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"The Kamaishi miracle": lessons learned from the 2011 tsunami in Japan

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The tsunami that hit the east coast of Honshu Island in Japan in 2011 not only made Fukushima a martyr city, a universal symbol of the current nuclear risk. It also struck many agglomerations exposed to the deadly wave that came from the Pacific Ocean. Kamaishi was one of them. It was also the place of a "miracle" that drew on good will and education of younger generations.

Japan still remembers the 2011 disaster. It must be said that the moment magnitude (Mw) 9 earthquake[1] was one of the most powerful ever to be recorded in Japan, and one that struck a vast area. But most of all, the resulting tsunami triggered the Fukushima nuclear power plant accident, an event that once again challenged expertise and trust in current disaster management.

Just under 300 km north of Fukushima, the city of Kamaishi has suffered greatly from the earthquake and the tsunami. Its inhabitants are still deeply affected, but are committed to the restoration and rebuilding of their city, which today stands as an example. This article aims to analyse "the Kamaishi miracle", and reflect on how education is an efficient strategy for disaster managers within the "mitigation-preparedness-response-recovery" cycle. Built on a review of existing literature and interviews conducted in Kamaishi, it will briefly present the city and the regional disaster record, then the facts concerning the event itself, and finally the impact of preventive education.

Kamaishi: a story intertwined with the movements of earth and sea

Kamaishi is located 593 km north of Tokyo in the Tōhoku region (which gave its name to the 2011 tsunami) and in Sanriku Fukko national park, southeast of the Iwate prefecture. Traditionally, Kamaishi was a small fishing village similar to others on the Japanese coast, until the discovery of iron in the region in the 18th century. The construction of Japan's first blast furnaces in this city in 1857 accelerated the development process. Today, the city is still known for its foundry, while fishing remains a local industry.

The city reached a demographic peak of 90,000 people in the 1960s, then slowly declined to about 35,000 today. In 1960, 4% of the population was elderly; a rate which is today 35%. Before the 2011 Tōhoku earthquake and tsunami, the city had around 40,000 inhabitants as well as two primary schools and two secondary schools, which became famous for what the media has called, "the Kamaishi miracle"[2].

[1] "The moment magnitude scale is one of the logarithmic scales used to measure an earthquake's magnitude (i.e. its "size"), related to the seismic energy released. Focused on the low frequencies of seismic waves, it accurately quantifies the energy emitted by the earthquake." (Wikipedia, *Editor's note*). It differs from the well-known Richter scale.

[2] Shohei Matsuura and Rajib Shaw, "Exploringthe possibilities of school-based recovery and community building in

In Kamaishi, the memory of this disaster and those that preceded it is everywhere. Signposts recall the height of the wave, and memorials stand in remembrance. One of them reads: "Just run. Run uphill ... And tell future generations that a tsunami reached this point."

Table 1: History of regional tsunamis and the resulting damage

Date	Name	Magnitude (Mw)	Damages	Max. height of the wave (m)
15 June 1896	Meiji Sanriku	8.2	Fatalities (F): 21,959 Houses endangered or destroyed (HED): >10,000	38.2
3 March 1933	Showa Sanriku	8.1	F: 3,064 deaths HED: >1,810	28.7
22 May 1960	The Great Chilean	9.5	F: 142 HED: >1,625	3
11 March 2011	Great Tohoku	9	F: 19,000 HED: >836,500	40.5

In this region, it is said that every generation has witnessed a significant disaster. The Meiji Sanriku earthquake in 1896 killed about 60% of the people of Kamaishi, mainly due to the tsunami. The 1933 Showa Sanriku earthquake, which caused little direct damage, saw the resulting tsunami kill 164 people, with 240 others disappearing.

Surrendering to the belief that humanity has now harnessed nature, and that we have achieved the ability to use technology to ensure individual safety[3], Kamaishi – like other places in Japan – invested in protection based on the erection of dykes and shelters or the distribution of floodplain maps. More recently, the construction of a breakwater wall near the harbour completed these efforts. When it was designed, the wall had to be buried over 50 meters deep along at least half of its total length. Eventually, at its deepest point, the wall was 63 meters high, setting a world record appearing in the Guinness World Records[4]. The construction of the Kamaishi breakwater began in 1978 and was completed three decades and some 1,6 billion US dollars later. This technical feat even revived the hope of an economic recovery for this declining former steel town.

Wall of water versus breakwater and pinewood barriers

Two years after the Kamaishi wall was built, Japan was devastated by one of the most powerful earthquakes in its history. The epicentre was located about 130 km off the eastern coast of Japan. Unlike the two preceding mega-tsunamis, this one grew very suddenly, despite the slow rise in sea levels. Most of the breakwater collapsed under the first twenty-metre wave, leaving Kamaishi defenceless. It is also strongly suspected that waves diverted by the breakwater, carrying waste and debris from the wall itself, aggravated the situation when they hit the city.

Toni District, Kamaishi", *Natural Hazards*, 2015, vol.75(1), 2015, p.613-633.

[3] Susan Cutter, *Living with Risk*, Edward Arnold, 1993, p.214; Samuel Nielsen and John Lidstone, "Public Education and Disaster Management: Is There Any Guiding Theory?", *Australian Journal of Emergency Management*, vol.13(3), 1998, p.14-19.

[4] Jacob Trucker, "The Failure of the Kamaishi Tsunami Protection Breakwater", *Journal of undergraduate engineering research and scholarship*, vol.1, 2013.

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We met Akiko Iwasaki in Kamaishi. She miraculously survived the disaster. She owns a small hotel by the water which she believes is "protected" by a barrier of century-old pines planted to stop tsunamis in the early 20th century. She lost a lot on 11 March. However, Akiko is glad that the wall was not in front of her hotel, for obvious professional reasons, but also because the century-old trees "did remain standing".

In total, 1,064 fatalities were counted. One third of the 5,000 houses were entirely or partly destroyed. The fishing industry was greatly affected, with more than 97% of fishing boats damaged. One of Kamaishi's peculiarities was the very low fatality rate among young people. The city mentions a survival rate for children of 99,8%[5]. Local teachers attribute this low rate to the disaster mitigation education programme, launched several years ago[6].

School children saved by disaster mitigation training

The challenge posed by earthquakes is a constant concern for the Japanese authorities. For decades, Japan has held regular expert meetings. In 2005, the region was warned that a mega-tsunami was to be expected within the next three decades.

Among the identified mitigation measures, the education of young people was quickly considered as an option. In 2005, Toshitaka Katada, a Civil Engineering Professor at Gunma University and a Disaster Prevention Specialist, conducted a first session at the Kamaishi Higashi Junior High School, at the request of the Kamaishi city Education Council. This experiment led to the creation of a comprehensive training programme in 2008 focusing on the history of tsunamis in the region, local geology and "survival training". The aim of the approach of the city and teachers was, and still is, to gain a better understanding of natural phenomena, rather than fear them.

Content based on local knowledge was then added to Dr Katada's training content. From their "elders", the region's inhabitants have inherited a lesson to reflect on: "tsunami tendenko". Tendenko, in the local dialect, means "each person" or "individually".[7] The idea is to protect your own life by immediately regrouping with your relatives in a predetermined location. The fact that many children, parents and relatives could demonstrate "tsunami tendenko" is the result of the reintroduction of that principle in the training. A school student actually introduced the practice of "safety maps", inspired by "tsunami tendenko", which was then formalised throughout the city. These documents are distributed to all households and must be visibly attached to the house's door in case of a disaster. They are used to inform that a house is empty and that its inhabitants have gone to the indicated evacuation point.

On 11 March 2011, school children had already had at least three years of training, and were better prepared than their elders to deal with the disaster. When the earthquake hit at 2:46 p.m., some of the children had already left school. Between 2:50 p.m. and 2:55 p.m., children at the Unosumai Elementary School, who were still at school, sought refuge on the building's third floor. Across the road, students at the Kamaishi Higashi High School decided to evacuate, and encouraged the primary school pupil to follow them. Together, they went to an official shelter located about 500 metres from the schools. When they arrived, around 3:05 p.m., the children

[5] Conference of the Kamaishi City Reconstruction Promotion Headquarters, 20 July 2018.
[6] Lucy Birmingham and David McNeill, *Strong in the Rain: Surviving Japan's Earthquake, Tsunami, and Fukushima Nuclear Disaster*, Palgrave Macmillan, 2012, p.256.
[7] Katsuya Yamori, "Revisiting the concept oftsunami tendenko: Tsunami evacuation behavior in the Great East Japan Earthquake", Chapter 5, *Studies on the 2011 Off the Pacific Coast of Tohoku Earthquake*, Springer, 2014.

noticed that the cliff where the shelter was located was threatening to collapse and they decided to go to a nearby retirement home. At 3:20 p.m., the official shelter was destroyed by the tsunami. Witness of the shelter's collapse, the group continued to evacuate to a third location. About 600 primary and high school students, adults and other residents survived thanks to this initiative.

Table 2: Great Tōhoku earthquake – losses among primary and high school students in three neighbouring municipalities[8]

	Total population	**Total fatalities**	**Number of primary school students**	**Fatalities among primary school students**	**Number of high school students**	**Fatalities among high school students**
Rikuzentakata	23 302	1951	1203	8	675	11
Kamaishi	39 578	1064	1297	3	996	2
Otsuchi	15 277	1397	769	3	449	2

The ground rules for teaching in Kamaishi's schools

After the interviews conducted as part of the symposium and the testimonies gathered when visiting the site, three evacuation rules emerged and must be remembered in the event of a tsunami:

- firstly, "do not trust the experts' hypotheses and knowledge at all costs", but always use your best judgment according to what happens when the earthquake occurs;
- secondly, "do your best by drawing on handbooks and best practices, while constantly adapting them to the current situation". Here, teachers are calling on their students' common sense. The best example of this is the official shelter that collapsed. Disregarding official instructions telling them to find a shelter and to stay there, students judged that it was better to move;
- thirdly, although there are no obvious signs indicating an imminent disaster, "take the initiative and evacuate". This third rule was applied by the Kamaishi Higashi group.

According to teachers, this third rule is difficult for two reasons. Firstly, because of the existing pressure on the group. If some do not wish to evacuate, this can be fatal for the whole group. The other danger is the natural tendency to think that we will survive no matter what. This hinders the evacuation process. The issue with this third rule is overcoming this preconceived idea.

Kamaishi's resilient model

After this disaster, a national committee of experts was tasked with reviewing disaster management procedures, taking into account the lessons learned from the earthquake.[9] Since 2011, disaster preparedness has become the national programme's primary objective. The Great Tōhoku confirmed that large-scale earthquakes may still happen, and that the Japanese coast is a vulnerable urban area. Furthermore, other disasters threaten Japan, which has about

[8] Based on the work of Pradyumna and Suganuma, *Japan after 3/11: Global Perspectives on the Earthquake, Tsunami, and Fukushima Meltdown*, University Press of Kentucky, 2016, p.496 and the conference of 20 July 2018 already mentioned.

[9] Kaori Kitagawa, "Continuity and change in disaster education in Japan", *Journal of the History of Education Society*, vol.44, 2014, p.371-390.

one hundred active volcanoes, some of which are considered a threat[10].

In light of these risks, the government is implementing preparedness measures. In December 2013, the fundamental law for national resilience was adopted. The first article clearly states that the law's objective is to develop Japan's resilience through nationwide disaster preparedness.

Alongside the national political reforms, mutual aid (kyojo) has increased since 2011, and supplements local or central government aid (kojo). This became evident with the mass arrival of volunteers in Kamaishi in 2011. Indeed, many former Kamaishi residents who were living elsewhere at the time of the event came to help[11]. Thus Akiko, helped by her friend Satoshi Ito and other volunteers, rebuilt her hotel, which reopened in January 2012. The national effort was complemented by international aid through, for example, the U.S. military's "Operation Tomodachi"[12]. The Singapore Red Cross[13] donated two cars to the city to transport elderly patients. The Association of Medical Doctors of Asia[14] (AMDA) also sent two medical teams to cover the needs of Kamaishi and its neighbouring city, Otsuchi.

Since the Great Tōhoku, regional governments have reviewed their risk mitigation and management plans: strengthening the resilience of infrastructures, raising ground levels and increasing the stocks of food and emergency blankets. The high school was moved to the highest point of the city and is now Kamaishi's main shelter.

Many studies were conducted to inform decision-making regarding governmental plans. Some concluded that if the forces deployed by the tsunami had stayed within the boundaries determined by the record of past events, the breakwater would not have given way. The Japanese government decided to repair the breakwater, including the new data in the calculations. The repair cost is estimated at 650 million US dollars. Although the local population has strongly opposed such expenses[15], the government has said that a working breakwater would be cost effective and efficient. Such a wall would encourage industry to remain in Kamaishi, and reassure tourists and local residents. It is also important to remember that Kamaishi will host the Rugby World Cup in September 2019, in a brand-new stadium that can seat 16,000 fans.

However, the 2011 disaster highlighted that humanity cannot rely solely on technology to improve its resilience. To paraphrase the philosopher, Francis Bacon: "Nature, to be commanded, must be obeyed". In other words, to take effective action, we must obey its laws, so as not to fail in our endeavour. Technological measures are undoubtedly crucial; but they cannot remove the need to educate the youngest in our society and search for resilient solutions that work with the environment.[16] Indeed, whatever their size, dykes and breakwaters can always be devastated by extreme phenomena. The pine trees of Kamaishi are evidence of this.

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[10] Observatoire permanent des catastrophes naturelles et des risques naturels, https://www.catnat.net
[11] Around 100,000 volunteers came to Kamaishi. Some subsequently decided to stay: Alex Martin, "Kamaishi mounts a soft-power recovery to revive tsunami-hit community", *The Japan Times*, 2018.
[12] Eric Jonhston, "Operation Tomodachi a huge success, but was it a one-off?", *The Japan Times*, 2012.
[13] In collaboration with Life Community Development, Singapore Red Cross website on 12 December 2018.
[14] Citizen Action team's Relief Database, on 12 December 2018.
[15] Onishi Norimitsu, "Japan Revives a Sea Barrier That Failed to Hold", *The New York Times*, 2011
[16] See the article on coastal erosion according to coast type by Giovanni Scicchitano *et al.*, "Terrestrial Laser Scanner techniques in the assessment of tsunami impact on the Maddalena peninsula (south-eastern Sicily, Italy)", *Earth Planet Sp* 64, 2012, p.8. Coasts with forests have a better score.

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