on yen-denominated securities by East Asia’s developing countries.

After the disaster, the Bank of Japan injected liquidity to ensure that there would be no shortage of cash or funds to lend and no spikes in Japan’s interest rates. Massive liquidity injections flattened the Japan Government Bond yield curve, with the 10-year rate moving in a narrow range between 1.1 and 1.2 percent.

As of March 30, 2012, the government has decided to inject capital (¥191.0 billion in total) into 10 financial institutions—three banks, four shinkin banks, and three credit cooperatives—operating in the disaster-stricken areas in accordance with the Act on Special Measures for Strengthening Financial Functions.

**BOX 2, continued**

and other institutions to revitalize the regional economy. To that end, special provisions concerning the disaster have been added to the Act on Special Measures for Strengthening Financial Functions. First, special provisions for disaster-affected financial institutions in need of the government’s capital injection to strengthen its financial functions have been added. For instance, when such a financial institution draws up a management enhancement plan, its top executives are not held responsible or required to set profitability and efficiency targets, on the grounds that the impact of the earthquake and tsunami is beyond their control. Furthermore, the costs the financial institution bears for receiving capital injection are substantially lower than the costs needed under normal conditions. In addition, a much longer period is allowed for securing the repayment funds. In return for receiving this capital injection under very favorable conditions, the financial institution is expected to play its financial intermediary functions in an even more active way. Second, special provisions have been incorporated for shinkin banks, credit cooperatives, and other cooperative financial institutions to further ease the requirements for capital injection. Under the amended law, the government and the central organization of a financial institution jointly inject capital, and the financial institution is required to conclude a management guidance agreement with the central organization. In the event that the injected capital is highly unlikely to be repaid by the set date, said capital will be liquidated and the financial institution’s business restructured. The Deposit Insurance Corporation’s funds are used as the source of capital injection. The amendments also include a five-year extension to the end of March 2017 of the time limit for applications for the government’s capital injection.
One of the critical challenges for the Japanese economy remains overcoming deflation to return to a sustainable growth path with price stability. The Bank of Japan and the government are working together to prevent the economy from falling into a vicious cycle between yen appreciation and deflation.

**IMPACTS ON ENERGY SUPPLY**

The damage resulting from the earthquake and tsunami is being compounded by the resulting shortages in energy supply. Energy supply disruptions have caused rolling blackouts that have disrupted Japan’s production capacity in its industrial heartland in the Kanto region, which accounts for about 40 percent of national GDP.

The Fukushima nuclear accident has pushed the government to explore alternative energy sources. Ministry of Economy, Trade and Industry (METI) established the Fundamental Issues Subcommittee under the Advisory Committee for Natural Resources and Energy to advise a new long-term energy plan. In the interim report, the committee emphasized the need to reform the demand structure, including energy conservation measures and controls on peak-time electricity demand.

In the short term, the shift toward other energy sources will boost imports from oil- and petroleum-exporting countries in the East Asia region, in particular Indonesia, Malaysia, and Australia.

**IMPACTS ON INDUSTRIAL PRODUCTION**

The main economic activities in the affected region are agriculture (mainly rice paddy fields) and fisheries, but manufacturing accounts for about a quarter of production in the region, and plants in the most severely damaged areas supply parts and products used in manufacturing elsewhere in Japan and Asia.

Damage to Japan’s industrial facilities caused a sharp drop in production following the GEJE, but swift reconstruction has minimized the long-term impact on production.

Japan’s METI reported that, as of August 2011, restoration works had been completed for 93 percent of the 91 production bases directly affecting Japan’s major manufacturing industries, including machinery, automotive, and consumer electronics. The automotive industry recorded the greatest fall in production, but recovered rapidly as facilities reopened and vital transport networks were repaired. Industrial production rebounded from April onwards with a growth of 6.2 percent in May and 3.8 percent in June. But this is still not sufficient to fully offset the initial 15 percent fall experienced in March. Production in June remained lower than in 2010 and was 5 percent lower than in February, on a seasonally adjusted basis. Most affected industries have now reached almost predisaster levels of production (figure 4).
The “double debt problem” generally refers to the financial difficulties facing individuals and business owners stricken by the GEJE who need to borrow to rebuild their destroyed houses and offices. But as they have existing loans on such premises, borrowing additional money results in two debts on the same property. The Japanese government as a whole worked on policy responses and formulated the Policy for the Double Debt Problem, which was released on June 17, 2011 (as explained in box 2).

**GLOBAL SUPPLY CHAINS**

**IT’S A SMALL (NETWORKED) WORLD AFTER ALL**

With the rapid progress of information and transport technology together with the promotion of free trade, humans have developed an extensive network of production, trade, and investment throughout the world. Moreover, we have intensive agglomeration of production and consumption in major cities throughout the world, which are mutually connected through a dense supply chain network. Today’s global production system is a complex, networked system that has operated efficiently under normal conditions. Nevertheless, recent megadisasters in Japan and Thailand have revealed the networked world’s vulnerability to major disasters.

The magnitude of the Japanese economic impact is partially attributable to supply chain network disruptions. The disaster-affected area serves as a major source of supply chain flow of goods (from procurement of parts to the delivery of finished products) for Japan’s...
manufacturing industry. Failures of parts and materials deliveries from this area have forced many manufacturers nationwide to suspend their operations. The automobile industry, the electronic equipment industry, and the metal industry were affected most severely because they particularly depended on key parts and basic materials produced in the disaster-affected area. Figure 5 shows that Japanese automobile production in the first and second quarter of 2011 were, respectively, 25 percent and 33.8 percent less than those in the same period the prior year.

Eastern Asia today, often called the World Factory, is based on a supply chain network centering around dozens of major cities and industrial agglomerations. Consequently, the impact of the GEJE and tsunami disaster could not remain limited to Japan. Figure 5 shows that automobile output in China’s Guangdong Province and Thailand declined, respectively, by 17.3 percent and 11.5 percent in the second quarter. Other Asian countries such as Indonesia, Malaysia, and the Philippines were also affected. The impact extended beyond Asia. In the United States, where automakers, including those of Japanese origin, depend on the supply of some crucial parts from Japan, production growth plunged from 15.6 percent in the first quarter to 2.3 percent in the second. These results reaffirm that disruption in a specific region affects the world through the supply chain network.

In the fourth quarter of 2011, when Japanese manufacturing industries had almost recovered from the impact of the disaster, the Eastern Asian supply chain was challenged again by the great flood in Thailand, the worst in 50 years. Automobile output in Thailand dropped by 61.5 percent in the fourth quarter compared to the same period of the prior year. Affected by the shortage of parts supplies from Thailand, Japanese automobile production was limited to a 4.5 percent year-on-year growth in November after recording 20.3 percent growth in October, although the impact was short-lived, and growth returned to 13.4 percent in December. Being the local hub of the automobile supply chain in the Association of Southeast Asian Nations (ASEAN), the Thai effect was felt more severely in Malaysia and the Philippines, while the impact on Indonesia was sharp and short (year-on-year growth rates dropped to 0.7 percent in November but showed greater than 20 percent growth in October and December).

Thailand is also known as the global center of hard disk drive production—accounting for almost 20 percent of world exports, on par with China. According to a market survey conducted by Kakaku.com, compared to the beginning of October 2011 retail prices of
popular-type hard disk drives (1 terabyte capacity and 7,200 rpm spin speed) in the Japanese market shot up 150 percent–200 percent by mid-November before settling down, but remained about two times as high as the preflood level at the beginning of February 2012.

**DISASTER STRIKES WHEN YOU LEAST EXPECT IT**

Recent experiences remind us of the vulnerability of supply chain networks, which contain some critical nodes wherein production of particular parts and components is concentrated among a few suppliers. Importantly, such concentrations do not result from planning failures. Rather, they are self-organized through market interactions. Because of scale economies, production concentration is preferred by both suppliers and customers. Although a trade-off relation exists between scale economies and transport costs to deliver products to distant customers, lower transport costs make the concentration of production more profitable, as shown in figure 6. Consequently, globalization (decline of broadly defined international transport/transaction costs) tends to enhance the formation of agglomeration within a global supply chain. Because of self-organization, it is not feasible to eliminate potential risks by agglomeration in highly complex supply chains. To complicate matters further, when a disruption occurs, it is impossible to find replacements from other suppliers, at least in the short run, because of a high degree of customization. An example from the 2011 disaster was the Renesas Electronics Corporation’s Naka plant, located in Ibaraki Prefecture. It produces a micro control unit (MCU) for high-quality motor vehicles that makes extensive use of electronic control technology. Over the years, Renesas has become a supplier of customized MCUs for major automobile companies throughout the world.

We might find other cases of dispersion forces if concentration increases the potential risk of disruption for the entire supply chain. Dispersions in this case might involve: building sufficient safety stocks (dispersion of products), use of multiple suppliers, and duplication of production facilities. These actions, which are components of so-called business conti-

---

**FIGURE 6: Trilateral trade-offs in global resilience**

- Scale economies
- Trade-off
- Transport costs
- Agglomeration/Dispersion
- Risk
nuity plans (BCPs), are aimed at increasing redundancy and resiliency. They garner great attention in the supply chain management literature.

But individual firms are rarely capable of taking sufficient actions to mitigate the potential loss from supply chain disruptions because they are generally reluctant to assume the loss of efficiency derived through scale economies. High impact/low probability events, such as huge earthquakes and tsunamis, make our predictions more diverse and imprecise. Generally, although people’s awareness of risk is tuned to a high level soon after experiencing an important natural disaster, heterogeneity in beliefs will increase with the passage of time. Moreover, uncertainty will be high in the decision-making process because the valuation of risks is difficult. In such a case, the market equilibrium can only reflect the opinion of the more optimistic firms, which avoids the costs of risk management. Agency problems might also be an issue. A risk-conscious buyer might wish to enforce a BCP on its supplier in the business contract, but the supplier’s implementation could be partial if monitoring costs are high.

Actually, the 2011 disaster was not the first supply chain crisis in eastern Asia, even in recent times. A strong earthquake in Taiwan in March 2000 shut down large liquid crystal display factories agglomerated around the Hsinchu Science Park. The outbreak of the SARS epidemic in southern China in 2002–03 sent ripples through the global supply chain. Japan itself also suffered disruptions after the Great Hanshin-Awaji Earthquake of 1995 and the Chuetsu Offshore Earthquake of 2007. Those disasters and their effects notwithstanding, critical nodes still widely persist.

**BETTER TO BE BRISK AND SLAPDASH THAN SLOW AND ELABORATE**

Prompt measures to remove bottlenecks are undoubtedly necessary to avoid prolonged dysfunction of supply chain networks. Agglomeration has a lock-in effect: that is, firms take actions reflexively to restore the agglomeration after it is damaged by temporary shocks. Collaboration among firms and/or government support stimulation of such efforts hasten rehabilitation.

Auto production in Japan recovered nearly to a normal level in August, five months after the shock. We might consider that the rapid recovery showed the high resilience of supply chain networks in the Japanese automobile industry. This was in part due to emergency relief measures taken by the private sector such as sending technical personnel from all rival customer firms collaborating to help rehabilitate damaged suppliers’ factories. The rapid revival of transportation networks (highways, railways, airports, and seaports) was also of fundamental importance.

After the Thai flood, the government implemented some measures to support firms striving for continuing production. These measures included: permission for temporary production relocation and outsourcing and the exemption of import tariffs on locally unavailable parts, components, and industrial equipment. Additional corporate tax exemption was also given to flood-hit companies. For the automobile industry, imports of assembled cars were allowed free of tax. Entry of foreign experts to engage in rehabilitation of factories was made flexible.
These measures were complemented by international cooperation. The Japanese government issued temporary work visas for six months to Thai workers employed by flood-hit factories of Japanese affiliates. By the end of 2011 about 3,700 workers had participated in the program. This program benefited Japanese firms who needed quick startup of back-up production in Japan to mitigate the disruption of the supply chain; it benefited Thai workers who might have lost jobs otherwise. The Bank of Thailand and the Bank of Japan launched a cooperative effort to provide Thai baht loans to flood-hit Japanese affiliates backed by Japanese government bonds.

PROVIDING IS PREVENTING: FINDING OPPORTUNITY IN CRISIS

There is no time to lose in emergencies. At the same time, it is necessary to consider whether returning to the predisaster situation is truly desirable if potential risks latent in agglomerations become glaringly apparent. We now confront the urgent task of promoting global disaster risk management of highly networked supply chains while our memory of 2011 is still fresh.

INDIVIDUAL FIRM/INDUSTRY LEVEL

The main issue will be to enhance the resiliency of the supply chain while maintaining its efficiency. To minimize supply disruption, each company can seek the best mix of the following strategies at the individual firm level:

- Elaborate a workable BCP that includes remote backup production provisions. Although this does not mean actual dispersion of production under normal conditions, repeated simulation training is necessary.

- Procure key parts and materials from multiple sources routinely, sharing the costs of dispersion between buyers and suppliers.

- Divide production and locate productive facilities in different locations, whether interregionally or internationally, even under normal conditions. Innovative production technology must be promoted by which higher-scale economies are obtainable with smaller production volumes.

- Coordinate standardization and sharing of parts and materials among companies. Avoiding excessive company-specific customization, such coordination provides sufficient lot size to suppliers by which dividing production facilities becomes economically viable.

These strategies have already been put into practice to some degree. Regarding strategy (1), when the earthquake halted desktop computer production at the Fukushima plant of Fujitsu, the company was able to restart production 12 days later at a factory 740 kilometers away in Shimane Prefecture in western Japan, which usually produced notebook computers, as had been simulated many times. This operation enabled Fujitsu to minimize the disruption period. Regarding strategy (2), Nissan has pursued a strategy of standardizing and sharing parts and materials aggressively through its experience of partnership with Renault. In fact, Nissan was able to recover production from the impact of the Thai flood quickly because it
was able to switch to other suppliers of its global procurement network. For strategy (3), high global market-share companies have recognized the importance of risk-averse dispersion to maintain their market positions. One such company, Nidec-Shimpo Corp., which supplies small motors used in various machine products, boasts an 80 percent share of the global hard disk drive motor market (according to the company’s Web site). When its three plants in Thailand were damaged by the flood, Nidec reacted quickly by increasing production capacity in China by 50 percent and that in the Philippines by 60 percent to compensate for the loss of operations in Thailand. This action avoided the collapse of hard disk drive production. The company announced that the proportion of the production in Thailand would be reduced from its original 60 percent even after the rehabilitation of the factories, thereby reducing the risk of concentration. As an example of strategy (4), companies are usually reluctant because they are concerned that the use of standardized parts would require compromises in product quality, leading to the loss of competitiveness. After the GEJE, however, METI took initiatives to coordinate parts sharing in the Japanese automobile industry, and it is expected that more concrete measures will be taken as well.

**LOCAL AND NATIONAL GOVERNMENT LEVEL**

As might be expected, local and national governments have roles in areas where private initiatives cannot suffice. Typically, public policies are expected to enhance the resilience of infrastructure of all kinds supporting industrial production and the daily life of people. For example, in Japan, earthquake-resistance standards for public facilities and infrastructure were revised based on analyses of the damage that occurred. Still, the 2011 disaster left us lessons of not mythologizing safety: provisions in land-use planning are necessary where there is a tsunami risk because tide walls can never be sufficiently high. Moreover, society must take a hard look at the benefits and shortcomings of dependence on nuclear power generation. Strengthening local infrastructure for prevention of urban flooding in developing countries should be greatly emphasized. On this aspect, international cooperation is necessary, for example, the Japan International Cooperation Agency (JICA) will aid the Thai government in presenting a new master plan for flood mitigation in the Chao Phraya Delta.

In broader perspectives, national spatial planning must be readdressed to decentralize the over concentrated economic-political functions in capital cities (for example, Tokyo, Bangkok, Manila, and Jakarta), and to develop a more resilient nationwide system of regions.

There is a need for accelerating the integration of the private sector into existing platforms and activities. One effective example of partnership and cooperation among national and local governments, volunteers, and the private sector is the Global Compact Network Japan (GCNJ). GCNJ joins the top corporate management of leading Japanese companies in a platform for linking corporate social responsibilities with business activities. GCNJ was established in 2003 and currently has a membership of more than 160 leading companies. GCNJ has been providing a platform for the private sector to address issues such as climate change and water, and create an enabling environment for PPP. After the GEJE, GCNJ organized a collective action program in which companies provided voluntary-based assistance to several disaster-affected cities in Miyagi Prefecture by utilizing and combining the resources and strengths of each company.
INTERNATIONAL COOPERATION

As we noted above, firms’ risk aversion functions to some degree as a dispersive force, but this necessarily involves additional transport costs. Because dispersion will be international, we must recognize transport costs in a broad sense including import tariffs and nontariff barriers, customs clearance procedures, communications costs, and even exchange rates. Countries must join forces to mitigate widely various costs related to cross-border transactions. Such cooperation will increase connectivity to the global supply chain and thus the chance of attracting investment.

The 2011 earthquake and tsunami disaster came as a further blow to the Japanese manufacturing sector, which had already been threatened by high factor costs and a strong yen. But when firms were inclined to transfer more production overseas, the Thai flood occurred, compelling firms to revise their risk assessments of excessive concentration of operations overseas. Given the existence of critical parts and material suppliers within Japan, Japanese firms will find it attractive to determine an appropriate mix of production in Japan and overseas. That will seem preferable to accelerating the hollowing out of the business environment for the improvement of taxation and expansion of free trade agreement networks.

Recently, the Thai government is proposing to Japanese local governments and industrial groups that small and medium-size firms in local industrial clusters invest as a group and establish sister clusters in Thailand. Sister clusters can operate with vertically linked specialization at normal times, thereby realizing cost reduction, while they can mutually back up production in cases of large natural disasters. Firms can thereby enjoy the same collective efficiency overseas through familiar face-to-face contacts as they do in Japan. This will promote locational diversification of small firms, for which related costs are unaffordable.

LESSONS

Measuring the full extent of the GEJE’s economic impacts will take time. All industrial sectors as well as services suffered significant direct and indirect impacts. A lot will depend on how the government will address the energy supply issues.

The Bank of Japan’s swift intervention to ensure immediate liquidity was instrumental in mitigating impacts related to yen appreciation and access to financing.

The government played an important role in alleviating the impacts on households and businesses thanks to the subsequent approvals of supplementary budgets and regulations such as the Policy for the Double Debt Problem (KN 6-4).

Unplanned concentration in supply chains is self-organized because of agglomeration economies. The network of agglomerations is efficient in normal times, but the global production system is thereby vulnerable to natural disasters.

When agglomeration is locked in, firms promptly react to restore the original structure against the damage of disaster. Cooperation among firms and supporting policies can accelerate the process.
Although quick restoration is necessary to avoid exacerbation of a crisis through prolonged dysfunction of supply chains, structural changes must be provided to enhance the resiliency of a supply chain, without mythologizing the safety of the status quo.

Resilience of supply chains demands a certain degree of geographical dispersion. To mitigate the loss of efficiency by dispersion, the previously described individual firm strategies (1)–(4), government policies, and international cooperation are in order.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

In today’s networked world, most countries are involved in the global supply chain, of which developing countries are an important part. A major disaster occurring in one country can have a global impact. Consequently, it is expected that developing countries will share the burden of strengthening the global resilience of supply chains.

Vulnerability is particularly high in many developing countries because political and economic activities are excessively concentrated in capital cities. An urgent need exists for bold measures aimed at decentralization and establishing backup systems for emergencies. Furthermore, recent rapid urbanization during economic growth has led to the destruction of natural systems of disaster prevention such as the water retention capacity of forests, thereby increasing risks of flooding. Moreover, urban sprawl is occurring in marginal areas where the infrastructure is unprepared for severe natural events.

A pressing need exists to remedy such weaknesses under international cooperation. Coordination among neighboring countries is also necessary in such areas as cross-border transportation systems and water resource management. Policy makers should assess natural disaster risks in a new light—as a mainstream issue that must be addressed by a country to play a major role in global production networks.

It is important that the impacts of a large-scale disaster such as the GEJE are not assessed and addressed in isolation but also by taking into account potential region- and worldwide impacts. Many countries in developing East Asia have strong ties with Japan and would be affected by an appreciation of the yen. In the immediate aftermath of the earthquake, when the yen appreciated sharply because of speculation about sizeable repatriation flows by insurance companies, corporations, and households, the Japanese authorities and the G-7 undertook a concerted effort to stabilize the course of the yen to avoid repercussions for the rest of the world, and East Asia specifically. Coordination among countries is fundamental in mitigating potential impacts of large-scale disasters.

KEY REFERENCES


The Great East Japan Earthquake (GEJE) occurred against the backdrop of a struggling economy and public finance system under stress, implying an exceptional fiscal cost and imposing a fiscal management challenge to the government of Japan (GoJ). In response, the government committed to a full-scale national initiative that has evinced its ability to quickly mobilize short-term liquidity but leaves in question its reliance on debt issuance and taxation measures to finance longer-term reconstruction. This note examines the fiscal costs of the event, the financial measures taken by the GoJ to fund these expenses, and the fiscal implications of these actions. Lessons learned and recommendations for developing countries are distilled from this discussion.

The Great East Japan Earthquake (GEJE) inflicted massive physical damage on private and public assets, destroyed livelihoods, and disrupted local and national economies. In the aftermath of the event, the GoJ announced a full-scale national response in which the government would support (i) rebuilding disaster-resilient regions, (ii) restoring the livelihoods of the disaster-affected population, and (iii) reviving the local economy and industry. To finance this approach, the GoJ mobilized a portfolio of fiscal measures that minimized the financial burden on local governments, residents, and industry but significantly increased the financial burden of the central government, and thus, indirectly, of the current and future Japanese population and economy. According to the Cabinet Office, the GEJE was a “crisis in the midst of a crisis” for the Japanese economy and its public finance (Cabinet Office 2011c). The GoJ has had to balance financing and executing an effective postdisaster response against planning how to spread the costs of this response across generations.

**FINDINGS**

Understanding the GoJ’s postdisaster roles and responsibilities, as stated in Japanese laws and as evidenced by past disasters, helps to explain the GoJ’s expenditures and revenues
TABLE 1: **Direct economic impact of the GEJE**

<table>
<thead>
<tr>
<th>Law(s)</th>
<th>Relevance to the GoJ’s contingent liability in natural disasters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disaster Relief Act (1947)</td>
<td>• Provides for disaster relief and welfare support (including</td>
</tr>
<tr>
<td></td>
<td>repair of private housing, cash transfers and/or loans, and so</td>
</tr>
<tr>
<td></td>
<td>on) to affected populations.</td>
</tr>
<tr>
<td></td>
<td>• Establishes subsidization of local governments’ measures by</td>
</tr>
<tr>
<td></td>
<td>the central government.</td>
</tr>
<tr>
<td></td>
<td>• Mandates the establishment of a disaster relief fund for</td>
</tr>
<tr>
<td></td>
<td>emergency relief activities by each prefecture.</td>
</tr>
<tr>
<td>Disaster Countermeasures Basic Act (1961)</td>
<td>• Is the cornerstone of Japan’s disaster risk management (DRM)</td>
</tr>
<tr>
<td></td>
<td>system.</td>
</tr>
<tr>
<td></td>
<td>• Sets out local and central governments’ responsibilities at</td>
</tr>
<tr>
<td></td>
<td>all points in the DRM cycle, including levels and forms of the</td>
</tr>
<tr>
<td></td>
<td>local and central governments’ postdisaster responsibilities</td>
</tr>
<tr>
<td></td>
<td>• Embeds financial measures as one of the eight core compo-</td>
</tr>
<tr>
<td></td>
<td>nents of Japan’s DRM system; under this section, defines</td>
</tr>
<tr>
<td></td>
<td>disaster-expense-sharing fiscal mechanisms that can be employed</td>
</tr>
<tr>
<td></td>
<td>by the government postdisaster (for example, subsidy, tax, and</td>
</tr>
<tr>
<td></td>
<td>debt measures).</td>
</tr>
</tbody>
</table>

related to the GEJE. Japanese law clearly defines the roles and responsibilities, including financial, of the local and central governments in disaster response. A number of laws lay out a broad scope for the GoJ’s legal contingent liability\(^1\) in the event of natural disasters, inclusive of responsibilities for disaster response, reconstruction of public and certain private assets, and social and economic restoration. At the center of these laws are the Disaster Relief Act and Disaster Countermeasures Basic Act (table 1).

Other laws, such as the Act on Special Financial Support to Deal with Extremely Severe Disasters (1962) and the Natural Disaster Victims Relief Law (1998) further extend the scope of the government’s financial responsibility. Additionally, a series of laws that provide for government support to provision certain lines of insurance (earthquake, agricultural, fisheries, fishing boat, and forest; see KNs 6-1 and 6-2), establish a contingent liability of the government to pay its portion of reinsurance payouts under these schemes.

**COST OF THE GEJE TO THE GOJ**

The GoJ estimates that the GEJE caused direct economic damages to private and public capital and infrastructure in the amount of ¥16.9 trillion ($210 billion), 4 percent of Japan’s gross domestic product (GDP). The indirect costs of the event in the short, medium, and long term are difficult to quantify but are likely much greater.\(^2\) Although originally forecasted

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1 As defined in World Bank (forthcoming), a contingent liability is a spending obligation arising from past events that will be incurred in the future if uncertain discrete future events occur.

2 Indirect losses are losses that result from physical damage, such as business interruption, reduced tourism, reduced tax revenue, and so on.
to grow during 2011, Japan’s GDP contracted by 3.5 percent during the first quarter and by 0.7 percent for the full year (IMF 2011; World Bank 2012).

While the public sector’s share of the direct and indirect losses from the GEJE is difficult to determine, it is undoubtedly significant. More easily analyzed are the fiscal costs of the government’s relief, recovery, and reconstruction measures after the GEJE. For short- to medium-term costs, government budgetary and cash-flow data (that is, disaster-related expenditures and revenues) can be used. For assessment of longer-term fiscal impacts, projections are more difficult, as they embody a great deal of uncertainty due to possible variances in expected tax revenues, changes in the Japanese bond market, and/or changes in the GoJ’s debt-management capacity. Furthermore, fat-tailed risks, such as the possibility of long-term impacts from the nuclear accident in Fukushima, could increase the fiscal costs of the disaster in the long run.

**CENTRAL GOVERNMENT SPENDING FOR THE GEJE**

As of mid-2012, total central government funding allocated to the GEJE totals ¥19.17 trillion (table 2). This total includes spending from the first contingency funding approved in Japan’s fiscal year (FY) 2010, through the most recently approved funding for the FY12. While earlier funding (that is, up to and including the second supplementary budget) was primarily for relief and recovery costs, the later budgets were primarily for reconstruction. Thus, a significant share of the later budgets may be disbursed for reconstruction projects over multiple fiscal years.

*Note:* The Third Supplementary Budget included a ¥2,489.3 billion allocation to repay the financing borrowed from FY11 pension funding. This repayment has been considered in this accounting of the GoJ spending on the GEJE.

**TABLE 2: Approved central government spending on the GEJE, FY10–FY12**

<table>
<thead>
<tr>
<th>Date</th>
<th>Fiscal year</th>
<th>Financing mechanism</th>
<th>Amount (¥ billion)</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Mar 11</td>
<td>10</td>
<td>FY10 General Contingency Budget</td>
<td>67.8</td>
</tr>
<tr>
<td>19 Apr 11</td>
<td>11</td>
<td>FY11 General Contingency Budget</td>
<td>50.3</td>
</tr>
<tr>
<td>2 May 11</td>
<td>11</td>
<td>1st Supplementary Budget</td>
<td>4,015.3</td>
</tr>
<tr>
<td>25 Jul 11</td>
<td>11</td>
<td>2nd Supplementary Budget</td>
<td>1,998.8</td>
</tr>
<tr>
<td>21 Nov 11</td>
<td>11</td>
<td>3rd Supplementary Budget</td>
<td>9,243.8</td>
</tr>
<tr>
<td>8 Feb 12</td>
<td>11</td>
<td>4th Supplementary Budget</td>
<td>6.7</td>
</tr>
<tr>
<td>1 Apr 12</td>
<td>12</td>
<td>FY12 Bridge Budget</td>
<td>9.3</td>
</tr>
<tr>
<td>6 Apr 12</td>
<td>12</td>
<td>FY12 Budget</td>
<td>3,775.4</td>
</tr>
</tbody>
</table>

**TOTAL** | 19,167.4
**TOTAL FY11** | 15,314.9

*Source:* Authors, with data from Japan Ministry of Finance (2012).

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3 Japan’s fiscal year runs April 1 to March 31. The GEJE struck on March 11, 2011, toward the tail end of FY10.
The GEJE imposed an exceptional cost on Japan’s central government: total central government funding for the event through mid-2012 represented 4 percent of FY10 GDP and 20.7 percent of GoJ’s initial FY11 general account budget (table 3). Considering only the costs incurred during FY11 following the event, these represent 16.6 percent of the initial general account budget and 3.2 percent of FY10 GDP. In comparison, central government spending on the Great Hanshin-Awaji (Kobe) Earthquake of 1995 totaled about 1 percent of Japan’s GDP at the time (IMF 2011).

The GEJE reconstruction period is planned for ten years, with the first five as the concentrated reconstruction period. The latest GoJ figures for central and local government reconstruction expenditures (released on July 29, 2011) estimate at least ¥19 trillion until the end of FY15 and ¥23 trillion for the full ten years (Reconstruction Headquarters 2011). As central government spending through FY12 has already exceeded ¥19 trillion, it is likely that total public expenditures on the GEJE will run fairly above these levels.

The central government is also responsible for its portion of insurance payouts under the public-private insurance programs for earthquakes, agriculture, fisheries, fishing boats, and forests. Payments for the government’s liability under the fisheries and fishing boat insurance, ¥93.9 billion, are included in the first supplementary budget. The central government’s share of payouts for the GEJE under the agricultural and forest insurance programs is still undetermined. Its payment under the earthquake insurance program, not financed by the supplementary budgets, totals ¥540 billion.

<table>
<thead>
<tr>
<th>TABLE 3: Estimated costs of the GEJE to the central government of Japan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of FY10 GDP</td>
</tr>
<tr>
<td>-------------------------</td>
</tr>
<tr>
<td>Total, FY10–12</td>
</tr>
<tr>
<td>Total, FY11</td>
</tr>
</tbody>
</table>

Source: Authors, with data from Japan Ministry of Finance and Cabinet Office.

4 FY10 GDP was ¥479.2 trillion and FY11 initial general account budget was ¥92.4 trillion (Ministry of Finance 2011).
5 This estimate includes the first and second supplementary budgets, which had already been approved at that time.
6 The level of payout for the agricultural insurance program remains uncertain due to the nuclear accident at Fukushima.
FIGURE 1: **Central government funding allocation for the GEJE, FY10–FY12**

*Source:* Authors, with data from Japan Ministry of Finance.

*Notes:* (i) Due to rounding, the sum of these totals is not exactly equal to total central government expenditure, ¥19,167.4 billion. (ii) This categorization of allocations is based on that used by the GoJ. In some cases, two GoJ categories have been combined when funding is for similar activities.

While these figures are informative, they must be interpreted with care. Some categories provide estimates of close to final or final totals for allocations to the category; others, such as repair and reconstruction and interest payments for reconstruction bonds, will continue to grow. In addition, because the local tax allocation grants to local governments represent a discretionary spending category, the governments can allocate these funds across the remaining categories (that is, the total of central and local government spending on disaster relief may be greater than what is captured here); similarly, the reconstruction grants for local governments increase the total amount spent on repair and reconstruction of buildings and infrastructure.

**COSTS TO LOCAL GOVERNMENTS**

The fiscal impact of the GEJE on local governments (prefectural and municipal) is much more difficult to assess, in great part due to the very limited availability of information on disaster-related expenditures and revenues at local levels. The scale of the disaster—primarily in the three most-effected prefectures, Fukushima, Iwate, and Miyagi—suggests that it far exceeded the capacity of local public finance to fund a significant share of reconstruction costs.

From the designation of the GEJE as an “extremely severe disaster” the day after the event, the GoJ’s decisions and policies have aimed to shift as much of the financial burden of the GEJE to the central government. For example, under the Natural Disaster Victims Relief Law, which provides subsidies up to ¥3 million to affected households, the central
### TABLE 4: Explanation of central government funding allocations for the GEJE

<table>
<thead>
<tr>
<th>Allocation category</th>
<th>Amount (£ billion)</th>
<th>Additional explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repair and reconstruction of buildings and infrastructure (public and private)</td>
<td>3.605.2</td>
<td>Repair and reconstruction of public and private buildings (airports, facilities, housing, schools, and so on) and infrastructure (sanitation, roads, railroads, and so on).</td>
</tr>
<tr>
<td>Local allocation tax grants to local governments</td>
<td>2,878.0</td>
<td>Special tax allocation for discretionary spending.</td>
</tr>
<tr>
<td>Reconstruction grants for local governments</td>
<td>1,848.0</td>
<td>Program for municipalities in the Special Zone for Reconstruction.</td>
</tr>
<tr>
<td>Public financing (loan) programs</td>
<td>1,433.3</td>
<td>Loan programs for small and medium enterprises (SMEs), agriculture and education industries, homeowners, and so on.</td>
</tr>
<tr>
<td>Economic and social restoration measures and miscellaneous expenses</td>
<td>4,050.6</td>
<td>Support to economic restoration such as employment measures, measures for SMEs, agriculture-related industries, and so on. Support to social restoration such as housing grants, health-care support, education assistance, and so on. Miscellaneous costs such as self-defense and police forces; food, fuel, electricity, and natural resource supplies; international information sharing; and so on.</td>
</tr>
<tr>
<td>Contingency reserve for recovery and reconstruction from the GEJE</td>
<td>1,200.0</td>
<td></td>
</tr>
<tr>
<td>Debris management</td>
<td>1,062.1</td>
<td></td>
</tr>
<tr>
<td>Disaster relief</td>
<td>773.2</td>
<td>Temporary housing, condolence money, and so on.</td>
</tr>
<tr>
<td>Disaster reduction measures</td>
<td>1,057.9</td>
<td>Earthquake-resistant building of schools (national).</td>
</tr>
<tr>
<td>Reconstruction from nuclear damage</td>
<td>836.9</td>
<td></td>
</tr>
<tr>
<td>Compensation for damage by nuclear accident</td>
<td>275.4</td>
<td>Security money, investment.</td>
</tr>
<tr>
<td>Interest payments for reconstruction bonds</td>
<td>125.3</td>
<td></td>
</tr>
</tbody>
</table>

*Source: Authors, with data from Japan Ministry of Finance.*
and local governments equally share the liability. Following the GEJE, however, the law was amended with the central government’s share being increased to 80 percent for the GEJE.\(^7\) The central government budgeted ¥352 billion between the first and second supplementary budgets to fund its additional liability under the program.

The role of the central government in funding reconstruction is emphasized in the central reconstruction policy, the *Basic Guidelines for Reconstruction in Response to the Great East Japan Earthquake*. The *Basic Guidelines* promote a full-scale national response that will “make use of all possible measures to support reconstruction efforts of the disaster-affected local governments,” and establish a Special Zone for Reconstruction within which local governments, residents, and industries are eligible for tax reductions and incentives and budget and financial subsidies. One of the most significant supporting subsidies is the reconstruction grant program for local governments. Under this program, after having their reconstruction plans approved, municipalities receive grants worth 50 percent of project costs for infrastructure and asset reconstruction and 80 percent for supporting projects. The remainder of the project costs can be financed by the special local allocation tax provided by the central government, effectively eliminating any additional expenses to the municipal government (Reconstruction Agency 2012).

Through FY12, the central government provided ¥1.6 trillion in GEJE reconstruction grants and about ¥3 trillion in local allocation tax grants to local governments. Restrictions on the use of the special local allocation tax grants have been relaxed for the GEJE reconstruction, allowing for spending at the discretion of local governments.

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\(^{7}\) This amendment only applies for the GEJE. Cost sharing remains 50/50 for all other disaster events.
Reduced tax revenues from special tax measures

The GoJ implemented a series of special tax measures designed to increase the cost sharing of disaster recovery and reconstruction by the Japanese population and private sector (table 5). Many tax incentive measures also aimed to attract the development of priority industries in the reconstruction zone. These tax incentives were complemented by financial incentives through subsidies in some cases.

In the longer term, these tax measures would help to widen and deepen the government’s tax base and raise tax revenue. In the short term, however, they reduced the tax revenues of the central and local governments. The central government, therefore, bore the full costs and compensated the local governments for their decrease in revenues (Reconstruction Agency 2012).

<table>
<thead>
<tr>
<th>Target</th>
<th>Goal of measures</th>
<th>Measures</th>
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| Japanese population and private sector    | Encourage contributions to recovery and reconstruction efforts | • Increase of maximum deduction from income tax for contributions to the GEJE.  
• Income tax deduction for investments in companies contributing to the regional recovery. |
| Disaster-affected population and enterprises | Relieve financial and administrative burden                | • Individuals: Special treatments for casualty losses, property damage (housing, household assets, motor vehicles), pension savings, and so on.  
• Firms: Special treatments for inventory and asset losses, withholding taxes, and so on. |
| Promote investment and growth in reconstruction zones |                              | • Tax incentives to promote investment, employment, and research and development in selected industries (for example, renewable energy, agriculture, and medical). |

**TABLE 5: Special tax measures in response to the GEJE**

Source: Authors, with information from the Japan National Tax Agency (2011).
GOJ’S SHORT-, MEDIUM-, AND LONG-TERM DISASTER FINANCING METHODS AND THEIR FISCAL IMPACTS

SHORT-TERM FINANCING MECHANISMS

The GoJ moved with remarkable speed to mobilize emergency relief funding following the GEJE. Within three days, the Cabinet Office was determined to draw down on Japan’s FY10 general contingency budget\(^8\) to procure and transport emergency relief supplies to the disaster-affected areas. A total of ¥67.8 billion was mobilized before the end of March; in April, another ¥50.3 billion was drawn down from the FY11 general contingency budget for transitional shelter. This funding was quickly mobilized because, unlike supplementary budgets, prior parliamentary approval was not required.\(^9\) Thus, the general contingency budget provided immediate bridge financing till more substantial funding could be mobilized (figure 2).

Within two months, the GoJ approved a ¥4,015.3 billion supplementary budget for relief- and recovery costs. For this First Supplementary Budget, the Ministry of Finance looked within the existing budget for funding sources. The approved budget relied on a combination of budget reallocation (¥660.6 billion), borrowing from the pension fund (¥2,489.7 billion), contribution from public works projects (¥55.1 billion), and liquidation of the full FY11 allocation to the Contingency Reserve for Economic Crisis Response and Regional Revitalization (¥810 billion).

This approach illustrates the GoJ’s resourcefulness, but also demonstrates the limitations of ex post budget adjustments to finance disasters. Budget reallocation was used for the first supplementary budget and again for the third (¥164.8 billion). In sum, though, less than 1 percent of the FY11 general account budget was reallocated to the GEJE recovery efforts, and budget reallocation contributed only 5.4 percent of current total central government spending on the event. Furthermore, more than half the funding for the first supplementary budget was borrowed from the pension fund, which allowed the government time to mobilize additional resources that have to be repaid at a later date. Finally, the government redirected the full FY11 Contingency Reserve for Economic Crisis Response and Regional Revitalization toward the disaster—the intent of this reserve, however, was not for natural disasters but for economic measures required to stabilize Japan’s economic situation during times of financial crisis.\(^10\)

In late July, the smaller second supplementary budget was passed. The GoJ was able to fund this budget with surplus from FY10, the result of higher-than-expected FY10 tax revenues and unused funds.

\(^{8}\) For the 23 years preceding 2010, Japan’s general contingency budget was allocated ¥350 million; in 2010 this allocation was lowered to ¥300 billion, representing about 0.3 percent of the central government’s initial general account budget for 2010.

\(^{9}\) Retroactive parliamentary approval is allowed for expenditures from the general contingency budget.

\(^{10}\) The Contingency Reserve for Economic Crisis Response and Regional Revitalization was introduced in the budget in FY10 in response to the worsening economic situation caused by the global financial crisis. The contingency budget had previously been used to support employment programs for college graduates as well as other economic support programs.
Medium- to long-term financing mechanisms

The government’s short-term measures funded relief-and-recovery activities while it formulated its reconstruction policy. When the Basic Guidelines policy document was released at the end of July, it set a conceptual framework of sharing the costs of GEJE reconstruction within this generation and not passing them on to future generations of Japanese. Financial resources provisioned for use by the Basic Guidelines are listed in figure 3.

On November 30, 2011, the bill on special measures to secure financing for GEJE reconstruction was passed. Its approval followed a great deal of debate about what debt and tax measures the government should take for the GEJE. Under the approved plan, issuance of Japanese Government Bonds (JGBs) financed the majority of the estimated reconstruction costs. The bulk of repayment costs for these bonds were secured through tax increases. Personal income tax, in the form of surtax, was raised for 25 years starting in 2013. A 5 percent corporate income tax cut that was initially planned in 2011 was postponed, and a ¥1,000 increase in per capita local tax (currently ¥4,000 per year) was included. Table 6 provides details on the increases and their projected revenue generation.

While the tax measures will be phased starting in FY12, reconstruction bond issuance commenced in early December 2011. In total, slightly more than ¥14.2 trillion of JGBs have been issued or planned thus far: approximately ¥11.6 trillion for the third supplementary budget of 2011 and nearly ¥2.7 trillion for FY12. Interestingly, about 25 to 30 percent of reconstruction bonds are being sold to retail investors with 3-, 5-, and 10-year maturities. A portion of these bonds are reconstruction supporters bonds that facilitate financial support and solidarity from the Japanese public. These bonds offer the lowest possible interest rate for government bonds (0.05 percent) for three years, before converting to standard JGB rates. The GoJ has recruited Japanese celebrities to market the bonds and is offering gold and silver commemorative coins to purchasers (figure 4).

Fiscal impacts of the GoJ’s financial measures

Although the GoJ is endeavoring to minimize debt costs and tax increases, the financial measures it has taken for reconstruction have had significant fiscal impacts. The GEJE was “a crisis in the midst of a crisis,” and the financial burden of the event has placed significant additional strain on public finance.
Even before the GEJE, Japan’s public finance under stress, as budget deficits of the central and local governments grew. Credibility of the JGBs and its sovereign debt rating was, and still is, declining—it is now rated at the same level as China by each major rating agency (figure 5). Compared to its accumulated central government debt-to-GDP ratio at the time of the 1995 Kobe earthquake, which was lower than one-half of GDP, the GoJ’s central government debt was about 140 percent and growing at the start of FY11 (debt ratios of Hyogo prefectural and municipal governments doubled and remain higher than prior to the event).

One of the factors driving the government’s increasing dependence on debt has been Japan’s aging population and decreasing tax revenue. The population share aged 65 and above is expected to increase from 21.5 percent in 2007 up to 40 percent in 2050. Such aging is already increasing the fiscal burden on the government, as it needs to spend more on social expenditure. In addition, in recent years, tax revenues have been declining due to the global financial crisis and tax cuts. While Japan still can increase some tax forms, others, such as the corporate income tax, are already high.11

11 According to the IMF (2011), Japan’s consumption tax (value added tax, or VAT) is the lowest of advanced economies with a VAT, and its personal income tax structure allows much room for deductions and provides low marginal rates for the middle class.
In sum, at the time of the GEJE, the GoJ had little leeway in terms of either its ability to utilize debt financing or taxation measures. Debt issuance increases demand for fiscal reconstruction that further undermines confidence in the creditworthiness of the JGBs. Regarding tax increases, the government was relying on existing room for tax increases to finance rising social expenditures. The aging of the population means that the government is less able to spread the costs of the GEJET intergenerationally because there is already such a high burden placed on the young and future generations.

While initial policy goals following the GEJE were to minimize debt issuance and to keep taxation measures temporary, the plan finally agreed upon was somewhat different than that initially proposed. Issuance of reconstruction bonds was widely accepted as a short-term measure to finance the reconstruction costs. Opinions differed, however, regarding their redemption period. Standard construction bonds have a 60-year maturity, leaving the burden of repayment to future generations. For reconstruction bonds, though, the GoJ proposed that they be paid back within 10 years, with tax increases also within the redemption period to secure revenues to redeem them.

Ultimately, negotiation and compromise resulted in the final package of debt and tax measures for the GEJE. A much-discussed increase of consumption tax was left out of the package. The marginal increase of personal income tax was low, but the surtax was put in place for 25 years, placing the public debt burden on the “shrinking,” relatively speaking,

12 The GoJ has proposed to increase the consumption tax rate by 5 percent to fund increasing social expenditure costs until the mid-2010s as a part of its “unified reform of tax and social spending” initiative.
The Financial and Fiscal Impacts

Furthermore, there is a risk that reconstruction tax revenues will not match with expenditures for servicing reconstruction debt, which is being aligned with the broader plan for government debt issuance. In addition, long-term uncertainty about macroeconomic conditions increases the risk of mismatch between projected and actual tax revenues.

In the context of the government’s gross outstanding debt, the additional reconstruction bonds issued in FY11 and FY12 make small contributions (figure 6). That said, they force a change in the government’s medium-term fiscal policy to reduce debt issuance year on year, as the total amounts issued in FY11 and FY12 are greater than the reduction in nonreconstruction debt issuance. This dynamic poses challenges for the government’s fiscal consolidation target to halve the deficit-to-GDP ratio from FY10 by FY15 (Cabinet Office 2010).

13 The Act for Special Measures for Securing Financial Resources Necessary to Implement Measures for Reconstruction Following the GEJE does stipulate, though, that reconstruction bonds must be redeemed by 2037, within the term of income tax increase (Article 71).
LESSONS

• The GoJ’s broad contingent liability to natural disasters results from its responsibilities explicitly defined in Japanese laws and the implicit expectations of society, which can result in extraordinary fiscal costs, as evidenced by the GEJE. The GoJ is expected not only to reconstruct assets, but to restore social and economic well-being following a major disaster. This role aligns with the Japanese values of solidarity and cooperation, but implies that the public finance system is highly exposed to disaster risks. The GEJE raised general account spending by nearly 16.6 percent in FY11—an earthquake striking Tokyo, for example, could stress the system much further. Quantitative analysis of the government’s contingent liability to disasters would be an important first step toward management of its financial exposure to this type of event.

• Local governments are at the frontlines of disaster response and reconstruction and thus the most aware of local needs, but local public finance has limited capacity to cope with large-scale disasters. The liability of the central government was expanded following the GEJE (for example, under the Natural Disaster Victims’ Relief Law), and transfer schemes were designed to allow the central government to fund locally designed reconstruction plans. While the magnitude of the GEJE exceeded what might be reasonably expected for local public finance to manage, it provides an opportunity to review and strengthen the effectiveness of local governments’ disaster-financing mechanisms.

• The GoJ’s contingency budget allows it to quickly mobilize funding for an effective disaster response. The flexibility and immediate availability of the GoJ’s contingency budget allowed it to approve funding within three days of the GEJE to finance immediate emergency relief. Although relief costs represent a very small portion of the overall amount spent on the disaster, they serve an essential function in mitigating additional fatalities and damages linked to a slow response effort.

• Tax measures can be used effectively ex ante to incentivize investment in disaster prevention and ex post to facilitate cost-sharing of reconstruction by the population and private sector. Japan has a series of laws that provide tax incentives for investment in earthquake mitigation. Although difficult to quantify, these incentives promote risk reduction and likely reduced losses from the GEJE in some areas. Following the event, the government immediately enacted tax relief measures for affected populations and industries, and it built tax incentives into its reconstruction policy. It also offered special tax deductions to individuals and corporations that contributed to the reconstruction and recovery effort, thus facilitating solidarity and cost-sharing by the unaffected population and private sector.

• Financial demands placed on the government by major disasters exacerbate the underlying structural problems of the fiscal system. The GEJE forced the government to issue additional debt and pass tax increases in an economic and fiscal environment in which these actions were not only unfavorable, but counter

14 Equally as important, it was able to smoothly execute these funds for reconstruction due to preagreements with private sector firms. See KN 4-1 of this series for additional information.
to fiscal management policy. The experience emphasized the imperative of having a robust fiscal system capable of absorbing large disaster shocks. For Japan to achieve prompt and enduring reconstruction, it should look beyond restoration, which brings the Japanese economy back to the predisaster state, and seek to strengthen the economy and society in a broader sense to prepare for the future.

- **A lack of ex ante financial planning for disasters can contribute to disagreements and possible delays around securing reconstruction funding.** Although Japanese law allows for the government to secure funding for disasters in broad terms, lack of a clear “blue print” for how the government would finance reconstruction opened space for prolonged deliberation on appropriate measures. Alternative plans and road maps for flexibly financing reconstruction under different scenarios, both in terms of the type and scale of disaster and the economic and fiscal environment, could be designed to prevent this from occurring in the future.

**RECOMMENDATIONS FOR DEVELOPING COUNTRIES**

Japan’s public finance responsively provided financing for an effective relief effort, but was stressed by the extensive burden of recovery and reconstruction funding requirements. In developing countries, where governments’ fiscal options to finance disasters are likely more limited—for example, due to structural weaknesses such as lack of income support, inadequate financial resources, and lack administrative capacity—fiscal impacts of these events can be even more substantial. The following recommendations could mitigate the impacts of disasters on governments’ long-term fiscal balances and increase their financial response capacity in the aftermath of a disaster.

**TREAT DISASTER RISKS AS A CONTINGENT LIABILITY OF THE GOVERNMENT**

- **Quantitatively assess the government’s contingent liability in the event of natural disasters.** Identify the government’s explicit (that is, stated by law) and implicit (that is, socially and politically expected) contingent liabilities for disasters. Historical analysis, complemented with information from probabilistic risk models, can provide a sense of the government’s recurrent financial needs as well as possible major losses from catastrophic events related to these contingent liabilities. In addition, where risks cannot be quantitatively assessed, they should be qualitatively identified and discussed. Clear definition of the government’s contingent liability helps to protect public finance from an open-ended financial liability to disaster events.

- **Develop a disaster-risk-financing strategy as part of the government’s broader fiscal risk management strategy.** The disaster risk financing and insurance strategy should combine ex post and ex ante measures to optimize the timing, cost-efficiency, and effectiveness of disaster funding. For short-term postdisaster liquidity needs, the strategy should rely on ex ante budgetary and possibly market-based instruments, such as contingency budgets, reserve funds, and contingent credit. For the longer term, major reconstruction costs, a “blue print” for mobiliza-
tion of ex post financial resources (for example, debt issuance and tax increase) should complement the ex ante measures. Scenario analysis should be conducted to ensure the robustness of the strategy for disasters of varying type, magnitude, and location under different macroeconomic and fiscal conditions.

- **Understand the roles and financial responsibilities of the central and local governments in this process.** Local governments should, to some extent, share financial responsibility for disasters affecting their territories. But local and central governments should agree together ex ante whether and how sharing of these financial responsibilities changes after severe disasters.

**REDUCE THE CONTINGENT LIABILITY OF THE GOVERNMENT IN THE LONG TERM**

- **Use fiscal tools such as taxation and subsidization to encourage ex ante DRM.** The government could decrease residential and private sector dependence on post-disaster government aid by using tax and/or subsidy tools to encourage ex ante DRM. Although the relative power and ease of use of tax versus subsidy tools varies across countries, the government could achieve similar ends through either means by offering tax incentives or subsidies for investment in disaster prevention. It could also promote minimum levels of prevention by imposing tax penalties or fees for underinvestment in risk reduction and/or for risk-increasing actions.

- **Promote the development of private catastrophe risk insurance markets.** The deepening of private catastrophe risk insurance markets shifts more of the burden of postdisaster recovery to specialized risks carriers. The government can encourage the development of functioning catastrophe risk markets by putting in place and enabling the legal and regulatory framework, developing risk market infrastructure, and facilitating risk-pooling mechanisms.

**REFERENCES**


Every country should develop strategies for managing low-probability, high-impact extreme events—strategies that reflect their own as well as global experiences with megadisasters. These strategies should integrate structural and nonstructural measures tailored to local conditions. Forecasting and early warnings, land-use planning and regulation, hazard maps, education, and evacuation drills are all vital. Lessons from the Great East Japan Earthquake (GEJE) can help improve these nonstructural practices, which in Japan have been shaped by trial and error after experiences with many natural disasters. The international community should develop knowledge-sharing mechanisms to help countries prepare for low-probability, high-impact extreme events.

**FINDINGS**

**NATIONAL STRATEGIES TO ADDRESS LOW-PROBABILITY, HIGH-IMPACT EXTREME EVENTS**

The Great East Japan Earthquake (GEJE) was the first disaster in Japan’s modern history that exceeded all expectations and predictions. Its dimensions were almost “beyond imagination” (KN 5-1). Its enormous impact prompted the government to seek a paradigm shift in disaster risk management (DRM), moving from structure-focused prevention to a strategy of mitigation by integrating structural and nonstructural measures.

Excessive reliance on structural measures proved to be ineffective, and even detrimental, when the forces of nature exceeded the structures’ design limitations. In some towns, evacuation was delayed because people did not expect a tsunami to overtop an embankment as high as 10 meters or more. Some could not escape the tsunami in time because they had moved their homes to the lowlands along the coast to be closer to their source of income. They felt safe because high embankments had been built (KN 2-2-2).

Addressing low-probability, high-impact extreme events requires an integrated DRM strategy, combining structural and nonstructural measures. Disasters should be catego-
rized into two levels: level 1 consists of disaster events that occur with relatively high frequency (with a return period of around 100 years or less) and level 2 consists of events that rarely happen (with a return period of around 1,000 years or more). The GEJE was a level 2 event as illustrated in figure 1. Level 1 events can be addressed mainly by disaster prevention structures, while level 2 events require an integrated DRM strategy.

Strategies for level 2 events should focus on saving lives. Measures to be used in an integrated manner to ensure immediate evacuation include installing disaster forecasting and early warning systems; land-use planning; designating and building of evacuation sites, shelters, and other facilities; and installing structures to delay and weaken the force of waves. Education, practice drills, and mutual help mechanisms are extremely important. Urban and land-use planners need to consider mechanisms for speedy emergency evacuation and for sustaining social and economic activities. People’s participation is the critical factor in the planning process.

During the GEJE, catastrophic damage was inflicted when structures were overtopped by the tsunami, reached their breaking point, and suddenly collapsed. Structures should be resilient enough to hold up, or succumb gradually, even when the natural forces exceed their structural design limitation. Nonstructural measures such as land-use planning, forecasting and warning systems, evacuation drills, and public awareness-raising, should be designed with enough redundancy and flexibility to address different disaster scenarios.

FIGURE 1: Magnitude of earthquakes in Japan

Source: Cabinet Office.
Strategies should take into account the unexpected. In the GEJE, many plans did not specify the actions to be taken in the face of an unexpected event, contributing to catastrophic damage to facilities, communities, and socioeconomic systems.

**STRUCTURAL MEASURES**

Structural measures will continue to play a key role in managing low-probability, high-impact extreme events. Although many disaster prevention structures, such as tsunami defense dikes and gates, collapsed and were washed away in the GEJE, some withstood the waves even after they were overtopped, reducing the force of the tsunami and delaying its penetration inland (KN 1-1-1). In a number of cases the dikes were not overtopped, and kept the hinterlands from being inundated. Postdisaster computer simulations for the Kamaishi Port indicated that the wave breakers around the port reduced the peak height of the tsunami by 40 percent: from 13.7 meters to 8 meters.

Damage by the tsunami of 10 meters or higher to structures and buildings was extensive and severe. Almost all buildings and structures made of wood were destroyed. Iron structures were left with only their skeletons. Most reinforced concrete buildings withstood the tsunami, although they suffered internal damage (KN 1-2).

After the Indian Ocean tsunami and Hurricane Katrina, design standards for defensive structures, such as dikes and water gates, have been reevaluated. The conclusion is that using only preventive structures to defend against low-probability extreme events is not an economically, environmentally, or socially viable option. For example, it is not realistic to try to protect hundreds or even thousands of kilometers of seacoast using embankments, even as high as 20 meters.

Tsunamis should be classified into two or more categories. Level 1 tsunamis may occur once in a 100 years; level 2 tsunamis are extreme events that may occur once in a 1,000 years or more. Disaster mitigation structures such as wave breakers and dikes should be designed to prevent inland penetration by level 1 tsunamis, saving lives and properties. Although these structures could be overtopped by a level 2 tsunami, they should be able to withstand complete collapse, thereby reducing the force of the tsunami and delaying its progress. In the case of level 2 tsunamis, the structure is not expected to achieve complete mechanical prevention, but rather to mitigate damage, in combination with other nonstructural measures.

Using infrastructure such as highways and trunk roads as defensive structures is also recommended. In the GEJE, coastal highways and trunk roads functioned not only as evacuation routes but also as temporary evacuation sites and even as dikes (KN 1-4).

People in Kamaishi city’s Katakishi district fled to the Sanriku-Jukan Expressway which had opened on March 6, 2011, just six days before the earthquake. The expressway, which was on a hill, first served as an evacuation area and then as a main road for delivering relief goods and reconstruction materials. National routes running along the coast served as embankments preventing the tsunami from advancing inland.
NONSTRUCTURAL MEASURES

As Sanriku’s coastal areas have been repeatedly hit by tsunamis, many towns and communities had developed both structural and nonstructural measures which mitigated the impact of the tsunami substantially.

In addition to information dissemination and evacuation measures, the following nonstructural approaches were found to be effective against extreme water disasters:

- Moving residential areas and public buildings to higher ground, while keeping commercial installations and activities based in the lowland coastal areas (KN 2-8).
- Securing evacuation routes (such as roads and stairways) that connect public facilities (such as schools) to higher ground (KN 1-4).
- Planting trees densely in coastal areas (KN 2-8).
- Using tall concrete buildings (four to five stories or higher) as evacuation places.
- Using highways and trunk roads as secondary protective embankments.

The government of Japan enacted a new law—the Act on Tsunami Resilient Community—to promote these nonstructural measures in the tsunami-affected municipalities (see KN 2-7). The act requires: restricting the construction of buildings in risk areas; introducing integrated tsunami mitigation plans comprising evacuation routes and facilities, hazard mapping, drills, and warning systems; relaxing the floor-space ratio of buildings to encourage the construction of taller buildings; reducing property taxes on designated evacuation sites; and relocating houses to higher ground.

EVACUATION

Evacuation is the highest priority in low-probability, extremely high-impact events (KN 2-6). A large number of casualties can be expected not only because of the scale of the event, but also because:

- The lead time is shorter because of the sudden or unexpected occurrence of the event.
- Information networks and tools tend to malfunction when sensors and communication lines are destroyed, constraining people to react without accurate information.
- Evacuation options tend to be limited as the means of evacuation become fewer, for example, roads become impassable, traffic jams occur, and so on.
- People base their actions on past experiences with less-severe disasters, leading them to underestimate the time they have to evacuate and the severity of the consequences.
Raising awareness, education, and practice drills are the keys to ensuring faster, more complete evacuation in extreme events.

In Kamaishi City, where 1,000 people died out of a population of 40,000, the casualty rate among school children was low. Only 5 out of the 2,900 primary and junior high school students lost their lives. A survival rate of 99.8 percent for these school children is most impressive in a city where 1 in 40 lost their lives: the rate for school children was 20 times higher than for the general public. According to one headmaster, “repetitive drills, school education, and hazard maps” were the reasons for the high survival rate (KN 2-3).

In Kamaishi city, “a touch of disaster” is built into various lessons. In mathematics, for example, students may be asked “If the speed of a tsunami is xx kilometers per hour when it hits land, how long will it take the tsunami to get from the coast to a house that is xxx kilometers inland?” In a field exercise, students produced a tsunami hazard map on their own by visiting hazard and evacuation areas within the school district.

The students were also trained in key concepts, such as:

- “Tsunami tendenko,” that is, “Everybody should immediately evacuate without caring for anything or anybody else at tsunami onslaught.”
- Do not believe in human assumptions of disasters, even one in a hazard map, as nature behaves differently from human assumptions.
- Do your maximum when encountering disasters. Always think and be prepared for the worst.
- Lead evacuation—you are saving others’ lives by showing that you are evacuating for life and death.
- Although more than 90 percent of students were out of school when the earthquake occurred on March 11 (whether they were walking home, playing outside, or in their homes), almost all of them headed for higher, safer areas on their own initiative and encouraged the others to run with them to safety. Having already discussed it in their homes, children and parents alike knew and trusted that they would all evacuate individually if a tsunami hit Kamaishi.

Keeping individual, community, and institutional memory alive between disasters is critical to successful evacuation. A number of monuments had been built in the coastal towns commemorating past events and citing lessons such as: “Run to a hill if you feel a strong shake or the sea suddenly withdraws.” An nongovernmental organization (NGO) has called for the planting of cherry trees to delineate where the tsunami reached on March 11, so that future generations would remember the extent of the flooding.

The elderly, the disabled, and foreigners or outsiders to the locality needed extra help in evacuating. Sixty-five percent of those who died in the GEJE were more than 60 years old, which raised the issue of how senior citizens can be safely evacuated.
HAZARD MAPS

Hazard maps are a useful tool for enhancing the preparedness of local governments, municipalities, and residents, but they can exacerbate the damage if not prepared or used properly. A number of cities and towns had produced and distributed hazard maps. In some of the towns they contributed to faster evacuation, but in others they actually provided misinformation since the tsunami was far larger than the hazard maps assumed. Casualties occurred because some of the designated evacuation sites and buildings where people had fled to were totally submerged. Many people who were living in nonflooding zones, according to the hazard map, had not evacuated when the tsunami hit (KN 5-1).

Both level 1 and 2 events should be accounted for in hazard maps so that people will have enough information to deal with either category. Hazard maps should indicate all evacuation options. Just distributing these maps to citizens is not enough—evacuation practices drills should be conducted using these maps. Preparing hazard maps with people’s participation will also help ensure effective evacuation.

FORECASTS AND WARNINGS

Accurate forecasting and early warning systems are vital for safe and quick evacuation and disaster response. In the GEJE, hundreds of thousands of people evacuated in response to the warning by the Japan Meteorological Agency (JMA) a few minutes after the earthquake. The Earthquake Early Warning System also enabled all the high-speed express trains, traveling at over 200 kilometers per hour, to come to a halt before the main tremor, which saved thousands of passengers. The emergency warning system announced the arrival of the main tremor nationwide on TV and other broadcasting systems, providing the public with a little lead time (a few to 10 seconds) to react (KN 2-2-1).

Although the earthquake and tsunami warning system helped save many lives, there was room for improvement and some key lessons emerged. Because of the unprecedented size and complexity of the event, the JMA’s first announcement underestimated the maximum tsunami height at 6 meters, while the actual height was more than 10 meters. Although the forecast was corrected 10 to 20 minutes later, the original estimate may have caused people to delay their evacuation, possibly leading to increased casualties. This occurred even though Japan is equipped with one of the most advanced forecasting and warning systems. The international community should invest not only in the installation of existing disaster forecasting and warning systems, but also in the development of new systems in combination with repetitive drills/practices. Advanced off-the-coast water pressure gauges and global positioning system (GPS)-based wave sensors have been effective in monitoring tsunami heights.

ADDRESSING “CHAIN OF EVENTS” EFFECTS

The disaster unleashed a chain of events that affected people and organizations beyond Tohoku, including national, regional, and global economies. Following are a few examples of the chain of events observed in Japan:
• Earthquake and tsunami ➞ nuclear accident ➞ power shortage ➞ economic stagnation ➞ social unrest.

• Earthquake and tsunami ➞ dramatic increase in telecommunication activity ➞ telecommunication system failures ➞ interruption of social and economic activities (KN 3-2).

• Earthquake and tsunami ➞ damage to specific industries ➞ interruption of parts supply ➞ global slowdown of industrial activities (KN 6-3).

Although it is impossible to foresee every eventuality, DRM strategies should include contingency measures for preventing the knock-on effects of low-probability, high-impact events (KN 1-5). Providing for sufficient redundancy in various systems is one way of breaking the chain; business continuity planning is another (see KN 2-1-4). Analyzing past examples of “chain of events” effects, and sharing them with the public, the business sector, and governments can help prevent them from recurring.

LESSONS

OVERALL STRATEGY

• Use integrated disaster mitigation strategies, rather than structure-focused disaster prevention measures, to address low-probability, high-impact extreme events.

• Categorize tsunamis into level 1 events (fairly frequent disasters) and level 2 events (low-probability, high-impact extreme disasters). Level 1 can be addressed by preventive structures; level 2 requires integrated measures.

• For level 2, prepare strategies that focus on saving lives.

• Use resilient disaster mitigation systems, structural and nonstructural, in strategies to address level 2 events.

• Consider and discuss what should happen if an event exceeds expectations. This is critical in establishing effective, functional strategies.

STRUCTURAL MEASURES

• Structural measures can mitigate low-probability, high-impact extreme events if they are resilient and resistant to natural forces.

• Structural measures should be included in an integrated disaster mitigation strategy.

• Highways and trunk roads along the coast should be used as secondary protective embankments against tsunamis.
NONSTRUCTURAL MEASURES

In addition to information dissemination and evacuation, the following nonstructural measures have been effective against water-related megadisasters:

- Moving entire residential areas and public buildings to higher ground while keeping commercial enterprises and activities in the coastal areas.
- Securing the evacuation routes (such as roads and stairways) that connect public facilities (such as schools) to higher ground.
- Planting trees in coastal areas.
- Using tall concrete buildings (of four to five stories or higher) as places for evacuation.

EVACUATION

- Drills, education, and awareness-raising are the keys to ensuring effective, more complete evacuation.
- “Tsunami tendenko,” that is, everybody should evacuate immediately without waiting for anything or anyone else when the tsunami is assumed/fearred to approach.
- Prior discussion at home and in communities about evacuation helps ensure its success.
- Blind assumptions should not be made about any disaster, even those reflected in hazard maps, as nature behaves differently from human assumptions.
- Individual and institutional memory about past disasters should be kept alive to facilitate successful evacuation.

HAZARD MAPS

- Hazard maps are a useful tool for enhancing the preparedness of local governments, municipalities, and individuals.
- Hazard maps should address both level 1 and 2 events.
- A hazard map functions well only in combination with awareness-raising, community education, and evacuation drills.
FORECASTING AND WARNING

• Forecasting and warning systems pay off.

• Tsunami and disaster warning networks should be built and used globally.

• The international community should promote and invest in the use and development of new technologies to improve the accuracy and timing of forecasts and warnings.

ADDRESSING THE “CHAIN-OF-EVENTS” EFFECT

• The indirect effects of extreme events travel far beyond the disaster-stricken areas, hence, building redundancy into systems helps break these chains of events.

• Probable chain-of-events effects should be considered in business continuity planning.

• Experiences of these effects should be evaluated and shared to help prepare for future events.

RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Every country needs a national integrated DRM strategy. Many of the lessons from the GEJE are relevant for developing countries. Different combinations of structural and nonstructural measures may be used depending on a range of factors, such as socioeconomic conditions, budgetary constraints, geography, and the scale of the disasters. In the GEJE, DRM systems relied heavily on structural measures and could not prevent damages from the tsunami (figure 2 [d]). The Japanese government is revising its tsunami DRM policies to better integrate structural and nonstructural measures (figure 2 [e]). Level 1 tsunamis will be prevented by structural measures and level 2 tsunamis will be mitigated by both structural and nonstructural measures.

It is advisable to develop integrated measures for both level 1 and 2 events. For developing countries, greater reliance on nonstructural measures may be the most realistic approach even for level 1 events. But it is important to build structural measures to prevent loss of human lives and properties from frequent disasters. Disasters, especially high-impact events, tend to discourage people from investing for the future. Governments and communities should keep repeating the message that “prevention pays off,” to avoid creating a vicious cycle between poverty and disasters.

Forecasting and early warning is fundamental. Developing countries can and should develop local networks for forecasting and warning about disasters. Countries can also join forces in building regional and international systems. For example, Sentinel Asia is a regional network for sharing satellite imagery and other observation data free upon requests by member countries.
a) Disaster damage and frequency without countermeasures. Larger disasters occur less frequently than smaller disasters.

b) Disaster damage can be mitigated by nonstructural measures: cases in cyclone DRM in Bangladesh and flood management before the early modern period in Japan.

c) Structural measures can protect against frequent disasters: cases in flood management in the very early modern period in Japan.

d) Structural measures protect against disasters that occur every few decades: cases of tsunami management at the GEJE and current flood management in Japan.

e) Tsunami damage will be mitigated by reconstructing resilient dikes and strengthening nonstructural measures.

Hazard maps are useful tools to help people save their own lives. Developing countries should take legislative, administrative, and financial measures to ensure that hazard maps are provided to all the disaster-prone localities. The international community should help countries to develop hazard maps that reflect the lessons described in this note. It would also be useful to create regional and global mechanisms to share good practices and examples of hazard maps.

Archiving disaster records and experiences in disaster databases is essential for designing viable DRM strategies. The government should stress the importance of these
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less visible but critical activities and the people who are engage in them tirelessly. Regional
data sharing would also benefit neighboring countries. Countries should put agreements in
place to share hydrological, meteorological, geological, and other information.

**Education, drills, and awareness-raising are indispensable** to avoid high death tolls
in low-probability, high-impact extreme events, particularly in countries where physical
defenses may be insufficient. The Japanese approaches to education, drills, and aware-
ness-raising have been developed over time through trial and error. But simply copying
them exactly may not be advisable in other, often more challenging, circumstances. The
first step is to evaluate, simulate, and test whether the Japanese measures are congruent
with local social and cultural practices and behaviors.

**Countries must learn from one another by sharing information and experience,** since
low-probability, high-impact extreme events happen infrequently in any given country. The
international community could facilitate regular dialogues and information-sharing mecha-
nisms, for example, through the United Nations. Regional cooperation mechanisms would
serve not only to help disaster-affected countries but also to mitigate the negative inter-
regional and international effects of megadisasters.