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# **PROJECT**

**Downtown Otsuchi in September 2018, flood gates and seawall under construction** (Jeremy Bricker)



# Japan Tsunami Reconstruction in Yuriage & Otsuchi

International and interdisciplinary research  
and education



**Yuriage and Otsuchi (Japan)**



**AUTHORS** Fransje Hooimeijer (TU Delft), Jeremy Bricker (University of Michigan), Frans van de Ven (Deltares), Adam Pel (TU Delft), Amin Askarinejad (Swiss Federal Office of Energy)

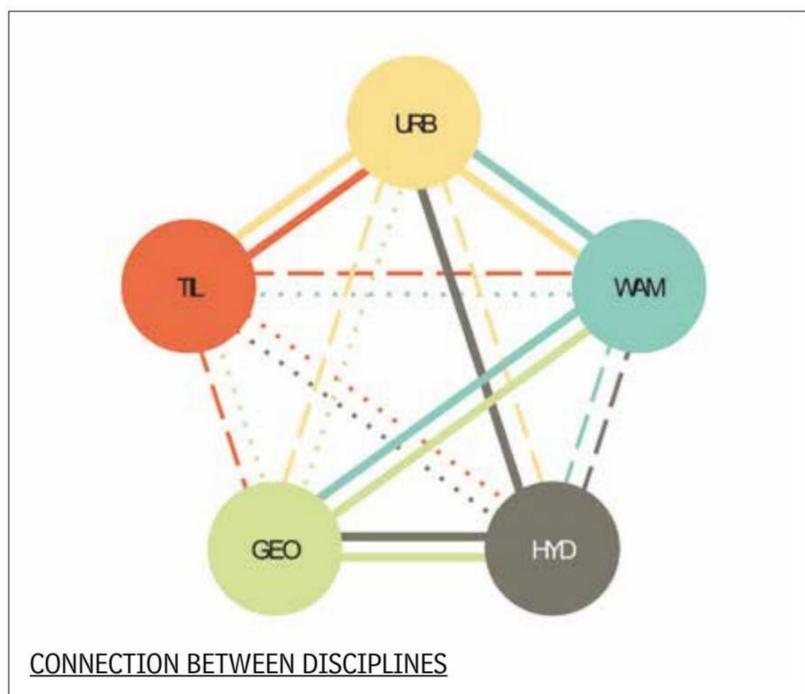
**TYPE OF PROJECT** Two student projects

**YEAR** 2017 and 2018

**PARTNERS** Tokiotech, Tohoku, Waseda and Tokio University, Municipality of Natori, Otsuchi disaster recovery office, Municipality Vlissingen

**LOCATIONS** Yuriage and Otsuchi (Japan)

**KEYWORDS** Tsunami, Interdisciplinary, Urban infrastructure, Designdelisti



CONNECTION BETWEEN DISCIPLINES

## INTRODUCTION

### After the earthquake

On 11 March 2011, Japan experienced a magnitude nine earthquake that caused an enormous tsunami that was felt across the Pacific Ocean. Waves with heights of up to 40 metres destroyed most of the eastern coastline in the Tohoku region; 560 square kilometres of land were inundated. Over 15,000 people died, and more than 2,500 people went missing (Conti, 2018). The displaced population is estimated at around half a million, and the damage at around US\$ 200 billion (Oskin, 2017).

This area was already in socio-economic decline due to the shrinking fishing industry, internal migration to other Japanese cities, and demographic changes. Yuriage is a coastal village, part of Natori, on the Sendai plain in the Miyagi prefecture. Almost one thousand residents of Yuriage lost their lives, and around 80% of the houses were washed away (Murakami et al., 2012). Otsuchi is a coastal village of approximately 10,000 inhabitants in Iwate Prefecture, located among steep mountain slopes. The disaster took 1281 lives (Nakai, 2013), while a built-up area of 216 ha was destroyed.

Both towns were reconstructed with the funding of and along the guidelines issued by the Government of Japan, which gave the municipalities a leading role in the reconstruction process on the condition that only what was there before could be reconstructed (Tanaka et al. 2012). In Yuriage, this resulted in moving housing out of the coastal zone, raising the town centre by 4-6 metres, and implementing vertical and horizontal evacuation routes. In Otsuchi, the main measure was the construction of a 14m-high seawall and floodgates, raising a 31 ha residential area by 2.2m, and restricting specific functions in the coastal zone.

### Challenge

The restrictions of the national programme meant that urban planning departments had to reconstruct the original, pre-disaster condition of the towns. The hydraulic engineering department engineered two levels of protection: L1, dike building, and L2, land-level raising and displacement. The research aim was to create an integrated approach and to research whether the post-tsunami reconstruction could include innovation and anticipate population shrinkage while creating high-quality urban areas.



Yuriage's reconstruction with top left the blocks of flats also with vertical evacuation routes, top right the view to the sea with only dedicated to industrial use, bottom left the new elevated residential area and bottom right the height difference between the housing area and the surrounding polder landscape (Fransje Hooimeijer)

### **PARTICIPANTS**

The research was done by TU Delft staff from the departments of Urbanism, Water Management, Hydraulic Engineering, Geo Science, and Transport, together with master students in Urbanism, Landscape architecture, Architecture, Management in the built environment, Hydraulic structures and engineering, Water management, Geoscience, and Transport. The field trip was organised in cooperation with staff and students from the Sustainability Science and Coastal Engineering departments of Tokyo Tech, Tohoku University, Waseda University, and Tokyo University. The methodology developed during this project guided the process and focused on integrating goals and ideas from all participating disciplines.

### **PARTICIPATING STUDENTS**

**Hydraulic Engineering** Xenofon Grigoris, Toni Glasbergen, Jochem Roubos, Jesse Salet, Álvaro Prida Guillén **Urbanism** Jesse Dobbelsteen, Nasiem Vafa, Marieke Oosterom, Neil Moncrieff, Gayatri Mujumdar, Emma Flores **Geo-engineering** Mustaqim, Femke van Overstraten, Nataly Filipouskaya, Antoine Gori **Transportation** Marieke van Dijk, Robert Moehring, Toshiya Yasaku, Eline van Unnik **Water Management** Sven Suijkens, Ainoa Areso, Ilse Nederlof, Sophie Broere **Landscape Architecture** Aditya Rao; **Building Technology** Nimmi Sreekumar **Management in the built environment** Aylin Özcan **Architecture** Zoe Panayi

# visions applied

## **PROJECT RESULTS**

### **Yuriage**

The impact of the 2011 Great East Japan Earthquake and Tsunami off Japan's east coast on 11 March was enormous, as were the consequences for the affected communities and the trauma sustained by the nation as a whole. Were its dikes and coastal defences to fail, the Netherlands would face a disaster of similar proportions.

A group of students from five disciplines investigated how multidisciplinary teams could work together in post-disaster reconstruction and how these working methods and recovery solutions might be applied to a hypothetical flood scenario in Vlissingen, the Netherlands. Two collaborative workshops were conducted – one in Yuriage and one in Vlissingen – in which the students performed interdisciplinary research and design.

### **The criteria**

For the Yuriage case, the focus was on the process of interdisciplinary cooperation that shaped a project vision that was elaborated upon with a conceptual design. The design requirements for the Japanese case had to meet the Level-1 and Level-2 protection criteria (City Population, 2018). Level 1 is for the inundation area of a 1:100-year tsunami, where no industrial or residential land use is permitted; Level 2 is the inundation area of a 1:1000-year tsunami, where only hospitals and schools must be safe. The design requirements for the Dutch case are that the primary flood defences should protect the area against a 1:4000-year storm and that the plan should account for 2 metres of sea-level rise. With these requirements in mind, two multidisciplinary teams prepared a vision and strategy for Yuriage.

### **Vlissingen**

In the second workshop, the merits of this vision were applied to Vlissingen. To prepare for a scenario in which a similar disaster would hit Vlissingen, Group A decided to reduce the circumference of the city and move a compact, elevated centre further inland. In this scenario, the centre of Vlissingen remains will remain in the same location to preserve the historical and emotional connections. The space between the sea and the new core will become a natural flood defence area with a coastal forest combined with dunes as a first layer of flood defence, suitable for seasonal and permanent flooding. The area will supply rainwater buffers, recreation, agriculture, and biodiversity to the city, which is elevated with the debris of the destroyed town. Water will also play a role within the city, as infiltration and storage capacity will be added to the streetscape in the form of water squares, urban infiltration strips, and blue-green roofs on buildings.

Group B chose to rebuild the area washed away by the hypothetical flood. The buildings, infrastructure, and cultural artefacts that survived have sentimental value, like the ones in Yuriage, which is important when recovering from a disaster. The new urban infrastructure plan consists of zones of typical land use geared to their relative flood vulnerability. The coastal zone is the main line of coastal defence with a dike that also plays a role in water storage and public space, mitigating as much as possible the forming of a barrier, by forming a functional connection between the city and the sea.

Although the city centre, the second zone, is elevated, there will be a greater acceptance of occasional flooding by floodproofing the building typologies and providing an evacuation infrastructure. The third zone changes most dramatically, as the low-lying agricultural and suburban lands will be allowed to be flooded periodically for flood attenuation, redirection, and water storage. The current traditional land use will be adapted to the cultivation of saline crops or the creation of a natural environment.

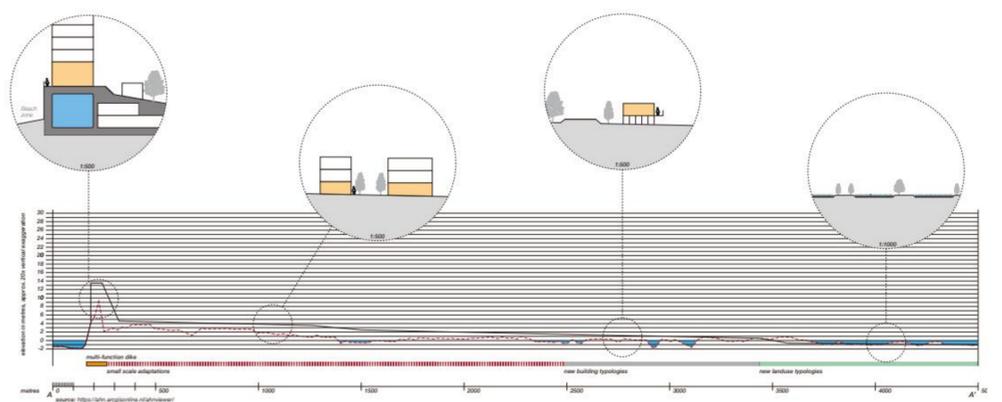
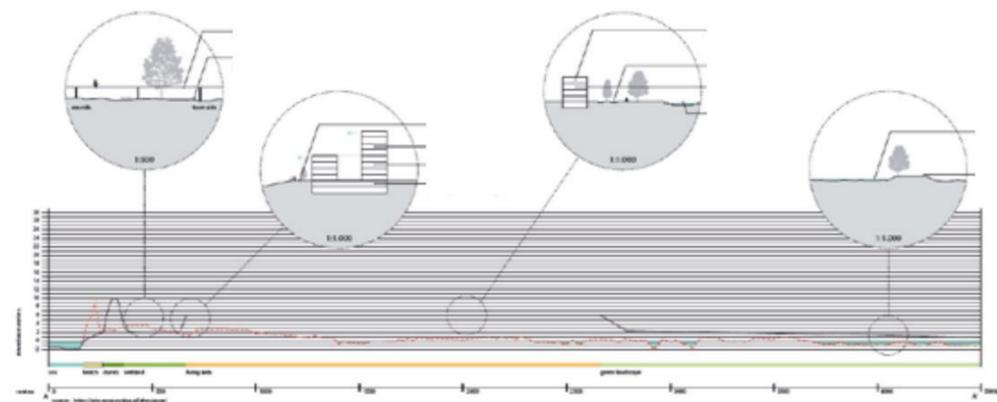
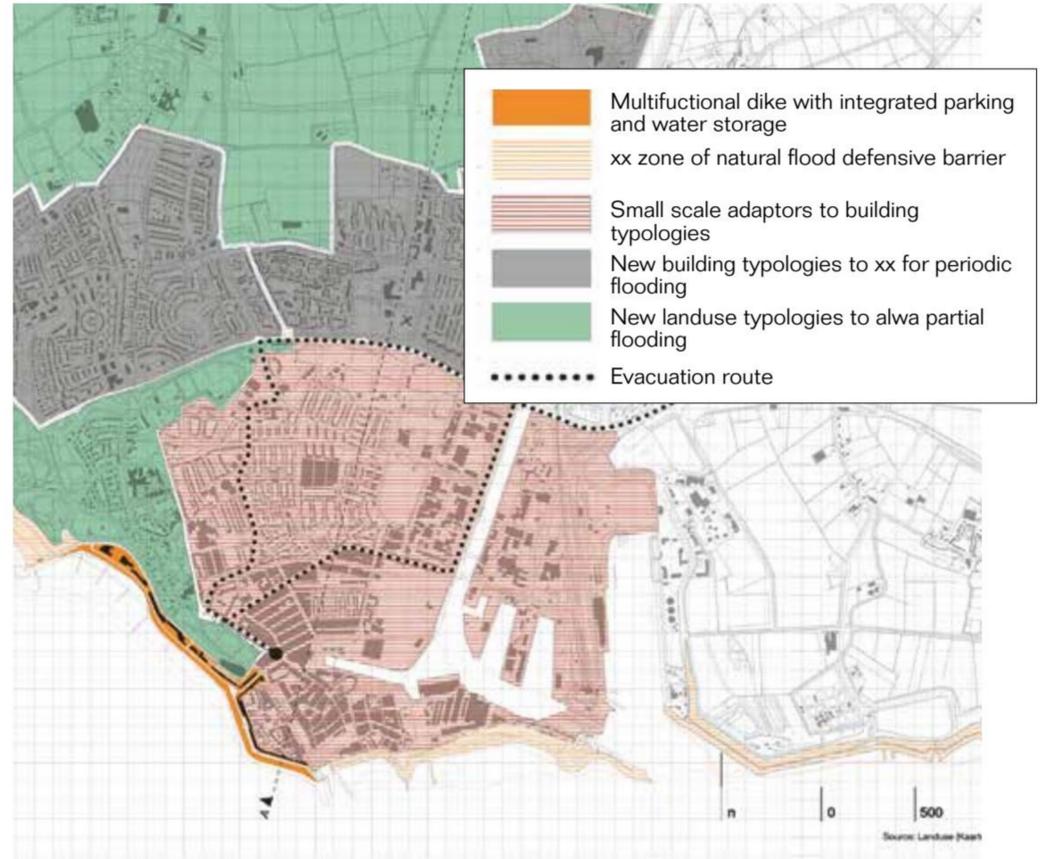
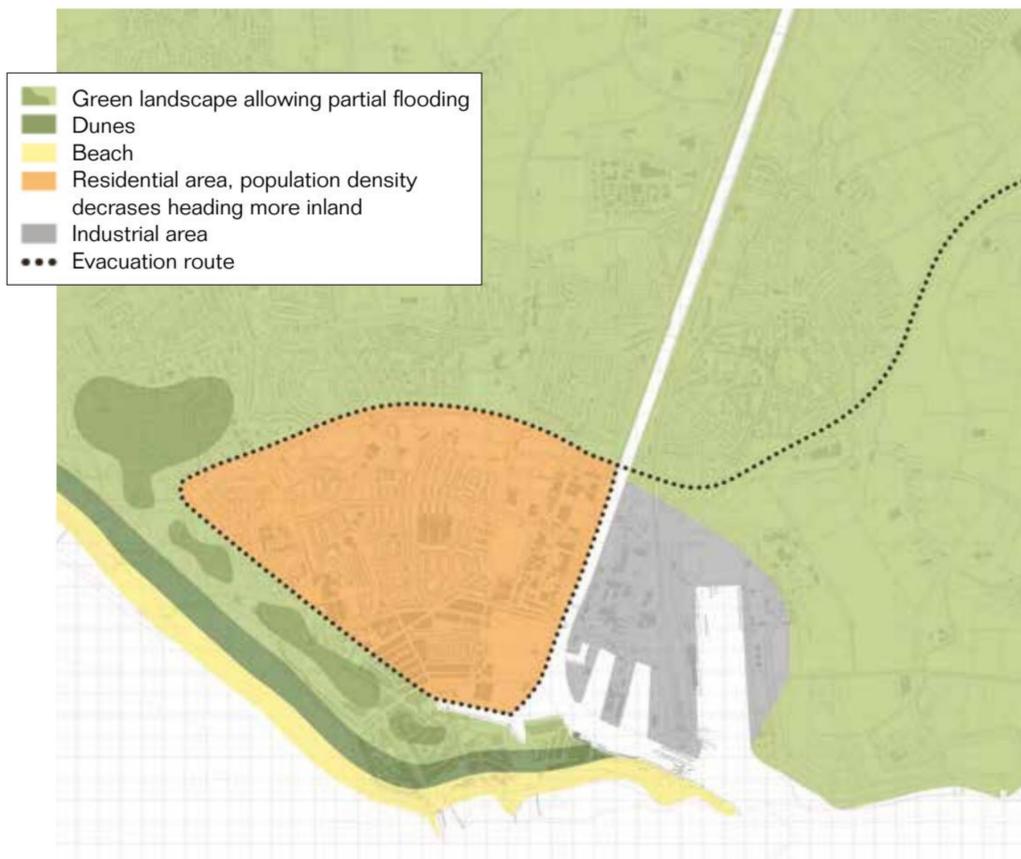
3.2.3 **PROJECT** Japan Tsunami Reconstruction in Yuriage & Otsuchi

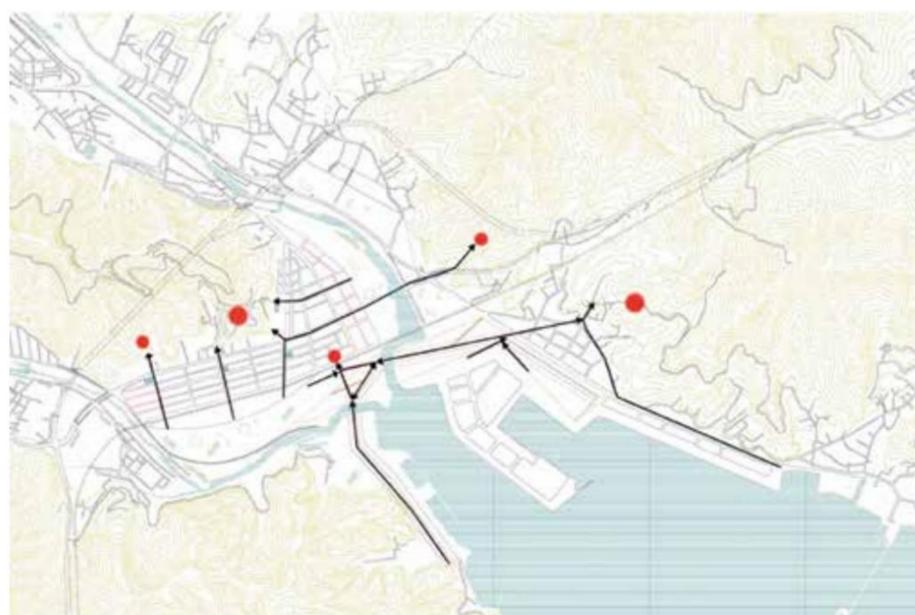
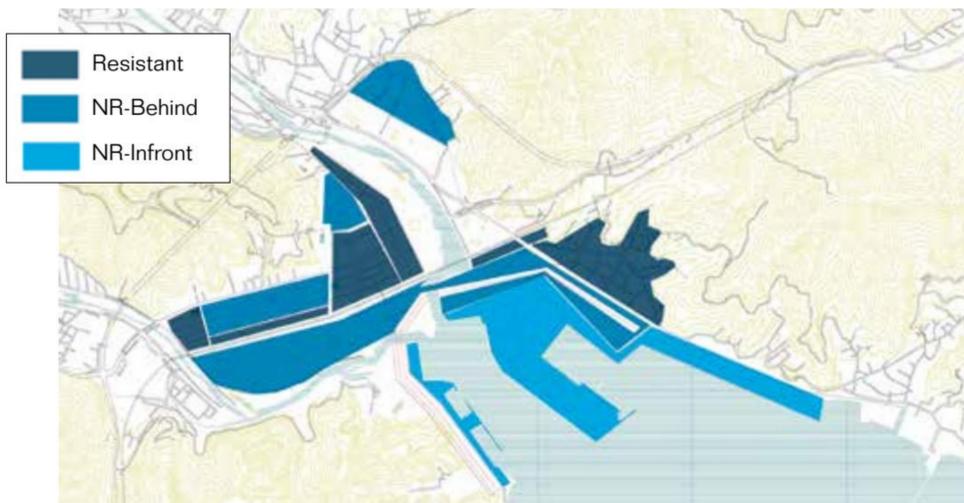


Top image shows the concept design for the reconstruction of Yuriage by team A in which they continue on the raised city and surround it with a natural buffer: a tsunami-proof forrest. Below: the application of this concept to Vlissingen, and the design details. (Source: Areso Rossia et al., 2018)



Top image shows the concept design for the reconstruction of Yuriage by team B in which they continue on the raised city and propose different functional zones. Below: the application of this concept to Vlissingen, and the design details. (Source: Areso Rossia et al., 2018)





**The reconstruction of Otsuchi: Land use; Building typologies and Evacuation map** (Source: Broere et al., 2019)

## Otsuchi

The tsunami reconstruction strategy for Otsuchi was captured in a transferable framework that could be used to build on the reconstruction plans of other municipalities subject to devastating natural disasters. The first step of the strategy was to define clear objectives and aims for the project. The objectives were fulfilled by creating a shared project vision for the technical disciplines involved, resulting from the scoping method (see chapter 2). The project vision stands for the resilient future development of Otsuchi, aiming to improve the day-to-day quality of life and provide the necessary safety measures in the case of a disaster. The design vision was worked out on two scales: the building scale and the urban scale.

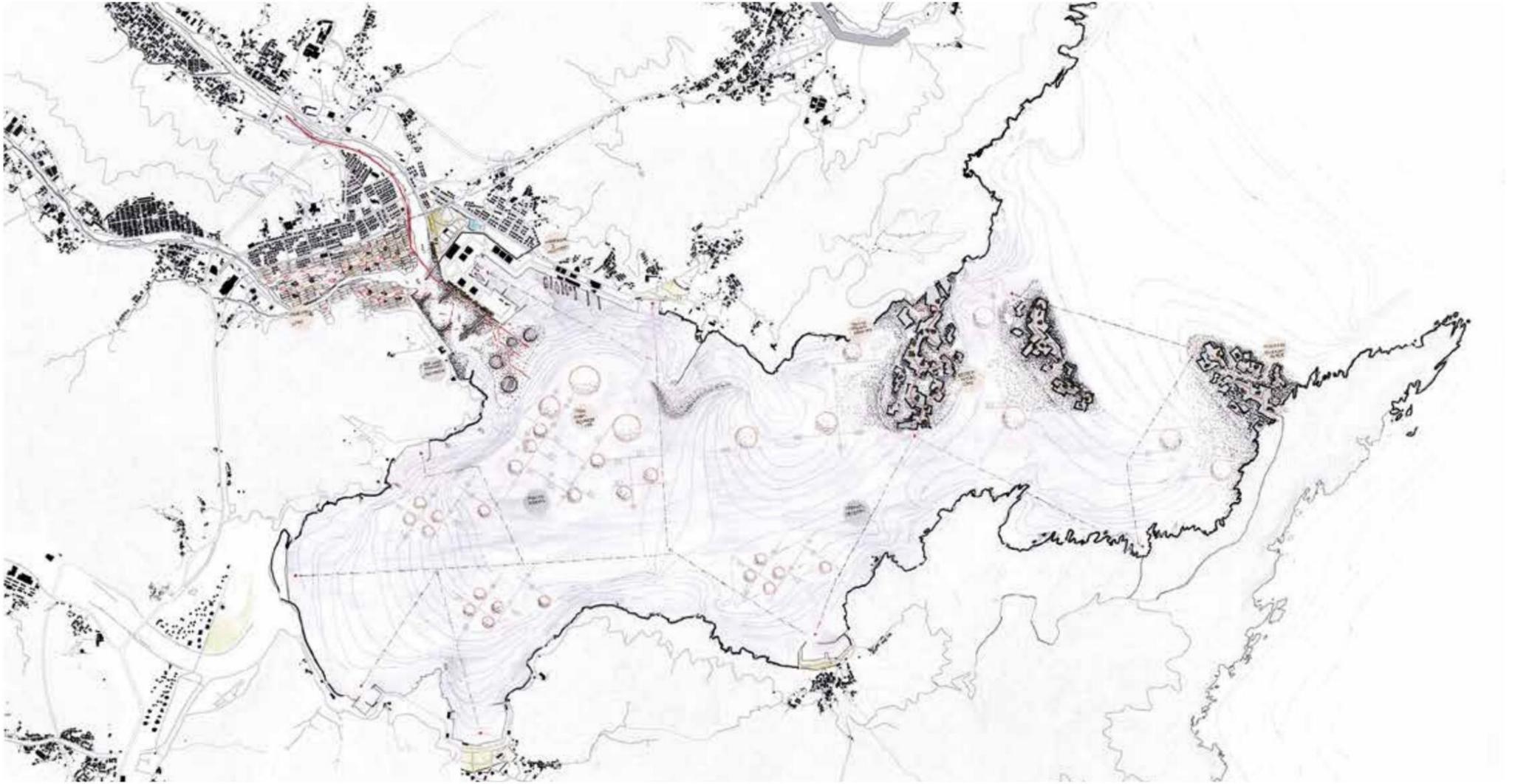
## The design

The design developed by the group consisted of a Level-1 multifunctional flood defence along the shoreline, and flood gates at the mouth of the Otsuchigawa and Kozuchigawa rivers to stop the tsunami from progressing upstream. The spatial plan was modified to reduce the material damage in case a Level-2 tsunami occurs. Furthermore, a more effective evacuation plan was developed to create awareness among the population about the horizontal evacuation routes and identify strategically optimised locations for new vertical evacuation buildings. Finally, the new spatial plan includes space for growth, to facilitate the return of citizens displaced by the previous tsunami.

a trans  
framework

## Spatial integration

The improvements to the interdisciplinary team's reconstruction plan provided by the interdisciplinary design concern the spatial integration of L1 and L2 measures. The dike can be lowered to L2 because the spatial configuration of residential and recreational natural zones behind the dike will reduce the consequences of flooding.



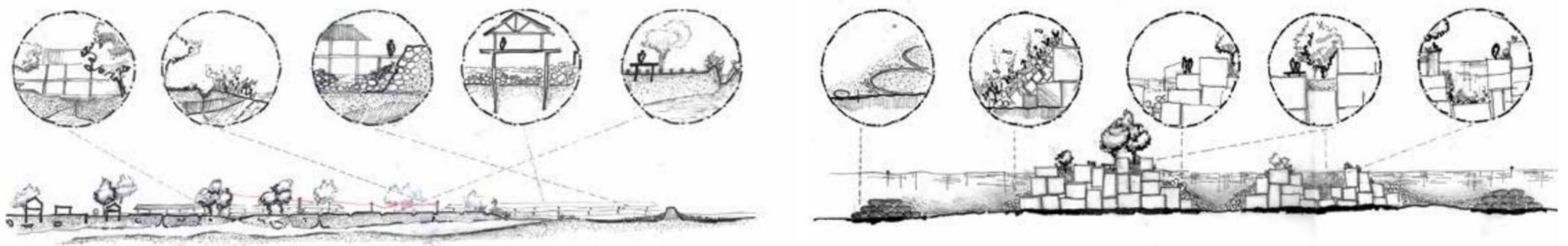
Masterplan Otsuchi showing the interventions on regional scale: the tsunami buffer in front of the bay, the production islands in the bay and redesign of the dike as a multifunctional public space (Aditya Rao)

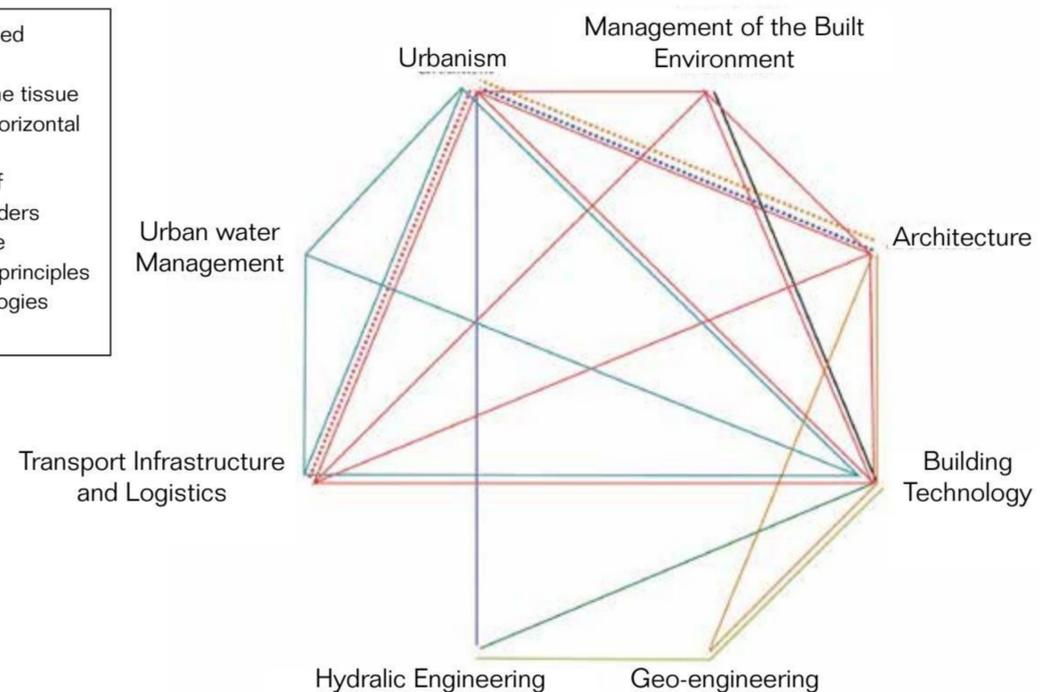
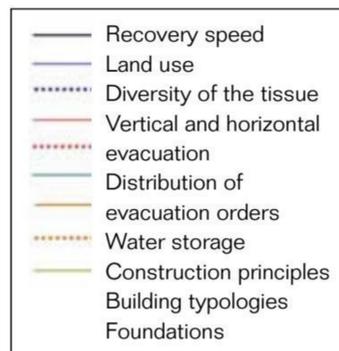
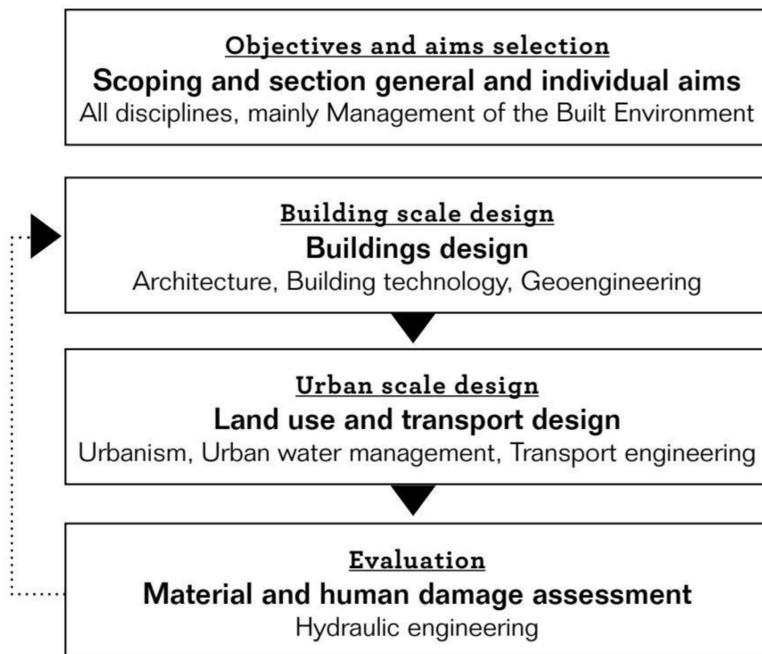
The redesign of the village in which housing is concentrated in the centre and the bufferzone is productive landscape with markation of the wells (Aditya Rao)

Details of the design of the landscape pergola that connects the village to the sea side (Aditya Rao)



sferable  
work





**Proposed interdisciplinary strategy for developing the new design for Otsuchi on the left that is supported by the interdisciplinary design connections on the right** (Source: Broere et al., 2019)

## EVALUATION

According to an evaluation conducted by the students, the civil engineering students felt they already had been trained in multidisciplinary work, while the architecture students had received training in interdisciplinary work. This is indicative of the greater trend where engineers are trained to solve problems with well-defined boundary conditions (tame or structured problems), while spatial-design students are more comfortable with wicked problems, in which they need to define the boundary conditions themselves. For these boundary conditions to be defined in a practical, implementable way, engineers need to be up to the task of tackling wicked problems head-on, together with architects and other non-technical disciplines. If engineers are not equipped for this task, then unfeasible, uneconomical, and unsustainable solutions may be promoted by disciplines without training in optimisation, innovation, and implementation.

## New approach

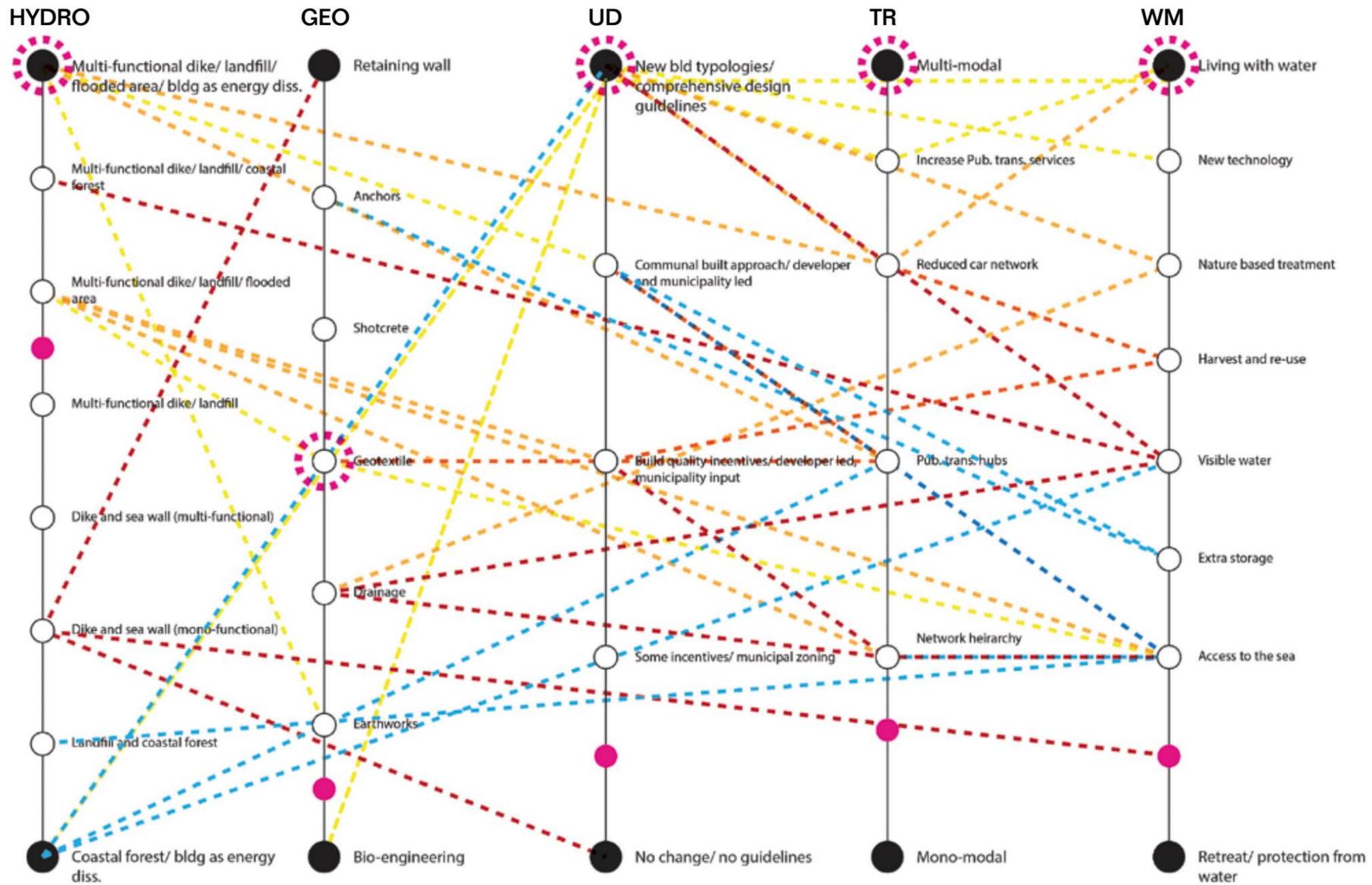
The projects in Japan have given a tremendous boost to interdisciplinary learning and resulted in the Tohoku method (see chapter 2). This enhanced the research collaboration between the participating faculties and research groups, especially urbanism, hydraulic engineering, water management, geo-

technical engineering, and transport. This extended to cooperation with the Japanese universities and with students from yet another discipline: environmental engineering. Working with local scientists and students is essential to making cultural connections. In Otsuchi, Mio Kamitani of the Otsuchi Disaster Recovery Office introduced the group to local people, which helped the students and staff to gain an insight into the trauma of the tsunami, which has had a major impact.

The interdisciplinary design required for this research project had the added benefit of coupling the experience of mentors from different disciplines with the open attitude of the students. The students enjoyed the professional discussions with the mentors, which helped them to reflect on the projects, the methods, and the theory.

## Longue Durée

The Longue Durée in the Japanese case is the historical way to deal with tsunamis: because they are far apart, people forget to adapt to the risks. In the towns in the area that was studied, houses have always been rebuilt in the flood risk zone over time. The students in both groups have incorporated this aspect by creating reminders of the risks in spatial interventions and by programming the flood zone with temporal functions.



The result of the scoping method of group B in Yuriage, showing the interventions and ideas per discipline allow for integration (Source: Areso Rossia et al., 2018)

### CONCLUSION

The interdisciplinary and international research education project focused on urban development in disaster reconstruction areas that had suffered from pluvial, fluvial, and coastal flooding. The ‘disaster’ condition was important because it yielded current and active cases in which, due to recent experiences, the aspect of safety and the role of infrastructure were quite important. A second important issue was that for experiential learning, which is a structured activity focusing on participation and interaction. Urban development is a natural arena for multidisciplinary and interdisciplinary design, balancing out sectoral or stakeholders’ interests. For example, interdisciplinary design can be found in urban spaces that serve diverse goals of multiple domains: as a green space for urban amenities and health (urbanism), an important

space for nature (landscape architecture), providing a good environment (architecture) that holds water but prevents flooding (water management) and that involves roads and transport (transport).

### Lessons learned

The lessons learned are about the relevance of team building, organisation, methods (scope, values etc.) and clear process steps; knowing what each discipline can and cannot do; and recognising that in infrastructure and environmental projects in post-disaster reconstruction, which are wicked by nature, the learning process is evaluated quite differently for disciplines used to solving tame problems than for disciplines used to dealing with wicked problems. There is not just one solution to the problem, there is not even just one problem.

# Colophon

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