Spatial development in and on flood defences

Spatial development in and on flood defences is as old as the defences themselves. Laws and regulations for building on flood defences have tightened over time, rendering management of flood defence maintenance and assessment of safety into preconditions that do not always reconcile with spatial development.

1. Introduction

status: this topic is still under discussion

Spatial development in and on flood defences is as old as the defences themselves. Aesthetically pleasing examples of spatial development on a flood defence is the Zeedijk in Amsterdam. A vibrant, bustling street in the heart of Amsterdam where people go about their daily lives without sparing a thought to the fact that they live on a dike. There are many similar examples in other cities as well. Laws and regulations for building on flood defences have tightened over time, rendering

management of flood defence maintenance and assessment of safety into preconditions that do not always reconcile with spatial development. We live in a time where we want to use the - limited - space we have as creatively as possible within the framework of the preconditions available.
Multifunctional land use of flood defences is therefore an important topic in the Netherlands. Spatial development in and on flood defences - in the context of a multifunctional manner - is aimed at combining water safety with other (capital-intensive) land uses such as living (houses on the flood defence), working (windmills on the flood defence) and infrastructure (underground parking garages).
Multifunctional land use is not necessarily new in the Netherlands, there are various examples in effect across the country. However, experience shows that the current climate is not conducive to getting new initiatives off the ground. This is partly due to the legal frameworks, governance and financing arrangements.

2. Related topics and Delta Facts

Keywords: Delta dike, multifunctional land use, Multifunctional designs
Delta Facts: Delta dikes

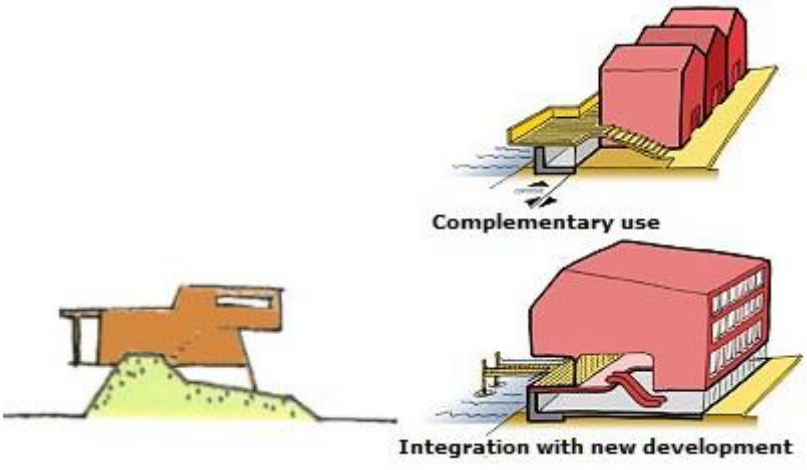
3. Multilayer safety strategy

Multilayer safety can be categorised into three main areas:
1 Prevention, 2 Spatial Planning, 3 Crisis Management
Spatial development in and on flood defences is neither a reinforcement measure nor a direct water safety goal, although the buildings may have a flood defence function, as is the case in Deventer and Dordrecht (the Dordrecht Wall) (Otter, 2003).
Construction of buildings can also have an impact on flood defence strength. Building on flood defences is integrated with flood defences and therefore falls under the first layer of multilayer safety. Buildings without a flood defence function will be provided with complementary functions (complementary uses). The need to apply reinforcement measures can provide an opportunity to put flood defences to multifunctional use.

4. Schematic

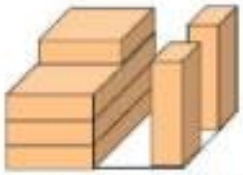
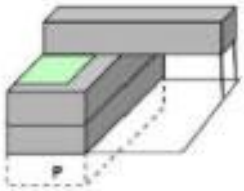
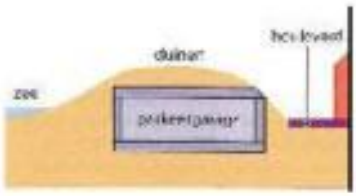
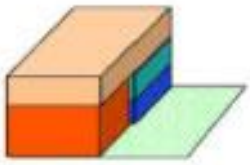
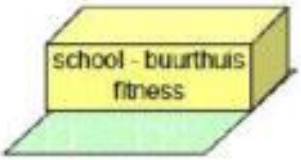
Building on flood defences by definition involves multifunctional use of land, where (multiple) land use functions are integrated with the flood protection function of flood defences. What makes spatial development in and on flood defences an attractive

proposition is that it fulfils the need for more space and brings (aesthetic or energy generating) added-value to buildings overlooking water.
Functionally, flood defences will serve as pedestal or separating element for the new buildings that are built in or on them. The figure below is an artistic rendering of a multifunctional flood defence:



(source: Koning, 2003, p. 19; Veelen et al., 2010)

A distinction is made between four types of multifunctional land use, which can also apply to flood defences. The table below (source: Ellen et al., 2011) shows a rendering of multifunctional land use in sand/soft structures.

Beschrijving	Visualisatie	Voorbeelden multifunctioneel medegebruik waterkeringen
Intensivering: Een mogelijkheid voor betere benutting van de ruimtevoorraad ligt besloten in intensief ruimtegebruik, door verhoging van bebouwingsdichtheden en efficiënter gebruik van de ruimte. Bij intensivering gaat het in feite niet om 'meervoudig' ruimtegebruik, maar om een doelmatiger ruimtegebruik door één functie. We moeten hier bijvoorbeeld denken aan een efficiëntere inrichting van een bestaande ruimte, zodat er meer van dezelfde functie in terecht kan (Habiforum, 2001).	 (Bron: Reijden et al., 2003)	 Kampen: waterkering in de stadsmuur/huizen (Otter, 2003)
Gebruik maken van zowel ondergrondse, als bovengrondse ruimte: Hierbij draait het om het stapelen van functies, waarbij zowel ondergronds als bovengronds gebouwd wordt. Voorbeelden zijn wonen boven winkels, parkeergarages, werfkelders, de metro, hoogbouw en het ondergronds bouwen, verzonken bouw en het bouwen boven overkappingen van infrastructuur (Gemeente Utrecht, 2005).	 (Bron: Reijden et al., 2003)	 Katwijk: Garage in de duin (De Wit et al., 2010)
Verweving: Met het verweven van functies kunnen op eenzelfde locatie meerdere functies een plek krijgen. Deze vorm van meervoudig ruimtegebruik kan onderscheiden worden op twee schaalniveaus: op gebouwniveau (binnen een gebouw komen meerdere functies voor) en op planniveau (binnen het programma komen meerdere functies voor, die zijn verspreid over meerdere gebouwen).	 (Bron: Reijden et al., 2003)	  Scheveningen: Dijk in Boulevard: wonen, werken, recreëren samengebracht.(www.denhaag.nl)
Volgtijdelijk en flexibel gebruik maken van dezelfde ruimte. Ruimtes kunnen beter worden benut als er op meerdere tijdstippen verschillend gebruik kan plaatsvinden. (Gemeente Utrecht, 2005). Het concept Tijdelijk Anders Bestemmen (TAB) valt ook onder deze vorm van multifunctioneel ruimtegebruik.	 (Bron: Reijden et al., 2003)	 Rotterdam: Stadsstrand

It should be noted that multifunctional land use can also be achieved in dikes, dams and dunes, structures, which may or may not be integrated with special flood defence structures.

5. Technical specifications

Spatial development on flood defences depends strongly on the flood defence type, in that it must always meet the water safety standards in place. Flood defences have various functions and are found in different locations, such as sea dikes, river dikes and dams. Several possibilities are:

- Traditional dikes have largely been created by human ingenuity. In many cases, spatial opportunities have already been harnessed by building a road on the crest and populating the slopes with buildings. The impact of spatial development and landscaping on dike strength needs to be further investigated.
- Dunes are a natural phenomenon that typically offers much more space than is actually needed for water safety. But flood defence managers often choose to use only a section of a dune as flood defence. The impact of large objects on dune strength is an area about which little information currently exists.
- Structures integrate the flood defence function with the water management or transport function, for instance. Such structures are often very specific and offer, simply as an integrated solution, opportunities for (even more) versatile use of space.
- With new types of flood defences such as hybrid barriers (integrated dike/dune) or the delta dike and multi-dike come new opportunities for using the space in and on flood defences more effectively.
- Both standard and innovative flood defences must be designed and tested to meet management and maintenance standards. Currently, this represents a significant knowledge gap for spatial development in and on flood defences. A specific issue is continued accessibility for inspection. Other major concerns about multifunctional flood defences are resilience and future proofing.

6. Governance

Legislation on spatial development in and on flood defences serves as an important aspect of governance, as it involves dealing with the Water Act, the Public Works and Water Management Act, the Flood Defences Act and the Water Permits. While spatial planning is addressed at provincial level, the Certification and water assessment are important factors for water boards, whereas the Environmental Licensing (General Provisions) Act (WABO) and zoning plans play a role at local government level. It should be noted that the 'frameworks of flood defence managers are currently a precondition for spatial development in and on flood defences - flood defence managers assess building applications against these frameworks (Erenstein, 2007, p. 21).

Water Permit

Building on flood defences requires a Water Permit, given the different purpose for

which they will be used. The water permit application is typically submitted to the municipality, where the competent authority may be the Department of Waterways and Public Works, the water board or the province. The application form describes this as follows: "You intend to perform work in, on, above, on or under a public works structure or the adjacent protection zone. A public works structure is a surface water body, storage area, flood defence or supporting structure (e.g. a sluice or weir)." Form A3 outlines a number of important elements with respect to activities in, on or near flood defences, see examples.

Windmills

The construction of windmills on, in or over public works structures is subject to a separate policy, the Wind Turbine Installation Policy.

Article 7 of the Policy provides as follows:
"Primary flood defences

1. Wind turbines shall not be installed in the core zone of primary flood defences. Core zone is defined as the actual dike, dune or dam body, being the primary flood defence referred to in the Flood Defence Act.
2. Wind turbines shall not be installed in any location outside the core zone of the primary water where their proximity would compromise the flood protection function of the primary flood defence for the purpose of complying with the safety standards set forth in Article 3 of the Flood Defence Act".

This means that construction of a wind turbine on a public works structure will not be permitted by the Department of Waterways and Public Works. The policy does not specify how a water board should deal with the construction of a wind turbine on a secondary flood defence, only that the primary flood defence function of a dike may not be compromised by the development of buildings (Erenstein, 2007). In other words, a 'risk-informed' approach will need to be adopted towards construction. Wave action and erosion, for instance, must be factored into the design and construction of buildings in coastal areas (Erenstein, 2007). The knowledge obtained from the spatial planning processes of the water boards will be used in spatial development in and on flood defences. There should be room for integrating spatial functions with developments on flood defences. Combining the core function of flood defences and other functions will translate into an integrated approach. But it will also make the issue of jurisdiction more complicated; besides (sectoral) water

legislation, spatial planning legislation will also come into play (Ellen et al., 2011).

Obstacles

According to the delta decisions, a resolution will need to be adopted in 2014 about a national policy framework for the (re-) development of built-up areas. In this context, the Delta Commissioner has posed an identification norm: Existing policies and instruments concerning flood defences do not allow multifunctional land use. This requires careful analysis to determine how obstacles can be eliminated without compromising the flood protection function of existing flood defences, thereby taking into account financial-economic, spatial, technical and administrative-legal obstacles."

In answering the identification norm (Ellen et al., 2011), values appear to be regarded as one of the greatest obstacles; i.e. the values and (norm) interpretations that guide and/or determine decisions. Within the context of financial-economic obstacles, issues that will be given specific attention include liability for and management of risks and the lack of a clear framework for assessing and allocating costs and benefits.

The figure below shows a rendering of the legal constraints of a 'go' or 'no go' for multifunctional use of flood defences. It should be noted that the legislation does not fundamentally prohibit multifunctional land use (Ellen et al., 2011).

Source: AT Osborne, 2011.

In all cases, the obstacles posed by the policy and legislative instruments turned out to be minor. This means that spatial development in and on flood defences is not

impossible and that it depends mainly on the parties' willingness (and not on constraints or ability).

7. Costs and benefits

The costs of construction of an additional function on an existing flood defence are normally borne by the promoter of shared land use.
Future dike reinforcements may create obstacles and additional costs, and therefore confusion about which party will be responsible for the costs. One example is the installation of wind turbines, where the flood defence currently meets the standard, but will fail to do so if the standard becomes more stringent. In which case, the question is which party will bear the additional costs resulting from shared land use.

8. Lessons learned and on-going study

The Association of Provincial Authorities (IPO) has started a discussion on the multifunctional use of flood defences for wind energy. Perhaps the scope of the Wind Turbine Installation Policy should be extended to include multifunctional solutions. And serious efforts should be made towards filling the knowledge gaps in the area of design, assessment and management.

In the Krammer Sluice Locks pilot project, Royal Haskoning DHV is conducting a technical exploratory study on the feasibility of installing turbines on dikes within the core zone. It is a qualitative study that looks at the consequences brought about by functionality (macro-stability), dike reinforcement (complications) and management and maintenance (cost and intensity).

An exploratory study along the same lines was conducted for the Ministry of Infrastructure and the Environment to evaluate the soft seawalls in the Tweede Maasvlakte (second Meuse Plain). It revealed a number of aspects that would render installation of wind turbines difficult; more specifically the impact of dune erosion, which occurs when wind turbine is added to the profile and compromises its safety (D. Hordijk, Royal Haskoning, personal correspondence).

Another trend is the six-yearly review, where increasingly more attention is paid to objects in and on the dike. Within the Sterkte Belasting Waterkering (SBW, Strength and Loading of Water Defences) programme, NWO/KW cluster, simple and detailed test methods are being developed for spatial development. Results are expected in

2016.

The TU Delft, TU Twente and WUR are currently conducting a study within the STW cluster Chemicals, Water & the Environment that focuses on the "Integral design of multifunctional flood defences; 100x safer, 10x smarter".
The study's goals are described as follows:

- Develop and design new technology for multifunctional and flexible flood defences, especially in urban areas (delta urban development and architecture) and in river areas (landscape and ecology).
- Obtain a better understanding of the behaviour and failure probability of multifunctional flood defences during extreme flood and storm surges (with numerical modelling, technical tools and experimental work, such as laboratory experiments).
- Develop new governance and asset management principles for multifunctional and multi-level flood protection.
- Integrate new knowledge disciplines in the area of the consequences and the design of multifunctional flood defences.

The study is closely linked to the research questions of the Delta Programme, Safety sub-programme, component Delta dikes and the research programme of Knowledge for Climate, where research proposals can be submitted in the context of the 3rd instalment. Furthermore, there is a relationship with the Multi-dike platform initiated by WINN and CURnet, where knowledge is developed through pilot projects.
A project is currently underway in the framework of the Corporate Innovation Programme of the Department of Waterways and Public Works to study the potentials and challenges associated with flexible use of flood defences. The thinking is to allow capital-intensive functions that can be hoisted or easily moved for future dike reinforcements. Arrangements (governance, legal, economic) are also being considered to make flexible use possible.

9. Knowledge gaps

The main knowledge gap in this area of research is the approach to assessment and related knowledge. There is no manual available for assessing multifunctional flood defences. Revision of the dike standards will cause uncertainty for shared use, given the intense and demanding nature of the projects. Additionally, the legal safety assessment and design tools (Dutch: wettelijke toets en ontwerpinstrumentarium, WTI) is not designed for multifunctional flood defences, although the WTI can be

extended to include additional rules through an advanced assessment. This needs to be further researched (Ellen et al., 2011).
In the SBWDuinen project, a study is currently underway to assess the impact of spatial development (Non-Flood Defence Assets) on dune erosion and floods. There is a fear that more dune erosion will occur around the assets, or that the assets could cause a breach. Also, there are no quantitative observations with which models for dune erosion and inundation can be validated.

In relation to the multifunctional use of flood defences, there is currently no effective design, assessment and management tool available for analysing the additional costs of flood defences versus the benefits of shared use. A particular concern is the lack of clarity about how to allocate the costs and benefits, who will bear or benefit from them and how they will be used for a project. (Ellen et al., 2011)
The B&O side of shared use must also be considered. Covering the legal aspects of shared use correctly (especially in the future) is a big challenge. The legal aspects in the final/demolition phase and liability also need to be taken into account due to the difference in the economic life of the assets (20 years for wind turbines and 100 or more for a flood defence).

Multifunctional flood defences provide opportunities for alternative earning models. Obtaining broader financing for the realisation of multifunctional use suffers a knowledge gap. There is a need to study the possibility of saving co-financing costs for flood defence managers. This can be done by placing the responsibility for management and maintenance on the promoter or by meeting a more stringent standard.

10. References & links

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More information

For more information about multifunctional use, see recent experiences and studies.

Policy rules

- Beleidslijn Kust (2015)
- Waterwet (2009)
- Watervergunning
- Structuurvisie Infrastructuur en Ruimte (2012)
- AmvB ruimte

Websites

- Expertise Netwerk Waterveiligheid
- Nirov
- Multidijk
- Kennis voor Klimaat

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11. Examples of activities

Examples of activities in, on and near flood defences.

Form A3 of the water permit outlines the following activities in, on and near flood defences:

Other activities in or near surface water bodies, where the following options for shared use are described:

- Constructing a building, such as a house or business premises
- Constructing utilities (measuring and control stations, etc.)
- Building a boathouse
- Installing mussel seed collecting systems
- Installing measurement piles
- Installing fish traps or other gear
- Installing a wind turbine (farm)
- Installing a radio mast/tower

Activities in, on or near flood defences, where the following options for shared use are described:

- Constructing a building, such as a house or business premises, beach pavilion or beach house

- Installing a water inlet or water outlet structure
- Installing a wind turbine (farm)
- Laying a driveway or performing earthworks
- Building a dredge spoil depot or soil storage site
- Organising a competition or event*
- Cultivating/removing plants/trees
- Drilling or probing
- Installing sand banks on the beach for temporary buildings
- Moving sand on the beach (different from sand banks)

** This indicates that a dike can also serve for multipurpose use. For more information about Tempory Different Usage (TAB).*

12. Disclaimer

The knowledge and diagnostic methods presented in this publication are based on the latest insights in the professional field(s) concerned. However, if applied, any results derived therefrom must be critically reviewed. The author(s) and STOWA cannot be held liable for any damage caused by application of the ideas presented in this publication.