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KNOWLEDGE NOTE 5-2

CLUSTER 5: Hazard and Risk Information and Decision Making

Risk and Damage Information Management

GFDRR
Global Facility for Disaster Reduction and Recovery

THE WORLD BANK

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Risk and Damage Information Management

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

FIGURE 1: **Interface of the MLIT hazard map Web portal. The interface shows (in green) the municipalities for which tsunami hazard maps have been published. Clicking on the municipality takes the user to the municipality's Web site, where the actual hazard map can be accessed.**



Source: MLIT.

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)**

End user	*Use of data*
Cabinet Secretariat	Spot checks of areas of interest, for example, Sendai airport, Fukushima nuclear power plant. Pre- and post-event images. Maps of maximum inundation.
Cabinet Office	Overview map using ALOS post-earthquake images. International Charter products. Imagery related to Fukushima nuclear power plant.
Ministry of Land, Infrastructure, Transportation, and Tourism	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.
Ministry of Agriculture, Forestry, and Fishery (MAFF)	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.
Fisheries Agency	Collaboration sought to assist in offshore search for lost ships.
Ministry of Environment	Request to assist in mapping debris floating off the coast of Sanriku. 560,000 m^2 of debris already identified in vicinity of Rikuzentakata alone.
Ministry of Education, Culture, Sports, Science, and Technology	Images of Fukushima nuclear power plant.
Geospatial Information Authority of Japan	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.
Miyagi Prefecture	Sighting of an SOS sign in a park in Miyagi Prefecture was reported by the International Charter.
Iwate Prefecture/University	Monitoring of road accessibility.
Kanto Regional Development Bureau	Mapping of liquefaction areas provided through International Charter.

mitted footage of the approaching tsunami live on national and global news channels, contributing to the quick mobilization of resources.

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 km^2, 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**

Municipality	*Population total (2007 census)*	*Population within inundated area*			*Difference as percentage of total population*
		As estimated by GSI	*As estimated by private company*	*Difference between GSI and private company*	
Miyagino-ku	182,678	17,375	11,858	5,517	3.0
Wakabayashi-ku	129,942	9,386	8,700	686	0.5
Taihaku-ku	222,447	3,201	2,519	682	0.3
Ishinomaki	167,324	112,276	102,670	9,606	5.7
Shiogama	59,357	18,718	173	18,545	31.2

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).

FIGURE 2: **Commercial per-building exposure dataset (left) and post-3.11 aerial photograph of the same area (right). The open source All311.ecom platform provides the ability to overlay the two. These maps can be accessed at volunteer centers in the Tohoku region. Local governments can apply to have the system installed at no cost in their areas.**



Source: All311 website.

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.

BOX 1: **Crowd-sourced damage assessment using remotely sensed data in Haiti and Christchurch**

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.

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 thesplatforms use a map interface, against which the data hosted on the system are visualized spatially.

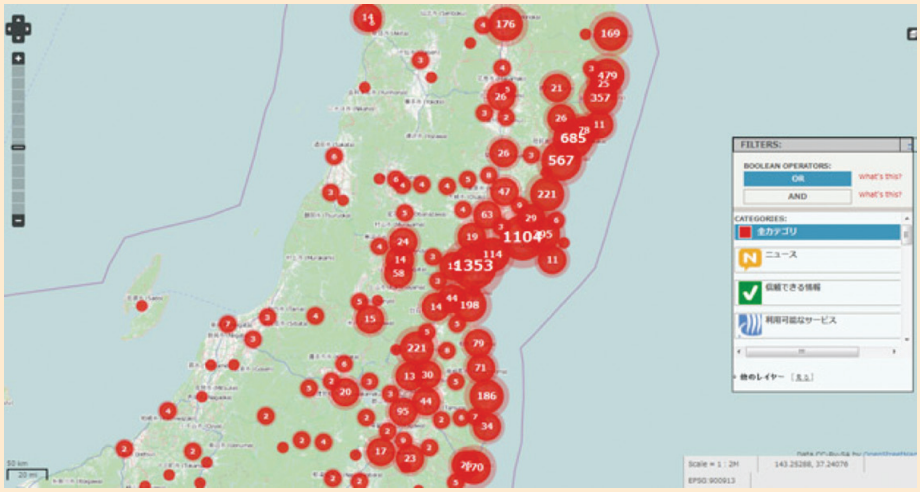
USE OF SOCIAL MEDIA FOR BOTTOM-UP INFORMATION SHARING

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.

FIGURE 4: **The interface of Shinsai.info based on the Ushahidi platform. The red circles show the number and locations of the requests from local communities. The diameters of the circles are proportional to the number of requests logged at that location. Open Street Map Japan, prepared following the event by local and international OSM volunteers, is used as the backdrop.**



Source: http://www.sinsai.info.

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

ALL311. 2011. http://all311.ecom-plat.jp/. (in Japanese).

Corbane, C., K. Saito, E. Bjorgo, L. Dell'Oro, R. Eguchi, G. Evans, S. Ghosh, B. Adams, R. Gartley, F. Ghesquiere, S. Gill, T. Kemper, R.S.G. Krishnan, G. Lemoine, B. Piard, O. Senegas, R. Spence, W. Svekla, and J. Toro. 2011. A Comprehensive Analysis of Building Damage in the January 12, 2010, M7 Haiti Earthquake Using High-Resolution Satellite and Aerial Imagery. Photogrammetric Engineering and Remote Sensing, Special issue on the 2010 Haiti Earthquake.

Fire and Disaster Management Authority. 2011. Presentation on Disaster Management Measures of Municipalities and Their Response to the Great East Japan Earthquake, slide 2. First meeting of the Enhancement and Strengthening of Earthquake and Tsunami Countermeasures in the Regional Disaster Management Plan, available at http://www.fdma.go.jp/disaster/chiikibousai_kento/01/shiryo_05.pdf (in Japanese).

Geographical Information Authority of Japan (GSI). 2011. Estimate of the inundation area. http://www.gsi.go.jp/kikaku/kikaku60001.html (version 1). http://www.gsi.go.jp/common/000059939.pdf (version 5) (in Japanese).

Global Facility for Disaster Reduction and Recovery (GFDRR). 2011. Volunteer Technology Communities Open Development. World Bank Group: Washington, D.C. http://www.gfdrr.org/gfdrr/sites/gfdrr.org/files/documents/Volunteer%20Technology%20Communities%20-%20Open%20Development.pdf.

JAXA. 2011. Use of Satellite Based Data for the Great East Japan Earthquake and Tsunami. www.jaxa.jp/press/2011/04/20110406_sac_earthquakes.pdf (in Japanese).

MLIT. 2011. Disaster Portal. Available at: http://disapotal.gsi.go.jp/ (in Japanese).

EEFIT. 2011. The Mw9.0 Tohoku Earthquake and Tsunami of 11th March 2011—A Field Report by EEFIT. London, UK. From http://www.istructe.org/resources-centre/technical-topic-areas/eefit/eefit-reports.

Sawada, H. 2011. Remote Sensing for Emergency Mapping. PowerPoint presentation. http://stlab.iis.u-tokyo.ac.jp/~sawada/files/GreatEarthquakePresentatio0425.pdf (in Japanese).

Statistics Bureau. 2011. www.stat.go.jp/info/shinsai/zuhyou/sai.xls (in Japanese).

Ushahidi. 2011. http://www.ushahidi.com/.

ZENRIN. 2011. http://www.zenrin.co.jp/news/110415.html (in Japanese).