LEVEES IN A CHANGING ENVIRONMENT: FLEXIBLE & STRATEGIC LAND USE PLANNING

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Abstract

Water is wonderful and the Dutch love it! Yet there is much work to do. Now is the time to invest in plans to ensure the future safety and liveability of The Netherlands. Implementation of flood protection measures is already in full swing, with more programs scheduled to be executed over the following decade. However, the limits of the current approach have almost been reached. The Netherlands is already densely populated, while climate change leads to increased flood risk of highly vulnerable areas. The cost to implement measures is increasing, with available resources being under pressure. It is clear, that innovations in addressing flood protection measures, are necessary. In order to be able to anticipate on potential floods by means of effective and efficient protection measures, a more integral approach is required. A combination must be made between flood protection and spatial developments.

We observe that the current approach of dike reinforcements, is sufficient for the time being, but is nevertheless sectoral. Neither is it sufficiently robust for the long term. Opportunities to integrate flood safety measures with spatial plans seem to be few and hard to materialize. Processes and time periods are different between the two. In addition, policy making in public (national versus local), and public-private partnerships, are hindered by steering (legal) frameworks, complex organizations and a risk-averse attitude.

There is an urge for more insight into the possibilities for an integrated and flexible approach to dike reinforcement both in time and space. A framework enabling multifunctional levees, as part of this integral and flexible approach, has been developed and analysed on the basis of several cases within the Netherlands both in urban and rural areas. In this paper, this framework is addressed, and insights are given into new flexible strategic planning processes for both flood risk management and spatial planning

Introduction

A significant part of the world population lives in flood-prone areas. This includes coastal zones, river plains exposed to coastal or fluvial flooding risks and lowlands sensitive to flooding due to heavy rainfall or groundwater. More extreme weather events are expected to occur more frequently in many parts of the world, thus increasing the risk of damage to residents, economy, ecology and cultural heritage (Colette, 2007; Prasad et al., 2009). According to Kron (2005) climate change will result, in many cities, into more extreme flooding. Maplecroft (2014) show that the UK is among the countries with the greatest risk to their economic output, from flooding, behind the US, China, India, Bangladesh, Germany and Japan.

The urban population is expected to grow over 4 billion in the next 30-35 years (UNFPA, 2007). Population dynamics have a critical influence on each of the three pillars (social, economic and environmental development), leading to a necessity to arrange for sustainable cities in a broad sense (UNFPA *et al.*, 2013).

Expectations are that socio-economic and demographic trends will have a great impact on the Dutch way of living and working. Therefore, they will also have an impact on the way the Dutch deal with water and water management in the future. Economic interests must be protected. Behind the dikes lies 2.000 billion euros of invested capital. The size of the Dutch population may still increase (through immigration) or it may stabilize or shrink slightly (WPRB, 2009). The growth in the number of smaller households is slated to continue and, in the case of further economic growth and a continued rise in the ageing population, there will be a greater demand for living space and recreational facilities. This means that urbanization and the pressure on available space and water will continue to rise, especially in the Dutch Randstad conurbation. The Randstad 2040 Strategic Agenda estimates that there will be 500 000 new residences in the Randstad region by 2040 (I&M, 2008). Space is thus becoming of high value for the Dutch. In a delta where people have drastically interfered with the landscape, water management will demand a sustained effort.

A new Dutch policy, which was activated in 2009, is designed to create a reversal in thinking. Instead of increasingly adapting water systems to suit our own needs, the Dutch aim to give natural processes more space, making them more robust and less dependent on technology and changing circumstances. The consequences of climate change make the necessity that much greater. Examples of climate change include an accelerated rise in sea levels, higher peak discharges in the rivers, periods of drought or flooding and a shifting ecological balance.

This paper introduces a new integrated and flexible approach to synchronise flood safety and spatial planning in both time and space. A framework enabling multifunctional levees, as part of this integral and flexible approach, has been developed and analyzed. This framework is based on several cases within the Netherlands, both in urban and rural areas. Here this framework is addressed. Moreover insights are given into new flexible strategic planning processes for both flood risk management and spatial planning.

Flood Risk Management in the Netherlands and its influence on spatial planning

Flood risk management is an important part of the way the Dutch live in the Netherlands. The Dutch have a long history of attempting to control the floods. Already in the ninth century the Dutch were fighting against the water. There is a saying, stating that ‘God created the world and the Dutch created the Netherlands’. In the past centuries dikes have been created to reclaim the land (Kolen *et al.*, 2012). Prior to the devastating flood in 1953, dikes were built by the height of the previously known highest water levels plus a margin of safety.

Approximately 700 million euros per year is available for construction and maintenance of the dikes, to maintain the required safety level. The Netherlands is probably one of the best protected deltas of the world. However, continuous investments are required in

order to keep it safe. Expectation is that the required yearly budget will increase in the future due to sea level rise, subsidence and increasing safety levels going hand in hand with economic growth.

In recent years, a new strategy has emerged in the Netherlands related to new governmental policies on spatial planning and water management. The vision and mission of both policies are linked together, creating opportunities for incorporating measures for water management into city (re)building and landscaping. The Dutch are anxious to prevent situations like the flood disaster in Zeeland, the islands of South Holland and Western Brabant in 1953, and pre-emptive evacuations, due to high river levels in the mid-1990s. Our safety must be guaranteed now and for the future. It is essential, that we find solutions to potential future flooding problems. We also have to ensure that the Netherlands can adapt to the consequences of climate change.

Every six years, the safety of our dikes and dams is assessed and tested against statutory standards and current technological and hydrological (pre)conditions. Any part of the dike and dam, that does not fulfil the statutory standards, must be reinforced. The regional water authorities and the national government are partners in the protection of the Netherlands against flooding. The national government is in charge of the protection of the coastline and the maintenance of the dams, which close off the major sea-arms in the western part of the country. The other water barriers (dikes, dunes and quay-walls) are managed by the regional water authorities.

In the Netherlands the Water Assessment (WA) was introduced in the 21st century. It is an approach in which water is considered to be a guiding principle in spatial planning. This is a turnaround from a technical 'water follows function' towards a more socialised 'function follows water'. The WA is based on intergovernmental cooperation without changing the formal institutional framework (Van Dijk, 2008), thus leading to a stronger relationship between spatial planning and water management.

Conceptual model

Based on the so-called 'Dutch layers model' (VROM, 2008), the researchers identified three layers, (1) the layer of the substratum, (2) the layer of the networks and (3) the layer of the occupation pattern. These layers have different temporal and spatial scales. To these three layers, we added the element of coherence. We consider this coherence between the layers as the domain of spatial planning. Main assumption of the developers (De Hoog, Sijmons and Verschuuren, 1998) of the original model was that the substratum physically transforms slower than the networks, which in turn, transform at a lower rate, than the physical structures on the occupation layer.

For this research a literature review and several interviews were conducted to develop the framework. The framework was then tested on a fictional case in strong collaboration with one of the local stakeholders.
The framework was then adjusted and used on a real case. The data is gathered through triangulation of methods, such as a literature revision (secondary data) and by investigating a case with reference to semi-structured interviews, and a workshop (primary data). Triangulation in research refers to the use of multiple techniques for collecting data within a single study (Adami & Kiger, 2004).

Research showed that opportunities are created in the spatial area around a dike if the perspectives of time and space are taken into account. Integrated water management transcend boundaries in the physical system, as well as in the human system (2) include organisations both public and private and (3) is focussed on horizontal and vertical (national and local) (Karstens, 2009).

Temporal scale
Dikes and dams know for the domain space, a relative slow development path. Until now they are being constructed for a life span of 50 – 100 years in the Netherlands. Recently questions arose whether this long planning horizon is still relevant, as new technological insights and changings norms, induce a shorter life span. Road infrastructure already knows a shorter life span. The built environment (housing) knows a life span of 30-50 years, but demands and wishes are always present. From a cultural heritage point of view, buildings know a longer life span.

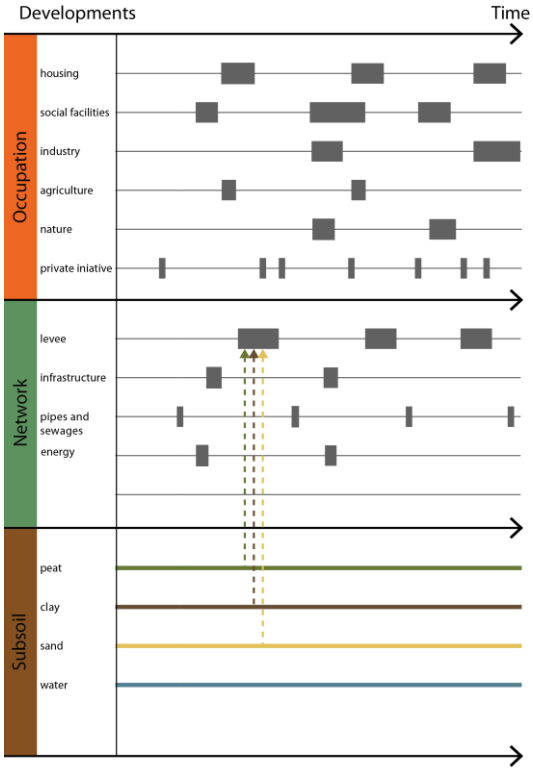


Figure 1 Three layer model

Figure 1 show that developments in time usually occur in the occupation and network layer. De substratum layer is of importance on the life span of dike reinforcements projects reoccurrence. A dike on peaty subsoil knows more subsidence and therefore a shorter life span to maintain the statutory standards. It is possible that the adjustments to dikes and dams can be synchronised to one or more other (spatial) developments. Whether the pace is equal to each other should be determined. The same applies for the spatial scale in which the development takes place.

Spatial scale

In case the flood safety and spatial development cannot be executed in more or less the same time frame, opportunities must be sought to create flexibility in space. Naturally the dike offers space for spatial development, either from existing or new functions. When the dike will not be reinforced, the water authority can offer flexibility. But only when the new function will not hamper the (daily) maintenance and reinforcements of the dike.

Developments can be developed independently in time of each other. Although there is a need that developments anticipate on one another (figure 2).

- Dike reinforcements can anticipate on future spatial developments
- Spatial development can anticipate on future flood safety development.

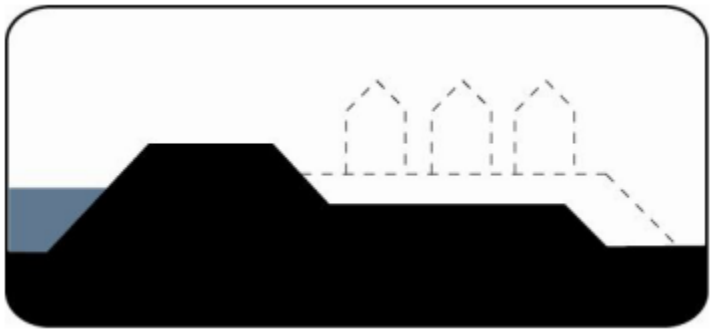


Figure 2 Schematic representation of anticipation on developments.

Combining both scales

According to Karstens (2009), the human system refers to the science around economics, spatial planning, sociology and policy. These social phenomena sometimes emerge on different scales in time and space. For this study the focus lies on the 'governance' around flood safety and spatial planning. The definition 'governance' does not only refer to a shift from problem solving capacity of the central and formal institutions of the government to decentralised authorities, market and social community. It also refers to the more hybrid arrangements in what political decisions about dealing with social issues take place (Bekkers, 2007). Typical for 'governance' is the self-regulating capacity. The government does not control from top-down approach, but becomes the inspector of the project. As stated before, decisions are taken in the presence of full-member group discussions. Another characteristic of 'governance' indicates the dependence between involved actors, which means, that collaboration is required in order to manage the environmental issues (Bekkers, 2007).
Another aspect identified by Karstens (2009) are the cross-scale interactions. Humans do not think in the long term, while most of the physical and human system processes operate at a very slow rate. Hence, if the long-term processes are being recognized and accepted, the human are challenged to combine these two scales.

Two strategies: synchronisation & anticipation

Two strategies have been identified. Naturally for each strategy possible advantages and disadvantages can be discussed. An important distinction between the two follows from the question, whether there is a flood safety issue and/ or the spatial development plans can be flexible, in time, and shifted, so that both coincide.
Strategy 1 deals with synchronising both developments in time. It this isn't possible the task lies ahead to create enough space to anticipate on possible future developments (strategy 2). In the next paragraph both strategies will be further discussed.

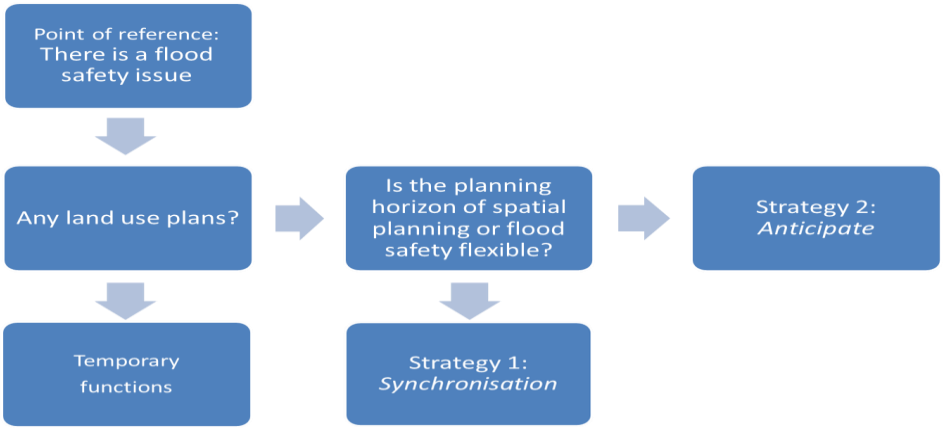


Figure 3 The different strategies explained

For each strategy we can also define different time scales, leading to different visions on possible solutions to create flexible and strategic land use planning.

Synchronisation

Synchronisation is another word for harmonization, or basically the linkage of the agendas from two or more stakeholders. Defining budget, execution, sharing costs and maintenance together. During synchronization, stakeholders are overlying and combining activities and developments.
In addition, there might be 'forced' synchronization, whereby developments are being accelerated or slowed down in order to bring them together (figure 3).
In practice, investments on an early stage lead to more benefits for the common developments. Flexibility in time and budget is one of the requirements to achieve synchronisation. More important is the prevention of programs and policies that introduce double regulations and perhaps conflicting policies after synchronising.
Collaboration not just happens, collaboration must be managed, although in a different way (Agranoff & McGuire, 2004). For successful sustainable collaboration conditions, such as openness, security, progress and content are required (van den Heuvel *et al.*).
In this synchronization, it should be noted, that future visions, climate changes are important, but cannot be entirely investigated. This part will mainly focus on strategies that enhance collaboration which can be applied to future challenges.

In the report of multifunctional flood defences (Tromp *et al.*, 2012), the discussion is on integrated management, which could be improved by positive incentives and a pro-active attitude of stakeholders.
More often, it is seen, that good partnership will enhance the process. In the NeWater report (Van Walsum *et al.*, 2005) it is found that the degree in which stakeholder are prepared to share costs and benefits, has large consequences for the design of a water management system.
The search for mutual coordination between governmental and non-governmental stakeholders is still inadequately used. According to Tromp *et al.* (2012) distrust against the collaboration is large because the pro-active person is not in line with the designated person for financial responsibility.

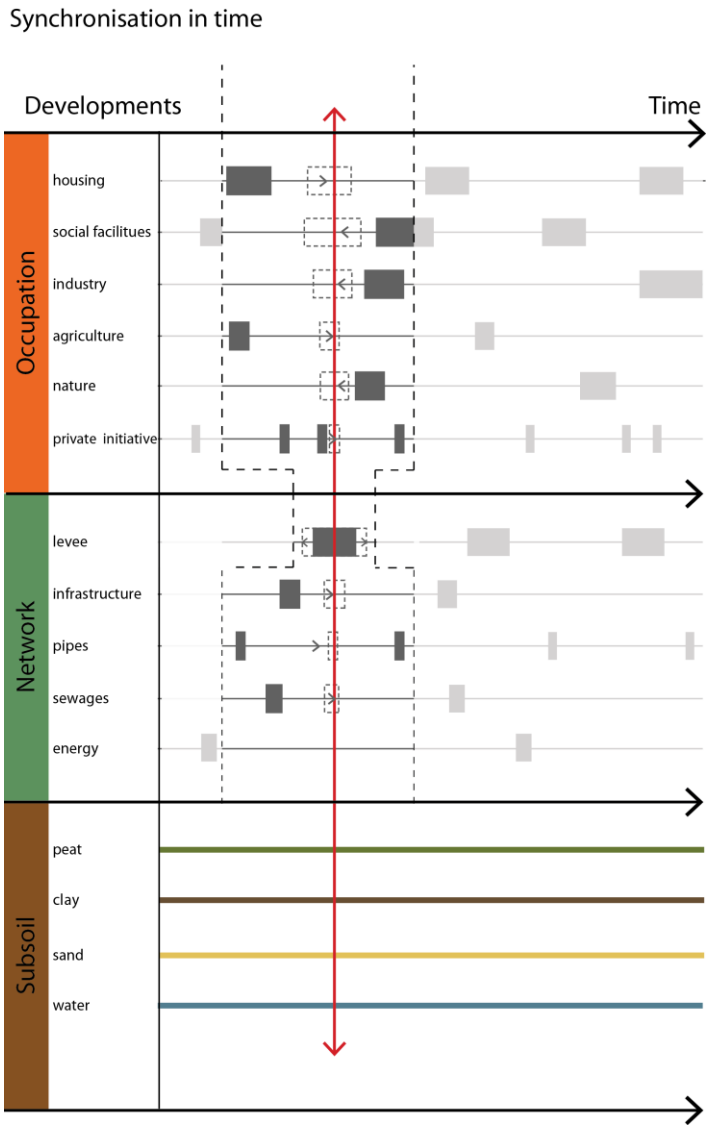
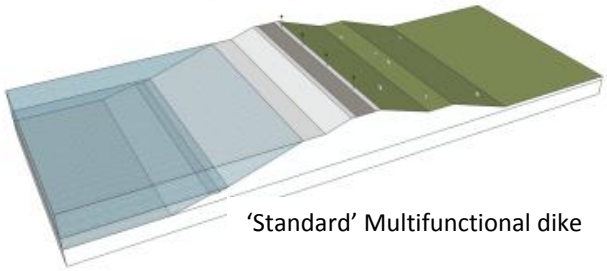


Figure 4 Synchronisation opportunities

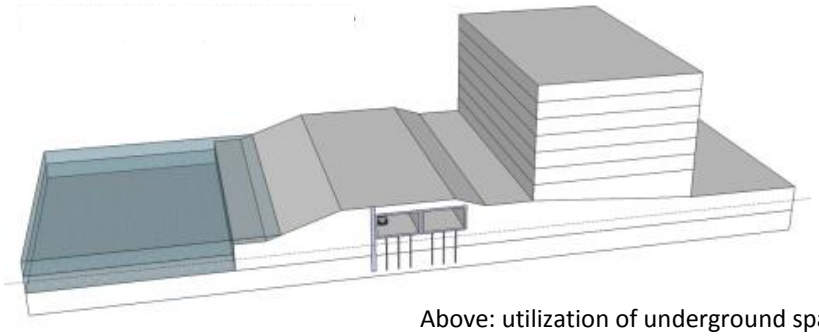
In table 1 the benefits and obstacles are further explained. These aspects are specifablly applicable in the Netherlands. In figure 5 some inspirational possibilities for synchronization are shown.

Table 1 Opportunities and obstacles further defined for 'synchronisation'

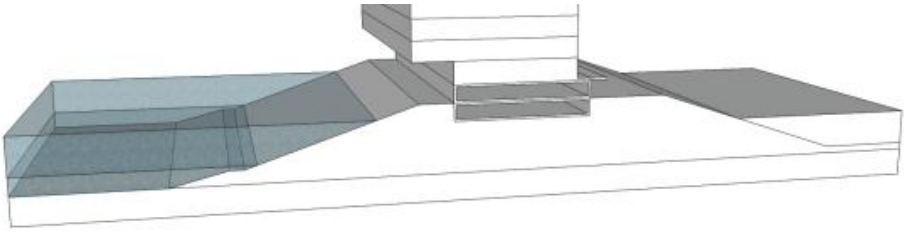
Synchronisation	
Opportunities	Creating surplus value for environment
	Increasing public support
	Local and financial profitable solutions
Obstacles	Dependent on third parties
	Tension between individual versus public interest
Institutional aspects	New law as juridical instrument for integral approach Formal project decision on managerial level needed to ensure integral exploration
Financial aspects	No flexibility in current debate Positive stimulus in cooperation required
Organizational aspects	Managerial space, recognition and support needed for integral approach
	Integral project manager needed, different competences
	Involvement of triple helix required, public-private partnerships

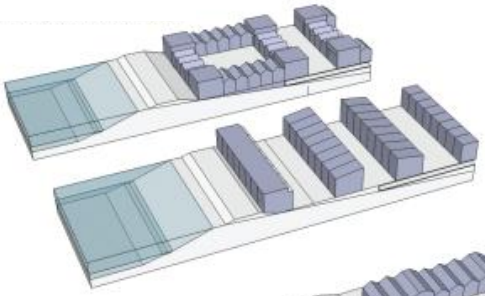


'Standard' Multifunctional dike

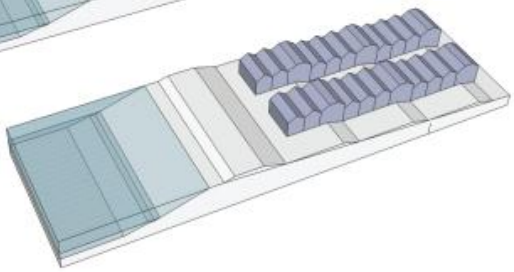


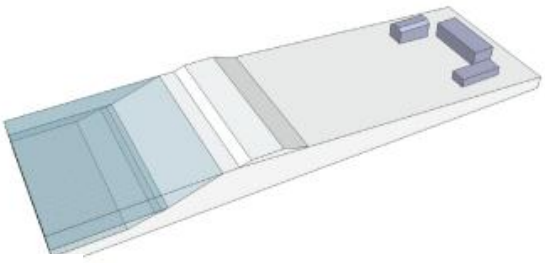
Above: utilization of underground space
Below: adaptive integral levee





Integral 'super' levee





Urban area

Rural area

Figure 5 Inspirational possibilities for synchronisation

Anticipation

In case synchronisation is not an option, two other possibilities can be identified. The first is a sectoral vision where the two developments occur independently from each other.
The second option with possible cost-benefits and societal surplus value is anticipation. Depending on the temporal scale, either the flood safety task or the spatial development will be starting point for anticipation.

For each temporal scale (short, mid and long term) different benefits and obstacles can be mapped out. These are listed in table 2. They include institutional, financial and organizational aspects.

Table 2 Opportunities and obstacles further defined for strategy 'anticipation'

	Time scale on which flood safety occurs		
	Short (0-12 years)	Mid long (12-24 years)	Long (>24 years)
Opportunities	More synergy, delaying dike reinforcement by taking temporary measures Ability to facilitate future spatial development	Temporary functions in order to anticipate Adaptive building, and thus anticipating on flood safety	Adaptive building is feasible Ability to facilitate future spatial development
Obstacles	Outlay must precede returns and lay with different stakeholders stakeholders are not aware of each other's agenda	Temporary use of land is difficult to anchor in law Desire to adaptive building cannot be tied in plans	Difficult to anticipate on this long term due to possible changes in law and regulation. Execution of measures should be in a certain time frame
Institutional aspects	New law as juridical instrument for integral approach		
Financial aspects	Anticipation on future development does not have any stimulus A fund at the regional water authority would be an option		
Organizational aspects	Different views on the integral approach Communication is important due to dynamics and complexity of the task		

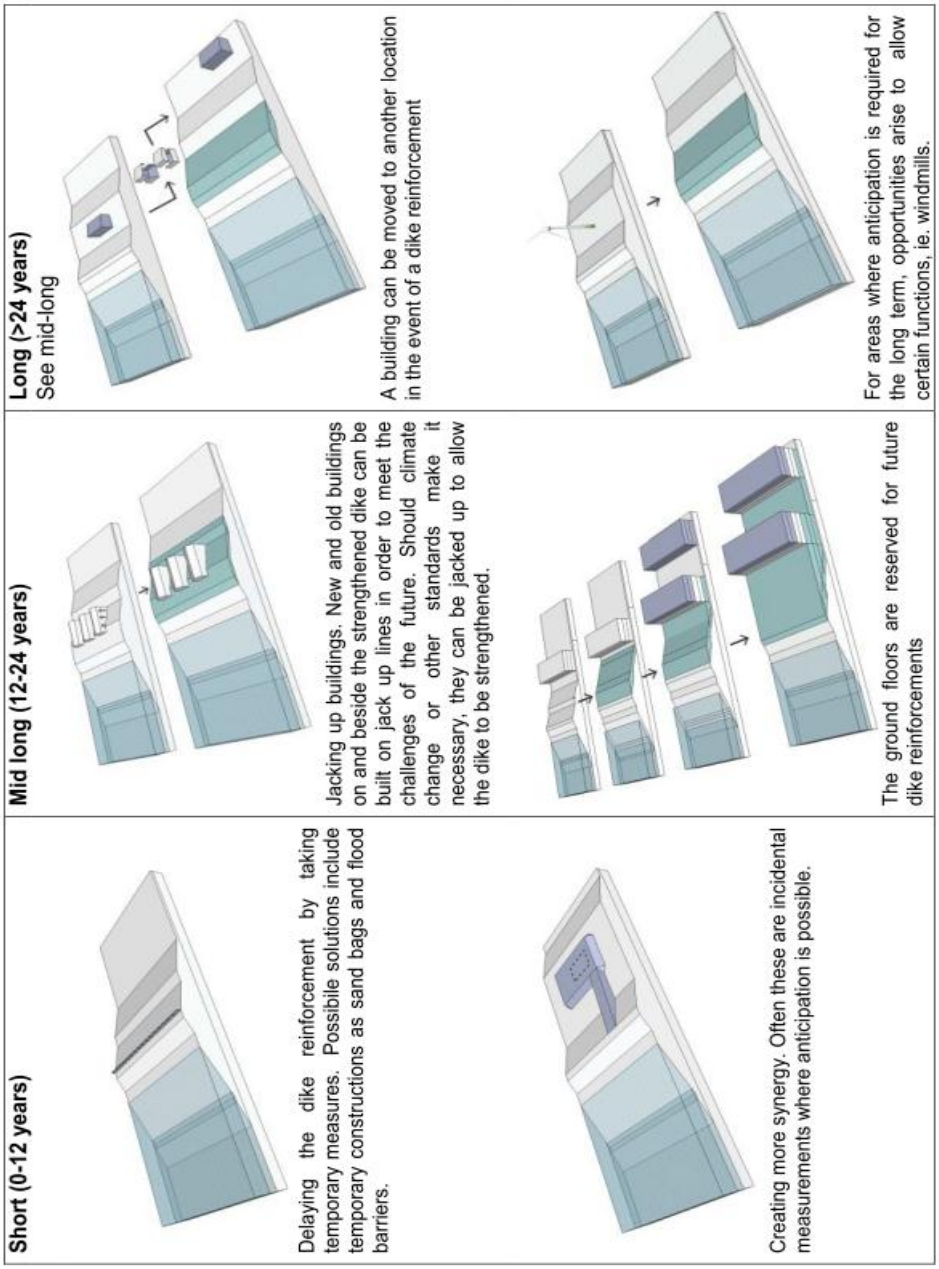


Figure 6 Inspirational possibilities for anticipation

Case Regional Water authority Rivierenland, the Netherlands

Case description

We focus on the dike strengthening project between the villages Kinderdijk en Schoonhovenseveer (KIS), as shown in figure 7.

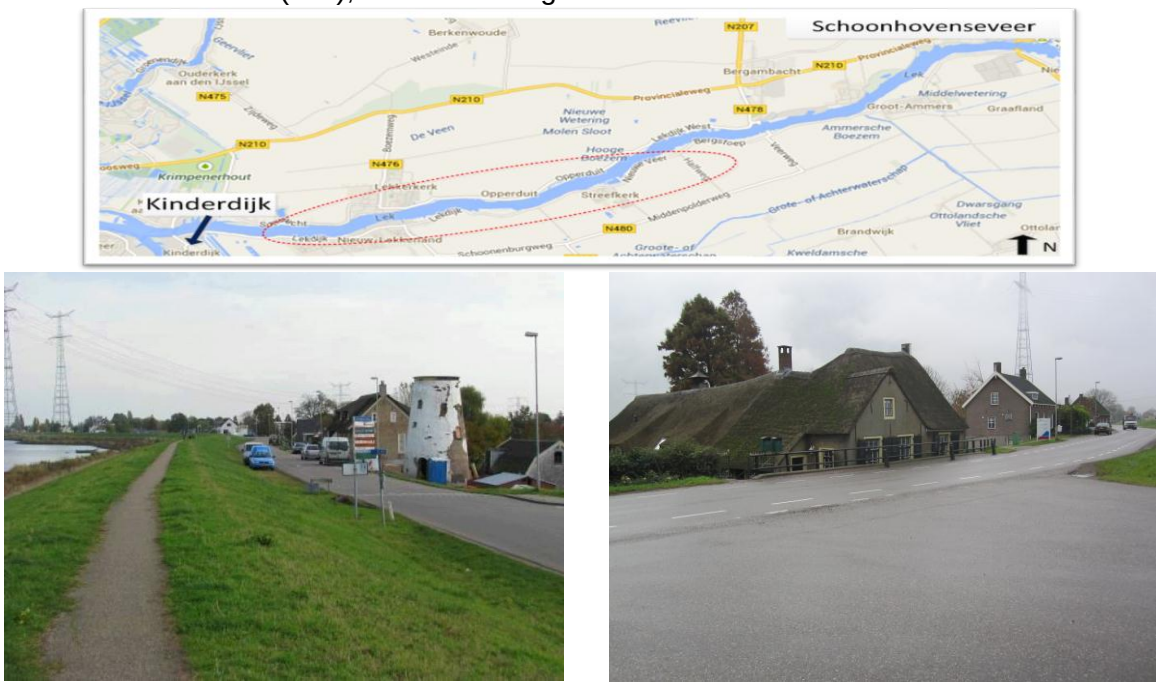


Figure 7 Photos from the location

The Lekdijk itself is one of the main characteristics in the area, which was constructed back in the middle ages, when the first people settled in the area. These first settlers started with building on the sand hills rising above peat lands (World Heritage Centre UNESCO, 1997). Next development focussed on the reclamation of marshland by draining the area. The Lekdijk is a primary flood defence that directly protects the hinterland from potential flooding. First expansions of villages were concentrated near the dike and around the churches. This led to a long ribbon development along the dike. Also the land division of the agricultural fields, which stand perpendicular on the dike, are distinctive for this landscape. Buildings are often located within 30 metres of the dike. In addition to providing safety, flood defences often have other social functions, such as transport, leisure, cultural historic value, residential and nature. These facilities have to be taken in consideration in the dike reinforcement. The safety of the Dutch dikes and dams are, every six years, assessed. The dike section of KIS failed to meet the safety criteria in 2005 and was put on the list of the National Flood Protection program (HWBP).

During the preparations for the dike reinforcement project, it is important to acknowledge the cultural values. During the last dike reinforcement in the 1980s, several dike sections were strengthened with a 'tuimelkade'[1] on the riverside, illustrated in figure 8. By using

[1] Tuimelkade= soil barrier on top of the dike

this kind of infrastructure to strengthen the dike, the buildings were preserved. For the new dike reinforcement 53 households could experience disturbance, with possible demolition and rebuilding.

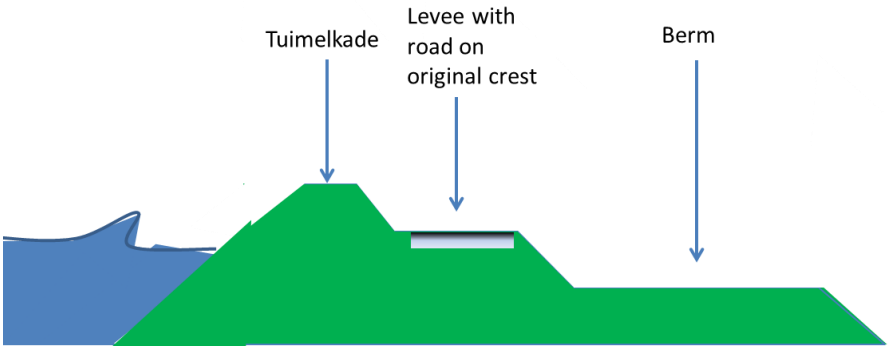


Figure 8 A 'tuimelkade'

The Regional Water Authority Rivierenland (hereafter: Rivierenland) had the responsibility to develop a plan for the dike reinforcement. Rivierenland had the ambition that the proposed solution would be sustainable and flexible, knowing the uncertainties around climate change and water level rises. The widely accepted solution, building a construction between the houses and the road such as sheet piles, meant disturbance and damages to buildings during the execution phase. Moreover constructions can never be removed from the dikes as that would mean hydraulic cracks in the subsoil. Several options were investigated where the local stakeholders were actively involved.

Synchronisation and anticipation

During the development of the plan several stakeholder meetings were organized. And several opportunities for synchronisation and anticipation were identified. In this paragraph these are described in more detail.

Multi purpose levee

Within the project there was sought to identify innovative solutions to strengthen the dike. One of the proposed solutions is to construct an unbreachable dike. This is a dike which is around 100 times stronger than the current norm and on which housing is possible. This unbreachable dike, also known as a climate robust dike, will be built in Streefkerk, see figure 9.

The dike reinforcement was seen as an opportunity for spatial development of centre of the village Streefkerk (as proposed in the plan of the municipality) and the expansion of the marina (wish of the owner of this marina). The whole design is based on strengthening the relationship between the village and the marina and river. Living with the water instead of only protection. This historical relationship is restored by a system of public spaces, which are connected with each other by means of a walking route, between the town centre and the river. The original starting point was to synchronise, also the institutional plans, as well as the execution phase. During the project this appeared not to be possible, as there was a tight time frame for the dike reinforcement. So two different development plans will be developed, one for the dike body and one for the development of the town centre. The local municipality was not pleased as the

spatial and financial opportunities, couldn't be cashed in with the dike reinforcement. Therefore Rivierenland facilitated the whole process around the spatial design of the unbreachable dike. The design of the public space is fully detailed, whereas the buildings are yet to be decided upon.

Also the mentioned walking promenade formed a point of discussion between Rivierenland and the municipality, as there was no money available. Rivierenland was not able to adopt it in the reinforcement plan, as it was not subsidabel and the municipality had no money either. The cooperation in institutional way was quite optimal.

Figure 9 Impression of the location of the multi purpose levee (left) & schematic representation of the levee (right)

Separate cycle path

A second opportunity was the free lying cycle path on the dike between Kinderdijk en Schoonhovense Veer. The cycle path is now part of the road lying on the crest of the dike. Main argument for a free lying cycle path was the safety of the cyclists. The desire came from the sounding group (with representatives of residents and civil society) and the municipality. The latter forced by the wishes from the sounding group.
The finances turned out to be the biggest stumbling block. The cycle path was not part of the provincial cycle path plan. Moreover it was not directly part of the dike reinforcement, so the flood protection program was not willing to subsidize it. Moreover Rivierenland also felt no responsibility for the realization. The desire for the cycle path was, however, emphatically expressed by both the municipality and the sounding group, and is also incurred at the administrative level high. Ultimately, the province was willing to fund. The question of who was responsible, and thus would also have to take the funding ensured that the cycle path was very late in the process in the dike reinforcement project. As in absence of funding the cycle path would not have ben be realized. To a limited extent, the cycle path also led to changes in the dike profile, but these were easily made in the design, also late in the process.

Bypass Nieuw-Lekkerland

A third opportunity lay around the church in the village Nieuw-Lekkerland. The current capacity of the road (see figure 10) is insufficient for the traffic flow. The municipality had a desire to improve road safety, liveability and flow by creating a bypass of the main road. The desired new location would be on the crest of the dike. This dike was

constructed next to the church during the last reinforcement in the eighties. The existing road would be more care-free and safer for cyclists. Also here the financial issue was the main hurdle, but there also played an administrative component.

Figure 10 Impression of the location of the bypass in the village Nieuw-Lekkerland

The construction of a new access road on the already constructed dike did not belong to the primary task of Rivierenland. In context of efficiency of the project Rivierenland was willing, to cooperate in the creation of this, and also contributed financially to this development. The remaining costs are paid from municipal funds and from the provincial cycle path plan - given the fact that this development makes the existing dike road safer for cyclists. The role of Rivierenland can be described as ensuring that their interests are kept and, sometimes that, means given in for certain demands from other stakeholders. For the municipality this development was a serious desire. At the administrative level there were quite a few discussions needed for closing the financial gap.

Adaptive building – demolition and reconstruction of houses

As mentioned earlier, the dike between Kinderdijk and Schoonhovense Veer is characterized by ribbon development. To retain that image, the municipality required that homes, that were to be demolished, should be rebuilt. In total 54 owners of were given the choice whether they want to sell their home or to rebuild after the dike reinforcement - about 30 owners have decided to sell, the others for rebuilding. Rivierenland has decided, that every house that they rebuild has to be built on jack up lines. This ensures flexibility for (possible) future dike reinforcement. The value of future-proofing and flexibility is difficult to express in financial figures. For that reason, it is difficult to compare both approaches.

Conclusions & Recommendations

On-going urbanization, changing demands of society, and climate change are major drivers for more climate resilient development. Moreover, due to future uncertainties, such as sea level rise, subsidence and public demand for increased safety levels, the amount of Euros spent on the maintenance of dikes, will increase in the coming decades in the Netherlands. Next to this, pressure for space enables us to adopt multifunctional spatial planning approaches. From this perspective, the traditional dike with the sole function of a hydraulic barrier might not prove to be the most optimal use of space and money.

The regional water authorities have developed themselves to real network players. From a sectorial perspective, they are seeking for an integral perspective with support from (regional) partners in order to fulfil their functional tasks.

Water authorities not only play a role as manager of flood defences, but also a developer of flood defences. Interventions on flood defences are by definition interventions in space, both horizontally and vertically.
For the regional water authority, creating space for future developments is of utmost importance to ensure safety in the Netherlands. This space creates a solid basis for the future. We see it as the starting point to be able to anticipate and synchronize together with local (public and private) partners.
We strongly encourage regional water authorities and other parties to take the following steps:

1. For synchronization and anticipation *collaboration between organizations* is essential. This means that frameworks and agendas of one organization, has to adapt in one form or another to the frameworks and agendas of other organizations. The aim is to work towards an integrated approach. For the regional water authority, this means that they proactively seek and understand the interests of other parties
2. *A spatial dike vision from a life-cycle analysis*. The reveals the agenda of the regional water authority for a certain period and it makes it easier to seek to common opportunities with other stakeholders. In this way, a win-win situation can be created. This provides flexibility and enhances their role of a network partner. New, upcoming, legislation in the Netherlands requires more integrality and coordination of rules and plans.
   A dike vision can be an important element in this integrality and makes the regional water authority an active partner in the spatial environment at the strategic level. Such a vision is already partly offset by the area- visioning in the Delta Programme developed with government, provinces and municipalities .
3. *Funding*. With a fund a regional authority can make investments in spatial development & flood safety provided that the benefits come over time. This buffer does not develop by itself. Benefits can occur from multiple aspects, profits from wind turbines for instance can later be used to pay for the more complex statutory assessments. Or investments in spatial development, placing them already on a berm, leads to a less expensive future dike reinforcement project. Also the regional water authority can act as a developer, as around many dike reinforcements purchase and sale of land and buildings is required.
4. *Active ' building' policy for space on and next to flood defences*. More space for development can be created, when insight is given how 'simple' techniques create more flexibility, with and around building for future reinforcements. Given the fact, that this area around a dike is a special environment, it is not illogical to require specific construction methods around dikes. The municipality has to supported this policy as they are the competent authority for the buildings.

In creating a flexible strategic planning both, regional water authorities as well as municipalities, have to show their will and start working together. Respecting each other interests and seeking for the most optimal solutions, is the key issue to create surplus value for your local residents.

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