CONFERENCE PROCEEDINGS

TOHOKU UNIVERSITY

THE GREAT EASTERN JAPAN EARTHQUAKE 11 MARCH 2011 – LESSONS LEARNED AND RESEARCH QUESTIONS

11 March 2013, UN Campus, Bonn

Editors: Dinil Pushpalal, Jakob Rhyner, Vilma Hossini

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Editors:
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Reviewed by UNU-EHS

11 March 2011 will always be remembered. Remembered by people in Japan, who experienced it as the worst day of their lives when confronted with great loss, fear and uncertainty. But, also, remembered around the world as a day when disaster took on unthinkable dimensions given the intensity as well progressing catenation that emerged that day. Yet, we must admit that it easily might have been even worse: the bulk of the radioactive cloud was blown out to the open sea and not towards Tokyo.

In areas of the Tohoku region, entire towns were washed away by the tsunami, greatly reducing the populations of some communities. Even in a highly developed country like Japan, the Great East Japan Earthquake and Tsunami pitilessly revealed the limits of and weak points in the scientific and technological systems in place, both in relation to the early warning system and crisis intervention. However, this applies not just to the immediate aftermath. Probably more than any other disaster, the long term socio-economic consequences, particularly in the Fukushima region, are a heavy burden.

On the second anniversary of the Great East Japan Earthquake, the United Nations University's Institute for Environment and Human Security (UNU-EHS), together with the University of Tohoku, has organized a scientific workshop. This workshop was integrated as a timely addition into the programme of and annual UNU-EHS PhD Block course entitled "From Vulnerability to Resilience in Disaster Risk Management". The workshop provided researchers with a unique forum in which to explore and share the lessons learned following the Great East Japan Earthquake and Tsunami and further strengthened collaboration between Tohoku University and UNU-EHS. In particular, it paved the way for the development of additional joint activities between the two institutes through scientific events and the development of capacity on addressing human security and vulnerabilities in disaster areas.

I would like to express my gratitude to Tohoku University, and specifically to Professor Dinil Pushpalal and his team, for the excellent cooperation and friendship. Let us dedicate this workshop to the people of Japan, particularly to those whose lives were devastated by disaster and to those who have dedicated and continue to dedicate their time, resources and capacities to mitigate the aftermath of 11 March 2011.

Professor Jakob Rhyner
UNU Vice Rector for Europe
UNU-EHS Director

The Great East Japan Earthquake shifts the dimensions of Japan physically and Japanese mentally. It is the greatest tragedy Japan has experienced after the Second World War. The impact economically and emotionally is very large. The emotional largeness of the disaster can be seen through the attitudes of the Japanese people. One of those attitudes, which is quite remarkable, lies with Japanese who returned to their homeland to visit their relatives, neighbours and friends just after the disaster after abandoning Japan for years. Words such as kizuna ("bonds") and Ganbaro Nippon ("Try hard, Japan!") quickly became household words through the efforts of volunteers and those supporting victims of the disaster. The Japanese character kizuna was also chosen as the character that best represented 2011.

This background has pulled many towards research on the disaster using their particular expertise. These proceedings summarize one of those collective efforts by scholars who have examined the Great East Japan Earthquake from various angles. Although studies can be found primarily in Japanese, English-language studies are difficult to find. On the other hand, it is important to document those landmarks of the disaster before they are erased by intensified reconstruction efforts. As we approach the third anniversary of the disaster and reconstruction proceeds with haste, it will become more difficult to find the disaster's footprints over time. All of these factors encouraged us to publish these proceedings, putting forth the lessons of the Great East Japan Earthquake for the international community.

These studies have been actively supported by many victims and stakeholders of the Great East Japan Earthquake, who provided invaluable information about their experiences during the tragedy. On behalf of all of the authors, I would like to convey my utmost gratitude to those anonymous individuals.

This conference was financially supported by the Future Global Leadership Programme (Global 30) through the International Post-Graduate Programme in Human Security at Tohoku University and by Grants-in-Aid for Scientific Research (kakenhi). Finally, I would like to extend our sincere gratitude to the above two institutions and our utmost counterpart UNU-EHS.

Professor Dinil Pushpalal
Chief Coordinator, International Post-Graduate Programme in Human Security
Tohoku University

We would like to express our gratitude to the following colleagues at UNU-EHS (alphabetical order) for their valuable work in designing and copy editing the publication: Sonja Rosina Ayeb-Karlsson, Megan Goettsches, Janine Kandel, Giulia Mariani, Andrea Wendeler. Further we would like to thank all participants, experts and facilitators who took part and contributed to this successful event.

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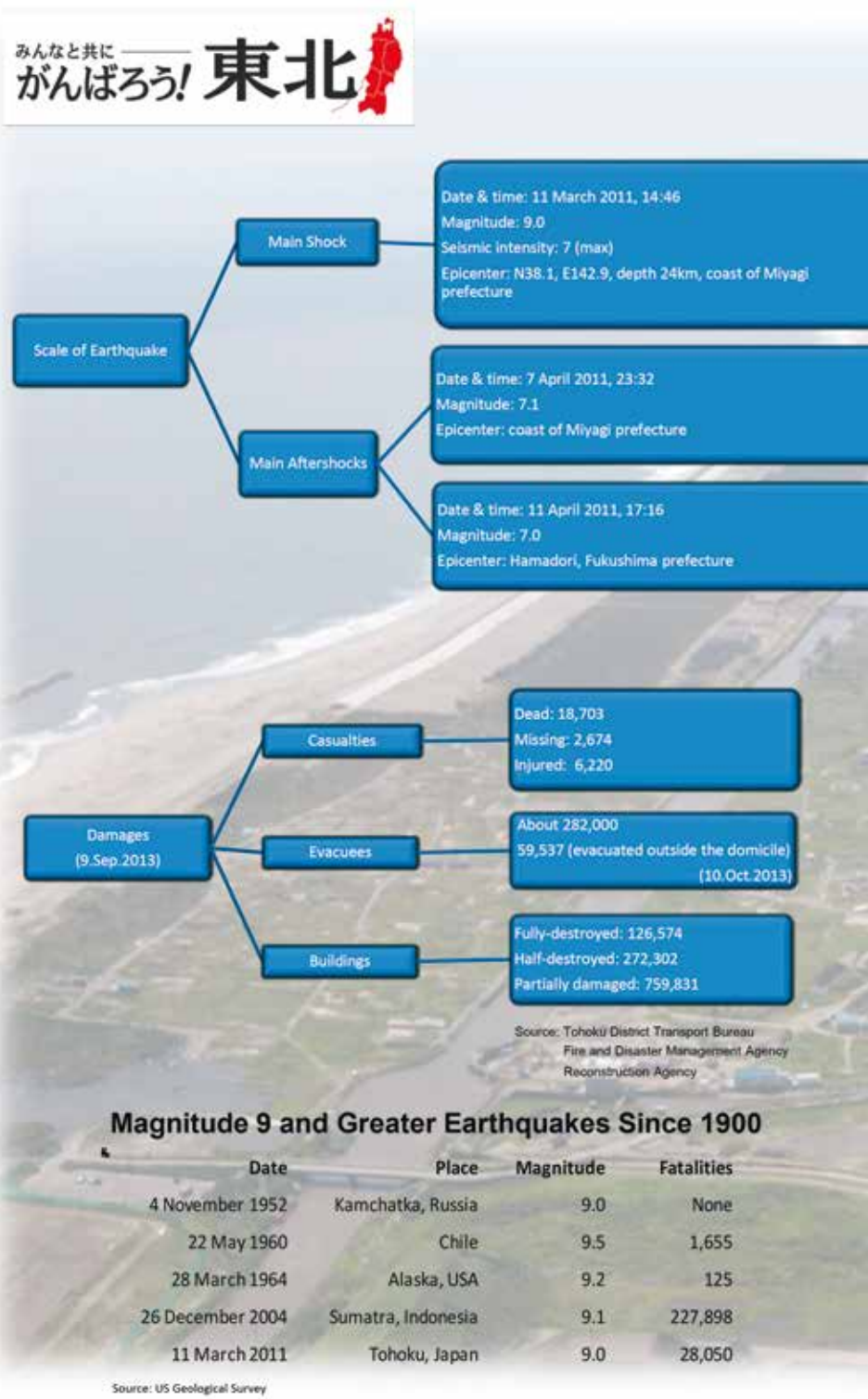

Magnitude 9 and Greater Earthquakes Since 1900

Date	Place	Magnitude	Fatalities
4 November 1952	Kamchatka, Russia	9.0	None
22 May 1960	Chile	9.5	1,655
28 March 1964	Alaska, USA	9.2	125
26 December 2004	Sumatra, Indonesia	9.1	227,898
11 March 2011	Tohoku, Japan	9.0	28,050

Source: US Geological Survey

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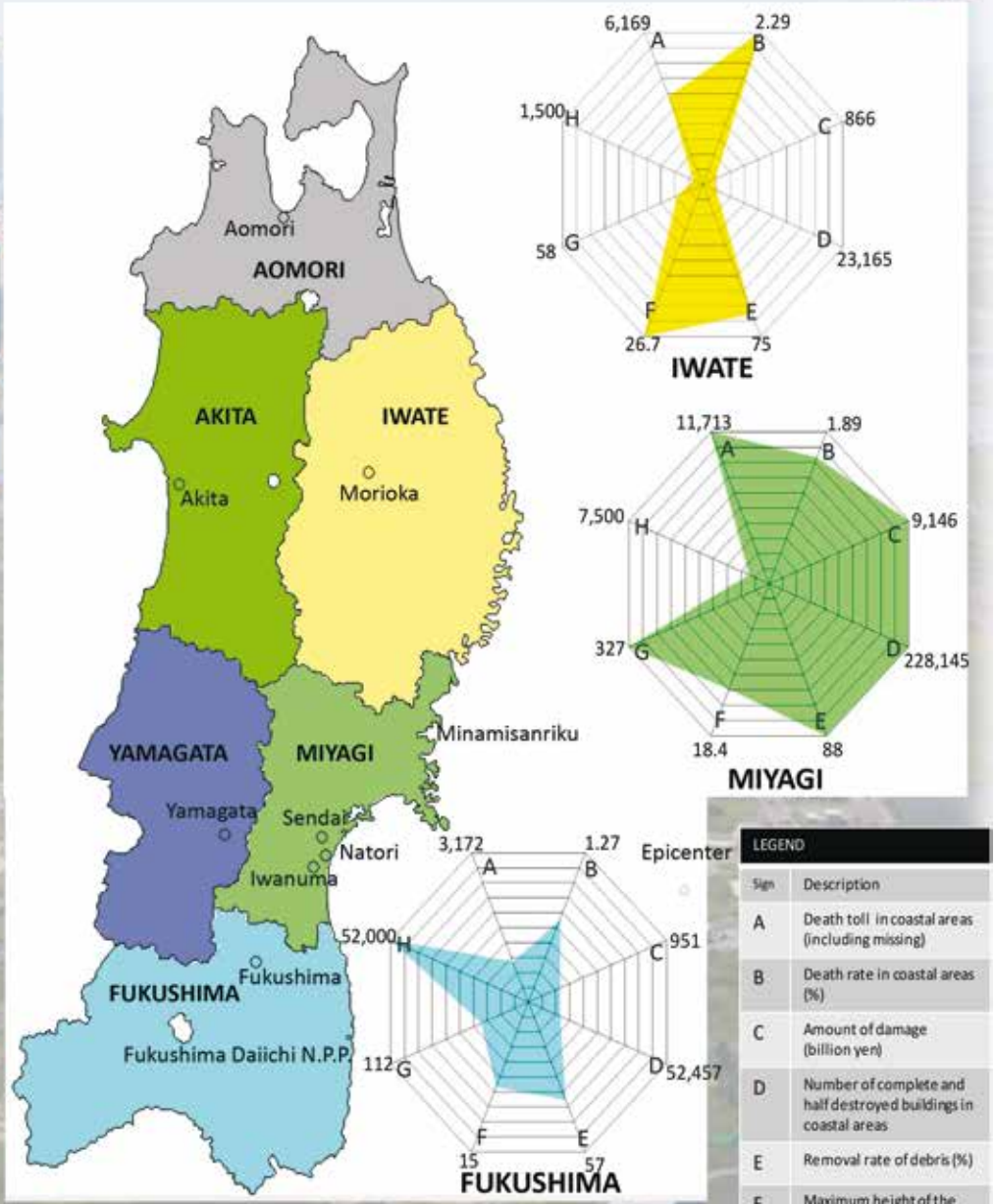

LEGEND	
Sign	Description
A	Death toll in coastal areas (including missing)
B	Death rate in coastal areas (%)
C	Amount of damage (billion yen)
D	Number of complete and half destroyed buildings in coastal areas
E	Removal rate of debris (%)
F	Maximum height of the tsunami (m)
G	Flooded area (km²)
H	Number of refugee moved to other prefectures

Source: Prepared by Koichi Ogata using statistical data given in the following references.

1. Fukushima Prefecture
2. Geographical Survey Institute
3. Iwate Prefecture Web Site
4. Ministry of the Environment
5. Miyagi Prefecture Government
6. Reconstruction Agency
7. The 2011 Tohoku Earthquake Tsunami Joint Survey (TTJS) Group
8. "*Toukei to chizu de miru higashi nihon daishinsai hisai shichouson no sugata*," Japan Statistical Association, March 2012

Taken 10 years before the tsunami *Source: Tohoku Chiikizukuri*

Taken 2 weeks after the tsunami *Source: Tohoku Chiikizukuri*

Taken 10 years before the tsunami *Source: Tohoku Chiikizukuri*

Taken 2 weeks after the tsunami *Source: Tohoku Chiikizukuri*

A Journey through the Lands of the Great East Japan Earthquake

Dinil Pushpalal

This chapter presents an overview of the Great East Japan Earthquake (GEJE) and perspectives on important issues in reconstruction. The focus is primarily on Miyagi Prefecture, with particular attention paid to three cities / towns: Minamisanriku, Natori and Iwanuma from which victims, stakeholders and local politicians were interviewed. Information acquired from local and national newspapers, online databases, published reports and statistics have also been used. This chapter concludes with a summary of the lessons learned from the study.

Topography, demography and damages

Following the GEJE, 342,000 people were evacuated and sheltered in evacuation centres. This catastrophe took the lives of 15,879 people, mainly from Miyagi Prefecture. Miyagi Prefecture surrounds Sendai Bay, which has a 130-km-long coast extending from Ishinomaki to Soma in Fukushima Prefecture.

Minamisanriku was the northernmost city investigated. The area is notable for its jagged coastline. The run-up and inundation heights of the tsunami were very high in these rugged coastal areas, which experienced some of the highest death rates and greatest damage to infrastructure (see Figure 1). The terrain helped to amplify the damage by constricting the tsunami's path and funnelling the wave thousands of metres into the valley. These smaller valleys are typically home to semi-independent fishing hamlets whose residents have historically organized under their own keiyakukai or "community contracts" (Sanriku Project, 2012).

Unlike Minamisanriku, Natori and Iwanuma are located on Sendai Plain, a fairly low-altitude area of paddy fields near the shoreline. Natori is situated southeast of Sendai facing Sendai Bay. The Yuriage fishing harbour and the Teizanbori Canal (see Figure 2), which run from the Natori River to the Abukuma River, are the city's most significant topographical features. Sendai International Airport, the gateway to the Tohoku Region, is located in Natori, which has two coastal regions, of which Yuriage was the most heavily destroyed district (see Table 1). Once a highly active fisheries port with about 7,000 residents, Yuriage lies near the Natori River, where the tsunami rose more quickly (Suppasri and Mas, 2013). Including firefighters on duty, 752 deaths and missing persons were reported here and more than 80 per cent of all houses were partially or totally destroyed (see Figure 2 and Figure 3c).

Iwanuma has a 10-km coastline positioned between Sendai International Airport to the north and Abukuma River to the south. The Teizanbori Canal is landward to the coast, a man-made transportation channel excavated by Date Masamune, the powerful daimyo ("territorial lord") from the Tohoku Region. On 11 March, a strong earthquake with an intensity of 6 lower rocked the city. Immediately afterwards, a very large tsunami hit the plains of Iwanuma extending 5-km inland and freely flowed up the Abukuma River intruding even further inland claiming 187 victims. The earthquake caused extensive loss of property and life among

residents of the eastern part of the city known as the Tamaura District. More than 68 per cent of the houses in eastern Iwanuma were totally or partially destroyed. Unlike Minamisanriku and Natori, Iwanuma has neither active fishery ports nor residents employed in the fishing industry.

Region	Population		Households		
	Total population before GEJET	Employees in the fishing industry before GEJET	Deaths and missing persons	Total households before GEJET	Completely and partially damaged houses
Minamisanriku	17,687	1,434	839	5,368	3,312
Togura	2,421	283		681	521
Shizugawa	8,211	415		2,725	2,057
Iriya	1,906	4		519	12
Utatsu	5,149	732		1,443	722
Natori	73,193	41	991	26,435	2,902
Yuriage	7,101	35	752	2,549	2,083
Shimo-masuda	4,766	0	86	1,619	477
Other	61,326	6	153	22,267	342
Iwanuma	43,903	2	187	15,987	2,028
West	16,303			5,762	99
Central	19,064			7,497	77
East	8,536			2,728	1,852

Table 1. Demographics and damage in the investigated regions.
Sources: Kahoku Shimpo, 2011; Minamisanriku, 2012; Natori, 2011; and Iwanuma, 2011

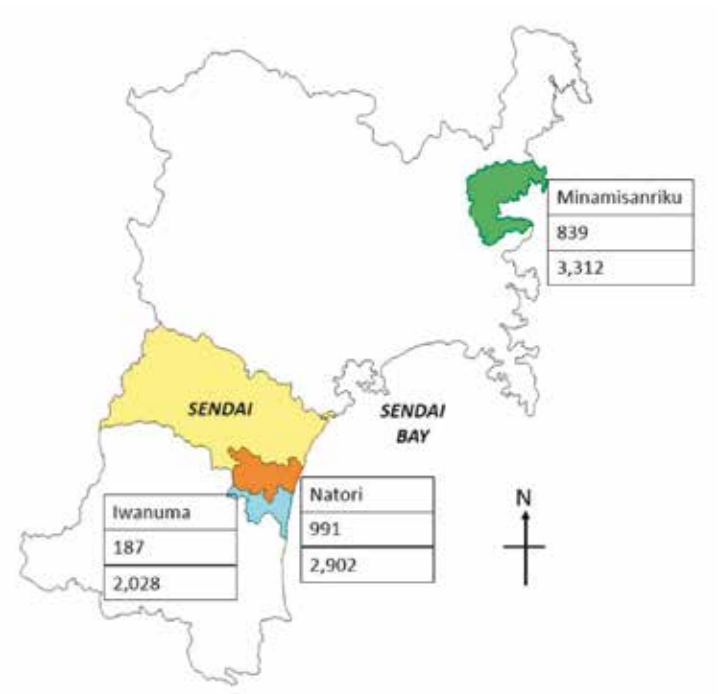

Figure 1. Map of Miyagi Prefecture indicating the three cities / towns investigated. The upper number in each box indicates the number of deaths and missing people and the lower number indicates the number of houses completely or partially damaged. Source: Author's compilation.

Figure 2. Aerial views of Natori River, Yuriage fishing harbour, Sendai Bay and Teizanbori Canal, which runs parallel to the shoreline. Source: Author's compilation.

Figure 3 (a)

Figure 3 (b)

Figure 3 (c)

Figure 3 (d)

Figure 3. Typical topographical features of (a) Minamisanriku, (b) Matsushima, (c) Natori and (d) Iwanuma. Source: Author's compilation.

A pattern in the damage

Figure 4 shows the maximum inundation heights reported for coastal cities from Kesennuma to Iwaki. At a glance, it is apparent that the bar graph delineates a curve similar to the shape of Sendai Bay shown in the map. The tsunami inundation heights in those regions near the inner bay (e.g., Natori and Iwanuma) were lower than in the frontal regions (e.g., Minamisanriku). Two explanations for this phenomenon may be considered. First, this behaviour may be due to the natural breakwater created by the shape of the bay that protects the regions along the inner bay. Second, the inundation heights may be related to the narrow river valleys of the frontal regions versus the plains of the inner bay. Though neither hypothesis can be directly proven, there are records indicating that the narrow rivers of the Minamisanriku region amplified the tsunami's impact by constricting its path and funnelling the wave thousands of metres into the valley.

In addition, as shown in Figure 4, in Matsushima the waves only reached a height of about 3 m, inundating the lowest floors of buildings facing the bay. Thus, their destructive power was much less than that caused by the tsunami waves of more than 12 m that hit the adjacent towns of Onagawa and Shichigahama. While the tsunami destroyed towns all along the Sanriku coast, Matsushima's famed cluster of about 260 islets served as a natural buffer (see Figure 3b), weakening the impact of the waves and protecting the coastal town from devastation despite its proximity to the epicentre of the 9.0-magnitude quake. It is also notable that Onagawa, along with its nuclear power plant (NPP), was hit by 19-m-high waves (Figure 4). In contrast to the Fukushima Daiichi NPP, the Onagawa NPP operated by Tohoku Electric Power Company was shut down safely and its gymnasium served as a shelter for nearby evacuees for three months. The Onagawa NPP may now serve as a trump card for the nuclear lobby in regaining the public's trust by demonstrating that a nuclear facility can withstand even the worst disasters.

Current status of reconstruction

At the time of writing, Minamisanriku and Iwanuma had already begun the reconstruction process. Iwanuma initiated a relocation project in August 2012 to collectively relocate coastal residential homes to an inland district. The city was the first municipality from among Iwate, Miyagi and Fukushima, the three Tohoku prefectures that were hit hardest by the earthquake and tsunami to launch such a group relocation project. Iwanuma plans to relocate 348 homes to the 20-hectare Tamaura Nishi District and build 156 public housing units in the same district, with the goal of making them available to affected citizens in April 2014. The project is estimated to cost about 10.8 billion yen (House of Japan, 2012).

Minamisanriku began the construction of a new town in February 2013. The city plans to build 930 public homes in eight locations through 2015 (Minamisanriku, 2013). Minamisanriku overwhelmingly chose to adopt the higher-ground relocation approach because it has experienced several severe tsunamis in the past, including the tsunami that occurred as a result of the Great Chilean Earthquake in 1960. Residents have been taught for centuries to "run away if a tsunami is coming"; but, the town mayor Mr. Jin Sato insisted that he wanted to build a new town for the next generation in which his people "could sleep without fear" (Sato, 2012).

Figure 4. Maximum reported inundation heights for coastal cities from Kesennuma to Iwaki.
Note: Prepared by the author using a Google Earth map and statistical data from the Japan Statistical Association (Eto, 2012).

Unlike Minamisanriku and Iwanuma, relocation plans for Natori are still chaotic due to the conflict between those residents who want to return to their previous neighbourhoods and those who are against it. However, Natori has planned a new 120-hectare residential area for evacuees after setting aside 50 hectares of land as disaster danger zone on the eastern (seaward) and western (landward) sides of the Teizanbori Canal. The plan includes a collective relocation area on 45 hectares of embanked land (5 m above sea level) located on the western side of the Teizanbori Canal; however, this site is still within the area inundated by the 11 March tsunami (Kahoku Shimpo, 2013).

Back to the past or away from the past

There are two factions in the relocation process: those who prefer to return to their previous homes and those who do not. Those who prefer to return are generally elderly inhabitants who are engaged in the fisheries industry or who feel nostalgic about their childhood neighbourhoods. Another important factor is the financial background of the evacuees. Evacuated households have not been sufficiently compensated to buy new land. In particular, elderly residents worry about losing

familiar neighbourhoods and, thus, prefer to return to their original neighbourhood or at least to relocate collectively. Although Minamisanriku is a town primarily engaged in the fisheries industry, it has firmly committed to higher-ground relocation because of the lessons learned from their tsunami-stricken past. Iwanuma became the first municipality amongst the regions destroyed to launch a group relocation project as its inhabitants definitively agreed to collectively relocate to a new area located comparatively far from the seashore. This decision reflected the fact that there was no fishing port in the city nor were most of the residents engaged in the fishing industry.

Meanwhile, the more chaotic situation in Natori is due to residents who want to return to their original neighbourhoods and the political support they retain. In individual interviews the city conducted in the spring of 2013, 25.2 per cent of all residents still intended to "return to their native home"; however, that percentage had decreased from 34.1 per cent in the summer of 2012 (Katou, 2013).

Japan is an elderly nation; 23 per cent of its population is 65 or over and by 2050, this figure will rise to nearly 40 per cent. Demographics like these have never been seen before. The above relocation plans suggest that the declining population and shifting employment from primary industry to tertiary largely influenced social perceptions during resettlement. Those few individuals who still engage in fishing-related activities will become commuter fishermen resulting in a changing tradition. On the other hand, substantial urbanization can be seen in inland cities which have proven safe such as Sendai. This isolation of the seashore could be considered a benefit acting to protect the natural environment; however, it could also be criticized as abandoning the fishing culture which was passed down through many generations.

Collective household relocation and compensation by local authorities

Collective household relocation is a government project aimed at collectively relocating residents living in dangerous areas to safer places. The cost of purchasing the relocation land is borne by the government. However, most residents must bear the cost of constructing individual houses, although there is a partial subsidy in some cases. While the relocation process differs from place to place, the example of the Tamaura District in Iwanuma is discussed here.

According to the land acquisition policy of the government, land owned by residents will be purchased by the government at prices based on pre-disaster rosenka land valuations (a system that overestimates the value of land fronting major roads). Hence, the amounts paid for land along the shoreline will be low. In contrast, land values at the relocation site have risen to several times those prior to the disaster, placing a heavy burden on residents. Those who cannot afford to buy their own land or house can rent disaster recovery public housing (either an apartment or detached house). In Iwanuma, residents in six districts will be relocated. The number of households in the six districts is less than 400, of which about 300 are planning to move to the new relocation site. The remaining 100 households have chosen to live elsewhere by purchasing a house, renting an apartment or through other means (Ujiie, 2013).

A town without fear

Figure 5 shows a cross-sectional image of the future town of Minamisanriku. The residential zone will be moved to higher ground above a sloped greenbelt. When a disposition survey was conducted amongst all households in the town in July 2011, 68 per cent were in favour of building a new city on higher ground. The design can accommodate 14,555 people, which is the expected population by the year 2021 accounting for aging individuals and allowing for residents who plan to return if Minamisanriku becomes safer. It is assumed that 35.9 per cent of the population will be more than 65 years old in 2021. The essence of the design concept was "a town easy to escape". Based on the assumption that a severe tsunami will occur again, houses and public facilities will be positioned on higher ground. The design aims for a compact town and unified design for public facilities (Minamisanriku, 2012).

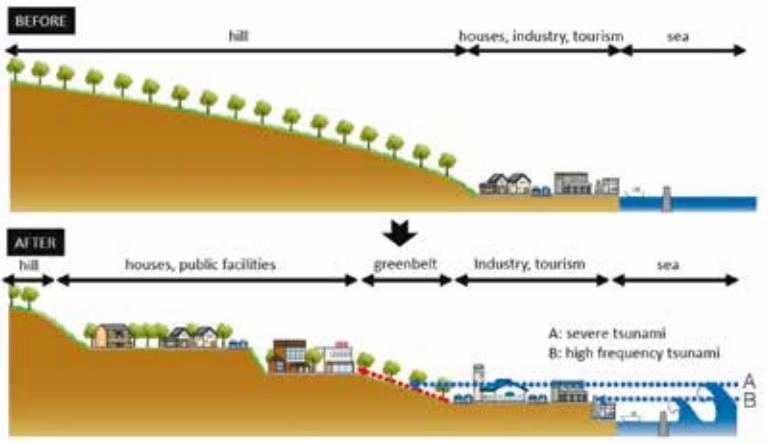

Figure 5. Cross-sectional image of the future town of Minamisanriku.
Note: Adapted from Minamisanriku (2012).

Building a resilient community

As part of reconstruction efforts, resilient communities which rethink the weaknesses of pre-earthquake communities are being planned. The Tamaura District in the city of Iwanuma is discussed here as an example. While the municipal government intents to rebuild the infrastructure, leaders from the local population are working to re-invigorate the district and make it more resilient than it was before the tsunami. The largest industry in Tamaura was agriculture, but most of those working in the industry were not full-time farmers. Rice was the primary crop in

Tamaura along with smaller quantities of tomatoes, melons and vegetables. Although there is an industrial park, given the district's proximity to Sendai International Airport, many companies located there were merely warehouse firms, and therefore did not contribute to the employment of residents.

The area of agricultural land damaged by the tsunami included 1,200 hectares, 65 per cent of the total farmland in Iwanuma. Of that, about one eighth was cultivated in 2012 and one fifth was cultivated in 2013.

While agriculture in Tamaura faces many issues on the way toward reconstruction, various challenges existed before the disaster, including (1) an aging population and lack of successors, (2) low profitability due to excessive reliance on agricultural cooperatives, (3) a lack of skill in growing products other than rice, and (4) intense competition among neighbouring farmers with no notion of partnership. The individualization of the farming system forced each farmer to have their own machinery and tools thus decreasing cost-effectiveness as opposed to a system of sharing equipment. The disaster then caused new problems such as the loss of houses, workshops, machinery and tools making it very difficult—especially for part-time farmers—to start over again from scratch. As a result, about 90 per cent of the farmers left the industry, resulting in abandoned agricultural land. Therefore, citizen groups in Tamaura decided to focus on revitalising the agricultural industry using the large area of land abandoned due to the tsunami.

As a countermeasure, a Tamaura citizens' group is planning an agricultural amusement park to attract tourists from outside the area (Ujiie, 2013). The plan also includes expanding sales channels, differentiating products, and promoting crops other than rice. Through these efforts, they aim to make agriculture profitable. Visitors will be invited to regular events to experience farming, learn about nature through farming, and other activities. The objective of this amusement park is to make Tamaura a fun, exciting, beautiful and fertile place.

Lessons learned

The following lessons have been learned through this investigation:

1. Damage due to the tsunami was predominantly determined by the topographical features of the land impacted by the tsunami rather than proximity to the epicentre. Narrow riverbanks are more vulnerable to a tsunami due to the amplification of the tsunami's impact, constricting its path and funnelling the wave further into the valley. Experience from GEJE could be used to identify safer locations in tsunami-prone areas.

2. Development of residential areas in safer inland locations is a feasible solution for relocation. A commuter system for fishermen should be encouraged to save lives as well as to protect the seashore.

3. Locating industrial infrastructure near the shoreline and residential areas far from the shoreline is a feasible solution for planning in tsunami-prone towns. Large industrial buildings may act as obstacles to tsunami movement, decreasing the speed of the waves and reducing the damage to inland residential buildings.

4. Collective household relocation appears to be an efficient way to resettle evacuees. In particular, elderly members of society prefer familiar neighbourhoods; thus, they tend to return to their original neighbourhoods or may at least wish to collectively relocate elsewhere.

5. Compact towns and a unified design for public facilities are recommended. Particular attention should be given to providing escape routes when planning tsunami-prone towns.

GEJE raised new research questions that require solutions not only for the sake of Japan but the rest of the world. It has become clear that against such a low-frequency high-magnitude disaster, traditional disaster prevention and mitigation measures were not sufficient. This disaster revealed the limitations and weaknesses of state-of-the-art scientific and technological systems. A tsunami is an act of nature that is impossible to prevent, but for which it is possible to prepare. It is hoped that the lessons described herein will be useful in protecting lives and property from the next tsunami, wherever it may occur.

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The 2011 Great East Japan Tsunami: Background, Characteristics, Damage and Reconstruction

Anawat Suppasri

This paper summarizes the background and reconstruction information for the 2011 Great East Japan Tsunami from a civil engineering perspective. The massive earthquake generated a tsunami with a wave height of 40 m. Casualty and building damage data were used to analyse and develop a vulnerability function. Results showed that nearly the same fatality rate was found for people in the Sanriku area where the tsunami was taller. This may be a result of people in the Sanriku area experiencing tsunamis more frequently than people living in the Sendai Plain. Building damage data showed the vulnerability of wooden houses in the affected area. Damage occurs when the inundation depth is greater than 3 m, and wooden houses are totally washed away when the inundation depth is greater than 6 m. Finally, in the last section of this paper, current reconstruction processes in some affected areas are introduced, (e.g., placing tsunami inundation warning signs in key areas and establishing monuments), and the current situation in the tsunami-affected areas is discussed.

Tsunamis in the Tohoku Region and the 2011 Great East Japan Tsunami

In the past, people believed that a tsunami occurs after substantial shaking from an earthquake. For example, a strong earthquake in 1611 caused considerable tsunami damage in the Tohoku region (Figure 6 and Suppasri et al., 2012c). However, an earthquake in 1896 1) was of a low magnitude, but was later classified as a tsunami earthquake, a quake that can generate a higher tsunami wave than a typical tsunamigenic earthquake and 2) occurred during the night. There were approximately 22,000 fatalities from the 1896 disaster, with the tsunami reportedly having had a maximum run-up height of 38.2 m. In 1933, another large tsunami was generated and had a maximum run-up height of 28.7 m. However, the death toll was only about 3,000. This was probably because the 1933 tsunami occurred just 37 years after the greatest one on record in the Sanriku area and people evacuated quickly because of their high tsunami awareness. There were some people who ignored orders to evacuate because of their misconceptions regarding the earthquake in 1896, believing that large tsunamis were generated only by small shaking earthquakes (Yamashita, 2008). A great tsunami struck the Tohoku region again in 1960, but no tremors were felt prior to the tsunami making landfall. However, one of the strongest earthquakes on record (magnitude 9.5) occurred in Chile that year and generated a tsunami that struck the Tohoku region after approximately one day. The maximum height of the 1960 tsunami was 10.7 m, and 142 deaths were reported. This prompted the development in Japan of the world's most advanced tsunami countermeasures. The 2011 Tohoku tsunami was generated by an earthquake where the rupture was observed in both deep (typical for tsunamigenic earthquakes) and shallow regions (similar to the 1896 event), and had an unexpected magnitude of 9.0. This is why the inundation distance was as far as 5 km and the run-up height reached 40 m. The resulting death toll was approximately 19,000.

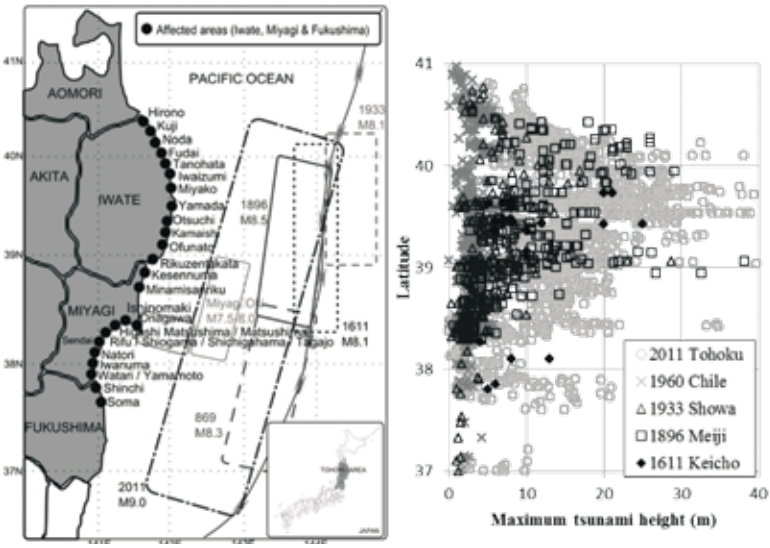

Figure 6. Historical tsunamis in the Tohoku region and areas that were affected by the 2011 Tohoku tsunami. The maximum heights for the historical tsunamis are shown. Source: Suppasri et al., 2012c.

Human loss and building damage due to the 2011 Great East Japan Tsunami

The Meiji–Sanriku Tsunami of 1896 had an average tsunami height of more than 10 m and a high fatality rate (Figure 7a). Thirty-seven years after the 1896 event, the tsunami following the 1933 Showa–Sanriku earthquake had a lower fatality rate even though the tsunami height was almost the same. Fatalities from the 2011 Tohoku tsunami along the Sanriku coast (North Miyagi to Iwate) were similar to that of the 1933 Showa–Sanriku tsunami. While the 2011 Tohoku tsunami was large, the experiences of people along the Sanriku coast with tsunamis may have helped to limit the number of deaths. The 2011 Tohoku tsunami along the coast of the Sendai Plain was a smaller tsunami, but had a higher number of casualties. This data shows the importance of experience in reducing human loss during a tsunami. Examining the tsunami damage to buildings is also important for the reconstruction process. Understanding the characteristics of building damage will help guide land use management and city planning decisions to prevent damage caused by future tsunamis. Tsunami fragility curves developed by examining the preliminary damage to wooden houses from the 2011 Tohoku event are shown in Figure 7b. As preliminary data for the 2011 event in Miyagi Prefecture, Japan, 150 wooden houses were considered (Suppasri et al., 2012b). Even though most houses in the Miyagi Prefecture are constructed using wood, the majority of the houses are quite new and strong because of revisions made to building codes after the Miyagi-oki

earthquake in 1978. Thus, 3–4 m is the critical inundation depth for Miyagi, and the prefectural plan is to not build houses in locations with an expected inundation depth greater than 2–3 m.

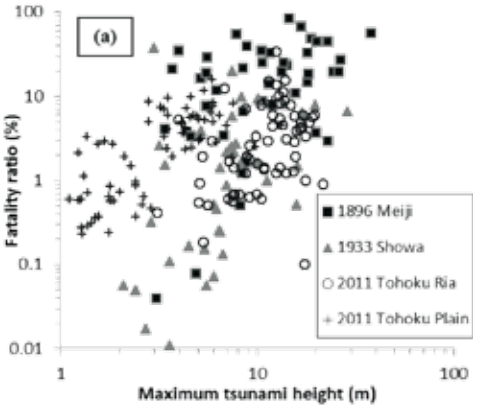

Figure 7a. Tsunami fatality rate in the Tohoku region from historical tsunamis in Japan. (Suppasri et al., 2012a).

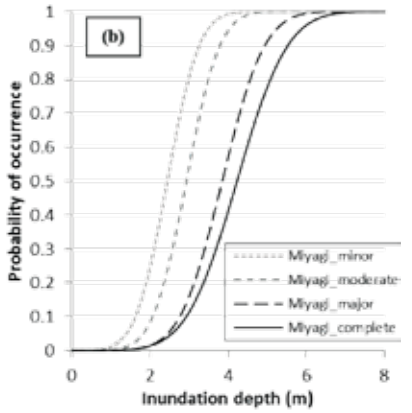

Figure 7b. Tsunami fragility curves of wooden houses in Miyagi Prefecture. (Suppasri et al., 2012b).

Reconstruction after the 2011 Great East Japan Tsunami

Tsunami inundation signs are now being placed in the areas affected by the 2011 Tohoku tsunami in Miyagi Prefecture. For example, a pedestrian bridge in Natori, shown in Figure 8a, is located almost 2 km from the sea but less than 500 m from the Natori River. The tsunami inundated about 2 m in that area and some people survived by staying on the pedestrian bridge. Another example can be seen from Sendai International Airport, as shown in Figure 8b. The airport is located approximately 1 km from the sea. A tsunami wave 3-m high inundated the airport's first floor, while most passengers, staff, and nearby residents survived by staying on the second and third floors. Similar to information already in place in other countries following the 2004 Indian Ocean tsunami, these signs will add to the current tsunami warning system and awareness regarding the 2011 earthquake. For historical tsunamis such as the 1896 Meiji–Sanriku and 1933 Showa–Sanriku tsunamis, some stone markers, temples, and shrines display recorded tsunami stories, although damaged structures were never used as memorials. Figure 9a shows one large fishing ship that was moved more than 600 m inland by the 2011 tsunami in the city of Kesennuma. Although the city would like to keep the ship as a memorial, strong objections from those who lost their families and houses because of the ship mean it will most likely be removed. Until now, overturned buildings were considered uncommon types of tsunami damage since most buildings simply collapsed or were washed away. There were, in fact, six overturned buildings in Onagawa and some in other locations. Owing to objections from the building owners and local residents, it is likely that the town can only preserve three buildings, such as the one shown in Figure 9b, as memorials (Onagawa, 2011). The expressway located 5 km from the sea in Sendai (Figure 10a) helped protect areas located behind it from the tsunami. Some people survived by climbing up to the expressway. Consequently, the city built stairs along this expressway so that people will be able to reach the top of the expressway easily during future evacuations (Sendai, 2011). The city of Iwanuma plans to construct artificial hills, the height of which varies from 10–15 m, using debris from the tsunami (Figure 10b). In addition to being a memorial park, these hills, dubbed "Millennium Hope Hills", will reduce the energy of a tsunami as well as serve as an evacuation site in the event of future tsunamis (Iwanuma, 2011).

Figure 8a. Pedestrian bridge in Natori. (Suppasri, 30 May 2012)

Figure 8b. Sendai International Airport. (Suppasri, 25 January 2012)

Figure 9a. Large fishing ship in the city of Kesennuma. (Suppasri, 29 April 2012).

Figure 9b. Overturned building in the town of Onagawa. (Suppasri, 29 March 2011).

Figure 10a. Stairs to an expressway in Sendai. (Suppasri, 25 January 2012).

Figure 10b. Millennium Hope Hills in the city of Iwanuma. (Suppasri, 16 August 2013).

Conclusions

It is clear from the fatality figures that experience and evacuation plans help to reduce human loss from a tsunami, which was especially apparent along the coast of the Tohoku region. This stresses the importance of education in disaster prevention in terms of increasing both tsunami awareness and evacuation preparedness. Tsunami fragility analysis of wooden houses could also help with reconstruction. For example, a new town should be constructed in a location where the estimated inundation depth is less than 2–3 m. Reconstruction in the Tohoku region is continuing and includes the placement of tsunami inundation warning signs, establishing memorials, and developing other ideas that serve as warning signs and help to maintain tsunami awareness for future generations.

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Resettlement after the Great East Japan Earthquake and Tsunami in Tohoku

Hitoshi Yonekura

In the second year after the Great East Japan Earthquake and Tsunami (GEJET) of 2011, preventive involuntary resettlement projects by the government entered the implementation phase and various problems arose in the resettlement areas hit by the tsunami. After a brief introduction to the disaster and concerns from international organizations, this paper reviews the resettlement schemes set up by central and local governments and points out various problems and hardships during the phases of planning and implementation. In the resettlement projects for the victims, reducing the overall burden on victims, land procurement, and the disposition of mortgages have become serious concerns. The differences in institutional capacity, financial capability and administrative manpower have caused serious disparity between the victims belonging to different local administrations. Several lessons can be learned from this huge disaster. Among others, during the implementation phase, a flexible response by administration is needed, working on a case-by-case basis. The amendment of acts or local regulations, establishing or reforming institutions and agencies should be completed in a timely manner.

Great East Japan Earthquake and Tsunami (GEJET) and increasing disaster in Asia

An unprecedented tsunami hit the coast of eastern Japan in 2011, killing some 20,000 people within hours. It was incredible that a developed economy, such as 21st century Japan, could experience such destruction. The Japanese people with their well-organized social systems believed they were protected from such disasters. Approximately 470,000 people were evacuated from the disaster in March 2011. Of those, only about 150,000 people had returned to their homes by the middle of 2013.

The risk of natural hazards has increased not only in Japan but also in other Asian regions. The Asian Development Bank (ADB) pointed out that the Asia-Pacific region accounted for 38 per cent of global economic losses due to natural disasters during 1980–2009. At the same time the region generated almost 25 per cent of the world's gross domestic product during this period (ADB, 2012, Executive Summary, p. v). ADB reported as follows:

> People living in the Asia-Pacific region are now four times more likely to be affected by natural disasters than those living in Africa, and 25 times more likely than those living in Europe or North America; most of the large cities in the world classified as having extreme risks of climate vulnerability are in Asia, and the region faces expected annual disaster losses in excess of $19 billion; policy makers, governments, and communities need to recognize that natural disasters are becoming increasingly endemic in the Asia-Pacific region, and that they can derail economic growth and development.

The World Bank paid considerable attention to GEJET and compiled a major report on the disaster in 2012 (World Bank, 2012a).[1] The report focuses on resettlement as one of the non-structural measures, which is closely linked to the issue of

1 The report comprises 1) structural measures; 2) non-structural measures; 3) emergency response; 4) reconstruction planning; 5) hazard and risk information and decision making; and 6) the economics of disaster risk, risk management and risk financing.

human security with regards to planning and implementation. This paper focuses on displacement and resettlement projects carried out after GEJET.

Overview of resettlement project after GEJET in Japan

Involuntary resettlement

The World Bank divides involuntary displacement and resettlement (DR) into three categories: development-induced DR, disaster-induced DR (including preventive DR) and conflict-induced DR. Reducing involuntary DR is important and necessary, but is not always possible. Operational Policy 4.12 of the World Bank (formerly called O Directives / Bank Procedures 4.12) describes resettlement as a process to assist displaced persons to replace their housing, assets, livelihood, land and access to resources and services and to restore their socio-economic and cultural conditions. Involuntary resettlement can often cause insecurity or hamper human rights. In order to overcome this critical problem, the World Bank has emphasized the following points:

i) Preventive measures should be incorporated in to comprehensive risk reduction strategies in order to be effective;

ii) The objective of resettlement is to protect the lives and assets of persons at risk and to improve or at least restore their living conditions;

iii) Resettlement programmes should be implemented with some flexibility so that they can respond to any problems arising during the process; and

iv) The programme should be tailored to suit the characteristics of the population involved and the context in which they will be implemented.

Regarding resettlement project implementation, the World Bank makes a number of requests for the treatment of displaced persons:

i) They should be informed about their options and rights pertaining to resettlement;

ii) They should be consulted on the choices offered to them and provided with technically and economically feasible resettlement alternatives; and

iii) They should be provided with prompt and effective compensation at full re placement cost for the loss of assets directly attributable to the project.

It is pointed out that particular attention should be paid to the needs of vulnerable groups among those displaced, especially those living below the poverty line, the elderly, women and children, ethnic minorities or other displaced persons who may not be protected through national land compensation legislation.[2] This study aims to investigate how and to what extent these essential activities requested by the World Bank are executed in Miyagi, where a large-scale displacement project is underway after GEJET.

2 Fortunately, resettlement of indigenous peoples or ethnic minorities did not become a critical problem in GEJET, except for foreigners who remained in Tohoku.

Basic plan of resettlement after GEJET

After GEJET, it was estimated that 22,000 households (HHs) needed to be resettled to higher or further inland zones in the three disaster prefectures (as of February 2012). Those affected were asked to evacuate and to move to safer places to prevent another tsunami disaster.[3] Ishinomaki in Miyagi Prefecture, which was the area most seriously hit by the tsunami, needed the resettlement of 6,900 HHs, Higashi Matsushima 3,000 HHs and Sendai 2,000 HHs. The total cost of the GEJET resettlement project was, however, estimated at only 350 billion yen, a very small amount compared to the total reconstruction budget of 19 trillion yen over five years.

On 23 March 2012, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) approved the plans for Iwanuma and Ishinomaki. These cities applied for the Group Relocation Project in Miyagi. Once approved, the resettlement projects began successfully. By September 2012, the authorized resettlement plans under the Group Relocation Project consisted of Iwate (13 areas with 260 HHs), Miyagi (92 areas with 5,017 HHs) and Fukushima (57 areas with 660 HHs) (Kahoku Shimpo, 11 September 2012). Resettlement plans in Fukushima Prefecture were delayed because of warnings about a radioactive zone. In this relocation project, the central government intends to support victims with maintaining their communal ties and relationships among community members; affected populations may consider their individual circumstances and select from several types of resettlement.

Resettlement and rehabilitation plan of Sendai

Based on the group relocation for disaster mitigation, Sendai selected a resettlement zone and named it the High Hazard Risk Zone.[4] This project is subsidized by the central government. In addition to this project, the city government initiated the City Support Zone as a complimentary programme, which is financed by the city government. In line with selecting the high hazard risk zone, a tentative implementation plan was announced as a midterm activity in September 2011. After parliamentary deliberation, the final plan was decided upon in December. The plan covers 3,860 HHs in total, comprising 1,560 HHs under the relocation project and 2,300 HHs under the city support programme (Mainichi Shinbun, 26 February 2012). As of June 2012, the resettlement plan covered seven places in the east coast zone of Sendai, the area most seriously hit by the tsunami. Plans included resettling residents in 14 residential estates in the inner zone. The total project cost was estimated at 56.7 billion yen (Kahoku Shimpo, 22 June 2012).

Although other local governments (autonomous municipalities) made plans to cater to each community (traditional settlement unit, hamlet or village), Sendai created an integrated plan and implemented it in a unified manner under its city administration. As of September 2012, 1,432 proposals had already been submitted to the city administration to join the relocation (92 per cent of all target HHs) in Sendai. In September, the city government started the implementation process. In October, target HHs and new relocation areas were reviewed. The total target HH number fell from 1,706 to 1,545. Community-based relocation dropped from

3 In Iwate Prefecture, 9 municipalities, approximately 60 places, and 3,300 HHs; in Miyagi, 11 municipalities, 140 places, and 16,000 HHs; and in Fukushima, 6 municipalities, 50 places, and 2,600 HHs.

4 The act is titled the "Act on Special Financial Support for Promoting Group Relocation for Disaster Mitigation."

1,001 to 837, while individual resettlement increased slightly from 334 to 335 and those displaced who wished to be resettled into public housing rose from 371 to 373. According to the implementation plan, the resettlement project needs to be completed by the end of fiscal year 2015 in order for the remainder of the subsidy to be distributed.

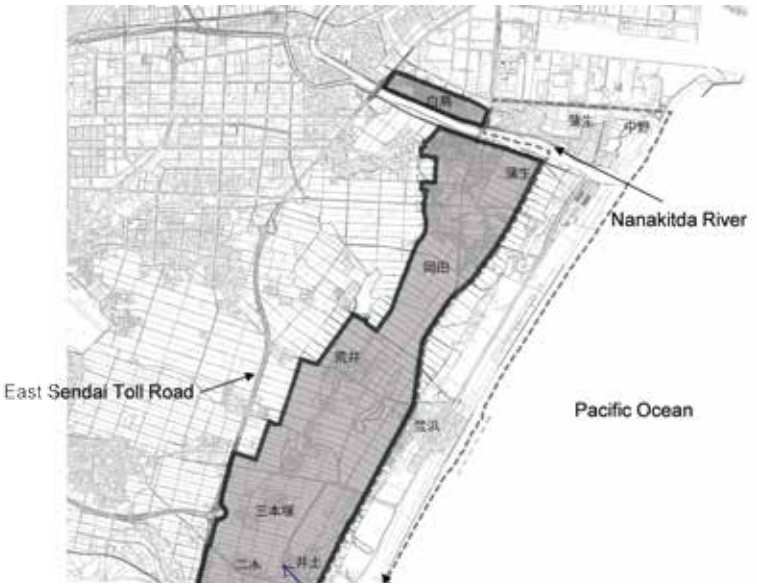

Figure 11. High Hazard Zone and City Support Zone in Sendai. (Sendai, 2011).

Hardships of group relocation during the planning phase

When the city decided to launch the Group Relocation Project in Sendai in May 2012, it was not fully prepared. About 500 HHs remained undecided about re-settlement. The perceptions among people were negative, particularly amongst the affected population, following Mayor Emiko Okuyama's address regarding the initiation of land surveying and negotiations towards procuring a site. The main opinions were as follows (Blog "Earthquake Diary in Sendai" May 2012):

- The mayor was polite but lacked compassion;
- Land ownership related to human rights was being handled without much thought;

- There was no consideration for the attachment of the victims to the place where they were born and raised,
- Smooth implementation of the project was no justification for overlooking the trauma of victims;
- Administrative barriers were prohibitive, with officials not considering the views of the victims.

The following remarks from an official were considered insensitive and a mockery of the victims' situation: "The Group Relocation Project cannot resort to 'forced expropriation'; but, as new houses cannot be built in the high hazard risk area, the victim cannot secure a new residence there."

Land valuations by city authorities were reduced by about 20 or 25 per cent after GEJET. This meant that the difference between the land price of the new resettlements and the original residences had widened, which became a serious burden for the target population because the increased cost was not subsidized by the government. Estimated land prices in disaster areas such as Arahama were 10,500 to 17,800 yen per square meter; on the other hand, the price of land at the resettlement destination site in Arai (to where the largest number of HHs will be resettled), for example, ranged from 60,000 to 81,500 yen. The cost of land at the destination site was approximately four to six times that of the departure site in 2012. This hindered the smooth implementation of group relocation. The financial burden on those affected was serious and became a critical problem in Sendai. Local governments were responsible for implementing the Group Relocation Project and requested subsidy from the central government. Since the project cost was substantial, it was impossible for local governments to manage without financial support from the central government.

In relation to the demarcation or zoning of a certain area after the disaster, a minor difference among the people even within a small area could sometimes force the project to be carried out in a different manner and/or resulted in the splitting of the community. While some people were able to resettle through the Group Relocation Project, others who were not recognized under this project due to the demarcation rules, were covered by other countermeasures such as ground levelling without resettlement. The strict conditions for proposing a group relocation project were as follows[5]:

i) *Joint approval* of the resettlement plan, which prioritizes victims' concerns; and

ii) *Resettlement of entire households* in each targeted disaster area. Getting consent and approval was a long process with many barriers to securing the subsidies. The substantial difference in land prices between the departure and destination places made the situation worse.

5 These conditions are lessons from previous disasters such as the Southwest Hokkaido Earthquake in 1993, the Kobe Earthquake in 1995 and the Niigata Chuetsu Earthquake in 2004.

In the case of forced resettlement, the World Bank's operational policy (OP) indicates that compensation under domestic law is to be supplemented with additional measures necessary to meet the replacement cost standard where domestic law does not meet the full cost of such compensation. Such additional assistance is, however, often varies from local governments or municipalities and is insufficient in covering the full replacement costs. The capability of the local government is especially important in responding to this problem. There is no binding policy on providing government support for the increased value in obtaining an asset in Japan. This principle, however, needs to be reconsidered given the seriousness and nature of the disaster, particularly when an asset is linked to human security or human rights issues.

Problems during the implementation phase

1. Maintaining community

The Group Relocation Project has struggled to support communities of victims a year and a half after GEJET. Due to the varying conditions for each household and the demarcation of high-risk zones, different programmes were initiated, some of which were subsidized by the government and others which were not. Therefore, members of a community did not necessarily resettled to the same destination housing estate. Victims were worried that mutual relationships shaped over time would no longer be maintained (for instance, neighbourhood associations and other groups that supported various activities, mutual ties, and available help based on location). Split resettlement made these relationships hard to maintain.

2. Delay of land procurement

Proposals for resettlement were concentrated within certain convenient estates. Other estates close to the high-risk hazard areas or remote locations were rarely selected. This was because it would have required a rearrangement or redesign of resettlement implementation and, as a result, would increase project costs. Although displaced persons were confronted with different hardships and situations, their attitudes toward the selection of a place for resettlement were not much different. Local governments were obliged to procure additional land in destination estates where it was convenient to live but where land prices were higher.

Many municipalities, in fact, could not provide the data on land prices, which was essential in order for individuals to make a decision. This made it difficult to settle land prices between victims and buyers, causing long disputes between the concerned parties.

The tradition of land registration was also a problem, because land registration is often not renewed after the death of landowners. Cadastres made long ago and the property lines for parcels of land were often not clear, causing severe settlement disputes. The more critical hardship was that financial institutions mortgaged many land parcels; this complicated the land titles. The Financial Service Agency requested the release of mortgages to commercial or cooperative banks in October 2012 (Kahoku Shimpo, 12 October 2012). Banks were, however, reluctant to release them, because the mortgages could become poorly performing loans.

Therefore, this request for the release of mortgages was not well received, and many municipalities needed to take additional measures to promote land transactions causing bottlenecks in the relocation project. These measures may work for municipalities with additional funds since they may be able to procure the land using mortgage arrangements.

After beginning the expropriation of land in the disaster areas, it became apparent that there was inadequate manpower to complete the necessary landowner investigations, land surveys and registrations. This made the process long and tedious. The city of Sendai needed to recruit a substantial number of officers to take charge of land administration.

3. Burden of victims and alternative means of resettlement

There are alternative means of resettlement that apply different regulations to enable the disposal of land in departure zones and prepare destination estates for resettlement. In areas outside of the Group Relocation Project, Sendai proposed a cooperative style of resettlement known as the "Land Consolidation Project." The origin of this is not as a supporting scheme for disaster prevention, but rather as land consolidation for farming development. The target population, however, was confused by the complicated administrative procedures and higher cost burden (Kahoku Shimpo, 13 August 2012). Only a limited number of farmers could utilize such alternative means. Displaced persons, meanwhile, requested more realistic and feasible assistance.

The Group Relocation Project subsidized by MLIT provides the most comprehensive support covering land procurement by the city (local government), the leasing of city-owned land, interest subsidies for housing loans and relocation cost support. In Sendai, the release of mortgages was still being reviewed as of 1 December 2012. On the other hand, the Land Consolidation Project subsidized by the Ministry of Agriculture, Forestry and Fisheries only supports land procurement by local governments. However, displaced persons who continue to live in the affected areas only receive support for the levelling of land.

Table 2 shows the cost by item of a resettlement project based on the estimates for a typical household for an affected person in Natori. The cost of construction for a new house is estimated at 20 million yen. Victims living outside the resettlement project zone need to secure this amount for the construction of a new house without government support. Neither an interest subsidy for a housing loan nor moving cost support are available. Since they do not need to procure new land but simply construct a new house, the burden on affected persons is in relation smaller than for victims who need new land for resettlement.

On the other hand, resettlement beneficiaries must spend much more money to recover their living conditions, particularly due to the costs incurred by the large difference in land prices between the destination and departure areas. The government does not compensates for the higher cost of the new land. No exception is made even for the victims of a major disaster. The Group Relocation Project almost seems to be an involuntary resettlement. Victims must resettle because

new housing construction is not allowed in the departure area. Since involuntary resettlement can often cause insecurity or hamper human rights, the World Bank guidelines regarding involuntary resettlement point out that the objective of resettlement is to protect the lives and assets of persons at risk and to improve or at least restore their living conditions. The Group Relocation Project aims to restore the living conditions of victims and assets, but with the expenses borne mostly by those affected. Considering the hardships faced by the region's residents, it is questionable whether such a rule truly fulfils equality under the law. As the World Bank pointed out, involuntary resettlement such as the Group Relocation Project should be implemented with some flexibility so that any problems arising during implementation can be addressed. The government prepared alternative complimentary means of support, such as loan interest subsidies for housing or relocation costs. These, however, appear as cosmetic solutions rather than real support to assist those affected in recovering their living conditions.

	Type of resettlement	Buying price of land	Rebuilding cost of housing	Selling price of land	Interest subsidy for housing loan	Support for moving costs	Total expenditure for resettlement per HH
Group Relocation Project	Buying project land	9,700	20,000	3,420	4,380	200	21,700
	Rental of city land	0	20,000	3,420	2,630	200	13,750
	Land buying by individuals	11,200	20,000	3,20	4,380	200	23,200
Land Consolidation Project	Rebuilding on self-owned land	0	20,000	0	0	0	20,000
	Land selling and resettlement	11,200	20,000	6,280	0	0	24,920
Non-Project Zone		0	20,000	0	0	0	20,000

Table 2. Cost Estimation of Resettlement by Alternative Means (Natori) (Unit: 1000 yen).
Source: Kahoku Shimpo, 1 December 2012.

Flexible countermeasures to settle, cope with or avert problems

1. Problem of mortgage / fixed mortgage of housing loan in the Group Relocation Project

One of the most critical problems in implementing land procurement for resettlement was mortgaged land parcels. Local governments could not smoothly carry out the procurement, which also caused difficulty in community-based resettlement. The Group Relocation Project requires the beneficiaries of the project to sell their disaster-affected lands to the local government; otherwise, the central government will not fully disburse project funds. The city of Sendai required the target population to sell land that was free of mortgage commitments to the government. Because of this, those who could not sell their land were forced to resettle on their own or move to public housing. In order to avoid such a situation, Sendai surveyed and identified 800 land parcels (in total, 3,300 parcels) with mortgages or fixed mortgages as of March 2012. About a quarter of the land was under a mortgage. Since this represented a high rate of mortgaged land, the city took countermeasures to reduce the burden on affected persons who could not sell their land because it was impossible to obtain a release of the mortgage. Fortunately, most banking institutions agreed to release mortgages on the land by the end of 2012.

2. Supporting programme for reducing the burden on individuals

At the end of May 2012, the city of Sendai decided to reduce the burden on affected persons to accelerate the recovery of their living conditions. This support had the following components:

i) The cost of purchasing a new house in an area outside of the Group Relocation Project, rebuilding a house in a disaster area and moving to resettlement estates;

ii) Inclusion of displaced persons moving outside of Sendai;

iii) Establishing community support institutions such as non-profit organizations; and

iv) Estimation of the total cost at 7.1 billion yen, which was financed by the city.

Other smaller local governments, however, found it hard to finance the costs due to budget constraints. The differences between the burdens borne by displaced persons were, therefore, widened by the different financial capabilities of local governments. Such differences could also be widened by the application of different resettlement projects. Thus, to ensure the same level of support for each affected person, various support methods were applied to those who needed individual base resettlement not covered by the Group Relocation Project.[6] The government covered interest on loans up to a maximum of 7.08 million yen for rebuilding a new housing unit as well as the cost of moving which amounted to

6 Natori was reviewed and designated the zone for the Land Consolidation Project (121.8 ha). The designated area was fixed and the Group Relocation Project was not simultaneously applied in the zone: i) Under this project, the city could procure the land of victims except for the lands mortgaged; ii) This project aimed to promote the resettlement of victims to the western side of the city where the hazard risk is lower. On the eastern side of the Teizan Canal, the Group Relocation Project was implemented and the victims were supported by a maximum of 7.86 million yen per settlement HH. Meanwhile, on the western side of the canal, such a subsidy was not provided. In this case, the city government was responsible for compensating in order to reduce the gap. However, Natori could not afford the expense of 9.6 billion yen and gave up the project (Kahoku Shinpo, 11 October 2012, http://www.kahoku.co.jp/spe/spe_sys1062/20121011_04.htm).

780,000 yen in Sendai. Even if an individual needed to move outside of the city of Sendai, the victim in the high-risk hazard area was supported by the extension of central government support.

Lessons learned

This paper reviewed the planning and implementation of resettlement being carried out in the area of Miyagi Prefecture affected by GEJET. Several lessons can be learned from this devastating disaster:

i) Since it takes a long time to obtain the consent of displaced persons for resettlement projects, the grand design of reconstruction and implementation policies/projects should be set up in a timely manner so they can shift smoothly to the implementation phase.

ii) Different projects related to resettlement are geared towards different levels or degrees of support, particularly as this relates to compensation schemes. This can cause disparity among affected persons and resettled populations and bring dispute to the integrity of the community.

iii) Alternative or supplemental measures, including unprecedented steps, should always be considered and applied if necessary, especially in order to reduce the burden placed affected persons and resettled populations.

iv) During the implementation phase, a flexible response from the administration is needed, particularly in identifying legal, financial and administrative deficiencies on a case-by-case basis. The amendment of acts or local regulations and establishing or reforming institutions or agencies should be carried out in a timely manner according to needs.

v) Consistency in the approach to local governance is essential. The differences in institutional capacity, financial capability and administrative manpower can lead to serious disparity between affected persons and resettled populations belonging to different local administrations.

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Agricultural Recovery Efforts in Tsunami-Damaged Areas: Case Studies

Katsuhito Fuyuki

The Great East Japan Earthquake and Tsunami of 11 March 2011 (GEJET2011) caused extensive damage to agriculture in the Tohoku region. Miyagi Prefecture was particularly affected by the massive tsunami that flooded 10 per cent of all cultivated acreage. Furthermore, rural communities were severely damaged and, thus, require a significant amount of time for recovery. This paper focuses on specific issues relating to agricultural recovery efforts in tsunami-damaged areas in Miyagi Prefecture.

Damage to the agricultural sector in Eastern Japan

First, this paper will describe the extent of the damage to the agricultural sector in Eastern Japan. The agricultural landscape of six prefectures in Eastern Japan was damaged by the tsunami. The most severely damaged cities and towns, where over 30 per cent of the cultivated acreage was flooded, were concentrated in the southern part of Iwate Prefecture, the northern part of Fukushima Prefecture, and the entirety of Miyagi Prefecture.

GEJET resulted in a staggering 947.6 billion yen or approximately US$10 billion worth of damage to the agricultural sector. Most of the damage involved agricultural lands and facilities. The area of farmland that was washed away or flooded by the tsunami was estimated to be around 20,200 hectares of paddy fields and 3,400 hectares of upland fields (MAFF, 2012b). Most of the damaged farmland was accounted for in three Tohoku prefectures, namely Iwate, Miyagi, and Fukushima. In Miyagi Prefecture, over 10 per cent of the cultivated acreage was flooded. Most of the flooded areas were paddy fields.

Table 3 shows the estimated area of farmland in Miyagi Prefecture that was washed away by the tsunami. Over half of cultivated land was damaged by the tsunami in the southern part of this prefecture, and paddy fields were devastated in some cities and towns. For example, 93.4 per cent of the town of Shichigahama, 78.6 per cent of the town of Watari, and 77.8 per cent of the town of Yamamoto were flooded. In Sendai, 40.7 per cent of the cultivated land was flooded, but the eastern part of the city was more seriously affected. In Wakabayashi and Miyagino wards, the paddy fields were almost totally destroyed.

Agricultural restoration situation

This section summarizes the current status of agricultural restoration efforts in Eastern Japan. Table 4 shows the agricultural recovery plan by the Ministry of Agriculture, Forestry and Fishery of Japan (MAFF). According to this plan, damaged agricultural fields will have reached full recovery by 2015. However, the Miyagi Prefecture Governor announced in February 2013 that recovery might be delayed by a few more years.

City, Town	Cultivated area (ha)	Flooded by tsunami (ha)	Percentage (%)
Miyagi Pref.	136,300	15,002	11.0
Kesennuma	2,220	1,032	46.5
Minamisanriku	1,210	262	21.7
Ishinomaki	10,200	2,107	20.7
Onagawa	25	10	40.0
Higashimatsushima	3,060	1,495	48.9
Matsushima	1,030	91	8.8
Rifu	471	0	0.0
Shiogama	73	27	37.0
Tagajou	365	53	14.5
Shichigahama	183	171	93.4
Sendai	6,580	2,681	40.7
Natori	2,990	1,561	52.2
Iwanuma	1,870	1,206	64.5
Watari	3,450	2,711	78.6
Yamamoto	2,050	1,595	77.8

Table 3. Estimated area of farmland washed away or flooded by the tsunami. Source: MAFF, 2012a.

Prefecture	Farming resumed in FY2011	Farming resumed in FY2012	Farming resumed in FY2013	Farming resumed in FY2014	Others	Total
Iwate	10	310	30	0	380	730
Miyagi	1,220	5,390	5,450	1,970	310	14,340
Fukushima	60	610	2,670		2,120	5,460
Total	1,290	6,310	5,480	4,640	2,810	20,530
Share	40%		26%	22%	13%	100%

Table 4. Area of tsunami-damaged farmland available for the resumption of farming. (Unit: hectares).
Source: MAFF, 2012b

Salt removal was completed or launched in 39 per cent (8,310 hectares) of the tsunami-damaged farmlands by the end of March 2012 and farming had resumed on 40 per cent of all tsunami-damaged farms (approximately 4,090 farms) as of 11 March 2012 (MAFF, 2012b). Efforts to resume farming were supported by various parties such as local governments, agricultural cooperatives, private companies, and volunteers.

For example, 50–75 per cent of farmers have resumed at least part of their agricultural production operations in Natori, but less than 50 per cent of farmers have resumed production in Iwanuma (MAFF, 2012a). In Sendai, farming in paddy fields has resumed on the western side of the Wakabayashi Junction of the Sendai East Highway, although weeds have overrun the fields on the eastern side. The eastern area of Sendai has been divided into three parts. The first part, which is farthest from the coastline, had recovered by 2012; the second part will have recovered by 2013, and the third part, which is close to the coastline, will potentially recover by 2014 or 2015 (Sendai City Government, 2011).

Current agricultural situation in damaged areas and other agricultural recovery efforts

This section describes the current situation of agriculture in damaged areas and other agricultural recovery efforts. The Miyagi Prefecture Basic Disaster Reconstruction Policy includes basic concepts, which are also known as "Not just Restoration [but also] Restructuring." The concept is explained as follows: "While coordinating land usage, the prefectural government will make plans to improve agricultural output through agricultural land integration, large scaling of operations and transitions of crops planted. In addition, the agri-business for the 'sixth industry' will be proactively developed for the revitalization and reconstruction of competitive agricultural industry (Miyagi Prefecture official translation)" (Miyagi Prefecture Government, 2011).

The term "sixth industry" was created by MAFF. This term was derived from the concept of multiplying industrial sectors: first (primary) x second (secondary) x third (tertiary) to come up with the "sixth (senary) industry". "Sixth industry" efforts are expected to synergistically create new added value by integrating production, processing, and distribution activities (MAFF, 2012b). For example, in the "Cotton Project," some farmers have grown cotton on salted fields in the eastern area of Sendai that were damaged by the tsunami. This project was carried out in cooperation with a textile company.

Another example can be found in a plant factory, namely San-Ichi Farm, in Natori. This factory was established through the joint efforts of three farmers and one plant construction company. These farmers had previously established themselves in Sendai and cultivated paddy fields. However, their houses and paddy fields were destroyed by GEJET. Thus, they relocated their agricultural operations from Sendai to Natori and changed their farming operations from rice growing to running a plant factory.

Similar to these cases and in line with the prefecture plan, a number of private enterprises have already joined reconstruction efforts through cooperation with large-scale farmers. However, not all farmers have chosen to engage in such projects. Many medium- and small-scale farmers have not yet recovered, and have not enjoyed the benefits provided by external private companies because they are too small to execute transactions with such companies.

Figure 12 illustrates the age of regular farm workers in the damaged cities and towns of Miyagi Prefecture. As seen here, most farmers are elderly. Figure 13 shows the area of plantations in the region's cities and towns. Most of the farmers cultivate approximately less than one to three hectares of land and are, thus, considered small family farms. Figure 14 shows the distribution of farmers as engaged either full-time or part-time in planting. As seen in this figure, most are part-time farmers. Figure 15 displays the types of farms cultivated in these areas, with the majority classified as single-crop paddy farming.

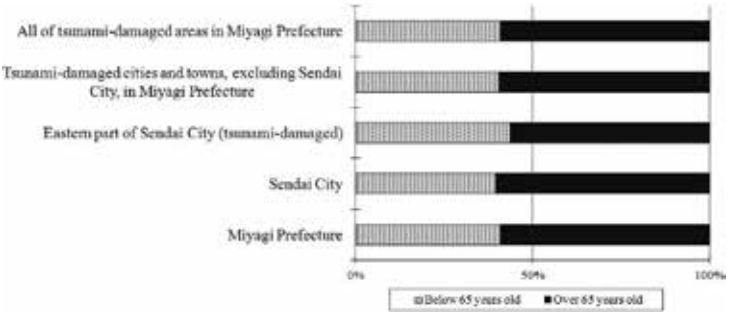

Figure 12. Regular farm workers (male).

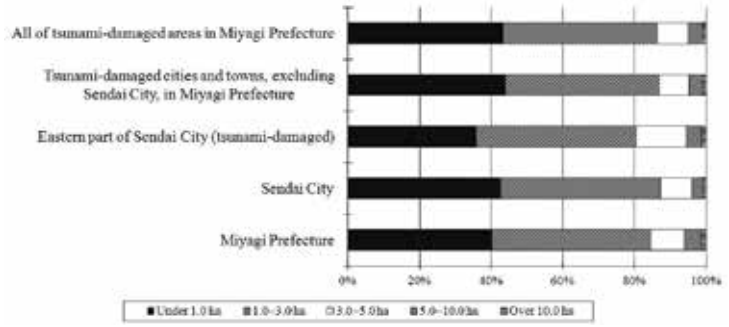

Figure 13. Classification of agricultural households by size of cultivated area.

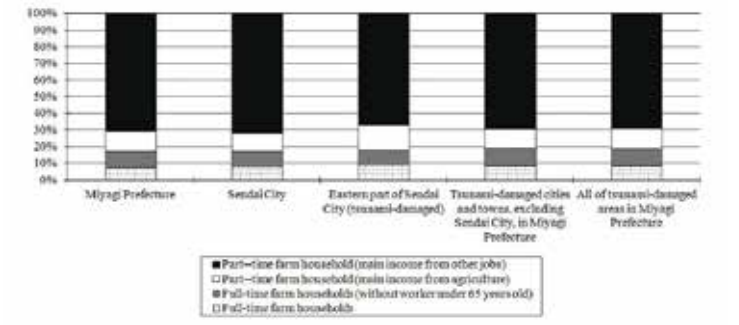

Figure 14. Classification of agricultural households by full-time and part-time farming activities.

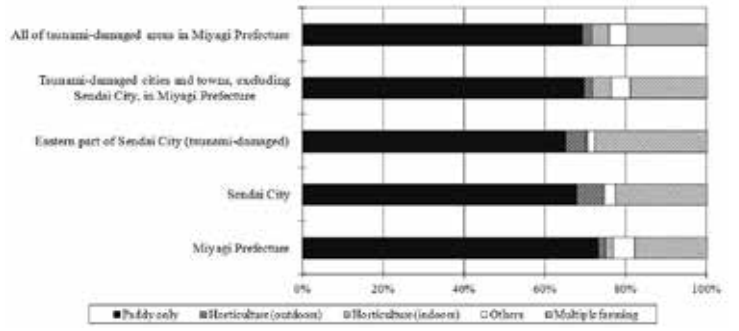

Figure 15. Classification of agricultural households by type of farming.

The characteristics of farmers in tsunami-damaged areas in Miyagi Prefecture are as follows: most are elderly, small-scale family farmers, and are primarily part-time and single-crop farmers. It is, therefore, difficult for these farmers to recover their farming operations in line with the priorities of the prefecture government.

Nevertheless, some damaged agricultural lands in the Fujitsuka Hamlet of the Wakabayashi Ward, which are close to the coastline and were extensively damaged, have recovered earlier than other regions. Why did recovery happen earlier in this area? This hamlet has been supported by Re-Roots, a non-profit organization (NPO) whose members are primarily students of Tohoku University, including undergraduate students from the Department of Resource and Environmental Economics, which is the author's department. Members of Re-Roots not only work

on the farmlands, but also sell their agricultural products at a temporary shop in the retail marketplace near Sendai Train Station (MAFF, 2012b).

Human security implications

From the point of view of human security, this paper shows that it is more important to support the recovery of family farmers and reconstruct community-based farming than to create new business-based farming. The government should, therefore, not only pursue the model of "large-scale agribusiness through the integration of farmlands," but should also closely examine the grave situation of small-scale family farmers and address their needs. For this purpose, the Japanese central and local governments should utilize NPOs in supporting recovery efforts among small-scale farmers.

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Sympathy as an Impetus in the Formation of Mutual-Aid Communities after Disasters

Shin Oyamada

Mutual-aid communities are normally built voluntarily in disaster-struck areas. Similar kinds of communities formed after the 2011 Tohoku earthquake and tsunami. In this case, calls for collaboration between *all* Japanese people such as *Ganbaro Nippon* ("carry on, Japan" or "hang in there, Japan") appeared on posters and stickers in towns throughout the country. In reality, there were frequent mismatches between victims' needs and the support provided in disaster areas. Thus, it is important to rethink the relationship between those affected and those providing support and to ask what is necessary for building effective mutual-aid communities. This paper proposes the ideal relationship between victims and supporters, and describes those suitable for creating such a relationship by using the concepts of "stranger," "care," and "sympathy." Supporters can be categorized as strangers to victims' communities. If support providers have "sympathy" for victims and treat them with "care," they can be accepted by those affected and help build effective mutual-aid communities. Through a survey questionnaire, the results suggest that, first, those who have bitter experiences tend to support victims. Second, those who have bitter experiences tend to have negative feelings towards the phrase *Ganbaro Nippon* and distinguish themselves from affected persons. Finally, those respondents who distinguish themselves from affected persons tend to select support actions that they think are needed by victims of the 2011 earthquake and tsunami.

Introduction

After the 2011 Tohoku earthquake and tsunami, the Japanese people united to overcome the difficulties faced by those affected. Many supporters went to the disaster areas as volunteers or gave donations to support relief efforts. The phrase *Ganbaro Nippon* ("carry on, Japan"), which was heard and seen all over Japan after the earthquake, captured the mutual-aid atmosphere of the time. However, some questions have been raised in regards to it. Nakajima (2011), a Japanese philosopher, criticized the phrase because it emphasized only the totality of the Japanese people and weakened concern for "irreplaceable individuals". As Nakajima says, people in the disaster areas are irreplaceable individuals, each with a different personality, different needs and a different background. If supporters do not pay attention to the diversity of those affected, aid activities may fail.

In fact, many examples of ineffective relationships exist. For example, Saijo (2012) writes that while the media reported that sufficient relief supplies from all over Japan reached the disaster areas, many victims did not receive enough of those items. Moreover, the author interviewed volunteer students at Kobe University who said they were unwelcomed by the affected population.

This paper examines the appropriate ways in which supporters may relate to affected individuals by focusing on sympathy, which encourages the formation of such relationships, in order to present a guideline for the delivery of effective reconstruction support.

Supporters as strangers

Victims in the disaster areas may see supporters as "strangers" (although many victims support other victims, this paper does not deal with those individuals because these two groups do not seem to have difficulty forming relationships). Supporters from outside of the disaster areas may share common knowledge of such localities with affected residents. Additionally, they are free to come and go from devastated zones. For these reasons, outside supporters seem alien to those receiving support and may be thought of as strangers. Simmel (1999) discusses the characteristics of strangers, who he claims act objectively and freely toward community members. Nevertheless, strangers are socially close to the residents since they now also dwell in the community. Supporters relate to the residents as strangers when they notice differences between themselves and the residents. Behaving consciously as strangers is a way to relate to community members.

This discussion is similar to those related to participatory development. Kubota (2002) argues that development workers should have sympathy for those in developing countries. Sympathy is different from pity in that sympathy is a way to understand other people by caring about them and about self–other differences. Pity, on the other hand, is an emotional understanding of other people from a self-centred standpoint. When development workers feel pity, they do not pay attention to residents, but focus on their own emotions. When they have sympathy, they are attuned to residents and are able to care about their needs, backgrounds, and so on.

The discussion from participatory development can also be applied to the reconstruction process. If supporters as strangers have sympathy towards rather than pity for those affected, they can better interact with those receiving support since they are aware of the differences between themselves and others.

Mutual-aid community

In general, if one sympathizes with other people, one concentrates on their uniqueness and effectively cares for them. However, not all people possess the ability to sympathize with others. Developmental psychologists indicate autistic children have difficulty in commiserating with other people. In addition, non-autistic individuals are also sometimes deficient in this capacity. Certain conditions promote sympathy. Those who share similarities with others have a tendency to sympathize easily with them (Davis, 1994). Thus, sympathy involves some kind of "locality". The fact that not all people possess the ability to sympathize with others (in this paper, this is called the "locality of sympathy") results in a locality of support. It is only when supporters can sympathize with victims that they can effectively relate to them. In this context, Nakajima's criticism can sufficiently be understood. Although the phrase *Ganbaro Nippon* encourages the Japanese people to carry on, it is impossible for everyone to relate to victims because of the locality of sympathy. Thus, if supporters do not sympathize with the affected populations, they can easily overlook their needs or backgrounds.

Effective relationships between supporters and victims can be built through sympathy. In this paper, this relationship is called a "mutual-aid community." A mutual-aid community is a model of the relationship between those providing support and those affected by the disaster. Mutual-aid communities are formed on the basis of numerous, familiar relationships between supporters and victims. In fact, such short-term relationships functioned effectively after the disaster in 2011. For example, through the industrial recovery process, managers of medium-sized companies inside and outside the disaster areas helped each other to resume production (Seki, 2012). Some victims may not have participated in a mutual-aid community and some supporters and victims may belong to multiple mutual-aid communities. The model can be useful for supporters in rethinking their supportive actions.

Hypotheses concerning sympathy

This section advances hypotheses in order to verify the locality of sympathy in the reconstruction process. It is, however, difficult to directly express the variables of sympathy, since victim diversity impedes a clear empathic understanding of them. This paper summarizes the analysis presented here, which indirectly tests the following hypotheses using relevant variables:

1: Those who have had bitter experiences tend to support victims.

2: Those who have had bitter experiences tend to resist the phrase Ganbaro Nippon.

3: Those who do not accept the phrase Ganbaro Nippon tend to support victims and consider their needs.

Hypothesis 1 means that having lived through bitter experiences similar to those experienced by affected individuals makes individuals more likely to sympathize resulting in altruistic actions towards victims. This is based on psychologists' insistence that sympathy makes people act altruistically (Davis, 1994).

Hypothesis 1 alone, however, cannot explain sympathy and any concern regarding self–other differences. Even if one acts altruistically, one may merely do so because of pity rather than sympathy. This paper uses resistance towards the phrase Ganbaro Nippon as an index of self–other differences. Those who have had bitter experiences will resist the phrase, which seeks a sense of Japanese unity, since they sympathize with the affected individuals and care about self–other differences (hypothesis 2).

However, resistance to the phrase may merely indicate a disregard for others and not necessarily consciousness of self–other differences. Therefore, it is necessary to confirm its validity through hypothesis 3. If one is merely indifferent to others, hypothesis 3 will not be verified since one does not pay attention to the needs of others.

Hypotheses 1 and 2 may not hold true when bitter experiences are too severe. As Hoffman (2000) explains, traumatic experiences may result in a shift of one's focus towards oneself ("egoistic drift").

Results

Survey questionnaires were administered to test the hypotheses. Respondents included attendees of a workshop on disaster reconstruction, which took place on 25 June 2011. In addition, respondents were drawn from visitors to the Tohoku Rokkonsai (Tohoku Six-Soul Festival) to assist disaster reconstruction, which took place 16–17 July 2011 in Sendai, the capital city of Miyagi Prefecture. Finally, third-year students majoring in a social action programme at Kobe University were surveyed on 26 July 2011. Table 5 provides an overview of the respondents' characteristics.

The hypotheses were tested by partial correlation analysis. First, hypothesis 1 was tested. Table 6 shows the relationship between bitter experiences and support actions controlling for gender, age and the distance between one's home and the disaster area. Some figures support hypothesis 1. However, those with deceased family members chose "working in a support action" and many selected "nothing." This indicates that their experiences were too painful for them to focus on the emotions of those affected (egoistic drift).

Hypothesis 2 was then tested. Table 7 shows the partial correlation coefficients between harsh experiences and resistance to the phrase Ganbaro Nippon. In support of hypothesis 2, those who have family members who were hospitalized were more resistant to the phrase Ganbaro Nippon, while those who were hospitalized or nearly died tended not to oppose the phrase. Bitter experiences which were not related to others may have little influence on resistance towards the phrase. In order to test this interpretation, there is a need to sort out such experiences by focusing on the "relation to others." The partial correlation coefficient between loss of a family member and resistance to the phrase is rather low, which can be interpreted as egoistic drift.

Finally, hypothesis 3 was tested. Here, it was assumed that the statement "I think the victims need money" would correspond to the statements "I made donations" and "I bought products," since the former is an economic need and the latter provides economic support. Moreover, it was assumed that the statement "I think the victims need volunteers" would correspond to the statement "I visited the disaster area as a volunteer." Using only the data from respondents who felt resistance to the phrase, Table 8 shows the relationships between the needs of victims as imagined by respondents and their corresponding support actions. The numbers in brackets show the figures for the respondents who do not feel resistance to the phrase. In general, the figures for those who feel such resistance were greater than for those who do not feel resistant. This result supports hypothesis 3.

	Number of respondents	Gender	Average age
Workshop on Reconstruction	39	male: 23 female: 16	33.7
Rokkonsai	87	male: 35 female: 52	44.9
Kobe University Students	18	male: 4 female: 14	20.4

Table 5. Overview of respondents. Source: Author's compilation:

	See victims	Volunteer	Work	Donation	Buy	Follow news	Live	Nothing
I was hospitalized	0.062	0.010	−0.076	0.092	0.262*	0.007	−0.008	−0.059
My family member was hospitalized	0.068	0.078	0.027	0.155*	0.100	0.152*	−0.042	−0.138
My family member died	0.056	0.052	−0.166*	0.137	0.089	0.108	−0.067	−0.030
I nearly died	−0.116	0.056	−0.072	0.020	−0.120	−0.081	−0.037	0.021
I lost things	0.113	0.142*	0.117	0.901	0.138	0.120	−0.078	−0.123
Nothing	−0.092	−0.068	−0.036	−0.083	−0.158*	−0.136	0.068	0.108

Table 6. Partial correlation coefficients between bitter experiences and support actions.
Source: Author's compilation.

NOTES: "" represents 10% level of significance. "Work" refers to "worked on reconstruction", "Buy" means "went sightseeing in the disaster area or bought as many products made in the disaster area as possible" and "Live" means "lived with victims as a victim."*

	I was hospitalized	My family member was hospitalized	My family member died	I was nearly dead	I lost things
Feel resistance to the phrase	0.008	0.156*	0.003	0.058	–0.005

Table 7. Partial correlation coefficients between bitter experiences and resistance to the phrase *Ganbaro Nippon*. Source: Author's compilation. NOTES: "*" represents 10% level of significance

	Donation	Buy	Volunteer
Victims need money	0.110 (0.107)	0.178 (0.166)	-
Victims need volunteers	-	-	0.259 (-0.165)

Table 8. Partial correlation coefficients between victim needs (as imagined) and support actions. Source: Author's compilation.

Conclusions

This paper focuses on sympathy in the formation of relationships between victims and supporters. When supporters care for the victims through sympathy, they have a conscious awareness of self–other differences. Sympathy will reduce ineffective relationships between those providing support and those affected. As discussed in section three of this paper, not all individuals possess the ability to sympathize with others. The knowledge of this locality of sympathy can encourage supporters to rethink their support actions. This is particularly important when the environment of mutual aid spreads over a rather wide area. If an individual cannot sympathize with affected individuals, one can indirectly provide support by giving donations or supporting others who provide direct support. Three hypotheses about sympathy were tested in order to verify the locality of sympathy. These hypotheses were tested using a survey questionnaire, with results that tended to support these hypotheses. Hypothesis 3 was most strongly supported, since there was no contradiction with the hypothesis. As for hypotheses 1 and 2, bitter experiences need to be sorted out by specifically focusing on the "relationships to others," e.g., bitter experiences concerning family members, friends, pets and so on. A larger sample of volunteers would be useful in future analyses since many of the volunteers in this study were Kobe University students. An experimental study of the dynamic process of mutual aid is necessary because a survey questionnaire cannot fully capture the relationship between strangers and victims. Such a study would provide supporters with useful tips for relating to victims during the reconstruction process.

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A Study of the Perceptions of Ecosystems and Ecosystem-Based Services Relating to Disaster Risk Reduction in the Context of the Great East Japan Earthquake and Tsunami

Philipp Koch

The following chapter is the result of joint research conducted by the United Nations University Institute for Environment and Human Security (UNU-EHS), Tohoku University and the International Union for Conservation of Nature (IUCN) in the coastal area south of Sendai. Based on the concept of ecosystem-based disaster risk reduction, a hypothesis was formulated by the researchers that "the role of ecosystems and ecosystem services was taken into account (by the affected people) during the reconstruction efforts following the March 2011 Tohoku chain of disasters" (Renaud and Murti, 2013). The hypothesis was formulated intentionally to highlight an optimistic perspective on the recovery process in the research area presented below. One aspect of the research conducted was to document the perceptions of people affected by the tsunami with regard to ecosystem-based disaster risk reduction. The methods applied, research area and results are presented in this chapter.

Methods

Perception is difficult to quantify, especially if only limited information about the interviewees and their backgrounds are available. Therefore, a qualitative approach was chosen that proved to be flexible but still delivered comparable results. To overcome the usual discomfort of an interview situation, especially with the topic at hand, a mixture of group interviews, group discussions and focus groups served to improve openness amongst interviewees. The major difference between the first two interview techniques is whether they focus on the information provided by the group (as in group interviews) or on the dynamics and interactions within the group (group discussions). Focus groups are usually used in market research, and groups ought to be heterogeneous to strengthen the discussion about a certain topic. In the case of field research, the groups were more homogeneous but "focused" on the topic of the March 2011 events. The term "focus group discussion" was used as an accepted term by the interviewees.

Questionnaire

A questionnaire was developed to address three topics. First, the interviewees were asked to describe landscape changes as well as changes to local ecosystems in recent decades before the March 2011 earthquake and tsunami. Secondly, questions about the role of ecosystems during the event were presented to the focus group. Finally, the recovery process and options to participate in it were included in the questionnaire. The questionnaires consisted of six to eight questions depending upon the situation. Additional questions were utilized as "warm up" questions at the beginning of most interviews to provide the context. In total, 12 interviews were conducted of which half were open-ended narrative interviews to gather background information and half were based on the questionnaire.

Locations

The research sites (Yuriage and Tamaura) were located south of Sendai in the neighbouring cities of Natori and Iwanuma (Figure 16a). These areas share the same landscape of a flat coast with sandy beaches, settlements and rice paddies. Yuriage (part of Natori) is located close to the sea at the mouth of Natori River, while Tamaura (part of Iwanuma) is located further inland. Figure 16b shows the inundation caused by the March 2011 tsunami in the research area. In Iwanuma, only smaller "hamlets" were located close to the sea and the damage to settlements was, therefore, less severe than in Yuriage.

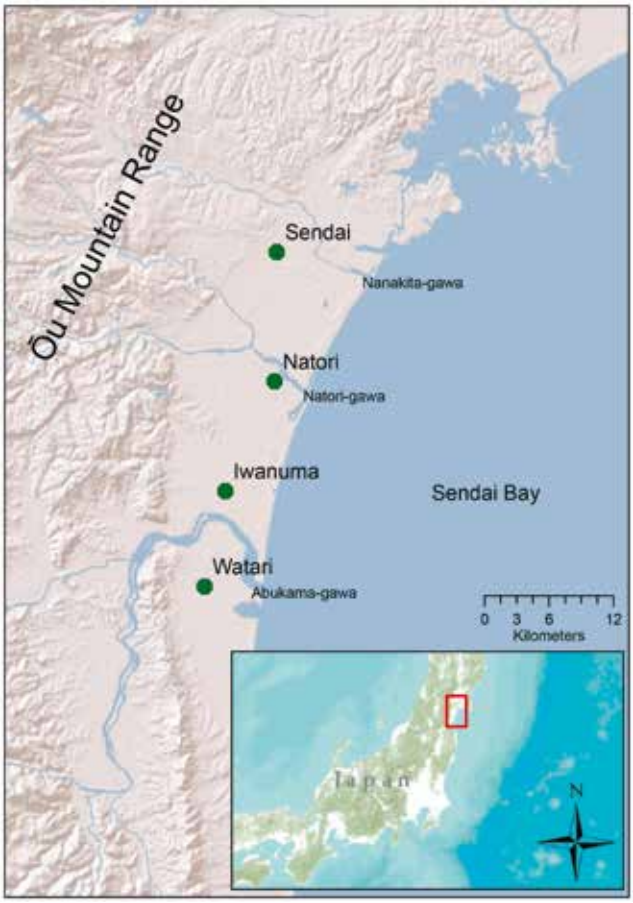

Figure 16a. Sendai Bay and Sendai Plain (the area also shows the majority of Miyagi Prefecture). (Source: Author's own).

Figure 16b. Inundated area during the Great East Japan Earthquake and Tsunami in the area of Yuriage (Natori) and Tamaura (Iwanuma). (Source: Author's own, inundation based on data from Haraguchi and Iwamatsu, 2011).

Results

The following section provides an overview of the findings from the research questions.

The first question aimed to understand the general perception of landscape changes over the last few decades. Starting with this, younger people had a detailed view about recent changes such as the rail link to the airport and new streets. In contrast to this, older interviewees tended to have a more general impression of changes. While all interviewees recognized changes in infrastructure and aspects

of daily life, only the older interviewees realized that there was a decrease in the number of rice paddies in opposition to an increased number of settled areas. Following this, interviewees were asked to describe ecosystems that could be found in the surrounding area. In all groups, rice paddies were reported as being part of daily life in the research area. The coastal protection (a forest of pine trees that forms a green belt along the coast) was also well recognized, while rivers or the sea were mentioned less often. Interestingly, the term "ecosystem" caused some confusion and the explanation "elements of nature" or other similar descriptions had to be used. Teizan Canal, built in the sixteenth century as a transport route, and Igune were understood as ecosystems. The word Igune in the Sendai dialect describes an isolated group of houses surrounded by a small forest within an area of rice paddies similar to a homestead woodland (Sendai, 2013).

To summarize the first set of questions, the focus shifted from ecosystems to their services, especially with regards to disaster risk reduction. First of all, the interviewees identified food (rice, fish and mushrooms) as a major provision of the ecosystem supplied by rice paddies, rivers, the sea and forests. Additionally, rice paddies serve as playgrounds for children. A third aspect was the recreational function of the surrounding ecosystems such as the forest, beach and Teizan Canal. An interesting finding was that disaster risk reduction as an ecosystem service was well recognized, especially by younger people and those actively involved in the recovery process.

The forest in the coastal area was planted at the same time as the construction of the Teizan Canal with the intention of protecting villages near the coast from high winds and to reduce the amount of sand being blown in from the beach. The forest on the mountain slopes performed a disaster risk reduction–related service by providing protection from erosion. Energy generated by dams along the rivers was also perceived (by the interviewees) as an ecosystem service. One interviewee (without referring to a specific ecosystem) also mentioned that climate regulation was provided by ecosystems. Although not necessarily an ecosystem by definition, islands were perceived as an important service since they can prevent or reduce the impact of a tsunami. This perception was derived from the experiences at Matsushima Bay (northeast of Sendai), where several small islands successfully reduced inundation along the coast by serving as barriers or wave breakers. Several disaster risk reduction services were identified and attributed to Igune. Interviewees identified the surrounding forest as not only providing protection from wind and snow, but as also providing them with firewood, food and building materials.

Moving from the topic of the general perception of ecosystems and their services to the events of March 2011 and the role of ecosystems, a very different image emerged. Most interviewees perceived the coastal protection forest to have played a role in the havoc that presided over the area that day. When the tsunami reached the coast, it uprooted pine trees and transported them inland causing many buildings to be destroyed in contrast to cases where no trees were present. Since the pine trees were perceived to be rather dangerous in a tsunami, people

wished for a plantation of bamboo, while they knew that this was not possible along the coast. This case is very subjective, since devastating destruction also occurred where no forest was involved (as happened in Yuriage). It was also reported that in some places the forest actually reduced the tsunami´s strength, thereby reducing the damage caused.

The Teizan Canal was often mentioned and interviewees commented that it did not have any influence in altering the tsunami´s power. Rice paddies, on the other hand, were perceived as a passive element of protection. By adding space between the coast and settlements, rice paddies served as "open spaces" or buffer zones providing additional time to evacuate as well as reducing the strength of the tsunami. The only ecosystems that were perceived as clearly positive were the islands in Matsushima Bay.

It should be noted that an interview was held where all of the participants were only indirectly affected by the tsunami (no loss of property, etc.). During this particular interview, the perceptions of ecosystems with regard to disaster risk reduction were in general very positive, although they had knowledge about the impact of uprooted trees. One person even described a case in Ishinomaki (to the northeast to Sendai) where trees had reduced the impact of the tsunami. This group also suggested that the now mostly destroyed coastal forest should not only be replanted but also expanded, while settlements and other infrastructure should be moved further inland.

The final set of questions sought to understand the perceptions around the recovery process and options to participate among affected people. In general, all interviewees were informed about the recovery and reconstruction processes. Most participants knew about the actions and construction plans for a 7.2 m high seawall from Fukushima Prefecture up to the northern border of Miyagi Prefecture.

In the following section, the recovery process in Yuriage (Natori) and Tamaura (the relocation area in Iwanuma) are described separately. Relocation will take place in both areas using different approaches.

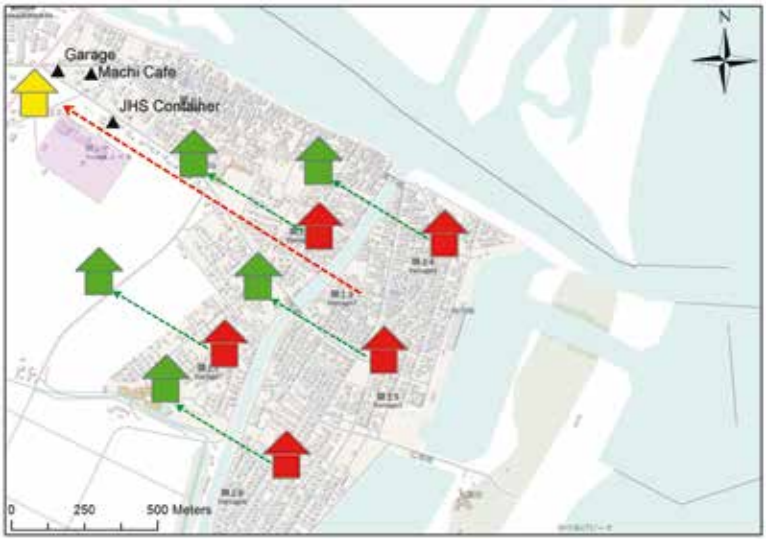

Figure 17. Relocation in Yuriage according to IG 6. Red houses indicate former residencies while green houses are new. The interviewees explained that moving from the east bank of the Teizan Canal (depicted by the red arrow) to the northwest bank is not possible due to the current reconstruction plan.
(Source: Author's own).

Figure 17 shows a map of Yuriage before the tsunami occurred, located directly on the coast with a small harbour. The tsunami destroyed the majority of buildings on the strip of land between the Teizan Canal and the sea. The house owners will have to move to parallel locations further inland (represented in Figure 17 by the shift from the red to green houses). If an affected person wants to move further inland, s/he will not receive any financial support from the government (Figure 17 red arrow). In addition to being shifted away from the sea, plans include raising the entire settlement area (by approximately 3.9 to 4.9 m) and the construction of a higher seawall (Figure 18). The interviewees also mentioned the possibility of plans to turn the area between the sea and the Teizan Canal into an area for industrial use.

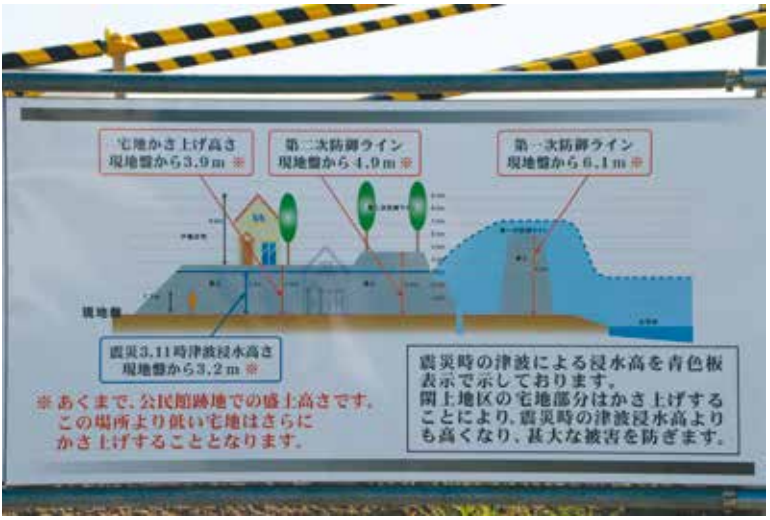

Figure 18. Official reconstruction plan in the Yuriage area. Explanations start clockwise from the top left: Heights for elevated estate area (3.9 m), height of the second protection line (4.9 m), height of the first protection line (6.1 m), "the elevated area is higher than the inundation depth, and extensive damage will be prevented (lower right text box)", inundation depth of the March 2011 tsunami (3.2 m).
(Source: Author's own, photo taken at Yuriage reconstruction site).

Reconstruction plans in Iwanuma

Similarly, the majority of people in Iwanuma decided to relocate to a new settlement. A professor of urban planning at Tokyo University originally from Iwanuma was actively engaged in this process and encouraged everyone to participate to make relocation an important issue for the local people. The decision to relocate to a new area of Iwanuma (namely, Tamaura) was taken by the inhabitants of all six hamlets. To keep communal ties intact, the six communities were to be grouped together representing the original communities within the new joined area (see Figure 19). Figure 19 also shows that, although the pine trees were perceived as dangerous in the case of a tsunami, the interviewees still perceived them as beneficial and included them in the reconstruction plan along with a small river and pond. The interviewees explained that a major downside of group relocation was that it was an all-or-nothing decision, since people who decided not to follow this plan might not receive any financial support from official sources.

Plans were also made to replant and widen the almost completely destroyed coastal forest to enhance its protective function and to serve as a buffer zone. In addition, plans included the construction of the "Millennium Hope Hills", an idea derived from the case at Matsushima Bay where the hills would serve as an evacuation area and "islands" to block and redirect the wave energy of the tsunami.

This was the situation as of the summer of 2012. Recently, plans have been changed from the Igune-like concept towards a densely settled area. This new plan differs drastically from the participatory plans (see Figure 20).

Figure 19. Model of reconstruction in the Community Room in the temporary housing area of Iwanuma showing six small settlements in one relocation area. (Source: Author's own).

Conclusions

Ecosystems and their role in disaster risk reduction were well recognized by interviewees, while the coastal protection forest played an especially ambiguous role in the tsunami. The construction of the "Millennium Hope Hills", replantation of the coastal protection forest and ideas regarding the use of rice paddies as buffers zones demonstrate the advantages of "ecosystems" and their services verifying the initial research hypothesis. However, the interviewees also recognized that there are limits when it comes to a certain scale of disasters. The use of ecosystem-based approaches presents a solid opportunity for sustainable development and should be included in any long-term plans for disaster risk reduction.

Figure 20. The development plans for reconstruction in Tamaura as of 2 November 2012. (Source: Iwanuma, 2012b).

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Japanese Literature Survey of Ecosystem Services in Disaster Risk Reduction

Koichi Ogata and Dinil Pushpalal

After the Great East Japan Earthquake, many researchers have attempted to conduct surveys on the condition of coastal forests at different locations. In this paper, a literature review was conducted to better understand the services provided by ecosystems such as coastal forests and Igune against the tsunami. Based on this literature review, the authors concluded that in some areas coastal forests restricted debris flow and reduced the impact of the tsunami, thus reducing the damage to inland homes. In particular, Igune situated on the eastern side of houses protected nearby homes by reducing the impact of the tsunami and restraining debris. The authors recommend that trees should also be planted on the eastern side of houses as a measure against future tsunami. However, many Igune were composed of Japanese cedar and had to be cut down due to damage from salt water. The authors found that, unlike Japanese cedar, bamboo is a salt-tolerant species and is a more suitable species for homestead groves.

Introduction

Coastal forests are critical ecosystems providing a habitat for wildlife species, controlling erosion, buffering high tides and winds and offering resources that support the livelihoods of the local population. These forests, usually composed of pine trees, also offer many advantages over other disaster prevention strategies. After a major tsunami struck the Pacific Ocean on 11 March 2011, many researchers have attempted to conduct surveys on the condition of coastal forests in different locations. In this paper, a literature review was conducted to better understand the services provided by ecosystems such as coastal forests and *Igune* (a homestead grove) against the tsunami. *Igune* is also related to the lives of people where trees are typically planted to protect houses from strong northwest winds (Figure 21). Inhabitants can cut *Igune* to use as materials for their houses and to clear space to grow vegetables among other activities. The width of *Igune* is narrower than the width of coastal forests due to the limited size of the site near houses and due to the management expenses for maintaining Igune.

Role of coastal forests

Evidence shows that coastal forests limited the damage caused by the tsunami. For example, in Ichikawa in the city of Hachinohe, Aomori Prefecture, coastal forests kept 22 ships and boats from being washed inland by the tsunami, thereby protecting the houses constructed behind the forest (Figures 22 and 23). In addition, coastal forests in Nagahama in the city of Ishinomaki, Miyagi Prefecture, protected nearby houses from being washed away (Sato et al., 2012). In the same city, 75 and 50 per cent of houses, which were within 200 and 300 m, respectively, of the seawall located along coastal areas were washed away. However, only 25 per cent of the houses that were within 300 m of the seawall and which were buffered by coastal forest were washed away. In general, damage was considerably less in areas protected by a broad swath of coastal forest compared to those that were not (Sato et al., 2012).

Figure 21. An example of an *Igune* surrounding a homestead in Japan in July, 2011. (Source: UNU-EHS, Working Paper, 2013)

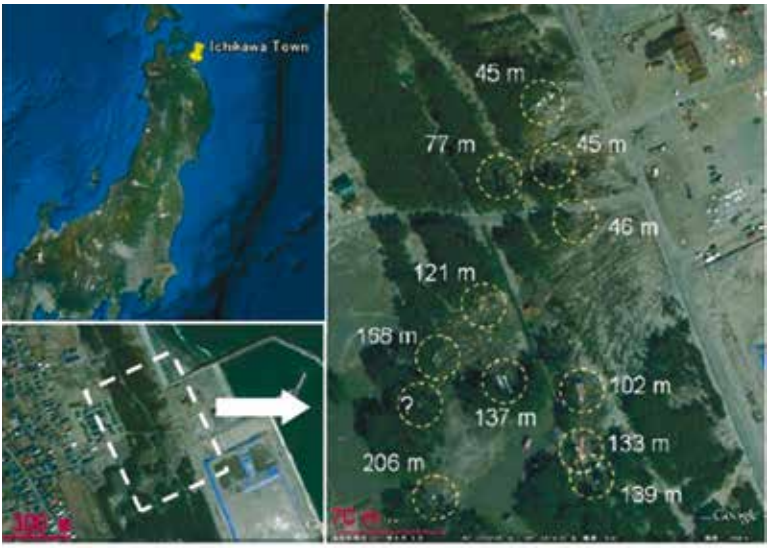

Figure 22. Position of Ichikawa with the locations of ships and boats washed ashore following the tsunami on April 5, 2011. (Source: Sakamoto, 2011; Google Earth).

Figure 23. An example of a ship stopped by a coastal forest following the tsunami. (Source: Sakamoto, 2011).

Damage situation of uprooted trees

Uprooted trees also caused large amounts of damage during the tsunami because they were washed inland where they destroyed houses and buildings (Figure 24). Tamura et al. (2012) studied tree uprooting and damage in pine groves in the Sendai Plain following the tsunami. They found that trees with minimal or no damage tended to have larger trunk diameters (>20 cm) and crown heights that were taller than the inundation height (Figure 25). Conversely, damaged trees had trunk diameters that were less than 20 cm and crown heights that were below the inundation level. Thus, a thick trunk diameter and tall crown height allowed trees to withstand the force of the tsunami (Figure 26).

In addition, Tamura et al. (2012) found that some uprooted trees had the same characteristics as undamaged trees (i.e., trunk diameter >20 cm and crown height above inundation level). However, uprooted trees tended to be found at low altitudes (~1 m above sea level) in marshes and lagoons with higher water tables. These trees had average root lengths of 0.8 and 0.9 m in the Sendai Plain and on Iwanuma Beach, respectively. Thus, it is believed that a tree's ability to withstand the force of the tsunami is related to its root length and the water table height of a given area. In Sendai Plain, where the water table is higher, many trees were over 100 years old and were, on average, approximately 17 m tall. In contrast, trees are typically over 25 m tall in the town of Fudai, Iwate Prefecture, where the water table is lower. It may have been difficult for the pine trees in the Sendai Plain to

Figure 24 (a)

Figure 24 (b)

Figure 24. An example of (a) a broken tree and (b) an uprooted tree as a result of the tsunami.
(Source: Ono, 2011)

grow taller and withstand the force of the tsunami because of the shorter root lengths caused by the higher water table. Likewise, many trees along the Teizan Canal survived intact where the bank is about 3 m. The higher height of this bank may have allowed trees to grow above the water table and to establish a larger, more durable root structure.

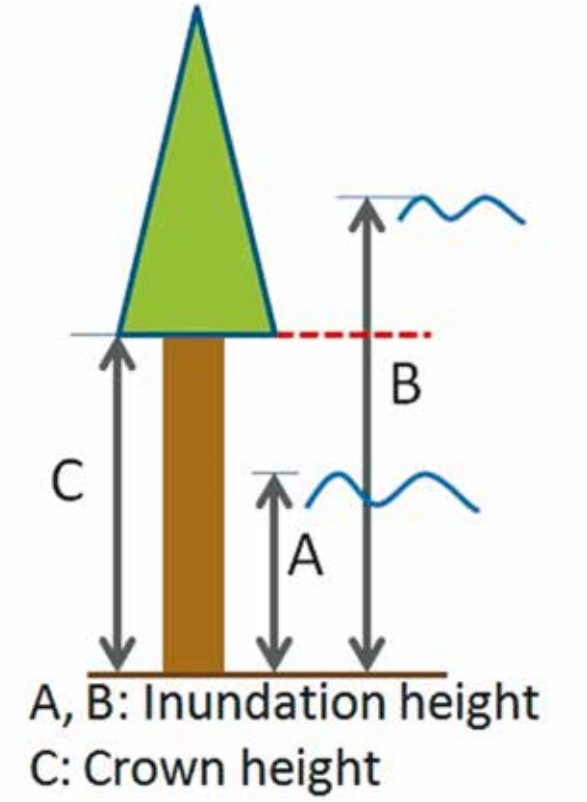

Figure 25. Inundation height and crown height. (Source: Authors' own)

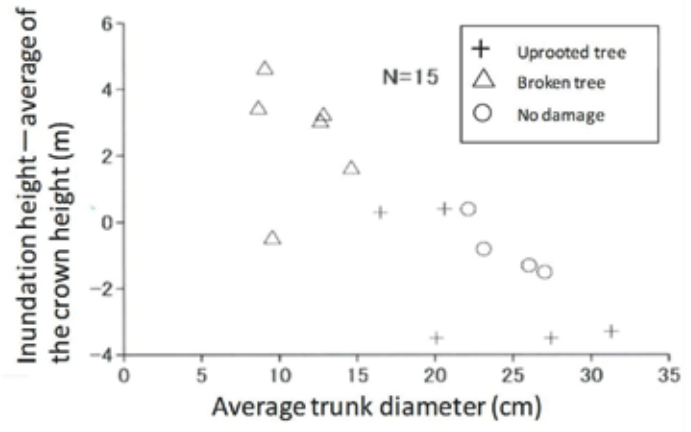

Figure 26. Relationship between the difference in inundation height and average tree crown height and the average trunk diameter for trees that were broken (triangles), uprooted (plus sign) or not damaged (circles) by the tsunami. (Source: Tamura et al., 2012)

Role of Igune

Koganezawa et al. (2012) conducted fieldwork and interviews to understand the function and damage to *Igune* in the Sendai Plain following the tsunami. They determined that *Igune* protected nearby houses by reducing the impact of the tsunami as well as the impact from uprooted trees and debris. Houses surrounded by east-side *Igune* tended to have less damage compared to houses without them (Figure 27). Most *Igune* were composed of Japanese cedar and were cut down after the tsunami because of salt damage since Japanese cedar is not salt-tolerant.

Ujiie et al. (2013) also conducted interviews in 53 households with *Igune* to investigate the function of these groves against the tsunami. Of the households surveyed, 64.2 per cent believed that the Igune protected their homes from the tsunami. Among these, three primary theories were put forth. First, they believed that the Igune protected their homes from debris, uprooted trees and cars washed out by the tsunami. Second, *Igune* situated on the eastern side of their houses decreased the impact of the tsunami so that their homes could not be washed out. Third, *Igune* located on the western side of their houses protected their belongings inside the homes and also protected the soil in the area from being washed out by the tsunami. A further 18.9 per cent indicated that the *Igune* did not protect their homes from the tsunami, and mentioned that there was no *Igune* situated to the east of the house and, thus, it did not serve any protective function against the tsunami. Finally, 7.5 per cent indicated that the *Igune* unfortunately increased the damage done to their homes by the tsunami. This group indicated that, since a lot of debris was caught in the *Igune*, debris remained around their houses and getting rid of it was more difficult

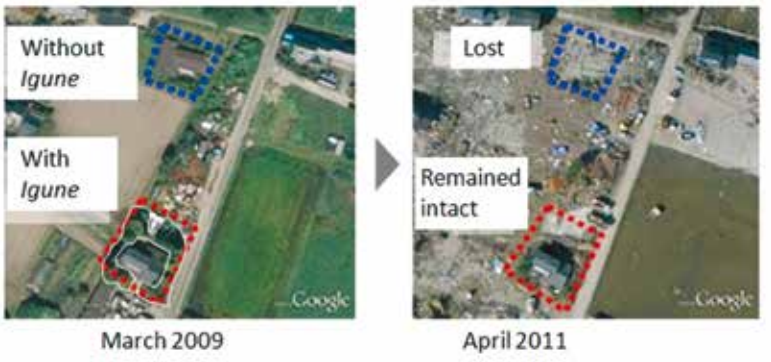

Figure 27. An example of a home that was not surrounded by an Igune and was later washed away by the tsunami (blue dashes) situated next to a home that was surrounded by *Igune* and was not damaged by the tsunami (red dashes). The white line shows the shape of the *Igune*. (Source: Ministry of Land, Infrastructure, Transport and Tourism, Japan, 2012)

Conclusions

Based on this literature review, the following conclusions and recommendations were made:

(1) In some areas, coastal forests restricted the debris flow and reduced the impact of the tsunami, thus reducing the damage to inland homes.

(2) *Igune*, especially on the eastern side of houses, protected nearby homes by reducing the impact of the tsunami and restraining debris. However, many *Igune* were composed of Japanese cedar and had to be cut down due to damage from salt water.

(3) Uprooted trees also caused a large amount of damage during the tsunami. Those uprooted trees tended to have shorter root lengths (~0.8 m), were found at lower altitudes (<1 m) and in places with higher water tables.

(4) Because the depth of pine tree roots tended to be shorter at lower altitudes with higher groundwater tables, inhabitants should mound earth around pine trees in coastal areas to reinforce the roots and, ultimately, the growth of the trees. This will increase the ability of these coastal forests to buffer the impact of natural disasters.

(5) As an important cultural asset of the Sendai Plain, Igune also acted as a buffer that protected homes from the tsunami and associated debris. Thus, trees should continue to be planted on the northwest side of homes, as is the customary practice, and on the eastern side as a measure against future tsunami. The authors understood that, unlike Japanese cedar, bamboo is a salt-tolerant species and is a more suitable species for homestead groves.

(6) The lifespan of concrete is usually about 50 years in comparison to the average 100-year lifespan of coastal forests and Igune. In addition, concrete structures (e.g., seawalls) did not provide protection from the tsunami as expected. Thus, it is important that ecosystems such as coastal forests and Igune are preserved, particularly as a measure to reduce damage from natural disasters.

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Distribution of Artificial Radionuclides in Animals Left in the Evacuation Zone of the Fukushima Daiichi Nuclear Power Plant

Manabu Fukumoto and the Group for Dose Evaluation in Animals from the Affected Area of the Fukushima Nuclear Plant Accident

As a consequence of the Great East Japan Earthquake, accidental explosions at the Fukushima Daiichi Nuclear Power Plant (FDNPP) released a large quantity of radioactive material into the environment. The effects of radiation, particularly of radioactive substances, to the human body have become a major concern for people worldwide. Cattle abandoned in the evacuation area and euthanized due to the FDNPP accident are extremely valuable for the analysis of environmental pollution, biodistribution, metabolism of radionuclides, dose evaluation and the influence of internal exposure. The results obtained from activities related to the abandoned cattle due to the FDNPP accident are summarized here.

Introduction

From the epidemiological survey of atomic-bomb victims in Hiroshima and Nagasaki, it is evident that acute exposure to a high dose of external radiation results in death in humans. Carcinogenic risk increased even in people who avoided death from acute exposure. However, the health effects of radiation exposure at less than 0.1 Gy are not clear. Cancer is one of the delayed effects of radiation, which appears after a long-term latency period without any symptoms, making it unclear whether or not cancer is a result of radiation exposure. The International Commission on Radiological Protection (ICRP) assumes that the carcinogenic risk caused by radiation is in proportion to the dose without a threshold dose — that is, the linear no-threshold (LNT) or stochastic model. The Japanese government adopted this LNT model for regulating radiation exposure with the aim of protecting the general public. Internal radiation exposure is caused by the integration of radioactive materials into the body through ingestion, inhalation or absorption through the skin. A succession of accidental explosions in the generator units at the Fukushima Daiichi Nuclear Power Plant (FDNPP) resulted in a large quantity of radioactive material being released into the environment. The effects of radiation, particularly of radioactive substances, on the human body have become a major concern for people worldwide.

The radioactive concentration of incorporated radionuclides decreases through both physical decay and biological excretion. Total radioactivity in the body decreases at a rate according to the effective half-life, which is a combination of the physical half-life and the biological half-life. However, radionuclides concentrate in specific target organs according to their chemical properties and via the food chain. Therefore, long half-life radionuclides emitting heavy particles are a major concern, since the target organs are exposed to low-dose radiation continuously. For example, since iodine is one of the main components of the thyroid hormone, radioactive iodine accumulates in the thyroid gland. Radioactive iodine 131 (I-131) has been attributed to an increase in the incidence of thyroid cancer after the Chernobyl disaster. However, the physical half-life of I-131, which is eight days, was too short to accurately estimate the dose just a short time after the accident. It has

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7 Yasushi Kino, Emiko Isogai, Tsutomu Sekine, Tomokazu Fukuda, Yoshikazu Kuwahara, Masatoshi Suzuki, Tsutomu Shimura, Yusuke Urushihara, Motoi Fukumoto, Kazuya Inoue, Shintaro Takahashi, Gohei Hayashi, Hisashi Shinoda, Mirei Chiba, Yoshinaka Shimizu, Toshihiko Suzuki, Atsushi Takahashi, Yasuyuki Abe, Hideaki Yamashiro, Jin Kobayashi, Motoko Morimoto, Shin Saigusa and Yuichi Obata.

been said that both natural radiation and natural radioactive substances have been in existence since before humankind. Artificial radionuclides such as radiocaesium that do not exist in the natural world have been released as a result of the FDNPP accident. Fears about the nuclear plant accident have increased given the fact that radiation is not detectable by our senses alone. The effects of internal radiation on the human body are difficult to evaluate scientifically; but, this evaluation is necessary for our protection.

The biological effects of radiation vary according to the quality, energy, dose and the dose rate of radiation and the organs exposed. Therefore, sievert (Sv) is defined as the unit that represents the stochastic biological effects of ionizing radiation integrally. Radioactivity, becquerel (Bq), is defined as the activity of a quantity of radionuclides in which one nucleus decays per second. When the effect of radioactivity is being discussed, Bq becomes Sv without our knowledge. Furthermore, the standard value of radioactivity concentration (Bq/kg of radioactivity) which is used for regulation is calculated using Sv through a scientific principle, but is not a purely measurable scientific value. Since the adverse effects of radiation on the human body are known, radiation and radionuclides must be strictly controlled, which makes animal experiments using radioactive materials quite difficult. The gap between our understanding of the biological effects of radiation in humans and the determination of regulatory values is too wide. It is not an exaggeration to say that, without nuclear accidents or the analysis of radiation therapy, there is no way to quantify the effect of radiation in humans. Therefore, those cattle abandoned in the evacuation area and euthanized due to the FDNPP accident are extremely valuable for the analysis of environmental pollution, biodistribution, metabolism of radionuclides, dose evaluation and the influence of internal exposure.

What is known from the measurement of internal radioactivity in cows found in the evacuation zone (1)

As a consequence of the FDNPP accident, huge amounts of nuclear fission products were released into the environment including tellurium-129m (^{129m}Te), iodine-131 (^{131}I), caesium-134 (^{134}Cs) and caesium-137 (^{137}Cs). Airborne surveillance of radioactivity 1 m above the ground was performed by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan and the Department of Energy in the United States within a radius of 80 km from FDNPP. However, these data do not reflect the amount of radionuclides ingested by animals. Therefore, this study sought to identify the radionuclides and measure their radioactivity concentrations in the organs of euthanized animals from the evacuation area. A total of 79 cattle, including three foetuses from pregnant cattle and three mother-infant pairs, were obtained between 29 August and 15 November 2011. Fifty-two of the cattle were from a village southwest of FDNPP and 23 were from a city north of FDNPP. Both locations were within a radius of 10 and 20 km from FDNPP.

In all of the specimens examined, deposition of ^{134}Cs (half-life: 2.065 y) and ^{137}Cs (30.07 y) was observed. Furthermore, organ-specific deposition of radionuclides with relatively short half-lives was detected, such as silver-110m (^{110m}Ag, 249.8 d) in the liver and ^{129m}Te (33.6 d) in the kidneys. Regression analysis showed a linear correlation between the radiocaesium concentration in peripheral blood (PB)

and the concentration in each organ. The resulting slopes were organ-dependent, with the maximum value of 21.3 obtained for skeletal muscles. Thus, the activity concentration of ^{134}Cs and ^{137}Cs in an organ can be estimated from that in PB. The levels of radiocaesium in the organs of foetuses and infants were 1.19-fold and 1.51-fold higher than that of the corresponding maternal organs, respectively. Furthermore, the radiocaesium concentration in organs was found to be dependent on the feeding conditions and the geographic location of the cattle.

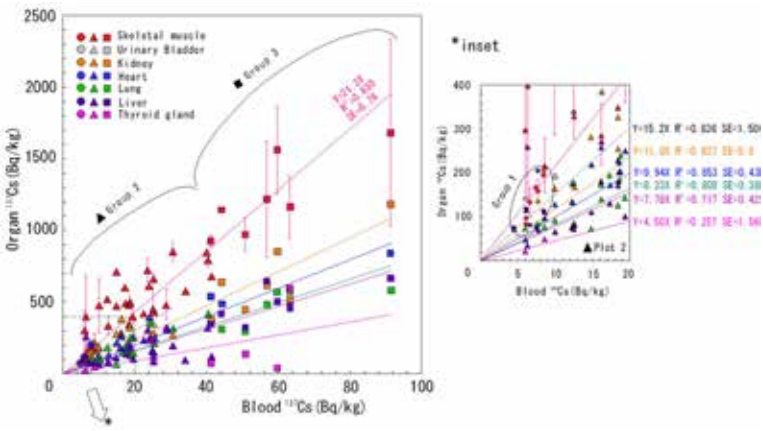

Figure 28. Cattle were divided into three groups in accordance with the place in which they were caught. Groups 1 and 3 were in the city of Minamisoma and Group 2 was in the village of Kawauchi, located north and southwest of FDNPP, respectively. Cattle in Group 1 were kept in a stall barn after the FDNPP accident, they were fed with radionuclide-free pasture grass and supplied with radiation-contaminated rainwater until euthanized. Cattle in Groups 2 and 3 were unleashed and were allowed to graze freely on contaminated grass after the accident. The profile of radiocaesium activity concentration could be divided into three groups in accordance with the locations where the cattle were caught.

Because infants are more susceptible to radiation than adults, more research about the effects of radiocaesium on infants is needed. After the Chernobyl accident, endocrine organs, especially the thyroid gland, were reported to have accumulated radiocaesium; however, in this study, the radiocaesium concentration in the thyroid gland was lower than what was found in the other organs. Therefore, the influence of radiocaesium on the thyroid could be smaller than previously assumed. Radioactive ^{110m}Ag is not a fission product, but is formed by the neutron capture of stable. This was detected in all of the liver samples and in 8 per cent of PB samples. There was no relationship between the activity concentration of ^{110m}Ag in PB and in the liver. According to the dose map by MEXT, the radioactivity concentration of ^{110m}Ag in the soil as of 14 June was lower than 1/100 of radiocaesium and lower than 0.5 per cent of the results from our soil data. These data indicate that the liver

is the primary target organ that accumulates silver. Interestingly, ^{129m}Te, which has a short half-life, was detected in 62 per cent of the cattle examined. The deposition of ^{129m}Te in the kidneys suggests that radioactive ^{132}Te also accumulated in the kidneys shortly after the FDNPP accident. The half-life of ^{132}Te is 3.2 days, and its decay product is radioactive ^{132}I, which is thyroid-tropic. These results suggest that the monitoring of ^{132}Te as well as ^{131}I warrants more attention in terms of assessing the health risks to the thyroid. This study was also expanded to the measurement of radioactivity in animals other than cattle. Overall, the radiocaesium concentration in each organ was higher in swine than in cattle, but its transfer to organs from PB was higher in cattle than in swine. These data indicate that the biodistribution of radioactive substances is species-specific and that further study is necessary to assess the effect of radionuclides in humans.

This study is the first to reveal the details of the systemic distribution of radionuclides in cattle attributed to the FDNPP accident.

Future aspects

Thus far, attempts have been made to collect tissue samples from animals in the evacuation zone in order to construct a tissue bank that represents a variety of species. As of 21 June 2013, samples from 238 cattle, 57 swine, 29 Japanese macaque, seven wild pigs and three horses have been collected. The future prospects of this study include dose evaluation using the materials collected, calculation of the effective half-life of radioactivity in nature and in organs using the temporal measurement of radioactivity concentrations in the environment and in organs and an analysis of the acute effects by histological examination. The ultimate goal is to accomplish research that will contribute to radioprotection. Importantly, the amount of radioactivity concentration does not reflect biological effects, but is the first clue for understanding the biological effects of radiation. This study also revealed that the problem is not only radioactive caesium but also other radionuclides. Therefore, efforts need to be made to carefully solve problems one at a time to progress towards the ultimate goal. A major concern is how the archive constructed as a part of this study will be treated. Accordingly, it is necessary to demonstrate the usefulness of the archive in order to make it valuable for the next generation.

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Tears of Namie: An Appraisal of Human Security in the Township of Namie

Dinil Pushpalal, Zhang Yan, Tran Thi Diem Thi, Yuri Scherbak and Michiko Kohama

"Tears of Namie", the title of this article, is a direct translation from the original Japanese Namie no Namida (浪江の涙). Although they have different meanings, the sound "nami" in the town's name has a homophonic relationship with *nami*, the Japanese word for tears (*namida*). The three Japanese characters of *Namie* and *namida* bear *sanzui-hen*, which represents the element of water. Named Namie, was the town destined to be destroyed by water or to burst into tears? Namie is one of the tiny Pacific Ocean littoral municipalities in the Hama-dori region of Fukushima Prefecture, the third largest prefecture in Japan. Until 11 March 2011, Namie was a peaceful and nature-rich home to 20,888 inhabitants. This article analyses the aftermath of the nuclear disaster and discusses it from a human security point of view. The authors conducted interviews with members of the affected population, stakeholders and local politicians. Information obtained from those interviews, local and national newspapers, online databases, published reports and statistics are utilized in the discussion here. The article concludes with a summary of the human security issues that have been addressed thus far.

Namie's misfortune

In 1898, Namie reached a historical milestone with the establishment of a Nippon Railway municipal station. In 1955, the population of Namie totalled 28,800; despite this, the town wanted to find a solution for its depopulation and financial difficulties. When Fukushima Prefecture invited nuclear power plants to be established in their territory in 1960, Namie was included as a candidate. However, the Fukushima Daiichi Nuclear Power Plant (FDNPP) was constructed in the nearby towns of Futaba and Okuma. FDNPP also contributed to the diffusion of the society and economy in Namie by slowing population decline. Many FDNPP employees lived in Namie and, thus, contributed positively to its economy. The population of the town of Namie stood at 20,888 in December 2010; about 2,500 of them worked at FDNPP. Approximately 30 per cent of all FDNPP employees lived in Namie.

Mr. Tamotsu Baba, the Mayor of Namie, recounted:

> …We learnt about the accident at 5:44 AM on 12 March from a television programme, in which the Prime Minister's office ordered inhabitants within 10 km to be evacuated. I personally made a decision on evacuation. I want to stress that there were not any directives for evacuation from our government. The town of Namie had an agreement with the government and Tokyo Electric Power Company (TEPCO) to be informed of any trouble if it happened. However, it never functioned (Baba, 2012).

The tsunami killed 184 people and completely destroyed 613 houses in Namie. Furthermore, the nuclear disaster together with the tsunami displaced the entire population of the town. On 12 March, inhabitants voluntarily evacuated using their own automobiles or buses provided by the town. Most of those who evacuated the area headed north-west along Route 114 since it was the only available escape route, and took refuge at the Tsushima Kasseika Centre. To make matters

worse, winds pushed the radioactive clouds in the same direction as the fleeing inhabitants. The Tsushima Kasseika Centre is also located within the boundary of the most heavily radiated area in Figure 29. According to the radiation levels shown in Figure 29, the inhabitants may have experienced more than 19 μSv/hour, five times more radiation than a chest X-ray.

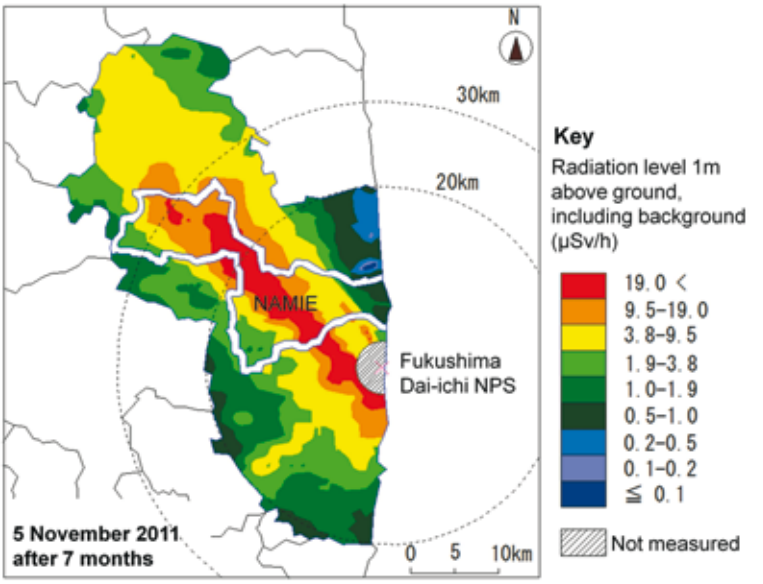

Figure 29. Radiation levels seven months after the disaster around FDNPP. Adapted from the Nuclear Regulation Authority, World Nuclear Association (World Nuclear News, 2013).

Evacuees

Temporary shelters located beyond the 20-km evacuation zone host 14,000 evacuees while 7000 evacuees now live in other prefectures. The town offices of Namie were moved to the city of Nihonmatsu in Fukushima Prefecture. Under guidelines established by the central government, TEPCO, the operator of the crippled Fukushima plant, has been paying 100,000 yen (US$990) a month to each resident who was forced to evacuate. The payments will continue as long as residents are evacuees. This figure was calculated by referring to the approximate 120,000 yen monthly benefit that is paid through automobile liability insurance to those who are hospitalized as a result of traffic accidents (Kotsubo, 2013). However, the Namie municipal government argued that the figure is too low since it does not take into account the terrible damage caused by the nuclear accident which forced

residents to evacuate. Nor does it take into account the fact that the disaster broke up communities which had been built up over many years. The Namie municipal government has asked that monthly compensation for psychological duress be increased to 350,000 yen.

Evacuees in temporary shelters are predominantly elderly since many young families have escaped with their young children to cities further away owing to anxiety related to invisible toxicants and also due to the lack of employment opportunities. Frustration, deteriorating health and a growing feeling of unfair treatment are being reported by residents who evacuated from the township. Residents claim that their health and the health of their families has deteriorated after evacuating and they feel more irritable compared to before the disaster. Stress is causing disputes among many evacuees, some have reported a lack of sleep and increased smoking or drinking since being evacuated. Depression and family collapse are also increasing. Conflicts between family members, between individuals from different generations, and between those who want to return and those who cannot leave have been reported. The majority of evacuated residents currently live apart from their extended family, which is another cause of increased frustration. More than half of the residents moved away from other family members (including elderly parents) with whom they lived before the disaster.

Another survey found that one third of the evacuees made the decision to never return to their hometown (Kodera, 2012). A questionnaire was sent to all 18,448 residents of senior high school age or above, among those, 11,001 responded (about 60 per cent of the total). Among those who responded, 64 per cent said they hoped to eventually return to Namie.

Those respondents who decided not to return gave the following justification for their responses:

- "There is no hope of radiation levels decreasing."
- "The nuclear accident will not be brought under control."
- "It will be difficult to rebuild the social infrastructure."

Among those respondents who want to return to Namie, 70 per cent stated that certain conditions would have to be met before they returned. A decrease in radiation levels, the rebuilding of the infrastructure for daily living and having a certain percentage of other residents also returning, were all key stipulations for returning.

The questionnaires also contained sections where respondents could expand upon their answers. Those sections showed the conflicting emotions among evacuees. One woman in her 30s who evacuated to Nagano Prefecture responded that she would not return to Namie. Nevertheless, she wrote:

While I want to return, I feel that in reality it is difficult. I cannot allow my recently born child to touch the soil of Namie. But, once I thrive with child-rearing, I want to return and live in Namie because that is the only hometown I have.

Even those who said they wanted to one day return expressed various emotions. One woman in her 20s wrote, "I want to one day live again in the Namie that I love. That is my only reason for having hope right now." One elderly woman wrote, "I want to die in my home in Namie where the spirits of my ancestors are. I am no longer afraid of radiation" (Kodera, 2012).

Restricted areas and their neighbourhoods

As a countermeasure to the accident at FDNPP, a restricted area to which entry is prohibited has been designated around the nuclear plant within a 20 km radius. However, there are many other locations with high radiation levels beyond the 20 km radius since radioactive particles have been carried by the wind from the damaged power plant. At the moment, those locations have extended to 11 villages, towns and cities including Minamisoma, Naraha, Tomioka, Kawauchi, Okuma, Futaba, Namie, Katsurao, IItate, Tamura and Kawamata. Those regions have been divided into four different categories according to the radioactive dosage (see Figure 30). Residents may return at will to visit and work without the use of protective equipment to areas marked in green. The only restriction is that they may not stay overnight. The radiation dosage in these areas is less than 20 mSv/year, which is the government's benchmark for permanent return.

Category	Radiation level
Areas in which evacuation orders are ready to be lifted	Less than 20 mSv/year
Areas in which the residents are not permitted to live	Over 20mSv/year
Areas where it is expected that the residents will have difficulties returning to for a long time	More than 50mSv/year
Deliberate evacuation area	----

Table 9. Evacuation zones. (Source: Authors' compilation)

While the evacuees from designated evacuation areas have been compensated by the government and TEPCO-regulated packages, inhabitants in nearby municipalities have basically been abandoned. However, the negative impact of the nuclear accident has spread throughout the entirety of Fukushima Prefecture, especially to cities such as Minamisoma, which is located adjacent to the 20 km restricted zone. Furthermore, a "black substance" resembling fungus which has spread along the roads of Minamisoma has increased anxiety among inhabitants. This black substance might have been carried by the wind from the damaged power plant. The authors have measured such hot spots in Minamisoma and have found a very high radiation dosage of 3.83μSv/hr, which is more than five times higher than the concurrent environmental radioactivity level in Fukushima Prefecture.

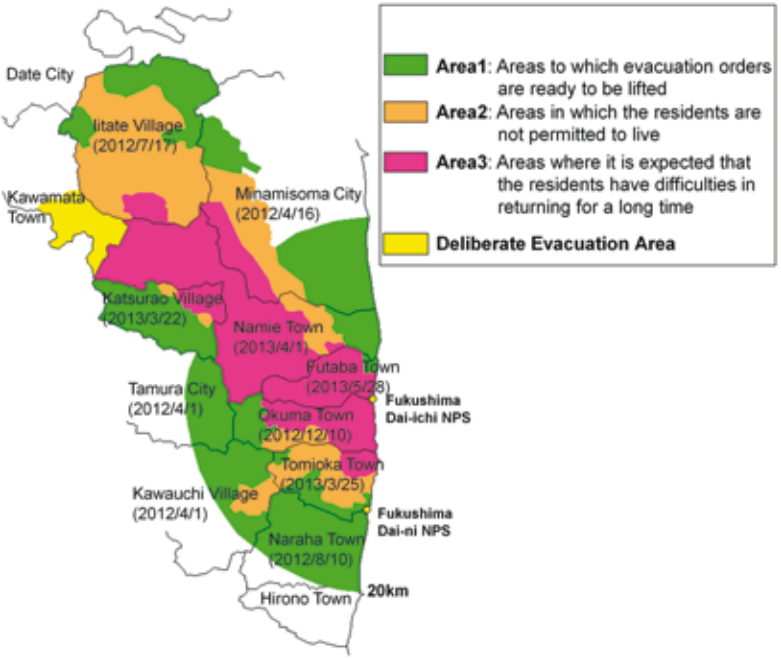

Figure 30: Restricted areas and areas to which evacuation orders have been issued as of 7 May 2013. (METI, 2013).

Mr. Koichi Oyama, an assemblyman of Minamisoma, insisted that:

> I am very much uneasy as a father. Looking at the high school girls who do not wear masks, looking at the elementary school children running barefoot, I worry from the bottom of my heart. If you can't swim in the sea, if you can't fish in a river, if you can't gather mushrooms in the hills, what does that youth mean? Even though there are many devices to measure radiation, who knows which radiation level is safe and which is not? If we cannot achieve freedom from fear here, we should be evacuated from Minamisoma. Is that not the right of a citizen? (Oyama, 2012).

The catastrophe at FDNPP not only affected people directly in Fukushima Prefecture, but also harmed the local economy. Sales of products from the prefecture have suffered, and tourist spots have also lost business because of rumours or misinformation about radioactive contamination. The sea off the coast of Fukushima Prefecture used to be a rich fishing ground where warm and cold ocean currents converge. However, after the nuclear crisis in March 2011, fishing in the southern

sea area ground to a halt. There is now commercial fishing on a trial basis in part of the northern Fukushima sea area. In an article by The Japan Times, a victim of this fishing crisis mentioned that:

…if such fish are unloaded at ports outside Fukushima Prefecture, nobody thinks twice about buying them. But, if they are unloaded at ports in the prefecture and then shipped to other places for sale, they attract suspicion because they are from Fukushima Prefecture.

In May 2012, Fukushima fishermen caught 18 tons of bonito off the coast of Hachijo Island near Tokyo and brought them to their home port, where radiation monitoring confirmed that they were safe. But, when the fish were shipped to Tokyo's Tsukiji wholesale market, the market did not even put them up for auction (The Japan Times, 2012).

The vulnerabilities of the victims of the Great East Japan Earthquake and Tsunami and the nuclear accident are listed in Table10. Those affected by the nuclear accident have been divided into two categories, in which "forced evacuation" represents those inhabitants who previously lived in restricted zones and "voluntary evacuation" indicates inhabitants who voluntarily left non-restricted areas because of anxiety. Each exposure has been qualitatively assessed using three indicators, "yes," "no" and "perhaps", according to the authors' experiences.

			Nuclear accident	
Exposure	Earthquake	Tsunami	Forced evacuation	Voluntary evacuation
Compensation for living expenses	No	Yes	Yes	No
Compensation for damaged houses	No	Yes	Yes	No
Possibility of return to previous home	Yes	No	No	Perhaps
Possibility of revitalization of local businesses	Yes	Yes	No	Perhaps
Possibility of revitalization of agriculture	Yes	Yes	No	Yes
Market value for products	Normal	Normal	No	No
Social discrimination	No	No	Yes	Yes
Health risk	No	No	Yes	Yes

Table 10. Vulnerabilities of the victims of the Great East Japan Earthquake and Tsunami and the nuclear accident. (Source: Authors' compilation)

Freedom from fear

While the earthquake and tsunami did not affect Fukushima differently than any other earthquake or tsunami would affect another city, the prevailing problems in Fukushima are considerably different. While reconstruction in other prefectures progresses, Fukushima is still struggling with the nuclear trauma. It is understood that inhabitants of Fukushima Prefecture predominantly live in fear and are vulnerable to all seven threats defined in the 1994 Human Development Report. Hence, the fears of inhabitants could be divided across the borders of Fukushima and other prefectures as "invisible fears" and "visible fears", respectively. While the "visible fears" can be reduced through physical solutions, the "invisible fears" of Fukushima should immediately be treated through transcendental actions.

The concept of human security is part of an ongoing debate over the meaning of security that has its origins in the aftermath of the collapse of the international structure following the break-up of the Soviet Union and an end to the Cold War. The debate focused on the shifting emphasis of discourse surrounding security from military and political issues to concerns that reflected the economic and social well-being of people and communities. Primacy shifted from states to focus on people and from state security to human security. Human security is people-centred (United Nations, 1994). It is concerned with how people live and breathe in a society, how freely they exercise their many choices and how much access they have to market and social opportunities. Moreover and most importantly, human security serves to prevent or address various threats to life ensuring the safety, health and well-being of individuals. Thus, from the perspective of human security, it is true that people affected by the nuclear disaster are facing various threats.

The value of human security should be applied to real situations and help make tangible steps towards the amelioration of various threats and insecurities affecting vulnerable people. Therefore, this study attempted to ascertain the threats or insecurities that nuclear disaster victims are facing.

Before concluding this chapter, let us cite Yuri Scherbak in comparing Chernobyl with Fukushima:

FDNPP disaster means that mankind has not adequately learned to react to emergency situations yet; it was unable to use the experiences accumulated through Chernobyl. Visiting Fukushima and listening to various people, I sadly realized that the vast experience of Chernobyl, which was accumulated through the bitter price of lives and health, was not utilized. This is not a matter of the pride and self-discipline of the Japanese people, who have demonstrated the finest examples of courage and stoicism during the earthquake and tsunami. This is a matter for Ukrainians, who have such large data sets with regard to the survival of people in the contaminated areas, agricultural fields and the influence of low radiation on the human body. We failed to provide our knowledge to the world; we failed to make it scholarly capital. I am thinking that now there are two radioactive towns in the world – socialistic Pripyat with its typical Lenin statues and ideological slogans of communist times, and capitalistic Namie with advertisements of Michelin tires and

McDonalds. They are so different but are united by human grief (Scherbak, 2012, translated by Alexei Kononenko).

In closing, the authors prefer to pose a research question: Can we find a difference between human security and state security in the nuclear domain?

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Dinil Pushpalal is a Professor in the Department of International Resources Policy in the Graduate School of International Cultural Studies at Tohoku University. He is also the Chief Coordinator of the International Post-Graduate Programme in Human Security. After joining Tohoku University, he engaged in research on the environment, resources and human security looking at issues through quantitative analysis beyond the traditions of sociology. His present research interests include ecological footprint analysis, clean development mechanisms and human security issues such as measuring human development. While his present hometown Tagajo, Japan was severely damaged by the 2011 Great East Japan Earthquake and Tsunami, the 2004 Indian Ocean Earthquake and Tsunami severely destroyed his birthplace of Galle, Sri Lanka. These events have persuaded him to investigate reconstruction issues from a human security point of view in cities and societies that have been destroyed. He travelled along the coastline of Miyagi and Fukushima Prefectures and interviewed a large number of stakeholders to gather their perspectives on burning issues.

Since 2012, **Anawat Suppasri** has been an Associate Professor of the Earthquake and Tsunami Risk Evaluation Division (Tokio Marine) of the International Research Institute of Disaster Science (IRIDeS) at Tohoku University. He obtained his bachelor's and master's degrees in civil engineering and water engineering & management from Chulalongkorn University in 2005 and the Asian Institute of Technology in 2007, respectively. He then completed his PhD in tsunami engineering at Tohoku University in 2010. His research interests are tsunami generation mechanisms, tsunami numerical simulations, tsunami fragility curves, tsunami evacuation and tsunami disaster education. His hometown in Bangkok is far from the affected areas of the 2004 Indian Ocean tsunami. However, he experienced the 3.11 earthquake when he was in his office on the 11th floor. Six months later, in the same year, his parents' house in Bangkok suffered from the great flood in Thailand. Right after the March 2011 event

in Japan, he was assigned to be a member of the tsunami joint survey team to assess the tsunami run-up height and damage to buildings, coastal structures and trees. At the time of writing, he had guided more than 30 groups of domestic and international visitors through tsunami-affected areas. At present, he is working with some local tsunami-affected area groups to support their reconstruction and evacuation plans.

Hitoshi Yonekura is a professor in the Department of Resource and Environmental Economics at the Graduate School of Agricultural Science at Tohoku University. His research fields are agricultural economics, development economics and area studies on Indonesia. He worked as a senior research fellow for the Institute of Developing Economies in Japan and for the CGPRT Centre (currently UNESCAP-CAPSA) in Indonesia. He also holds, at present, the post of executive advisor to the Japan International Research Centre for Agricultural Sciences (JIRCAS). His current research interests include poverty alleviation, upland crop economy, market institution, land ownership and tenure, and labour practices in rural areas. In line with these research topics, he studies human security issues and supervises the students of the Human Security Programme at Tohoku University. After the Great East Japan Earthquake and Tsunami, in his residential area in the north-western part of the city of Sendai, it took three days for the power supply to be recovered, one week for the water supply, and two weeks for the city gas supply. Fortunately, it was a very rapid recovery. Yet, the lack of information and with little prospect of a lifeline recovery, as well as continuous seismic activity, he experienced a critically unsettled state of mind in the aftermath of the March 2011 tragedy.

Katsuhito Fuyuki is an Associate Professor in the Department of Resource and Environmental Economics in the Graduate School of Agricultural Science at Tohoku University. After joining Tohoku University, he engaged in research on agricultural policy, food systems and agribusiness with a specific focus on the rice industries in Japan and other Asian countries. His present research interests include the restructuring of agriculture by agro-industry, recovery of paddy fields and human security issues among farmers in the tsunami-damaged area of north-eastern Japan. While he is a board member of Miyagi Consumers Cooperative Association and Miyagi Environmental Life Out-reach Network, he is interested in the relationship between farmers and consumers. Thus, his research interests also include slow food, organic farming and food safety. After the accident at the Fukushima Nuclear Power Plant caused radioactive contamination of farmland and agricultural products, he attended a large number of meetings with farmers and consumers, considering better relationships between them and improved food safety.

Shin Oyamada is a Research Associate in the Graduate School of Agricultural Science within the Faculty of Agriculture at Tohoku University. While he was a student at Tohoku University, he majored in environmental ethics. His doctoral thesis is about how strangers can naturally participate in local environmental conservation sympathizing with local residents. He currently studies emergency mechanisms related to strangers' sympathy with local residents focusing on the interactive process of local residents' narration and strangers' listening. Since his birthplace is Hokkaido in the northern part of Japan and his laboratory is about 10 km away from the coastal region, the earthquake did not directly cause much damage to him. But, he thinks there should be a guide for how people like him who do not have personal disaster experience can naturally participate in the reconstruction process. He has carried out research among people who do not live in the disaster area but want to help victims. He is now engaged in a programme to form consensus in the disaster area.

Philipp Koch is a student at the University of Bonn. He is currently completing his studies with his diploma thesis titled, "Spatial implications of the 3/11 event in Sendai with Special Emphasis on Ecosystems in Disaster Risk Reduction", focusing on the perspective of tsunami-affected people in the area of Sendai, Japan, with regards to ecosystem bases in disaster risk reduction. His work experience began as a student assistant at the University of Bonn. This was followed by a student assistant position at the United Nations University Institute for Environment and Human Security (UNU-EHS) in the Vulnerability Assessment, Risk Management & Adaptive Planning Section (VARMAP) headed by Dr. Jörn Birkmann in the WISDOM Project. He also worked within the Environmental Vulnerability & Ecosystem Services (EVES) Section headed by Dr. Fabrice Renaud. During his time in the EVES section, he was involved in the organization of training by the Partnership for Environment and Disaster Risk Reduction (PEDRR). Parallel to his work and studies, he completed an internship in International Nature Conservation at the German Federal Agency for Nature Conservation (BfN). His work at UNU-EHS provided the unique opportunity to cooperate with Prof. Dr. Dinil Pushpalal (Tohoku University) resulting in the thesis mentioned above. In addition, he also works for the German Aerospace Centre (DLR) assisting in the publication of a book.

Koichi Ogata is a first year master's student at Tohoku University. He received his BS degree in architecture from the Sendai National College of Technology. He is currently enrolled in the master's programme in International Resources Policy within the Graduate School of International Cultural Studies. Through this master's programme, he has the chance to understand various approaches related to both engineering and the natural environment. In 2012, he was an intern at UNU-EHS for three months and his research is related to the relationship between the March 2011 tsunami and ecosystem services. He has been an active participant in recent research which was a collaborative effort with several fellow students from his department under the guidance of Professor Pushpalal and

UNU-EHS on ecosystem disaster risk reduction. In this research, they were able to collect important data by conducting several focus group discussions and stakeholder interviews. In addition, he has worked on restoration projects and providing humanitarian aid as a volunteer in several areas affected by the tsunami .

Manabu Fukumoto is Chief Professor of the Department of Pathology in the Institute of Development, Aging and Cancer (IDAC) at Tohoku University. After graduating from the Faculty of Medicine at Kyoto University, he joined the Graduate School of Medicine, Tohoku University as an assistant professor of pathology. His primary focus is pathology and his present interests include the molecular pathological approach to elucidate radiation carcinogenesis and radiation resistance of cancer cells. Just after the Great East Japan Earthquake and Tsunami, he engaged in post-mortem examinations of many of the victims of the tsunami. He is now concentrating his work and that of his colleagues on the construction of a tissue archive, and on the radiological and biological assessment of animals abandoned in the evacuation area around the Fukushima Daiichi Nuclear Power Plant.

Zhang Yan is a second year graduate student in the Division of International and Regional Environment within the Graduate School of Environmental Studies at Tohoku University. She is also a graduate student from the International Post-Graduate Programme in Human Security and the Environmental Leader Programme in Strategic Energy and Resource Management and Sustainable Solutions (SERMSS) at Tohoku University. Her research primarily focuses on energy conservation and global environmental security, with special attention given to the utilization and development of renewable energy resources such as wind power and related manufacturing industries. When the 2011 Great East Japan Earthquake and Tsunami occurred, as its witness, she was deeply shocked by the extent

of devastation caused by the Fukushima Daiichi Nuclear Power Plant accident and tsunami wave. Particularly given the issue of Fukushima, her research interests were closely connected to the tragic events and are expected to further guide discussions and help reveal the real stresses and threats to victims from the perspective of human security. In particular, her research based on visits to radiation-affected area and interviews and meetings with victims and community leaders are key to designing interventions.

Yuri Scherbak graduated from the Kyiv Medical Institute and worked at the Kyiv Scientific Research Institute of Epidemiology and Infectious Diseases until 1987. Dr. Scherbak is an Ambassador Extraordinary and Plenipotentiary of Ukraine and a First Vice-President of the National Academy on Environmental Sciences of Ukraine. He began his political career in 1987 after the Chernobyl catastrophe when he became leader of the Ukrainian Green Party. Dr. Scherbak initiated and led the first parliamentary investigation of the Chernobyl accident and the nuclear catastrophes in Semipalatinsk and in the Urals. He founded and became the leader of the Ukrainian Green Movement (an organization which united more than 200 Ukrainian NGOs) in 1988 (becoming the Green Party in 1990). Dr. Scherbak later served as Ukraine's Ambassador to Israel, the United States, Mexico, and Canada (from March 2000 until May 2003). An eyewitness to the 1986 Chernobyl nuclear disaster, he wrote the sensational expose, Chernobyl, which was published in English in 1989. Scherbak travelled to the dangerous zone around the reactor at Chernobyl, lived there and interviewed firemen, first-aid workers, party and government officials, local media representatives and foreign visitors. The result is a collection of vivid eyewitness accounts unprecedented in their detail and frankness. He visited the evacuation zone and villages surrounding the Fukushima Daiichi Nuclear Power Plant and interviewed a large number of victims, and educated them through his experience on the Chernobyl accident.

About the Scientific Workshop and the Way Forward

On the occasion of the second anniversary of the Great East Japan Earthquake and Tsunami, Tohoku University, Sendai, Japan and the United Nations University Institute for Environment and Human Security (UNU-EHS) organized a scientific workshop. The workshop emphasized the different aspects and layers of a disaster – taking into account experiences of the people who were directly affected. Junior and senior scientists from both institutions highlighted different perspectives and phases of this cascading disaster, investigating and discussing some of the most important questions through the eyes of direct victims, volunteers and academics. Researchers from Tohoku University and UNU-EHS gave presentations on a variety of topics and discussed it with the audience.

The event took place within the framework of the annual PhD Block Course "From Vulnerability to Resilience in Disaster Risk Management", which provided participating international and interdisciplinary scholars with a unique forum for exploring new issues and sharing the lessons learned following the Great Japan Earthquake and Tsunami.

The scientific exchange was a strong momentum that successfully contributed to the strengthening of further cooperation between the two academic institutes. It will foster broader and continuing collaboration on joint workshops and research projects focusing on human security and vulnerabilities in disaster areas.

Following the workshop, a Human Security Special Lecture took place in December 2013 at the International Post-Graduate Program in Human Security at the Tohoku University in Sendai. Experts from UNU-EHS and Tohoku University were invited.

List of Abbreviations and Acronyms

ADB	Asian Development Bank
Ag	Silver
Bq	Becquerel
Cs	Caesium
DR	Displacement and Resettlement
FDNPP	Fukushima Daiichi Nuclear Power Plant
GEJET	Great East Japan Earthquake and Tsunami
GEJE	Great East Japan Earthquake
Gy	Gray
HHs	Households
I	Iodine
ICRP	International Commission on Radiological Protection
ICUN	International Union for Conservation of Nature
LNT	Linear No-Threshold Model
MAFF	Ministry of Agriculture, Forestry and Fishery of Japan
METI	Ministry of Economy, Trade and Industry
MEXT	Ministry of Education, Culture, Sports, Science and Technology
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
NPP	Nuclear Power Plant
NPO	Non-Profit Organization
OP	Operational Policy
PB	Peripheral Blood
Sv	Sievert
Te	Tellurium
TEPCO	Tokyo Electric Power Company
UNU	United Nations University
UNU-EHS	United Nations University Institute for Environment and Human Security

Figures

Tables

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