Social lives of tsunami walls in Japan: Concrete culture, social innovation and coastal communities

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Abstract. This paper is the beginning of a reflection on the ways in which the Great East Japan Disaster (2011) might have changed people’s perception of seawalls and hard coastal defence in Japan. A highly developed society that is prone to frequent large tsunamis and storm surges, Japan’s spending on physical coastal defence has few equals around the world. The development of sea defence became a priority during the 1960-70s when coastal engineers and related agencies developed national standards. One of the chief strategies has been the edification of seawalls and other hard structures, which today surround more than 40% of Japan’s coastlines. This technological advancement might have created a general sentiment of security and trust in the ability of these coastal structures to protect coastal communities, their infrastructures and their nuclear plants. On March 11 2011, however, this general sense of safety was hardly shaken by a M9 earthquake and its ensuing tsunami taking away the lives of over 15,000 individuals and causing a material loss of over 210 billion dollars. If experts had anticipated such a large earthquake, the height of the tsunami waves and the extent of the damaged suffered along the coast of northeast Japan surpassed even the most pessimistic predictions. Reflecting on the impact of this tragedy, this paper is a first attempt to appreciate whether Japanese people’s perception of and approaches to seawalls and other coastal defences might have changed as a result. The first part of this paper provides a brief analytical overview of the culture of sea defence and its socio-economic significance in Japanese society. The second part examines more specifically the ways in which seawalls might have influenced people’s behaviour during the events of the Great East Japan Earthquake, including their creating a false-sense of security. Finally, the third part focuses on relatively innovative approaches to coastal defence in post-disaster Japan, with a particular focus on a national project known as the Great Forest Wall. Rather than its engineering efficacy, the interest in this project lies in the ways in which the project might inform us of changing people relationships and ideas with coastal defence.

1. Introduction (change title)
Communities within 100 kilometres of the coast count for more than 40% of the world’s population and include 65% of the cities with more than 5 million inhabitants. Under the influence of global climate change, these communities may become more vulnerable to flooding hazards arising from typhoons or extra-tropical storm events. In addition, their growing populations also increase the risk of great disasters in the event of tsunamis. In response to these threats, societies have developed a variety of strategies both intangible (oral history, education and relocation) and tangible (evacuation shelters, groins, revetments, rock armours, offshore breakwaters, armouring, flood gates, coastal forests) in order to contribute to disaster risk reduction. Among communities exposed to tsunamis, especially those of the affluent world, seawalls are the most common technological responses. We observe that such responses have often not only changed the landscape dramatically but also the life of the population. Considering the profound impact of coastal defence on communities, this paper reflects on the ways in which new approaches to sea defences can successfully serve and be integrated within coastal communities.

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To begin this reflection, this paper examines the changes in coastal flooding mitigation programs in Japan following the Great East Japan Disaster (2011). The first part of this paper gives a brief analytical review of the culture of sea defence in Japan including its socio-economic significance. The second part examines more specifically at the ways in which seawalls might have influenced people’s behaviour during the events of the Great East Japan Earthquake. Finally, the third section focuses on an innovative approach: The Great Forest Wall. My expertise does not allow me to appreciate the degree to which this project may or may not improve Japan’s aptitude to cope with the large tsunami and coastal hazards. Instead, however, our interest lies in the capability of the project to reflect or provide a novel relationship between people and coastal defence in Japan.

2. The Culture of Sea Defence in Japan: Concrete Modernity
As a highly developed society prone to frequent large tsunamis and storm surges, Japan’s spending on physical coastal defence has few equals around the world. One of the chief strategies has been the edification of seawalls and other hard defence around its coastlines. The development of sea defence became a priority during the 1960-70s when coastal engineers recognised the need for the creation of national standards for the design and the construction of coastal defence [1]. Although breakwaters remain a major tsunami counter measure [2], the GEJE was followed by the reconstruction of tenacious embankments around the coastline of Northern Japan to withstand or at least slow down a Level 1 tsunami that is said to occur every 100 years [3]. Japan’s technological strategy means that today approximately 43% of the country’s 34,360 km of coastline are armed with coastal defence, formed essentially of seawalls and breakwaters.

One of the largest seawalls can be found on the coastline of Taro district of Miyako City in Iwate Prefecture (figure 1). Its construction began in 1933 when, after a long series of tsunamis, yet another wave came ravaging the district causing the death of a third of its population (911 individuals). Designed in an x-shape, this double seawall is 10.5 meter in height and 2,433 meter in length, and is known as the ‘Great Wall of China’.

In addition to their protective function, seawalls and coastal physical coastal defence have a social raison d’être. Starting with their economic values, these concrete structures may be seen as part of a broader means of developing of the construction industry in post-war Japan. In his critic ‘Dogs and Demons’, Kerr goes at length to explain how the construction industry and its concrete structures came to dominate Japan’s public expenditures, representing more than 40 per cent of its budget. Kerr reports that breakwaters alone represent a yearly cost of 500 billion yen (4.15 billion US dollars) for each of the Ministry of Agriculture, Forestry and Fisheries, the Ministry of Transport and the Ministry of Construction, year. Seawalls surround almost half of Japan’s 29,751 km of coastline [4]. Although it would difficult to give an estimation of the cost that their construction and maintenance represent, Taro’s seawall alone represented a budget of 400 million yen in 1978. In the face of the recent decision to build a new 400-mile chain of seawalls along the coastline of Tohoku for 820 billion yen to replace those destroyed during the 2011 tsunami, one may suggest that seawalls and other coastline defence continue to represent an important economic part of Japanese construction industry.

The huge number of large scale construction projects, such as the building of seawalls, is not exceptional in Japan. Especially after the Second World War, pork barrel projects allowed the leading party LDP to stay in power in the so-called 1955 system. Politicians gave large scale projects to construction companies within their election districts and gained votes in return. [5] As a result, even in very remote areas, large bridges, highways, or concert halls are no unusual sight. The high spending on such projects led to Japan being called a “construction state” (kensetsu kokka). Dewit [6] critically notes: “Japan has indeed an unparalleled devotion to building dams and roads, straightening rivers and coastlines, blasting tunnels and erecting bridges, and otherwise frenetically blighting the natural environment with vast quantities of concrete and steel. The many culturalists who claim Asians have a special harmony with the environment, in contrast to Westerners' rapaciously instrumental rationality, evidently put on the thickest of rose-coloured lenses when perambulating the fixed capital of the
Japanese countryside.” Therefore, the construction of seawalls in post 3.11 can also be seen in line with the historic financial stimuli invested in rural Japan.

![Figure 1. Taro’s seawall before the 2011 tsunami (Wikimedia Commons. Author Kihkyef, https://commons.wikimedia.org/w/index.php?curid=28852929)](image)

In addition to being a financial drive, concrete coastal defence have also played and continue to play an important political role. As mentioned earlier, hard coastline defence emerge as a response to devastating storm surges and repetitive tsunami. In 1979, Morgan already suggested that in Japan seawalls and breakwaters are ‘tangible evidence’ or demonstration of the concern of the central government and thus contributed to Japan’s opting for technological solutions with regards to coastal flooding mitigation [7]. As such, they contrast to other human responses such as disaster education and prevention, which might be seen as less measurable and thus making less of an impact on the public opinion. Regardless again of the fact of whether they are the correct response or not, seawalls and other technological solutions represent a visible proof for politicians and public figures eager to show their sense of responsibility for the safety of Japanese citizens.

An important dimension of Japan’s concrete coastal defence is their being a symbol of Japan’s modernization. While Boret carried out his doctoral research, he was often surprised to observe the extent to which concrete was exposed within the Japanese urban and rural landscapes while the same material might have been hidden in Europe. Informants would often respond that concrete was ‘kirei’. Kirei can be translated in the English language both as ‘beautiful’ and ‘clean’, an aesthetic, which they see as embodying ‘the very sense of modernism’ [4]. As such, one might argue that the admiration for concrete seawalls and breakwaters is as much about their technological prowess as it is about their pleasing aesthetic and being a symbol of modernity.
Although brief and incomplete, this overview enables us to appreciate that Japanese people’s use and perception of hard coastal defence is not only about the idea of protecting the local population from tsunami, storm surges or other coastal natural hazards. Indeed, I would hypothesize that lay people might be more likely to appreciate the symbolic and aesthetic values of concrete coastal edification rather than the functions as imagined and designed by engineers in laboratories. Yet, this is not to say that people living on the coastline did not understand their actual purposes. Indeed, the grandeur of seawalls, like that of Taro, did provide a sense of security, which, as we will see in the next section, fired back during the tsunami of March 11, 2011.

3. Seawalls during the Great East Japan Disaster: A False-sense of Security

On March 11 2011, a M9 earthquake triggered off the Tohoku region in Northeast Japan one of the most destructive tsunamis ever recorded in modern history. The waves reached up to 39.7 meter high and advanced up to 5 kilometres inland [6]. The tsunami caused not only the death of 15,854 people but also a material loss of over 210 billions US dollars [7]. People from all over the world witnessed on their television screens the extent of the devastation. They watched again and again videos of tsunami waves easing through Japan’s coastal defence and overtopping its large concrete seawalls. Even the giant seawall of Taro was considerably damaged and could not stop the district from being ravaged (Figure 4). These images were all the more distressing to local tsunami engineers and experts who had been preparing for the disaster for years onwards and who saw the earthquake and the tsunami of 2011 exceeded all their predictions.

Following the Great East Japan Disasters, fierce debates surrounded the inadequacy of the coastal defence of the Tohoku region. The X-shape of the aforementioned sea wall in Taro, for instance, led to an accumulation and increase in size of the tsunami at the center of the seawalls. In some areas, the sea walls were not properly maintained or not connected to each other and in some cases nearby riverbeds made the soil unstable which led to an easier collapse of the seawalls [2]. Two days after the tsunami, an article published in the New York Times argued that many experts had already warned against the inefficacy of seawalls to protect people [11]. Using quantitative data and statistical analysis, Aldrich and Sawada concluded that seawalls had no averting effect on the number of causalities. Instead they argue that social cohesion had a much greater impact on people’s behaviour. They found that those who evacuated and survived were “heavily influenced by neighbors and friends who urged them to do so or came directly to their homes to ensure their safety” [10].
Yet for tsunami experts, the efficacy of Japan’s coastal defence appears more variable. The Subcommittee on Tsunami Loads and Effects of the American Society of Civil Engineering (ASCE-EERI) reported that while 90% of unprotected areas were completely annihilated by the tsunami, the damaged suffered behind seawalls were rather localised. Based on this evidence, Omira et al. concluded that in addition to tsunami warning systems and education “coastal sea-defences, even though overtopped, helped to slow down the tsunami waves and reduced the extent of the impact” [8].

Rather than their actual efficacy, our interest lies in the ways in which seawalls and coastal defence in general might have provided coastal communities with a false sense of security. The mayor of Minamisanriku, who saw his town vanish literally under his feet as he was holding onto the communication mast of the town disaster prevention centre, touched upon this problem. In addition to the malfunctioning of the warning system, he reported to have said that the town's seawall…gave people a false sense of security” [12]. In Taro, Gillis suggests, “people standing atop the town’s monster seawall felt they were safe, but all were washed away… Seawalls also reduced the coastal population’s awareness of the sea more generally [13]. The lack of knowledge and the false-sense of security might have reduced the chance of people evacuating on time and as such maybe referred to as a ‘moral hazard problem’ [10].

4. Innovation in Post-3/11 Japan: The Great Forest Wall Project
In an attempt to draw lessons from the Great East Japan Earthquake, engineers and local governments have developed new approaches to coastal defence. For instance, they developed a ‘new generation of super levees’ combining both a seawall and a super embankment raising the level of the ground by up to ten meters. Such strategy means that coastal community are not fenced from the sea and should be
able to observe any threat coming from it, thus avoiding the creation of a false sense of security. However, super levees are relatively costly structures and cannot be built in all areas.

Another strategy is the creation of ‘The Great Forest Wall’ consisting mix-broadleaf forests planted on the top of newly built evacuation hills. The initiative is lead ecological experts, environmental advocates, local governments and Buddhist priests. Its chairman and vice-chairman are respectively Morihiro Hosokawa, a former Prime Minister and anti-nuclear advocate, and Akira Miyawaki, a Japanese botanist and director of the Japanese Centre of International Studies in Ecology. The councillors include artists, religious leaders as well as tsunami engineers. As will be explained below, this national project brings together thousands volunteers from all over the country.

The first element of the Great Forest Wall is evacuation hills. The hills are made of various layers: tsunami debris, various waste, soil dug on construction site and finally the topsoil for the trees. (Figure 3). The tsunami debris comprise trees, concrete and bricks, all of which have been crushed to make the base of the hills. The height of the hills vary 5 and 12 m depending on the choice made by the local governments and the central government, which are responsible for their construction.

![Figure 3. Section of a hill, The Great Forest Wall (Photo from the author, Sébastien P Boret)](image)

Forming the second element of the Great Forest Wall, mix-broadleaf forests are planted on the hills in order to slow down tsunamis and storm surge, and avoid the back flow of tsunami debris at sea. The use of forests in order to protect coastal communities is a fairly common and old practice in Japan [2,3]. Salt tolerant and native to the mountainous coastline area, black pines (pinus thunbergii) have been customarily planted along the coast to shield people from hazards and bad weather conditions coming from the sea [13]. However, their short roots and their low density meant that they offered almost no resistance to the great waves of the 2011 tsunami and even turned into debris [2]. Instead, the trees planted on the hills of the Great Forest Wall Project are broadleaf species that are native to the area. Most of these trees are evergreens and their roots to reach between four and six meters within 15~20 years making them strong and resistant to floods.
In order to plant these forests, the leaders of the project gather regularly thousands of volunteers from around Japan during their tree planting days. Only in 2013, 8,500 volunteers had planted over 60,000 trees in three different areas including Sendai, Minami Soma and Iwanuma. The mayor of Iwanuma has already announced a ten-year project plans for the creation of several 10-meter high hills within the 10 km that runs along its coast. The participation of volunteers is one of the innovative forces of this project by encouraging social activities and solidarity through the realization of coastal defence.

Although less mentioned, the third element of the Great Forest Hall Project, at least at “The Hills of 1000-year Hope”, one of the sites of the Great Forest Wall in Iwanuma, is disaster remains. Since the preservation of disaster remains causes serious debates in Tohoku [15], it may be surprising to see that the memorial park included remains of the city. Among these remains, one can observe the foundation of houses, a metallic tower and the gate of a shrine. In the same vein, the second site of the Great Forest Wall Project still in Iwanuma also comprises remains of the past including an old storehouse and a Shinto shrine. If this observation is limited to two sites, it might be said that the Great Forest Wall has not only the potential to connect people with the sea but also with the past.

Figure 4. Great Forest Wall Tree Planting Day (Photo by Sébastien P. Boret)
Leaving aside the question of its actual merit as a coastal defence, the Great Forest Wall may well represent a break away from conventional approaches. Firstly, the realization of coastal defence, which have always been the domain of scientists and the State, has here become a concern for people from all spheres of society. As such the project is above all a social initiative where people within and outside the region of Tohoku may contribute to the protection of future generations, improve the ecological environment and remember the past. Secondly, coastal defence, which has been seemed as fencing off people from the sea, is here a mean of bringing people closer to it. While carrying fieldwork on the site of the ‘The Hills of 1000-year Hope’, Boret observed people happily walking the steps leading to the top of the hills in order to appreciate the view of the coast and the sea with a sense of security. The result is a coastline defence, environmentally sustainable and socially binding.

5. Conclusion
The beginnings of this paper are rooted in the request to discuss how the observations of social scientists may help coastal engineers to improve the reconstruction of the Tohoku region. In all evidence, this paper has brought little novelty to coastal engineering, at least to Japanese experts. However, we hope that this embryonic reflection has pointed at some of the more subtle changes on the evolution of Japan coastal defence following the Great East Japan earthquake. For instance, it suggests a relative shift has taken place in laypeople’s perception of coastal defence. An example of this is The Great Forest Wall Project which shows some of the underlying social innovation that are taking place within coastal defence strategies during the aftermath of the 2011 tsunami. This project, despite its name, does not conceive coastal defence as fencing off people from the sea but as a way of creating a buffer or liminal zone, which preserve people’s relationship with the sea while still absorbing the energy of coastal flooding and limit their impact by using the very force of nature. As such, we might suggest that, like new Super Levees, and the Great Forest Wall, albeit through different strategies, does not create the false-sense of safety that might have been responsible for so many deaths during the 2011 tsunami. Finally, although coastal defence strategies remains heterogeneous in Japan, this paper may point out that the experience of the Great East Japan Disaster might not only have change Japanese people
perception and relationships with coastline defence and the sea as a whole, but also created a space where engineers and scientists may share their knowledge with coastal communities, thus bringing engineering and social innovations around a common project.

References
[1] Horikawa, K. History of Coastal Engineering in Japan. In Kraus, N. C. (ed.) History and Heritage of Coastal Engineering, 336-372. Danvers: ASCE.
[2] Suppasri, A., Shuto, N., Imamura, F., Koshimura, S., Mas, E. and Yalciner, A.C. (2013) Lessons learned from the 2011 Great East Japan tsunami: Performance of tsunami countermeasures, coastal buildings and tsunami evacuation in Japan, Pure and Applied Geophysics, 170(6-8), 993-1018.
[3] Suppasri, A., Latcharote, P., Bricker, J. D., Leelawat, N., Hayashi, A., Yamashita, K., Makinoshima, F., Roeb, V. and Imamura, F. (2016) Improvement of tsunami countermeasures based on lessons from the 2011 great east japan earthquake and tsunami -Situation after five years-, Coastal Engineering Journal, 58 (4), 1640011.
[4] Kerr, A. 2001. Dogs and Demons: The fall of modern Japan. London: Penguin Books.
[5]. Kingston, J. 2011. Contemporary Japan: history, politics, and social change since the 1980s. Chichester: Wiley-Blackwell
[6] Dewit, A. 1998. Caught Over a Pork-barrel: Decentralizing Japan’s 1940 Fiscal Regime, Studies in Political Economy, 57:1, 103-127
[7] Morgan, J. 1979. The Tsunami Hazard in Tohoku and the Hawaiian Islands, The Science Reports of the Tohoku University, 7th Series, Geography, Sendai: Tohoku University.
[8] Omira, R. et al. 2013. Performance of coastal- sea-defense infrastructure at El Jadida (Morocco) against tsunami threat: lessons learned from the Japanese 11 March 2011 tsunami, Natural Hazards Earth System Science, 13, 1779-1794.
[9] Ranghieri, F. and Ishiwatari, M. (eds) 2014. Learning from Megadisasters: Lessons from the Great East Japan Earthquake. Washington: The World Bank.
[10] Aldrich, D. P. and Sawada, Y. 2015. The Physical and Social Determinants of Mortality in the 3.11 Tsunami, Social Science and Medicine, 124, pp. 66-75.
[11] New York Times, March 13, 2011. Seawalls Offered Little Protection Against Tsunami’s Crushing Waves, article by Norimitsu Onishi
http://www.nytimes.com/2011/03/14/world/asia/14seawalls.html?pagewanted=all&_r=0 (accessed on October 7, 2015)
[12] Folger, T. 2012. The Calm before the Wave: When and where will the next tsunami hit? National Geographic Magazine. http://ngm.nationalgeographic.com/2012/02/tsunami/folger-text (accessed September 17, 2015)
[13] Gillis, J. R. 2012. The Human Shore: Seacoast in History. Chicago: The University of Chicago Press.
[14] Chow, Tsz-hin Clement. 2013. Tsunamis: The perception of risk and to minimize their damage, HKU (accessed on September 18, 2015)
http://hub.hku.hk/bitstream/10722/192409/1/FullText.pdf?accept=1
[15] Sakaguchi, N. 2020. Why didn’t the residents preserve the disaster remains? A case of the Great East Japan Earthquake and Tsunami. Presentation at the “2020 International Disaster Kataritsugi Forum”, Kobe, January 25, 2020.