

# Transferring Inter-disciplinary Flood Reconstruction Responses from Japan to the Netherlands

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## Abstract

Japan and the Netherlands have very different physical, historical and cultural contexts but they share a vulnerability to extreme flood related events and have, in both their (relatively) recent pasts, had to recover from such events: the floods of 1953 in the Netherlands or the tsunami that hit Japan's east coast in 2011. This paper describes the process and results of two workshops investigating flood reconstruction responses undertaken by students representing five disciplines at TU Delft in the Netherlands. A particular workshop method was employed to promote an interdisciplinary design process and then design responses investigated for the Japanese case were transferred to a hypothetical disaster scenario for Vlissingen, in the south of the Netherlands. The conclusions reached focused as much on the efficacy of the workshop method as the particular design proposals for both cases, as well as on what was learnt via the comparison between Japanese and Dutch contexts and reconstruction philosophies.

**Keywords:** *interdisciplinary design; international comparison; tsunami; Vlissingen; Yuriage*

## 1. Introduction

The impact of the 2011 Great East Japan Earthquake that followed the magnitude nine earthquake and level two (over 15m high) tsunami off Japan's east coast on the 11th of March, was enormous, as are the consequences for the affected communities and the trauma for the nation as a whole. Were its dikes and coastal defences to fail, the Netherlands would face a disaster of similar proportions. This paper describes the process undertaken by a number of students representing five disciplines at TU Delft to investigate how multidisciplinary teams could work together in post-disaster reconstruction and how these working methods, as well as recovery solutions, might be applied to a hypothetical flood scenario in Vlissingen, the Netherlands. Two collaborative workshops were conducted - one in Vlissingen and one in Yuriage, near Sendai on Japan's northeast coast, north of Tokyo - in which the students split into two groups, individually prepared preferred proposals for the post-disaster reconstruction of each case study by discipline and then came together in an interdisciplinary setting (integrating and sharing disciplinary approaches and methods) to refine the designs.

In the introduction the physical settings and interdisciplinary working process are explained, as well as the purpose of this project from the perspective of both the process and the design components that both played an important role in this research. The method is split up into two sections in which the approach undertaken in the process and the design phase are explained step by step. Hereafter the results section presents an overview of the outcomes achieved both during the process and the design stages. The most important findings on both of these phases are summed up in the conclusion. The details and calculations of the designs mentioned in the results can be found in the appendix.

## 2. Physical setting

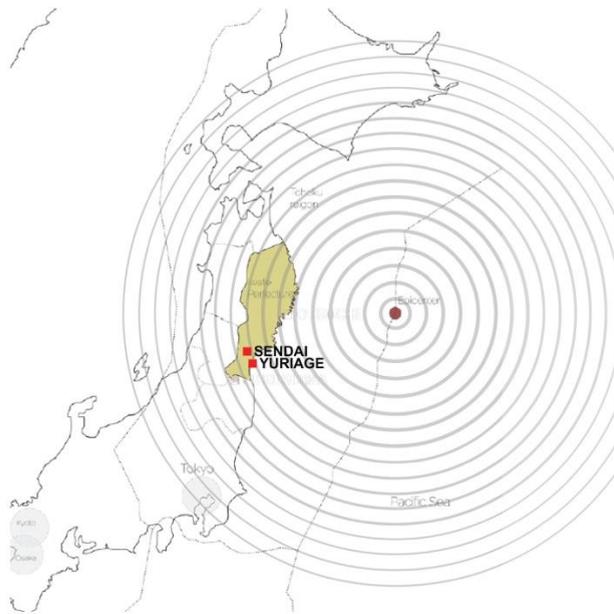
### 2.1 Yuriage

On March 11, 2011, Japan experienced a magnitude nine earthquake whose epicentre was 24 kilometres deep in the ocean 72 kilometres east of the Tohoku Region (3) and that caused an enormous tsunami that was felt across the Pacific Ocean [1]. Waves heights of up to 40 metres destroyed most of the eastern coastline of Japan

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and in the Tohoku region 560 square kilometres of land were inundated, including up to 10 kilometres inland on the Sendai plain (see Figure 1). Over 15,000 people died as a result of the tsunami and more than 2,500 people are still missing, not to mention the damage to property and infrastructure. The displaced population is estimated at around half a million and the damage at around US\$ 200 billion [1].



**Figure 1** Seismic impact on Yuriage (part of Natori municipality) located in northeast of Honshu Island in Tohoku Prefecture [7].

While Tohoku's inhabitants clearly recognise the Pacific Ocean as a source of potential catastrophes, (particularly) after the 2011 Tohoku earthquake and tsunami, the ocean provides a source of income (fishing is the region's most important sector) and is a significant contributor to cultural identity [2]. However, this area is in decline due to internal migration to other Japanese cities and a shrinking and ageing population, socio-economic characteristics that add to the challenges of reconstruction planning.

This situation applies to Yuriage too. Yuriage is part of Natori, a city in Miyagi Prefecture, and was completely destroyed after the earthquake and tsunami. Almost one thousand of a total 73.000 residents of Natori lost their lives and around 80% of the houses were washed away [3]. Pictures of Yuriage before and after the disaster are included in Appendix A1 of this paper. The site visit to Yuriage showed the current situation of the area, six years after the disaster took place (Appendix

A2). New measures for tsunami defence fall into three categories (Figure 2):

1. Physical defences: a coastal levee, coastal disaster prevention forests, and elevated roads.
2. Evacuation: Vertical evacuation facilities and evacuation routes.
3. Relocation: Moving residents to safer inland areas.



**Figure 2** Proposed measures for tsunami defense [10].

## 2.2 Vlissingen

A large part of The Netherlands is located below sea level and today these areas are protected by a complex series of dikes and large-scale, engineered flood defences, such as Zeeland's delta works. These uncompromising measures were largely prompted by the 1953 floods and storm tide (caused by a combination of a high spring tide and severe storms) that resulted in a water level of more than 5.6 meters above mean sea level in some locations. A delta committee was appointed to prepare the Delta Plan proposals for thirteen structures (large scale dams, sluices and storm surge barriers) to protect the country from future flooding [4].

Vlissingen is, like Yuriage, originally a fishing town and today's economy is still intertwined with the sea (both in terms of industry and the maritime sector). The town is located on the island of Walcheren, effectively separated from the mainland by a north south running canal with much of the town's peripheral landscapes below sea level, protected by coastal dikes, dune systems or sea locks. The fact that in October 1944, the allied forces bombed the dikes around Vlissingen to inundate the island and thus weaken the German position shows how vulnerable Vlissingen is to floods. Nowadays, Vlissingen is still vulnerable to coastal flooding, mainly due to sea level rise caused by climate change. However, the city's vulnerability to urban flooding is becoming even more pronounced. A visit to the municipality showed that the capacity of the current sewer system is insufficient. Rain showers are

becoming more intense, causing sewage overflows and flooded streets.

Vlissingen and Yuriage are both historical coastal, flood-prone cities (see Figure 3), both derive a large part of their cultural identity and economic significance from the adjacent ocean or waterways, and they both suffer from an ageing population [5][6].



Figure 3 Flood disaster 1953 in Zeeland, southwest of the Netherlands, and location of Vlissingen [8].

### 3. Approach and Methods

#### 3.1 Interdisciplinary working process

True interdisciplinarity between different professional fields is not mainstream and still forms an unconscious part of spatial development [14]. This exercise gathered a number of Masters students from different disciplinary faculties at TU Delft to learn, understand and consequently develop a framework for collaboration on flood and tsunami reconstruction projects. The faculties in question were Urbanism (URB), Hydraulic Engineering (HYD), Geo-Sciences and Engineering (GEO), Water Management (WM) and Transport Infrastructure and Logistics (TIL). There were two groups, one group of master students that did their graduation project on Yuriage [15] [16] [17] [18] [19] [20] and the group of master students who participated as part of a Multidisciplinary Project course (engineering students) and Honours project (Urbanism) who eventually developed the final design refinement phases, with the exception of a TIL student [21]. Difficulties inherent in cross disciplinary communication and collaboration were amplified by the variety of student backgrounds (representing five different nationalities) and the choice of the initial case of tsunami reconstruction in Yuriage, Japan. This ensured that all students approached the project with

similar levels of background knowledge as few had been to Japan before and none were very familiar with Japanese culture, lifestyles or planning and engineering approaches. Perhaps as a means to encourage easy communication, forge connections or simply as an act of academic whimsy, the two groups were separated by gender. This, however, might have added another layer of complexity to the evaluation of the chosen process as groups of males and females clearly work and relate differently to each other, although it was interesting to note these differences when faced with a common workshop methodology (which consisted of a total of five one-day workshops, and another three day-long workshop during the fieldtrip). In this case, refining the process and experimental collaborative framework was the principal goal of the workshop and so, perhaps due to a lack of familiarity with the Japanese social and planning context, the short duration of the fieldtrip to Japan (only one week long), some difficulties gathering informational and planning resources and lack of a clear set of project goals, the reconstruction proposals for the Yuriage condition were rather preliminary in nature. Due to the fact that it was a study project the process is more important than the end result (which in practice is the other way around). For this case, the plans for new approaches to tsunami reconstruction in Japan in general, and for the case of Yuriage in particular, were simply a means to test the chosen collaborative approach. This emphasis on a particular process was also clear when the ideas for Yuriage were applied to the case of Vlissingen. These results were far more developed, maybe due to greater comfort with the particular interdisciplinary design framework, or perhaps a result of greater familiarity between team members (both personally and in terms of their professional requirements and preferences), and a Dutch context that the majority of participants were better acquainted with.

#### 3.2 Purpose

##### 3.2.1 Process

The intent of these workshops was first and foremost to investigate how a combination of relevant post-disaster planning disciplines might practically and effectively work together to produce proposals that are more than simply the sum of technical requirements. This required an emphasis on knowledge exchange between disciplines, building a common understanding, and the application of a structured methodological approach in a (to most participants) foreign context. As such, the workshops were also a

venue for international exchange of knowledge and experience between the Netherlands and Japan (hosted by Tohoku University, Sendai) in the fields of disaster prevention and recovery.

Given the unfamiliar context, disaster and cultural characteristics explored in the Tohoku workshop, its role was to act as a "learning ground" for Japanese design methods and approaches; approaches that could be combined with Dutch practice and then applied to Vlissingen, the "test bed" for new collaborative and international design methods and ideas.

### 3.2.2 Design

Both countries have faced several water related disasters in the past and have implemented various mechanisms with which to protect themselves from storm surges (in the Dutch case) and tsunamis (in Japan). The Japanese strategically approach the location of urban settlement and transport routes to minimise loss of life, ensure evacuation and reduce damage to critical infrastructure. This acceptance of risk is quite different to the Dutch approach where a very low flood risk is accepted.

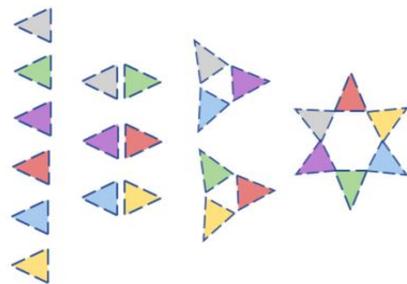
The physical (loss of life and infrastructure, including whole towns, as was the case with Yuriage) and psychological impacts of the 2011 tsunami clearly permeate all of the subsequent decision making for how to go about the post-disaster reconstruction. The study group as outsiders were in no position to comprehend the intricacies of Japanese urban and social patterns, but used a structured workshop approach to better understand current as well as historical mechanisms for flood and coastal protection.

The exposure to unfamiliar disaster recovery (not to mention cultural and settlement) processes does prompt one to reconsider and be more critical of local practices and assumptions. Also, the use of extreme scenarios (hypothetical in the Netherlands but very real in Japan) allows a clean slate to consider alternative coastal management and settlement practices for Vlissingen: a more strategic approach to the city akin to the Japanese philosophy.

## 3.3 Methodology

### 3.3.1 Process

The focus of the Yuriage workshops was to analyse multidisciplinary and interdisciplinary relationships between the five disciplines, and were carried out according to the charrette method [9]. This process refers to any interactive session in which a group of participants draw up a solution to a given problem. It consists of multiple sessions in which the group is divided into sub-groups, to enhance dialogue and contribution of ideas. The diversity within the sub-groups is intended to stimulate collaboration and promote the end goal of a shared solution. The goal for this specific project was to come up with an interdisciplinary design for both Yuriage (Japan) and Vlissingen (The Netherlands). The charrette model suggests a series of steps where disciplines are twinned in sub-group discussions and the size of each sub-group is gradually increased until, in the final session, one large group discussion is held with all disciplines (figure 4).



**Figure 4** Schematic representation of the charrette approach, each colour is a participating discipline with their scope, set of concepts and measures.

The first stage of the process consisted of an monodisciplinary analysis (i.e. a process conducted separately by each discipline) where a range of intermediate solutions between two possible extreme approaches (a minimum and maximum case for how a space might be built or designed according to the standards and principles of each discipline) are identified along an axis of techniques or possible approaches, also defined by each discipline. The current and ideal reconstruction positions for Yuriage are both placed along this axis according to each disciplinary perspective.

The next step marked the beginning of the charrette process and consisted of pairing up disciplines to discuss their set limits and explain why certain choices

were made (see Figure 5). For example, how the axis extremities were chosen and what observations saw the placement of Yuriage at a specific point along the line. Communication was critical during this exercise as certain design concepts may need more in-depth explanations to ensure each discipline understands what is being expressed. For example, GEO intended to use geotextile fabrics, but the benefits and limitations of such a (potentially unfamiliar) technique needs to be understood by all disciplines. This information exchange then took place between sub-groups of three disciplines before the final step of a group in which all disciplines were represented. The number of participants present at the workshop allowed for the creation of two design teams: Group A (made up of all females) and Group B (made up of all males), in which all disciplines were represented. Each group sought to forge connections between disciplines to identify how choices made by one discipline affected the others and reconcile these choices to produce an interdisciplinary design for Yuriage.

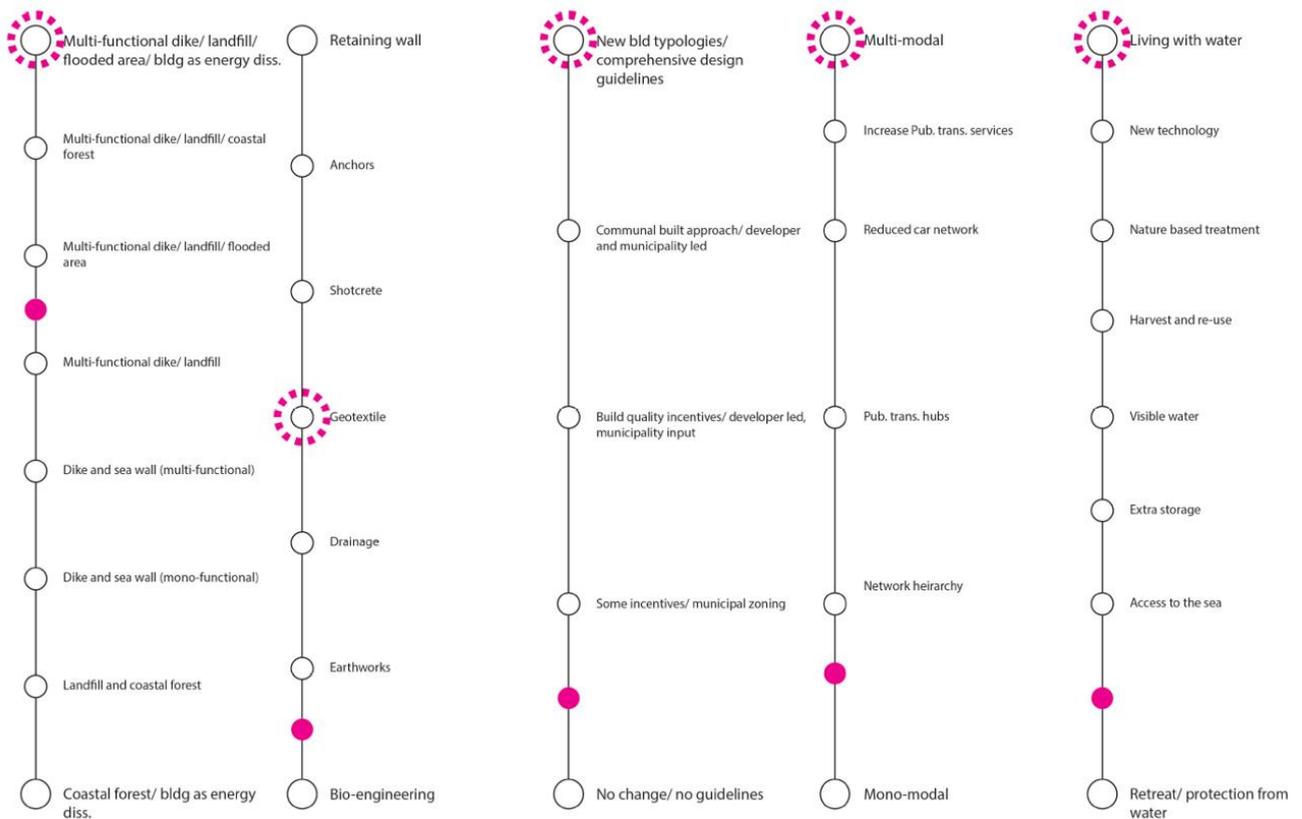
### 3.3.2 Design

For the Yuriage case, the focus was on the process of interdisciplinary cooperation that shaped a project vision that was elaborated via a conceptual design.

.This workshop process was repeated for the Vlissingen case, but the masterplan and disciplinary aspects were developed further.

A number of design requirements were set for each case including that boundary conditions (provided by the government of Japan and The Netherlands [10][11] are taken into account and that, for the Japan case:

- Level 1 protection line be provided against 1:100 year tsunamis, with no industry or residential areas to be built on the coastal side of this protection line
- Level 2 protection line be provided against 1:1000 year tsunamis; residential areas and industrial will be flooded by such an event. Only hospitals and schools should be safe.



**Figure 5** Schematic representation of the design process, showing the axis of minimum / maximum scale per discipline with notional positions of current (pink dot) and preferred approaches (pink, dashed circle) for Yuriage

For the Vlissingen case in the Netherlands:

- Primary flood defences should protect against a 1:4000 year storm.

- Sea level rise should be accounted for as the city should be protected against conditions similar to the storm in 1953, with an additional 2 meters sea-level rise. With these requirements in mind, all disciplines prepared a design most favourable from their perspective, which were then combined into a single design incorporating the most appropriate elements of each disciplinary design. Once the conceptual designs were prepared, each discipline refined their part of the design to incorporate their calculations or more detailed designs. Disciplines then reconvened to check if all the component parts still fitted together and if not, the designs were adjusted. This process was repeated until all aspects of each disciplinary design were combined.

## 4. Results

### 4.1 Process

#### 4.1.1 Scales of disciplinary measures

Prior to developing the interdisciplinary scopes, the study group visited the Yuriage site, were briefed by Natori municipal officials on the disaster and reconstruction process and held discussions with experts based at Tohoku University. This, along with each discipline's desktop analysis prior to the Japan trip, allowed the preparation of scale appropriate approaches.

Each of the disciplines determined a range of measures to be applied in the Yuriage reconstruction plan and placed them in a scale ranging from the most desirable (placed on the top of the scale) to the least desirable (placed at the bottom). The resulting scale functioned as a guide during the discussions between the disciplines. It helped to create understanding about the different, sometimes opposing, disciplinary perspectives among the group members and to define the links between them.

In the HYD scale, soft measures were placed at one side of the scale, followed by hard measures and ending up with a combination of both hard and soft measures at the other side of the scale. Initially, this scale was developed differently, with only nature-based measures at the bottom (min) and only artificial at the top (max), with the preferred solution, a combination of all, in the middle. However, this led to

misunderstandings and miscommunication with the other disciplines, so it was amended to the above mentioned scale from most to least preferred. GEO suggested a scale from engineered to nature-based solutions with measures going from retaining wall, anchors, shotcrete, geotextile, drainage to earthwork and bio engineering solutions. Interestingly, all disciplines, except for GEO, defined the extremes of each scale as the least desirable combination of disciplinary measures (min) on the bottom and the most desired (max) at the top. The GEO scale placed engineered solutions at the top and nature-based solutions at the bottom of the scale.

URB defined their scope between the extremes of innovative urban renewal (placed at the top of the axis as a preferred/ maximum approach) and conventional urban recovery (at the bottom of the scale, suggesting a minimum approach). The maximum approach includes the creation of new building typologies and implementation of new technologies (renewable energy, green/blue structures), whereas the minimum approach is confined to bringing back almost exactly what was lost, with additional measures to safeguard against tsunamis but with no change to the traditional urban planning approach in place before the event.

The TIL scope was defined between multi-modal (the preferred/ maximum approach) and mono-modal mobility infrastructures. Finally, the WM scope lay between the extremes of living with water (the preferred/ maximum approach) and protection from water by retreating from the coast.

The scales per discipline, as described above, can be seen in figure 5. The pink dot suggests where Yuriage's position currently is, as per each discipline's understanding, while the pink dotted circle suggests each discipline's preferred ("ideal") position for Yuriage in the reconstruction plan produced in the workshop. Yuriage's preferred position is at the top of the scale for all disciplines except for geo-engineering, a result of their alternate approach to the scale definition.

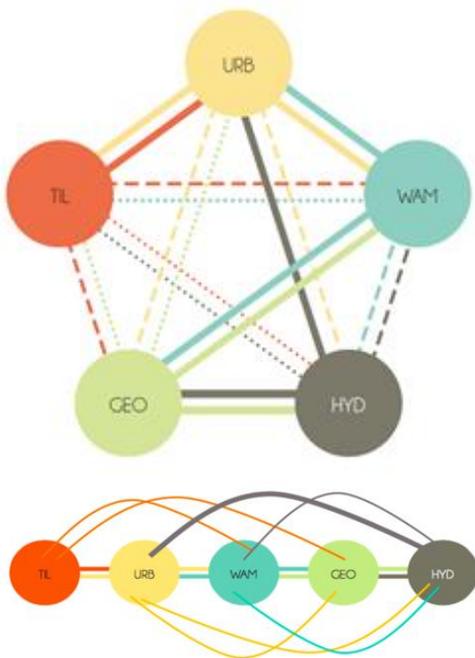
#### 4.1.2 Connections between the disciplines

Group A sought to identify what influence the design decisions of a given discipline would have on each of the other disciplines and characterised these links as either weak, medium or strong. For example, if HYD requires a dyke for flood defence, it will strongly influence the GEO discipline (strong link) since the type of soil plays a role in the design. This decision however will not have much influence on TIL (weak

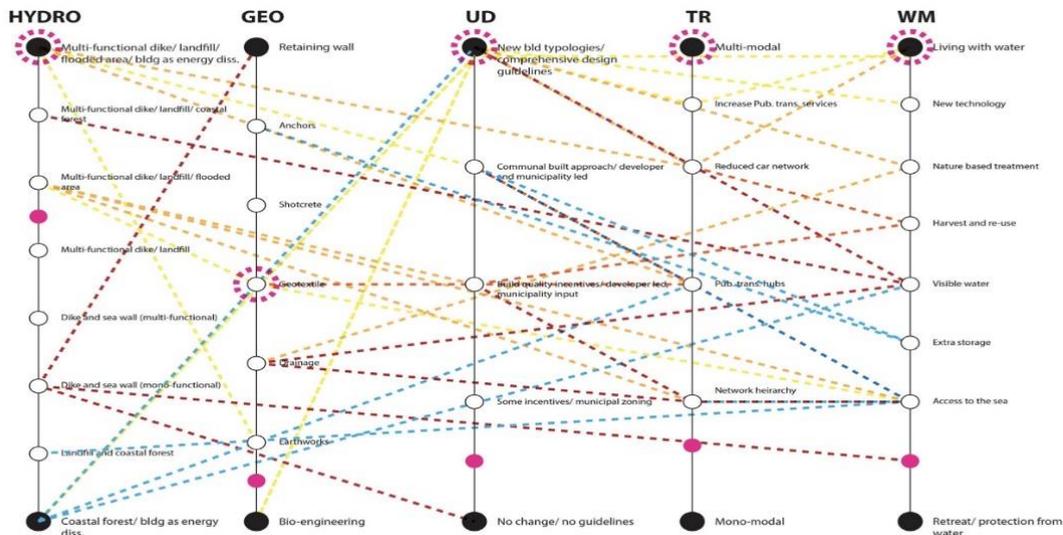
link), while for WM some drainage considerations may

**Figure 7:** Group B, illustration of all interdisciplinary links showing a strong link between the concept of the new build up area (URB) the use of geotextile (GEO) and visible water system (WM).

be required (medium link). See figure 6 for links between the five disciplines in which a bold line represents a strong link, a dashed line refers to a medium strength link and a dotted line represents a weak link.



**Figure 6** Group A, the lines show the strong (fat line) and weak (dotted line) between participating disciplines. The line colour indicates the direction of the perception, the grey lines consider hydraulic engineering relation to urbanism and geo engineering. The bottom visual indicates the strong relations that should be at the base of design decisions and feedback loops.



Almost all the strong links operate in both directions (double strong link) as there is strong link from TIL to URB, and from URB to TIL, although the links between HYD and URB are the exception.

Furthermore, the double strong links can be stretched out to form a line (figure 6, bottom part). This line represents the links that should influence the design, as well as suggest a sequence or starting point for design decisions. For example, HYD and GEO provide the engineering boundary safety conditions for the design and once this has been established, WM, URB and TIL can proceed to lay out their designs.

These feedback loops are also important when making decisions within a discipline to understand how they will affect the other disciplines. Again, in figure 6, the medium and strong links are shown as feedback loops that should be considered when preparing designs for Yuriage and Vlissingen. Interestingly, TIL's design decision process has little influence on the other disciplines (apart from the double strong link with URB) and GEO is the least affected by decisions made by other disciplines (excluding those of WAM and HYD).

Group B began by identifying solution sets through which disciplines could obtain co-benefits, so if a certain solution set overlapped with another discipline in terms of measures or goals, a line was drawn between these two sets (figure 7).

**Figure 8** Design proposal group A, illustrated section

Intensive discussions between students determined whether the influence was positive or not, but the goal was to determine which disciplines most influenced the others and in which areas was cooperation possible. The links were at first established between twinned disciplines and later were combined in a single overview (figure 7).

## 4.2 Design

### 4.2.1 Description of Group A proposals (Figure 8)

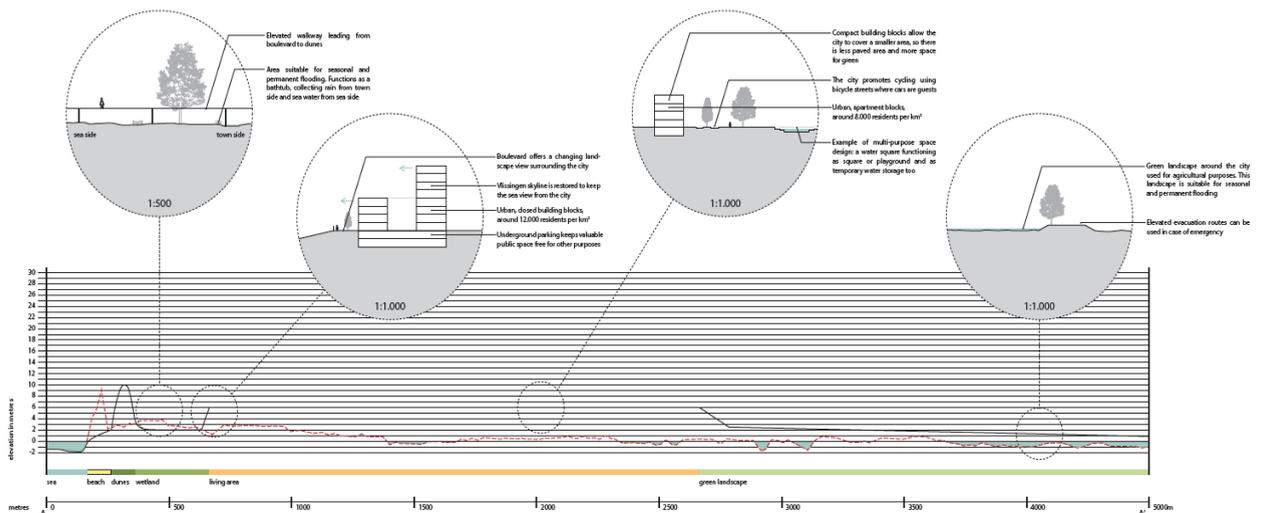
As the disaster scenario provided us with a tabula rasa, Group A decided to reduce the size of the town fabric. This promotes compact building blocks and multi-purpose spatial design in order to create a more climate resilient city. Furthermore, the new city core of Vlissingen will be located further inland. The footprint of the proposed area of aggregation covers a large part of the current town fabric, in order to preserve the emotional connection with this location. Locating the city core further inland allows us to utilise the wide strip along the coast and transform it into a natural flood defence area. This natural flood defence area contains a coastal forest combined with dunes as a first layer of flood defence. The strip of green between the dunes and the city is suitable for seasonal and permanent flooding, when the dunes are breached or overtopped. Furthermore, this vegetated area collects and infiltrates rainwater which flows from the city core. In order to include an extra layer of safety, the city

core is elevated by four meters. The elevation can be created with debris from the former town fabric. The green landscape around the city can be used for agricultural purposes and is suitable for seasonal flooding too.

When it comes to the experience of the new city, the connection between the city and the sea will be emphasised. Physically, this relation is present in the form of elevated walkways leading from the boulevard towards the beach. These walkways offer attractive routes for pedestrians to discover the new landscape. The skyline of Vlissingen will also be restored to offer a sea view to the residents. Water will play a role within the city as well, 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.

### 4.2.2 Description of Group B proposals (Figure 9)

While the disaster scenario that we were to contend with and the post-disaster reconstruction we were to plan for theoretically allowed us a clear slate (after the town had been flooded by a catastrophic storm surge), Group B chose to largely re-build on the current town fabric. This was under the assumption that aspects of the town layout and infrastructure might survive but also that the cultural connections with the current townscape were worthy of retention: the very same sentiments that saw the reconstruction of Yuriage in the same geographical location as the original village.



evacuation infrastructure and by new building typologies that might allow partial flooding of the ground floors without rendering the site

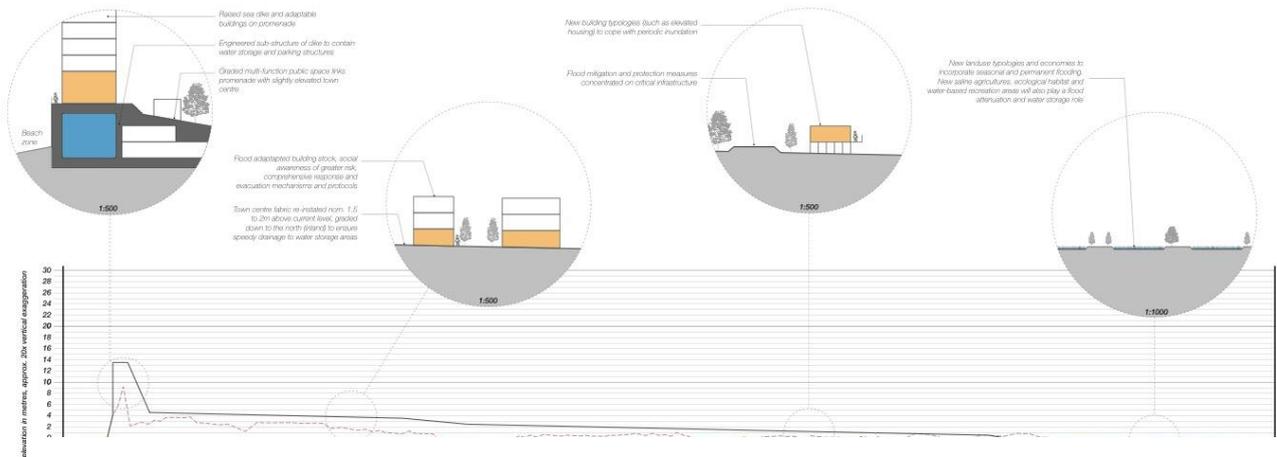


Figure 9 Design proposal group B, illustrated section

The urban landscape of Vlissingen was to be approached according to zones of land-use typology and flood management character (see figure 9 and appendix E2). These land-use zones were essentially dictated by the previous settlement typology (city centre, suburban, peripheral and agricultural landscapes), as well as by the factor most likely to indicate flood vulnerability: a site's elevation. Coastal protection requirements suggested a raising of the coastal dike to such an extent that the connection between the adjacent city centre and the coastal edge would be substantially obstructed. In order to mitigate the impacts of this, the dike was proposed to also play a water storage and public service provision role (car parking and other social functions) as well as contain a widened zone of public space that both moderated the change in level from the top of the dike back down to the adjacent city centre but also promoted sightlines and public accessibility.

The city centre was to be largely reconstructed, albeit with a slight rise in elevation to reduce elevation discrepancies and facilitate drainage towards water storage or infiltration areas. While this area (where most of the residents would continue to live) would be some of the highest in the new town site, there would need to be a greater acceptance of the risk of future flooding (an acceptance facilitated by the improved

uninhabitable). The most drastic change was proposed for the broad, low lying agricultural and peripheral

lands that are at present maintained to the same flood protection standards as the city centre. These areas would be allowed to be periodically flooded (and excavated as necessary to provide fill for artificially

elevated areas elsewhere) as a venue for flood attenuation, redirection and water storage, and the current traditional land use amended to the propagation of saline crops or the creation of natural habitat. Essentially the urban qualities of these peripheral areas are sacrificed to better secure the highly populated areas on the slightly elevated plinth that contains the city centre. Between these two zones lie an intermediary land-use on an area of steeper slopes that is intended to quickly carry away any floodwaters or excess storm water from the city centre to the low-lying flood plains. This area might still be populated, as long as the building typologies and public space design allow for this primary drainage function (housing on stilts and green corridors that double as uninterrupted, high capacity overland flow paths etc.).

### 4.3 Design steps per discipline

#### 4.3.1 Role of hydraulic discipline in the final design

The main scope of the hydraulic discipline was to provide the boundary conditions for the design. For this scope raw data were processed by simulating the 1953 storm conditions at Vlissingen using the SWAN software (Appendix C.1). Additionally, calculations were also made to define the final width (for Group A) and final level (for Group B) of the first line of defence. (Appendix C2, C3).

Hydraulics played more of a controlling role in the determination of the final design, by and ensuring that it complies with the safety and flood risk mitigation requirements. Interaction was mainly with URB and GEO by sharing inputs and receiving outputs, in order to find the optimal location, dimensions and layout of the protection works. Limits dictated by the boundary conditions (water levels and wave heights) had to be set and the other disciplines had to adjust their design to take into account these limits. However, there was the effort not to set very strict limits, in order to leave space for the fruitful input of the other disciplines. As discovered during the process, the hydraulic discipline leans more towards the technology than the human side and its scale of application is meso to macro, making it very broad.

Through the design process in Vlissingen, it became clear what principals need to be considered. Safety is the first priority, but socioeconomic and environmental factors should also be incorporated into the design to ensure it becomes more sustainable and resilient. The reconstruction time turned out to be of vital importance when designing, as a long reconstruction time would lead to people settling elsewhere and, thus, being unwilling to return to the place in question.

#### 4.3.2 Role of water management in the final design

From a water management perspective, incorporating climate resilient urban drainage solutions is the most important aspect. Several climate change scenarios predict an increase in rainfall intensities, and for Vlissingen hourly rainfall statistics were derived using 1990-2017 figures. Depth-Duration-Frequency and

Intensity-Duration-Frequency curves were determined by using an annual maxima analysis and the Gumbell distribution. These calculation can be found in Appendix D. Furthermore, the storage capacity required in the area was calculated with an urban drainage model, for which one of the most important inputs is the land use and runoff coefficient. This information was mainly derived from the urban design proposals.

The storage capacity is expressed in a Storage-Discharge-Frequency curve which shows the amount of cubic meters of water storage per hectare needed for a corresponding return period. The required water storage leads to a feedback loop for the urban design. For a return period of 25 years, a storage capacity of 225 m<sup>3</sup>/ha is needed, which corresponds with a spatial demand of approximately 5.6% of Vlissingen's total area.

#### 4.3.3 Role of Geo-Engineering in the final design

The geotechnical part of the design is the design and safety check of the primary flood defences. Group A wanted a natural flood defence barrier that demands a particular design for the profile of the dunes. This was done using Dutch regulations [12] and the sea conditions calculated by HYD. These regulations and conditions required a beach and dune width of around 450 meters and a height of 12,5 meters. These dimensions are used for the final design( See appendix B1 for the calculations).

Group B's design uses a dyke as primary flood defence, which is also designed according to the Dutch regulations [13], with the height determined by HYD. To limit the amount of overtopping, the height of the dyke should be almost 14 m. With slopes of 1:5 and 1:3, this gives a width of 70 m. The stability of the dyke was confirmed with D-Geo stability and is determined safe in different situations (See appendix B2 for the calculations).

#### 4.3.4 Role of TIL and Urbanism

As mentioned above the TIL students participated in the workshop, though for the final elaboration of the design the group lacked this discipline. Therefore, this perspective was part of the project, but was not further developed. The role of the students of urbanism was to do the larger landscape and urban analysis and propose the spatial integration of the group's decisions and input from the other disciplines.

## 5. Discussion & Conclusions

### 5.1 Process

True interdisciplinarity is still a challenge in today's projects and often represents more a sum of multidisciplinary approaches. The main purpose of the workshops was to investigate how several disciplines could effectively work together and whether a framework for interdisciplinary working could be set up and transferred to the Netherlands. Yuriage, therefore, acted as a learning ground for the more detailed design in Vlissingen.

During the charrette workshop sessions, collaboration is encouraged by starting with smaller sub-groups. Intensive discussion between disciplines, based on theoretical background before focussing on design aspects and solutions, stimulated true interdisciplinary solutions and visions. The principal challenge in the charrette approach was to adjust the scope of solution sets between disciplines. More technical focussed disciplines such as HYD and GEO were particularly difficult to match with other disciplines that might have had a broader scope of interests. Clearly, expressing how these disciplines affect each other was difficult and these problems were experienced by both groups. For disciplines where the interconnectivity was more clear, speedy and intensive collaboration was more possible from the outset.

The designs for Yuriage clearly influenced those for Vlissingen and this is likely a result of the use of the same interdisciplinary working framework. The established links between disciplines acted as a guideline in the technical elaboration and several feedback loops can be distinguished which were used by the group to fine-tune the technical details of the design in Vlissingen.

### 5.2 Design

The design produced for Vlissingen managed to incorporate most of the techniques the group learned during the Japan workshops. Contrary to the dominant Dutch approach of focusing mainly on the first line of defence, attention was given to multilayer safety with a larger scale, "broader" design that utilises a range of measures located more inland. The Japanese concept of elevated land proved useful in Vlissingen by suggesting that key parts of the urban environment are placed at a higher level to ensure that they remain

relatively safe, even if a breach of the primary defences occurs. Areas intended to flood are also used in Vlissingen to store part of the storm surge: by Group B in the redevelopment hinterland and by Group A between the dunes and the city centre. This not only makes the water volume more manageable but also creates a new topology where the Dutch notion of "Building with Nature" can be applied in this new brackish environment.

In Japan, strict attention is paid to emergency evacuation measures where disasters might occur with minimal time for evacuation, sometimes less than an hour, which in the case of Yuriage can be less than 10 mins. Japanese techniques might be applied in Vlissingen but in a more lenient manner, since the Dutch disaster timeframes are in the order of days before the arrival of a storm surge. In this respect, there is no need for a comprehensive network to facilitate immediate evacuation (as is the case for Yuriage) but an additional route out of the city (in addition to the single existing route) should be considered.

Concerning the primary defence, the Japanese technique of a high, wide sea wall is also proposed for Vlissingen but, in a form more integrated into the built environment, as a multifunctional dike in accordance with Dutch philosophy. Thus, this technique is transferable to the Dutch context after some adaptations. The Japanese knowledge of scour protection can also be utilised, so in the case of overtopping a complete, uncontrolled failure of the structure will be avoided. However, hard materials predominantly used in Japan are replaced by grass in the Vlissingen case to create a more natural, environmentally integrated result. However, while the concepts can be transferred, the types of materials used in the design are less transferable, as concrete is predominantly used in Japan whereas soil, for the structure and grass, for the slope protection, are used in the Vlissingen design. This choice is determined by the local availability of materials and unique circumstances of each place. The utilization of traditional techniques is another lesson learned from Japan, where the tendency to respect tradition is widespread also in tsunami protection philosophy, as seen by the incorporation of old canals and coastal forest in Yuriage's tsunami defence system. Therefore, in a similar way the revival of the dike in front of the promenade, already existing before the imaginary disaster in Vlissingen, constitutes the incorporation in the design of a traditional element of the city.

Although far more conceptual than Vlissingen, the design for Yuriage might apply Dutch concepts. The choice of dunes over hard dike measures in Group B's design and the use of a beach in front of the coastal levees to create more room for recreation by Group A are approaches important for Dutch urban planning, yet not sufficiently utilised in Japan. Interestingly, both final designs for Vlissingen incorporated flood resilient techniques encountered during the trip in Japan, and this may partly have been implemented in an unconscious manner. For example, Group A used the elevation of land and retreat from the coastline, which was also incorporated in the reconstruction plans of Yuriage. However, in contrast to Yuriage, instead of using mainly concrete structures, this space was designed with implementation of natural elements such as sand dunes and vegetation. In a way this could be compared to the concept of a coastal forest, which is an ancient Japanese flood defence technique. Group B's design for Vlissingen maintained the characteristic high-rise building boulevard of this city, but gave it a multifunctional use of flood defence and recreation. Similarly, in Yuriage the reconstruction will include a high sea wall, though this structure will not have a second purpose.

## 6. Conclusions

The Dutch and Japanese flood protection approaches may vary in applied techniques, materials and design choices, but there are aspects in both approaches that could work well together and provide future solutions for resilient cities. There is much the Dutch can learn from the Japanese approach, in particular in terms of evacuation, but it is important to remember that the disaster events which both countries deal with are different in both time, magnitude and after-effects. A tsunami in Japan represents a shock disaster with large impact and short evacuation time, while the flood risk in the Netherlands is due to sea level rise and storms which are predictable over a longer period of time. However, both deal with severe flooding and both have histories of flooding, so flood risk reduction is part of their spatial planning culture, but due to the difference in impact this culture is not so comparable. The final designs for the city of Vlissingen integrated the knowledge acquired from both the cultures and techniques used in the Netherlands and those acquired in Yuriage. The combination of traditional Japanese techniques, such as coastal forests or an energy dissipation canal, might allow for an "international and interdisciplinary design", where the positive aspects of

both Dutch and Japanese flood protection approaches are present.

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