

Sendai hailed as role model for resilient recovery

The way forward for infrastructure design in Japan

The archipelago that forms the modern nation of Japan sits at the nexus of four tectonic plates. The seismic activity these plates generate is a constant presence in daily Japanese life; more than 1,500 seismic events occur each year, including two of 5.0 magnitude or higher.^{1,2}

It comes as no surprise then that Japan leads the world in early warning systems to protect its population from disaster. Nor that the Japanese have a well-earned reputation for earthquake mitigation. Despite this preparedness, the 9.0-magnitude earthquake that struck off the northeast province of Tōhoku in March 2011 tested the resiliency of the nation in unprecedented ways.

A massive tsunami swept across the coastline within 30 minutes of the quake, changing entire landscapes and washing away villages and infrastructure. A 45-foot wave disabled the power supply and cooling at the Fukushima nuclear reactor, causing a meltdown in three cores and the release of radioactive materials. The Japanese government ordered the evacuation of more than 100,000 people from the surrounding area.³

The human costs were high:

- 15,800** people died;
- 6,100** were injured;
- 2,600** are missing; and

recovery costs are estimated at **¥17 trillion**.

However, the damage to the nation's infrastructure was remarkably low compared with what similar events have caused in other regions of the world. Mechanisms implemented long before 2011 to strengthen infrastructure against earthquakes, tsunami, and fire saved millions of lives while also mitigating economic losses. The infrastructure showed remarkable resiliency, attributable to the forethought of its flexible design.

Lessons from Japan

The farsighted decision to enforce some of the strictest quake-resistant standards in the developed world paid off, as very few building collapses occurred in areas unaffected by the tsunami. Meanwhile, reinforced shoreline breakwaters mitigated tsunami damage. Japan's bullet trains were programmed to automatically decelerate even before the earthquake hit, thus avoiding derailment—and providing an important object lesson in the vital role of infrastructure in disaster mitigation. The 2011 disaster also illustrated how preparedness contributes to protecting the social and economic fabric of a community.

Robust catastrophic planning has also contributed to social resilience. Early warning and alert systems, continuous national earthquake drills, and well-understood evacuation plans effectively limited the loss of life. The spirit of mutual assistance was widely on display. Groups of young people helped with the evacuation of the elderly from disaster-stricken houses and more than a million volunteers helped staff supply lifelines and assist in disaster relief.

Close cooperation between the public and private sectors was an indispensable part of the rescue, recovery, and reconstruction process. In several cases, local authorities had pre-established agreements with private companies to provide basic necessities to evacuees.

Building back stronger and smarter

While Japan's first response has been hailed as a model for other disaster-struck regions to emulate, the challenge now is long-term infrastructure rebuilding. Rather than repairing or replacing the damage, cities and towns are using the reconstruction effort to introduce innovative state-of-the-art technologies. They are building smarter, more efficient infrastructure to ensure a vibrant future.

A number of ground-breaking initiatives now underway in the Tōhoku area focus on leveraging new technologies to develop safe, sustainable, energy-efficient communities. Lessons from the 2011 earthquake are being incorporated into "Smart Community" and "Future City" designs to revitalize the region's economy and support the redevelopment of communities affected by the disaster.

Yutaka Saito, President & CEO of Information & Telecommunication Systems Company for Hitachi, says public-sector officials are making the effort to build a smart city—or city of the future—by applying innovative IT that combines safety and comfort. The private sector is playing an essential role in the development of the future city and its infrastructure, contributing innovative ideas, solutions, and technologies in a collaborative process with the public sector.

Mayor Emiko Okuyama of Sendai notes that the success of these future-oriented initiatives can serve as an example to other cities striving to address the complex challenges of demographic, climate, and economic change. Forged from the chaos of devastation, Japan's ground-breaking solutions ensure a more sustainable future in response to the global challenges of the 21st century.

1 Central Intelligence Agency, *The World Factbook 2013-14*, 2013.

2 Department of the Interior, US Geological Survey, "Japan Earthquake Density Map," November 1, 2012.

3 World Nuclear Association, *Fukushima Accident 2011*, 2013.

Interview with Emiko Okuyama, Mayor Sendai, Japan

In March 2011, a 9.0-magnitude earthquake struck northeastern Japan's Tōhoku region, causing a tsunami within the hour—a low-probability, high-impact event that is predicted to occur once every 1,000 years. Waves higher than 100 feet engulfed an area more than 30 square miles, including portions of Sendai, the closest major city to the earthquake's epicenter.

The city's coastal areas—including its seaport—were badly damaged, as was its airport. More than 600 Sendai residents died as a result of the disaster; some 200 were reported missing. Close to 7,000 homes were completely destroyed. Despite Japan's long-term reputation for attention to disaster preparedness, the economic losses amounted to the equivalent of 4 percent of GDP.

By March 2012, however, Sendai's post-disaster reconstruction had led to an economic upswing. The construction industry was booming, but so were the auto industry, retail sales, and hospitality, thanks to an influx of recovery workers. In October 2012, UNISDR recognized Sendai as a role model for its focus on resilient recovery. Okuyama was hailed for her political leadership in rebuilding for resilience.



Sendai has been lauded for its efforts in swift disaster recovery management. To what factors would you attribute this swift recovery?

After the 1978 earthquake, we learned some valuable lessons, especially that disaster management does not come cheap. You only get out of it what you put in. We had already begun replacing our old pipes for natural gas and water with highly elastic new ones. We were almost 80 percent done with this project. When hit by an earthquake, these new pipes don't break. Instead, they bend but stay intact.

And when we replaced our natural gas pipes, we segmented them so that we could shut off and repair only the damaged portions, thus maintaining uninterrupted supply. One of our above-ground sewage facilities was hit by the tsunami and lost electric power so we had to let the waste flow into the ocean. That wasn't our preference of course, but it was better than letting it build up.

We had also duplicated our sources as necessary so, for example, when natural gas supply ships couldn't reach Sendai because our port was completely destroyed, we were able to process our own supply of natural gas and distribute it to residents. This type of redundancy in sewage, gas, and water infrastructure—where the goal is to maintain a constant flow—is essential to overall disaster risk resilience.

What role did the local government play in the recovery?

In Sendai, we manage almost all our major roads and national highways at the local level. Same with water, gas, and sewage. We continually monitor our infrastructure to assess maintenance needs and establish immediate priorities. If the national government were involved, people unfamiliar with our local needs would be in charge and that would compound the disaster, substantially slowing the pace of recovery.

What plans do you have for resilient infrastructure going forward?

Following the disaster, we invested in elevated roads and added special tsunami evacuation roadways and facilities. We also imposed additional restrictions on the location of housing. And we are installing solar-powered generators so citizens will have an emergency supply of energy during a disaster.

ultimately lessen the burden on city government. We also need tighter regulations, as necessary. As we know, it was our strict building code that saved lives during the earthquake.

What role do private citizens play in disaster preparedness?

Private citizens, together with the public and private sectors, bear responsibility to increase their level of awareness for disaster

This is what makes a city tenacious—the willingness of the entire community to shoulder a share of the responsibility.

In the past, we always focused on roads, sewage, water, and fuel following a disaster. They made up the lifelines of the city. A new component is telecommunications; without information technology, we can't respond to disasters. And none of that infrastructure is publicly owned. After the 2011 disaster, we had serious problems resulting from poor telecommunications. The lesson we learned there is that the government and private sector need to share information completely.

A city is only adequately prepared for disasters when infrastructure is functioning at the optimal level, whether it's operated by the public sector or the private sector. I am convinced that we must collaborate, rather than take separate approaches.

How can the government incentivize the private sector to implement resilience measures?

I think grants and subsidies will allow the private sector to implement innovative technologies that will

preparedness. We work with the private sector, non-profit organizations, and local residents to conduct preparedness exercises every year—including informational sessions on disaster prevention at our schools. Those exercises prepared us to take action during a crisis. As a result, we were able to respond to the disaster faster in Sendai than neighboring municipalities did. This is what makes a city tenacious—the willingness of the entire community to shoulder a share of the responsibility.

How did you collaborate with the national government?

In the aftermath of a large-scale disaster, national funding is essential. But the overriding principle of the national government is that no action can be taken until a system is in place—with budget approval. Even to process the rubble, several months elapsed before we were able to settle on a unit price. But we

As our population continues to age, we have to ensure that everyone is prepared at all times.

needed to expedite our recovery, so before that unit price was determined, we went ahead with processing the rubble.

We need more flexibility during times of disaster to ensure we can start making initial payments. If the national government delegated some of its authority, local governments could take more immediate action—action that's desperately needed in the aftermath of a disaster.

During the reconstruction of infrastructure that spans various municipalities, how best can neighboring local governments work together?

We need a more formal mechanism in place that would allow us to do this faster, for example, building an embankment along a sea coast. Different local governments might settle on different heights for the embankment, thus delaying reconstruction.

How are you raising awareness of disaster preparedness among your residents?

As our population continues to age, we have to ensure that everyone is prepared at all times. We ask our condo residents to maintain a week's reserve of food, water, and medications. We will offer a certification to those condo buildings where teams of residents are prepared to help the older and less healthy among them. Eventually, we want all the condo buildings in Sendai to be certified in this way.

What kinds of cost-benefit analyses are you undertaking in the aftermath of the disaster?

We must take a long-term view of disaster risk management. We used to take a 200-year perspective. Then we got blindsided by the tsunami which has a probability of occurring once every 1,000 years. So we need to appreciate the earth's ultra-long lifespan.

Another factor is rapidly evolving technology, which often allows us to build new infrastructure at lower cost. The tsunami completely washed away one of our sewage treatment plants, a ¥110 billion facility. In retrospect, a 16-foot wall—requiring a very small additional investment—would have protected the plant. But thanks to new technology, we were able to replace the ¥110 billion facility with one that is more compact and sophisticated for only ¥68 billion.