Deltares

Enabling Delta Life

Water – its control and combination

Multifunctionality and flood defences

June 2013

Rijkswaterstaat
Ministerie van Infrastructuur en Milieu

AT OSBORNE
CONSULTANTS & MANAGERS

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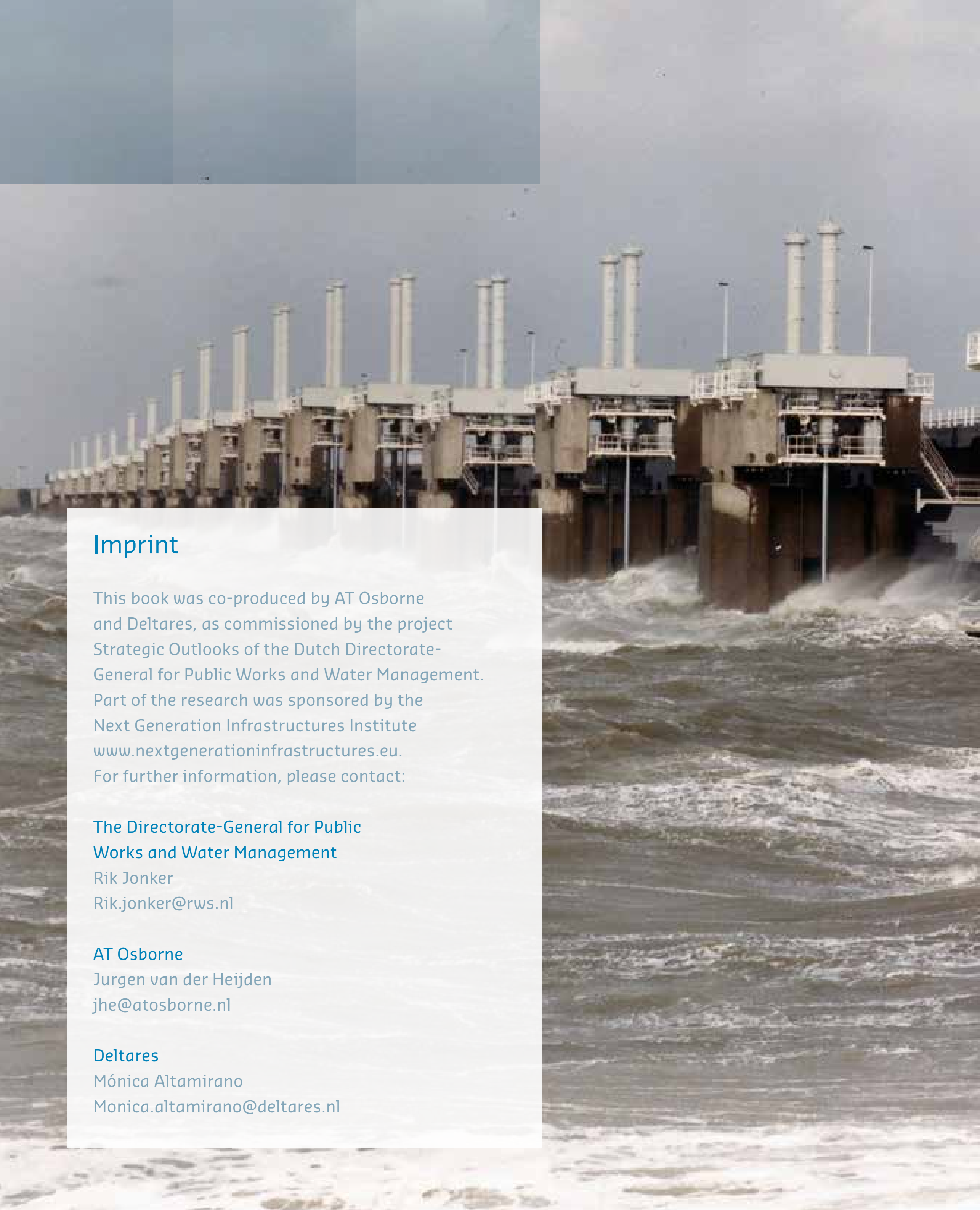
Commissioned by the Directorate-General for Public Works
and Water Management



Imprint

This book was co-produced by AT Osborne and Deltares, as commissioned by the project Strategic Outlooks of the Dutch Directorate-General for Public Works and Water Management. Part of the research was sponsored by the Next Generation Infrastructures Institute www.nextgenerationinfrastructures.eu. For further information, please contact:

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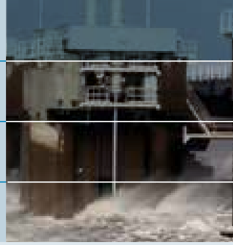

Preface

In 2014 the Dutch government will take important decisions regarding flood protection. For the water boards, the Dutch Directorate-General for Public Works and Water Management, provinces, municipalities and companies these decisions will bring about important new tasks. Measures to control water will become more and more part of integrated area development. In 2014 the new Dutch Flood Protection Programme will start. This programme furthers to explore the integration of water control in the development of areas as a whole. What is this really? Also, what's the demand of this on the cooperation of all involved parties?

Against this background the Project Strategic Outlooks of the Directorate-General for Public Works and Water Management asked AT Osborne and Deltares to map the possibilities of combining functions within in the area of water control. Question was also what this demands from the involved parties regarding their cooperation. This book is the result, and it's an atlas with dozens of inspiring examples of combinations from the Netherlands and abroad. Subject are combinations with roads, harbours, dwellings, workspace, energy, agriculture, landscape, nature, heritage, tourism, water purification, and water storage. This is a plea to take a look outside the own organisation for opportunities to combine and cooperate.

We hope this booklet will broaden the minds of all working on water control, and also those working on various projects that are apt for combination with water works. Making combinations is a joint effort!

AT Osborne
Deltares
Directorate-General for Public Works and Water Management, Project Strategic Outlooks

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Examples included in this book of multifunctionality involving flood defences

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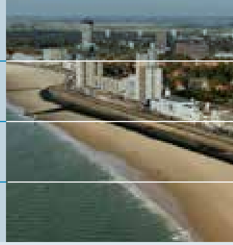
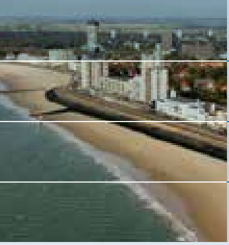


The Province of South Holland is preparing for the construction of the South-Western Ring Road Gouda. This road will cross the dike of the Hollandse IJssel river and then run parallel to it for a considerable distance over an area that lies outside the dike. The dike does not comply with the standards of the Flood Protection Programme. On the landside of the dike, there is no room for reinforcement, whilst the road will be built outside the dike. There, on the pre-existing elevated foreland, a wide embankment will be created, large enough and suitable for a two-lane dual carriageway with a service road.

Following consultation between the Province and the Schieland and Krimpenerwaard Water Board, the design of the road has now been modified in such a way that it can also serve as a dike over a length of half a kilometre. The flood defence structure will be moved outwards and combined with the road. The dike's embankment immediately forms that of the road. Costs for construction and maintenance exert pressure on the budget for both roads and dikes and not just on one budget. This will cost €850,000. That is about 20% of the cost of reinforcing the existing dike in the usual way. In addition to this cost saving, the quality of the area will improve considerably. This could possibly lead to new sources of revenue.

This example from Gouda shows how the combination of road and dike can save 80% of the costs and, at the same time, generate new sources of revenue. The damming function of the dike does not need to be compromised as a result, because we have been building roads on dikes for centuries. The oldest example of such multifunctionality involving flood defences is perhaps that of sheep on dikes. These sheep serve two functions, because they help maintain the dike and are also a form of livestock farming. As a result, the management costs fall for the dike manager, because he does not need to mow it. But the costs also fall for the farmer. The dike not only provides relatively cheap land, but also generates an income from livestock farming that would otherwise not exist.

Social added value for lower costs and with new revenues. That is the principle behind multifunctionality. There are already countless examples of this relating to flood defences. This book gives almost thirty. Some forms of multifunctionality are centuries old, but have been enjoying a resurgence of interest in recent years in new projects, due to their cost efficiency and added value. But there are also signs of hesitation because, after all, it is of prime importance that the damming function is not adversely affected.



Introduction

Cost reduction and added value explain the interest in multifunctionality. That is the reason for this outlook study. Examples of completed projects and projects at an advanced stage of preparation can help various parties understand the usefulness of multifunctionality. They can demonstrate the added value of this for society, in the context of water safety. They can also help draw the attention of water managers, regional coordinators and the market to new, productive forms of cooperation. We hope that this short book will make a contribution towards this.

In this book, we first explain what precisely we understand by multifunctionality and how it differs from the multiple use of space. This is followed by almost thirty examples. We then look at three case studies in more depth. This leads to conclusions about the usefulness of multifunctionality involving flood defences.

1

The principle of multifunctionality

1 The principle of multifunctionality

Multifunctionality can be defined here as an advanced form of the multiple use of space whereby the functions in question not only share the space, but are also mutually reinforcing.

Multiple use of space is an important concept in understanding multifunctionality. It consists of intensifying and interweaving the use of space by creating floors above or below ground, or introducing relationships in time. Creating floors can also be referred to as 'parallel switching', which means that a space serves two or more functions simultaneously. Just think, for example, of building underground and of high-rise. Relationships in time can also be referred to as 'serial switching', or allowing two functions to take place after each other (consecutively) in the same space. An example of this is an agricultural area that sometimes serves to store water. The only difference between parallel and serial switching is one of time. In both cases, they lead to an intensified use of space, because two or more functions take place either simultaneously or consecutively in the same place. This intensive and multiple use of space goes a step further if these functions become interwoven and start to reinforce each other. Then we speak of multifunctionality[1].

Examples can perhaps help to clarify these concepts. A tunnel with a building on top of it is a form of the multiple use of space. Unmistakeable advantages of this are the economical use of space and sharing the costs of the land. The tunnel does not improve the building, however, and vice versa. In fact, the risk of the opposite effect cannot be ruled out.

With multifunctionality, on the other hand, the functions are mutually reinforcing. By combining the functions of dike and road in Gouda, the road on the dike improves the layout of the area and generates added value for local residents. Farming on a dike is a form of the multiple use of space. But it is also a form of multifunctionality because the farmer with his sheep does some of the work for the dike manager. Without sheep, dike maintenance just means costs. With sheep, not only do the maintenance costs fall, but income is even generated from livestock farming. These extra revenues distinguish multifunctionality from the concept 'multiple use of space'. Supply chain integration is another term that can help to clarify multifunctionality.

1 See Ronald van Ark, 'Meervoudig ruimtegebruik: dogma of eye-opener? in G.M.A. van der Heijden, A.F.L. Slob (ed.) (2005), Meervoudig ruimtegebruik, Enkelvoudig recht; over recht dat zekerheid moet bieden aan innovatie,maar tegelijk obstakel is voor innovatie. Delft, Eburon page 12 et seq. and the NL Agency (2012): Future value now! The power of multifunctionality, Utrecht/The Hague, page 21 et seq.

1.1 Supply chain integration

The company Brabant Water has built a Thermal Energy Storage (TES) installation under Arnhem railway station to store heat and cold. This TES installation was not only designed, built and financed by Brabant Water, but this company also maintains and operates it. Brabant Water will even remove the installation when it reaches the end of its life cycle. Expressed in terms of modern contracts, this company has taken care of the elements Design, Build, Finance[2], Maintain and Operate. Contracts involving DB or DBFM have been around for some time, and nowadays we even see DBFMO included. In order to achieve greater sustainability and encompass the whole life cycle of a structure, the elements reduce, re-use, repair, retrofit, renovate and recycle can also be included in the contract. The abbreviation RE can be used to cover these. The TES installation under Arnhem railway station is an example of a complete DBFMORE contract.

The MORE in DBFMORE suggests going further than DBFMO. 'More' means not only seeing all the elements of the acronym DBFMORE as points about which agreements can be made in a contract, but also as links in the chain that encompasses the work process of designing, building, financing, maintaining and operating. Reducing, re-using, repairing, retrofitting, renovating and recycling[3] also form part of this work process.

D → B → F → M → O → RE

There is a sequence in this work process chain, because building naturally precedes maintaining or recycling. It is therefore important to build in such a way as to facilitate effective maintenance and recycling. Supply chain theory then refers to so-called forward and backward integration. Forward means that during the build, for example, a lot of thought is given to the intended use. Backward means that during the use phase, thought is given to following building projects, such as a restructuring of the existing structure in such a way as to facilitate even better maintenance or use later. This forward and backward integration form the two elements of internal supply chain integration.

D ↔ B ↔ F ↔ M ↔ O ↔ RE
(internal supply chain integration)

2 In this report, the word 'finance' relates to the full investment sum, public and private, and not only to the part that is funded by private parties as referred to in contract terminology.

3 Ben Spiering, Sjan Arts, Herman Heegstra, Jurgen van der Heijden, Derk van der Laan (2010), Creating value with infrastructure, Stronger chains, broader cooperation, Delft, Eburon.

Internal supply chain integration leads to numerous optimisations in the building process. It not only involves better maintenance or better usage, but also leads to the optimum use of raw materials. Reducing, re-using, repairing, retrofitting and renovating extend the life span to its maximum. And even the recycling of raw materials is built into the design. This internal supply chain integration is already a well-known phenomenon, due partly to the Cradle to Cradle principle.

Less well known is the term external supply chain integration, although it encompasses two familiar phenomena. First of all, it involves increases in scale. Two comparable chains are linked in this case, for example maintenance of a municipal road together with that of a motorway, or the construction of a bridge commissioned by a municipal and provincial authority. Another example is shared management of the verges by order of the Province and the G vernment. With increases in scale, the contractor can enter into a contract with two and perhaps even several road operators.

D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(maintenance of municipal road)
⇕
D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(maintenance of motorway)

The second form of external supply chain integration is increasingly common and concerns the integration of two less obvious chains. A good example is the energy road as it is known, whereby an energy company uses the road surface in the vicinity of buildings as a heat exchanger for a heat and cold storage system (TES). The advantage to the energy company is that it has access to a large extra surface area in the vicinity of large buildings as heat exchanger to supply these buildings with heat and cold. In turn, the road operator benefits because the road can be cooled slightly on very hot days and heated on very cold ones. That makes a difference in terms of maintenance, life span and smooth traffic flow. In this example, the combination involves using/operating, and that looks like this:

D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(road)
⇕
D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(TES)

This example revolves around use of the road in carrying traffic, combined with its function as heat exchanger. It is a question here of an operational combination, because the combination involves use. It also concerns a constructional combination because the TES can only be realized if a road surface is being laid or is undergoing major repairs.

The storage of contaminated silt in the embankment of a road is another striking example. That is done in such a way that this

silt is slowly rinsed clean by rainwater. The contamination in this water is also purified, because contaminants which dissolve in water end up in the sewage system and are purified in the sewage treatment plant. This purification of silt is an advantage, but the road does not benefit directly from this in the sense that use of the road is improved in any way. However, the use of contaminated silt instead of clean sand can reduce the costs of building a road by as much as forty percent. The road operator therefore benefits from the constructional combination. It is also an operational combination, because by using the embankment, water can flow away so that the silt becomes cleaner. If the road is ever demolished, it will leave behind clean - or at least cleaner - silt. There is therefore also a combination in terms of recycling, and that looks like this:

D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(embankment)
⇕ ⇕ ⇕ ⇕ ⇕ ⇕
D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(silt)

A constructional combination is also known as 'creating work with work'. Another good example of this is making a soil balance. The Lek Canal has to be widened at Nieuwegein because the Beatrixsluizen (locks) are to get a third chamber. This widening operation requires soil because of a new, higher dike. It turns out that an extra channel is being dug in the immediate vicinity, in connection with the project 'Ruimte voor de Lek' (Room for the Lek), so that the capacity for water collection will increase. The constructional combination consists of using the soil from the channel for the dike. That has big advantages for the construction and financing. In diagram form, it therefore looks like this:

D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(soil from channel)
⇕ ⇕
D ⇔ B ⇔ F ⇔ M ⇔ O ⇔ RE
(soil for dike)

This soil balance is a pure constructional combination that, unlike the energy road, does not result in an operational combination. That also applies, for example, to opening up a road surface to lay sewers, when fibre optic cable is laid at the same time. This classic example of creating 'work with work' does not result in fibre optic cable and sewer forming an operational combination, as with the road and energy. One could say that a constructional combination was all about DBF: design, build and finance. An operational combination revolves around MORE: maintain, operate and RE (re-use, reduce, etc.). Most combinations encompass all elements of the chain, from construction right up to operation, like the energy road and the road on the embankment. Some combinations are limited to construction

only, like the soil balance. One can also think of combinations which are solely operational. An example of this is the use of an existing structure for a purpose to which another function is then added. Just think of a school which also houses a nursery or a library.

What is the relationship between multiple use of space and a constructional combination and an operational combination? Multiple use of space can easily be achieved through a constructional combination, DBF. In addition, multiple use of space also offers advantages through shared maintenance (M) and a shared endeavour towards RE (re-use, reduce, recycle, etc.). Multifunctionality always involves the multiple use of space, but this use of space is limited to cost saving relating to DBF, perhaps DBFM, or even DBFMRE. Multiple use of space does not relate to operations (O), the functions which take place in the same place, either simultaneously or consecutively. Mutual reinforcement is what distinguishes multifunctionality from the multiple use of space.

Finally, the example of wind turbines on a dike is an interesting one. To start with, it is a multiple use of space that results in cost savings. The turbines generate rental income for the dike manager. The energy producer finds land that is cheaper than in an urban area. But is there also evidence of reinforcement between the two functions? At first glance, there is. After all, the dike contributes towards the quality of the energy generation because dikes offer a favourable wind climate due to their location on open water. In addition to this, there is usually enough room on a dike for several turbines, so that they can be maintained and operated more efficiently. And finally, the inconvenience caused to the surrounding area is limited due to the often remote location. The other way round, it remains questionable if the turbines help fulfil the function or improve the strength of the dike, for example because deep foundations anchor the dike better. Also, one quite frequently hears local residents and tourists complain about large wind turbines creating horizon pollution. Opinions on this therefore vary and that hits at the heart of this book. We are looking for examples of multifunctionality in which the damming function always plays a role. This reinforces another function, such as nature, traffic, housing or energy. In reverse, do these functions also reinforce the damming function? Only then is it a question of multifunctionality with advantages for the water manager too. It is these examples we are seeking.

1.2 Trend towards integration

We have seen that the multiple use of space is an important concept in clarifying multifunctionality. The first reason was given above, because multifunctionality always begins with the multiple use of space. The second reason is that the multiple use of space is an initial phase in a trend within

which multifunctionality is a later one. This trend began with an economy and society in which every social function was given all the room it needed to develop. That can be seen in earlier spatial planning in which every function had its own place in the form of residential developments, industrial estates, schools, museums, hospitals, agriculture, nature, water, et cetera. At the time, coordination between functions consisted solely of them not disadvantaging each other. So agriculture and nature had to remain separated, as did a hospital and an industrial estate[4].

We were able to develop this society so ‘simply’ because there was enough space and money for separated growth. There was no incentive whatsoever to act in a ‘plural’ way and create a connection between, for example, living and working; functions were deliberately separated to prevent them from causing a nuisance to each other. Nor was there any incentive, for example, to coordinate the production and use of a product and the re-use of raw materials. This incentive only grew during the past few decades, with the steady increase in the price of raw materials. A consequence of this is the emergence of the DB and DBF contracts and the accompanying internal supply chain integration. This leads to numerous optimisations, for example improved maintenance or improved usage. It also leads to an optimum division of duties between parties with a superior understanding of building, financing or maintenance. This is the essence of PPPs (Public Private Partnerships). In these partnerships, the public and private sector seek optimum cooperation in building and operating structures. PPPs, like the multiple use of space and multifunctionality, are in line with the trend towards more integration.

This trend is fed, first of all, by the growing awareness, perhaps since as long ago as the launch of the Club of Rome at the end of the 1960s, that it is no longer possible to separate social functions. We do not have the space for this and it is also too expensive to pay for all these separate functions. Tax revenues are inadequate to keep paying endlessly for care, education, culture, nature, et cetera. The relentless cuts of past decades demonstrate this. The increasing shortage of both space and cash explains the growing interest in the multiple use of space. You can save a lot of money by optimising the supply chain and working together well. PPPs, for instance, have always been an endeavour to optimise in an economy that focuses on costs, simply because there is less cash.

Education, culture and care have already been subject to cuts for a long time. For this reason, they increasingly make use of the same building, as witnessed by the almost two thousand residential care centres which have been set up in the past twenty

4 *H.A. Haccoû, F.M. Feddes (ed.): De functiescheiding voorbij, The Hague, SDU 2007.*

years. Housing and care change by being combined. They reinforce one another, so that the quality of both the care and the housing improves and the service does not deteriorate despite cuts. The paradigm of preventing functions from disadvantaging each other changes in this way to the reciprocal reinforcement of social functions. That is the trend within which the multiple use of space, multifunctionality and also PPPs fit. This changes society and the economy; people speak of the transition from a linear to a circular economy. Linear means working on a simple social function, which may not be allowed to damage other functions. Circular refers to working on two or more social functions which reinforce each other through the multiple use of space and multifunctionality.

The multiple use of space and multifunctionality mean making the most intensive possible use of existing facilities and resources, such as buildings, roads and equipment. Intensive use is a pillar supporting the circular economy. The re-use of raw materials is also such a pillar. Intensive use and the re-use of raw materials also show a lot of connections. The recycling of raw materials is the last step in a series 'reduce, re-use, repair, renovate and retrofit'. This series is in line with the intensive use of existing products. It is all about using raw materials which have been converted into products for as long as possible in the form of that product. It is then important to recover raw materials as purely as possible. The motivation for this is the rising price of raw materials. That makes it more economical to make better use of existing products and to introduce raw materials into a cycle.

The combination of the multiple use of space and multifunctionality is in keeping with the trend towards increasing integration and towards the transition from the current linear economy to a circular one. Multifunctionality has been added to the multiple use of space here in the course of time. Together, they show what the intensive use of existing products can yield. Combined with the cycle of raw materials, intensive use is a pillar of the circular economy, with integration playing a leading role in this. That places multifunctionality among the existing concepts of the multiple use of space, supply chain integration, PPPs and their interrelated development. To complete this story, finally, it is helpful to describe how people can work concretely on multifunctionality. That gives multifunctionality a place within modern public administration science.

1.3 From stakeholders to shareholders

At the heart of modern public administration science is the stakeholder. That is someone who is involved in another person's initiative. This involvement is often the result of the fact that the stakeholder represents an interest that is adversely affected by the initiative. This is also the relationship that we described in Chapter 1.3 relating to simple activities which are unrelated to each other and may not disadvantage each other. There is a difference between the stakeholder and the shareholder. The latter is also someone who represents a particular interest, but one that benefits from the initiative. Furthermore, the shareholder himself or herself can strengthen this initiative. In short, a shareholder is a stakeholder with an interest that forms part of the business case that arises through multifunctionality. It says a lot that this shareholder plays a very small role, if at all, in public administration science. Apparently, traditional public administration science is still geared fully towards a society in which functions are separated[5].

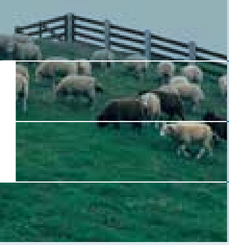
'Co-linking' (meekoppelen) means that combinations of projects initiated by different parties are sought. Meekoppelen is the term which the Netherlands Scientific Council for Government Policy (WRR) introduced in 1998 to establish a relationship between interests which can be mutually reinforcing ('co-linking interests')[6]. We interpret the term here as the quest for opportunities to combine. Co-linking is an attitude in which there is a targeted search for social added value, co-linking with other people's ambitions. It means entering into dialogue with stakeholders in a structured way about opportunities to combine and, in this way, ultimately making stakeholders into shareholders.

At first glance, the scope, deadline and budget of projects often reveal little room for multifunctionality. This sometimes makes it difficult to provide insight into their added value. Co-linking is therefore soon seen as a way of unnecessarily increasing the complexity and as a possible threat to remaining on schedule and on budget. The right attitude for co-linking, on the other hand, is that a project manager or environment manager feels they have the freedom to spend time on involving the surrounding area and on explicitly seeking opportunities. That is difficult, because co-linking is still insufficiently rooted in the standard working method.

Stakeholders can share the idea that added value can be achieved by linking ambitions

5 Hans de Bruijn, Geert Teisman, Jurian Edelenbos, Wijnand Veeneman (ed.), Meervoudig ruimtegebruik en het management van meerstemmige processen, Utrecht 2004, Lemma.

6 Netherlands Scientific Council for Government Policy (WRR), Ruimtelijke ontwikkelingspolitiek, The Hague 1998, SDU Uitgevers.



and budgets with each other, even if all the details have not yet been worked out. They feel that added value can be achieved on the basis of their experience with other stakeholders and their knowledge of the area. This feeling is, as it were, a business idea, which can be worked out in a business case. Then it becomes clear whether or not a business idea does actually yield added value. This is done by comparing the cost-benefit analysis of the business idea with those of the otherwise separate developments.

If the business case is positive, you proceed to draw up a business plan. In this plan, the stakeholders involved with a business case make agreements to execute the combinations jointly. The stakeholders then become shareholders of the business case. In this way, co-linking presents direct possibilities for realizing opportunities to combine because support has been found among the shareholders concerned, financing will be found in existing budgets and, with some operational combinations, it will even be possible to generate revenues. An open attitude is highly valued by the stakeholders. Whether or not stakeholders then actually become real shareholders depends on how the process proceeds and the viability of the business cases.

Finally

This section has clarified what place multifunctionality and the multiple use of space occupy in the broader fields of internal and external supply chain integration, the recycling mentality, the trend towards a circular rather than linear economy, co-linking and public administration science. This overview of the interrelationships will hopefully help the reader to place the examples given in Chapters 2 and 3. In this connection, we will fill in the following chart each time:

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space		
Raw materials		
Shareholders		

2

Concrete examples of combinations involving damming

2

Concrete examples of combinations involving damming

In the section below, the following examples of combinations involving damming are discussed. Each example is concerned with water management or protection against water. The columns indicate with which other functions the project in the example is combined.

Example	land / building	road / water-way	port	living / working	water storage	energy	agri-culture	land-scape / nature	tourism / culture	water treat-ment	page
Houtribdijk	X	X						X			22
SSRS		X				X	X	X	X		24
Beatrixsluizen	X	X									25
Vlissingen		X		X					X		27
Scheveningen	X	X		X					X		28
HafenCity	X		X	X					X		29
Stadseiland	X			X				X			31
Kampen	X	X		X					X		32
Dordrecht	X	X		X							33
Rotterdam	X	X		X				X			34
Tokyo	X			X							35
Yokohama	X			X	X				X		36
Almere	X		X	X				X	X	X	37
IJsseldelta	X	X		X		X	X				38
Brouwersdam	X					X					42
Overdiepse Polder	X			X	X		X	X			44
Koopmans Polder	X				X		X	X	X		46
Westenholte	X				X			X	X		47
Oesterdam	X							X	X		50
Punt van Voorne	X							X	X		51
Zeegras	X							X			52
Cadzand	X		X	X				X	X		54
Kristalbad	X				X			X	X	X	57
Katwijk	X			X				X	X		62
Gouda	X	X		X				X			67
Den Bosch	X			X	X		X	X	X		71

2.1 Networks

Roads and flood defences

A road on or along a dike undoubtedly constitutes the most well-known and most common example of a combination with a flood defence. It involves a multitude of local connecting roads, including cycle paths, access roads to and from private homes and businesses. Dikes have already been serving this transport and connection function for a long time. After all, the higher and drier dike, often built from robust materials, was much more suitable at many places in the low land for (local) transport than the surrounding wet area[7]. In addition to local roads, secondary roads and motorways are often built on dikes, such as the Afsluitdijk and on top of the Delta Works in Zeeland, as well as the example in Gouda with which this short book begins. Here and there along the river dikes we also find railways, e.g. for the connection between Dordrecht and Geldermalsen.

Combining the function of road and dike is cost efficient, because the dike's embankment also forms that of the road. The costs of construction and maintenance put pressure on the budgets for both roads and dikes, and not just on a single budget. In Gouda, this combination will save 80% of the construction costs. Added value is generated because areas are more accessible and can therefore develop better. Via the water board levy, the public in turn contribute towards maintaining the dike, and the revenues from this levy increase as the area increases in value. In this way, dike and road are a textbook example of an operational combination.

Figure 1: A road over a dike

Figure 2: A road through the dunes opens up an area for recreation

Dike and road are a constructional combination if they are built and also maintained at the same time. That does not need necessarily always to be the case. There are plenty of dikes without a road. And sometimes a road is added later, which can also make a difference financially. On the other hand, major repairs on a dike, or raising

7 Source, J.M. van Loon – Steensma, Robuuste Multifunctionele Rivierdijken, Alterra Rapport 2228.

it, mean that the road has to disappear temporarily. Then the constructional combination has an adverse effect.

Dunes are a different matter, with only a few similarities with dikes. The main similarity seems to be how they open up an area, for example for recreation (cycle paths and footpaths).

Example: Houtribdijk

The Houtribdijk is the long dike between Enkhuizen and Lelystad. The Directorate-General for Public Works and Water Management wants the Houtribdijk to comply with the safety requirements again by 2012, in accordance with the national agreements on flood defences. In this way, the Directorate-General for Public Works and Water Management also wants to make a maximum contribution to the other functions, duties and wishes which play a role on and around the dike. Road operator the Province of Flevoland wants the same thing and is looking into whether or not road safety and the flow of traffic on the secondary road can be improved with a clever combination of functions.

Naturally, water safety plays a role, but it is also important to improve dike management, the effects of the dike reinforcement on nature and the traffic safety of the secondary road. In order to carry out the necessary dike inspections, it is desirable that a road be built on the Markermeer side of the dike. By combining this new road with the existing secondary road, space will be created for separate traffic lanes, overtaking lanes or third lane solutions, for example. Improving the safety of the dike can also be combined with the development of nature. Various plans exist to create large areas of marshland on the Markermeer side of the dike. These would cushion the strong waves during westerly storms and, at the same time, form a new biotope for fish, birds and marsh vegetation. The constructional combination is strengthened even further if mud and clay from deepening the waterway between Amsterdam and Lemmer are used for creating the marshes.

	Cost saving through constructional combination	**New revenues from operational combination**
Multiple use of space	Dike forms road embankment, inspection road creates space for more traffic lanes	Improved traffic safety, better traffic flow, effects of dike reinforcement on nature
Raw materials	Possible use of same building materials for both dike reinforcement and road construction	Reduced fuel consumption thanks to improved traffic flow
Share-holders	The Directorate-General for Public Works and Water Management, Province of Flevoland	The Directorate-General for Public Works and Water Management, Province of Flevoland

Mooring points and ports

A flood defence structure can form the connection between transport by water and by land. Quays and dikes, for example, formed the most important routes in the historical trading towns, along which the warehouses and merchants' houses sprung up[8]. Ports and other mooring points can really be seen as former transfer points, places where people and goods can switch from one mode of transport to another. An operational combination is clearly involved here because the use of water as a means of transport and the use of the flood defence structure as a road reinforce one another by means of the transfer point.

The question is to what extent a quay, for example in today's westerly port area in Amsterdam, is still seen as a form of flood defence. The flood defence function has, in actual fact, been submerged under the function of port. The extent to which a water board can be asked to pay towards, for example, a quay wall that serves an important function in handling coal, is also questionable. The water board does benefit if more port activities mean more revenues from water board levies, which are used to maintain the flood defences. It is a constructional combination and, as explained above, an operational combination too.

Figure 3: A mooring point as transfer point

Internet cables in dikes[9]

Many of those who do not yet have access to broadband internet live close to dikes, according to MPs Afke Schaart and Anne-Wil Lucas. For this reason, they asked the minister if internet cables could be laid in the dikes. According to them, this would perhaps allow 'ambitions in the field of dike reinforcement and monitoring to be combined cleverly with digitisation'. The plan is a follow-up to news about installing sensors in dikes, thereby making it possible to monitor the dikes better.

Laying cables in dikes cannot be seen as a constructional combination, as the dikes are already there. One can speak of a constructional combination if the cables are laid when reinforcing or replacing dikes. Internet cables in the dike are definitely an operational combination. According to both MPs, the cable could not only be used to provide internet access in rural areas, but

8 J.M. van Loon – Steensma op cit.

9 VVD argues in favour of internet cables in dikes, Arnoud Wokke, TweakersNet, Wednesday 25 January 2012 15:37.

also for monitoring the strength of the dike by means of sensors.

Waterway management

Managing waterways is one of the core duties of water managers. Cuts are putting pressure on this. A lot has been achieved by spreading the cuts across the board. Traditionally, construction is given precedence, followed by management and maintenance. Construction comes and goes, but management is always needed. Would multifunctionality bring any benefits here? The concept of the Self Supporting River System shows the way.

Example: Self Supporting River System (SSRS)[10]

The SSRS project is a study initiated by the Directorate-General for Public Works and Water Management (RWS) focusing on management and maintenance. Normally, management and maintenance operations are only considered longitudinally in a river. With SSRS, they look beyond the boundaries of the particular area. A clearer picture of capital, products and markets produces new opportunities for cooperation. SSRS is based on two principles: avoid maintenance costs and look for benefits. Benefits occur when you utilise the possibilities of the area as a whole, such as:

1. Granting concessions to market parties for generating electricity through a drop in or damming of the river and combining these concessions with the upkeep of structural works.
2. Granting concessions to make use of RWS areas for cultivating or establishing crops for dry and liquid biomass. This reduces the cost of green maintenance along the river. These concessions can be combined with areas belonging to other parties, such as water boards and the National Forest Service in the Netherlands (SBB), giving rise to increases in scale. Of course, all of this takes into account the requirements to prevent hydraulic stagnation.
3. Changing the design of the summer bed in such a way that sediment can be extracted easily. Using this sediment elsewhere immediately means that something must be done to prevent subsidence.
4. Extracting heavy metals from silt. In this way, the silt is cleaned and raw materials are extracted.
5. Promoting the setting up of ‘water farms’. There, ‘wet’ farming is carried out, such as the cultivation of algae, duckweed and fish, making use of the nutrient-rich water, mainly the phosphates present.
6. Generating revenues from sustainable energy (solar and wind) by making space available.

10 See Future value now! The power of multifunctionality, op cit. page 22.

According to the researchers from the Directorate-General for Public Works and Water Management, SSRS can deliver affordable, reliable and sustainable river management. The aim of the study is to look at whether the three core responsibilities safety, sufficient clean water and shipping can be fulfilled at a 40% reduction in costs by 2021. Interesting is the postponement of investments through a combination of management and maintenance with natural processes, or Building with Nature (see page 48). This gives more freedom of choice for the future and creates flexibility value. That is to say, the area gains value by keeping options open and there is no lock-in by making investment decisions that fix the area for decades.

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	n/a because management case study	Revenues from various concessions and from making space available for sustainable energy; reduced costs for maintenance of structural works, green maintenance, silt cleaning and combating subsidence
Raw materials	n/a because management case study	Biomass, sediment, heavy metals, phosphates, agricultural products, energy
Shareholders	n/a because management case study	The Directorate-General for Public Works and Water Management, energy companies, producers of biomass, sediments and heavy metals, water boards, SBB and farmers

Example: Beatrixsluizen

The Directorate-General for Public Works and Water Management has plans to create a third chamber in the Beatrixsluizen (locks) and widen the Lek Canal in an easterly direction. In 2014, the irrevocable Planning Procedures Decree and the start of construction are expected. In addition to this, the Province of Utrecht is currently working on the sub-project ‘Room for the Lek’, in the context of ‘Room for the River’. The Province is at a far-advanced stage with its design, planning and estimates. Construction work is expected to start in 2013/2014. Both projects involve removing soil and, at the same time, they both need it. The implementation periods of the two projects also coincide nicely. Furthermore, the Directorate-General for Public Works and Water Management (RWS) has a tight budget and would benefit from the saving in costs. Naturally, the Province also wants to save costs, but the design and estimates are already virtually fixed for the Province. Yet it

looks as if they will be able to exchange soil in a shared soil balance.

Figure 4: The plan 'Room for the Lek'

In order to be able to reap the benefits, it is up to RWS to state now, insofar as possible, how much and what quality soil is needed and how much will become available in its project. Subsequently, there must be a discussion with Room for the Lek about the degree to which the scheduling and phasing can be coordinated so that the movement of soil is handled optimally. The logistics also require a lot of attention. In addition, sites/depots where soil can settle must be available. Finally, whether or not as part of the same contract, the possibility of a soil balance will form an appendix to the tender documents so that the contractor can come up with cost savings. RWS and Room for the Lek can then expect a lower quote from the contractor.

The business case is all about budget profit for both the Province and RWS, and about limiting carbon emissions. The budget profit can be achieved by cleverly synchronising the phasing of the work and moving the soil. The benefit in terms of carbon emissions can be achieved by cleverly relocating the soil and limiting the removal of soil as much as possible.

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Sharing depots to allow soil to settle	n/a because management case study
Raw materials	Building materials for one project are made available by the other project; it is unnecessary to use building materials from elsewhere.	n/a because management case study
Shareholders	The Directorate-General for Public Works and Water Management, Province of Utrecht	n/a because management case study

2.2 The flood defence structure in the built environment

Promenades

Promenades are a unique form of road over a flood defence structure because they do not simply provide access to an area, but link an urban area directly with coastal tourism. There aren't too many examples of this in the Netherlands. The main examples are Vlissingen, Scheveningen and Zandvoort. There is also Katwijk, where the coast as flood defence needs reinforcing, as in the three other towns. On sunny summer days, the coastal resort has a parking problem, so reinforcing the flood defences is an ideal opportunity to solve this problem. The combined construction of flood defence structure and multi-storey car park is possibly cheaper than an underground car park built separately. This case study is described in detail in Chapter 3.

Example: Vlissingen

Following consultation between the Province of Zeeland and the Municipality of Vlissingen, the option of interchangeable floors was introduced for buildings on the Bankert and Evertsen Boulevards in 1995. This means that the distance from floor to ceiling on the ground floor is so high that the floor height can be raised as the promenade rises if the flood defences have to be heightened. This principle, including the floor height, was included in the review of the land-use plan (1996). This is a premature and masterly example of 'adaptive delta management', but is it also one of multifunctionality?

The buildings on the promenade, including hotels, derive their value to a very significant extent from the location. The other way round, this location, the promenade cum flood defence, derives its value from the municipal area. That, in turn, helps to fund the upkeep through municipal taxes, although that money does not go directly to the location itself, but via the Municipality. Consequently, this is a question of an operational combination, which is strengthened by making the buildings flexible. There is no evidence of a constructional combination, because it only involves the buildings and not the construction of the flood defence structure.

Figure 5: The promenade in Vlissingen

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	(Saving on building costs due to flexible construction)	Revenues from well-functioning buildings, including taxes which benefit the area, including the flood- defence structure.
Raw materials	(Saving on building materials due to flexible construction)	n/a
Shareholders	(Hotel owners)	Municipality of Vlissingen, Province of Zeeland, hotel owner

Example: Scheveningen

The promenade in Scheveningen around Keizerstraat is a weak link in our coastline. In order to guarantee safety for the coming fifty years, the coast at Scheveningen is being reinforced with an (invisible) dike in the promenade, which should be able to withstand water levels which are only exceeded, on average, once every ten thousand years. On the beach in front of the dike and under water, extra sand is being brought in (suppletion). That will break the force of the waves, so the dike behind does not need to be high and the sea views are not lost. This latter point is important in terms of spatial quality.

Now that the flood defences are being reinforced, the Municipality is grasping the opportunity to improve the spatial quality at the same time and redesign the promenade. That makes the dike and promenade a constructional combination.

In terms of costs, it means about a 10% difference in the total construction sum[11]. The Municipality, the Delfland Water Board and the Government are sharing the financing and the responsibilities, including for the upkeep. As operational combination,

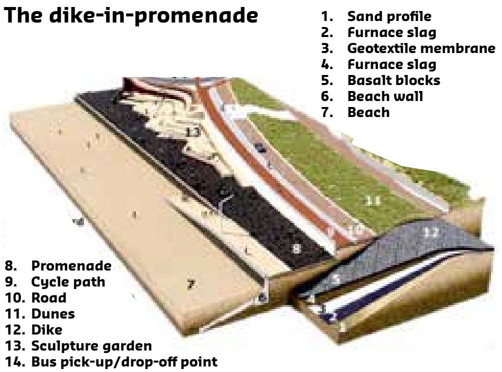


Figure 6: The dike-in-promenade in Scheveningen

11 *Bron: Financiële meerwaarde. Integrale gebiedsontwikkeling. Quick scan o.b.v. vijf cases. Ecorys in opdracht van Ministerie van Verkeer & Waterstaat, Rotterdam 25 februari 2010.*

the dike and promenade add value to each other insofar as the dike has not been raised enough for the promenade to lose any of its value for the area. Higher tax revenues due to the promenade can make a contribution, albeit indirectly, to the upkeep of the dike.

	Cost saving through constructional combination	**New revenues from operational combination**
Multiple use of space	Cost saving due to same building process	Tax revenues related to the promenade can contribute towards the upkeep of the dike indirectly
Raw materials	Use of the same building materials for both the dike reinforcement and the construction of the promenade	Use of the same building materials for upkeep of both the dike and the promenade
Shareholders	Municipality, Water Board, Directorate-General for Public Works and Water Management	Municipality, Water Board, Directorate-General for Public Works and Water Management

Living and working along the water [12]

The Netherlands is not the only country where lots of cities have formed on natural elevations along rivers. Examples abroad include New York and Hamburg. There, and in other places, roads and transport (as well as living and working) are combined with the flood defences in, for example, a promenade. Water adds a unique quality to living and working. Urban waterfronts are the face of the city and therefore deserve a lot of attention when it comes to improving the spatial quality.

Example: HafenCity in Hamburg[13]

In twenty-five years' time, a new residential and commercial area outside the dike will have been created on a former port site in Hamburg: around ten kilometres of quayside for homes, culture, tourism, leisure and offices. It involves 5,500 homes and offices on half of the 150-hectare project. This combination must comply with strict requirements because the level of the river Elbe can rise quickly during a storm surge. Parking and work activities are allowed below a certain level, but living is not. This results in a streetscape with many buildings erected on flood-resistant plinths. Windows are made of reinforced glass and there are

12 *Source: Robbert de Koning, Liesbeth Eshuis (2008): Rivieren & Inspiratie, Ruimte voor de Rivier, Eburon, Delft.*
13 *Source: Rivieren & Inspiratie op cit.*

mechanical shutters around the buildings, which can be closed at high water. Evacuation routes and passageways have been made for rescue and emergency vehicles.

Figuur 7: HafenCity in Hamburg

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process, insofar as HafenCity also functions as flood defence	Insofar as HafenCity also serves as flood defence, this neighbourhood reinforces this and, the other way round, the flood defences help determine the value of the neighbourhood
Raw materials	Use of the same building materials for HafenCity and elements of the flood defences	Use of the same building materials for upkeep of HafenCity and flood defences
Shareholders	Municipality, entrepreneurs, local residents	Municipality, entrepreneurs, local residents

Example: Stadseiland in the river Waal, Nijmegen

In Nijmegen, they chose to build a Stadseiland (an urban island) in the river Waal. The aim is to start construction in 2013; this involves a constructional combination of flood defence structure and urban neighbourhood. The Municipality made this plan in collaboration with the project 'Room for the River', because a solution is needed for periods of high water in the Waal. The classical solution is to raise the dike. Now, however, they have chosen to move the dike backwards and dig a channel to accommodate the water. Between channel and river, an island will be formed, which will be made so high that it will not flood. This will create room for the combination with urban development. In addition to a constructional combination, Stadseiland is also an operational combination, because its use will generate revenues for maintaining the flood defences. These might well be revenues from taxes which return to the island itself, and the flood defences, via an indirect route, but that does not detract from the fact that these revenues relate to operations.

For a long time, safety was what legitimated the use of hard structures which rigidly control the water system. Until recently, a dike along the Waal was the preferred solution, but that idea has gradually begun to lose favour. Projects such as that in Nijmegen embrace the natural dynamics of nature and water, in preference to strict control of the system. According to this approach, water is not seen as a threat, but as an instrument for creating a high-grade area with safety as an integral part of it. Nature and water have evolved into partners of hydraulic engineering for human purposes such as safety. At the same time, improvements to the ecosystem ride on the back of this (see page 48).

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for urban neighbourhood and flood defences	Better quality homes, as well as nature and water; revenues to maintain the flood defences
Raw materials	Use of the same building materials for urban neighbour-hood and flood defences	Use of the same building materials for upkeep of urban neighbourhood and flood defences
Shareholders	Municipality and Project 'Room for the River'	Municipality and Project 'Room for the River'

Example: Kampen[14]

In Kampen, as in Hamburg, measures have been taken to make homes flood resistant. In this case, the homes explicitly form part of the flood defences. The 'Kampen-Midden flood defences' are almost two kilometres long in total. The old city wall forms a large part of the flood defences (over 1.5 km). At points where streets and squares interrupt the wall, the dam consists of separate elements which close the dam when water levels are high, like check valves in the road surface or separate stop logs. In total, the dam consists of 84 of these moving parts, together accounting for around two hundred metres.

Figure 8: The Kampen-Midden flood defences

The city wall and homes in Kampen were not built as flood defences. There does not seem to be any evidence of a constructional combination, because then the wall and homes would have been built as flood defences right from the start. Due to the building activities to retrofit the wall and homes, as well as make them suitable to serve as flood defence, there is a constructional combination. That also makes the project an operational combination because homes can be used as flood defences. They increase the quality of the flood defences and, the other way round, the flood defences ensure that Kampen can retain its character and quality as a historic town. A not insignificant fact is that the residents of Kampen feel very much involved in the project.

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving by retrofitting the existing homes and making them into flood defences	Homes reinforce the flood defences and, the other way round, these help to retain the value of the homes and the city; improving social cohesion
Raw materials	Partial use of the same building materials which already serve a function for homes	Use of the same building materials for upkeep of homes and flood defences
Shareholders	Municipality, Water Board, residents	Municipality, Water Board, residents

14 *Bron: www.wgs.nl*

Example: Voorstraat, Dordrecht

Right in the centre of Dordrecht, Voorstraat forms a primary flood defence which, as such, comes under the jurisdiction of the water board. As in Hamburg and Kampen, measures have been taken in this street which can reinforce the flood defence function. This means that, as in Kampen, there is a constructional and an operational combination. And, just like in Kampen, the residents of Dordrecht are involved. In terms of multifunctionality, you could say there was an extra 'social combination' because it brings neighbours into contact with other. In Dordrecht, drills are held after late-night shopping at places where stop logs and other provisions are located, to prepare for wet conditions. This is relevant as the Delta Commissioner has stated that residents will have to play an increasingly large role with respect to flood defences. Dordrecht and Kampen are the first examples of this.

Figure 9: Rear view of the houses on Voorstraat, Dordrecht

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving by retrofitting the existing city wall and homes and making them into flood defences	Homes and city wall reinforce the flood defences and, the other way round, they help to preserve the value of the homes and the historic town; improving social cohesion
Raw materials	Partial use of the same building materials which already serve a function for the city wall and homes	Use of the same building materials for upkeep of city wall, homes and flood defences
Shareholders	Water Board, residents Municipality, Water Board, residents	Water Board, residents Municipality, Water Board, residents

Example: Step Dike (Trapdijk), Rotterdam[15]

The project 'Waterwegcentrum (Waterway Centre) Hoek van Holland' gave rise to the idea of the 'step dike'. Through the use of vertical walls, diaphragm walls or sheet piling, no space-demanding embankments are needed with dike reinforcement, so the available horizontal surface can be designed efficiently for urban use. This signifies an operational combination. After all, use as flood defence is possible as well as there being space available for urban functions. Urban functions are even strengthened as new space is created, for example also with roads which have been better integrated and cause less nuisance. Moreover, the function of flood defence is further reinforced if the urban functions contribute towards the strength of the flood defences. That is possible, for example, by creating a park on the bottom 'step of the ladder', which can absorb the initial flooding in a simple way. If everything is built at the same time, we can also speak of a constructional combination.

Figure 10: Step Dike, Rotterdam

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for Step Dike and urban functions on this dike, such as roads and park	Flood defence creates space for urban use, whilst urban functions help make the Step Dike stronger
Raw materials	Use of the same building materials for urban functions and Step Dike	Use of the same building materials for upkeep of urban functions and Step Dike
Shareholders	Municipality and Water Board	Municipality and Water Board

15 Source: www.klimaatdijk.nl

16 See Future value now! The power of multifunctionality, op cit. page 16.

Example: Super Dike, Tokyo

In Tokyo, a Super Dike is being built with other buildings and roads on top of and inside it. This Super Dike is reinforced underground with steel sheet piling and strengthened internally with concrete slabs. The dike has already been partially completed and is being built in phases.

Analogous to the Japanese example, concepts for super dikes are also being developed in the Netherlands. It is clear that these are all constructional combinations, so that the building costs for both the dike and buildings could fall. It is also clear that super dikes are operational combinations because the dike and the buildings physically reinforce one another. Integrating the foundations of the buildings with the underground strength of the dike has advantages for the dike as flood defence and for the land with urban functions.

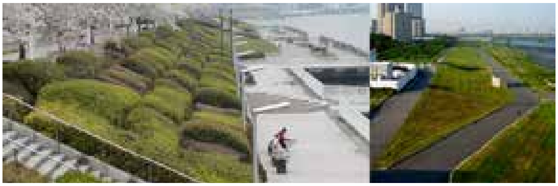


Figure 11: Super Dike, Tokyo

Retention basins in the city

In some Asian countries, public spaces in densely-populated areas subject to flooding have been designed in a well thought-out way for multiple use. In the Netherlands, the best example up to now is the water plaza, which was created in Rotterdam[16]. The water plaza might not serve a direct function as flood defence, but it certainly helps avoid wet feet. The retention basin is part of a larger system in which flood defences also play a role. The example in Yokohama described below is much more an integral part of a flood defence system than the water plaza in Rotterdam.

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for Super Dike and urban functions on this dike, such as roads and buildings	Flood defence creates space for urban use, whilst urban functions help make the Super Dike stronger
Raw materials	Use of the same building materials for urban functions and Super Dike	Use of the same building materials for upkeep of urban functions and Super Dike
Shareholders	Municipality of Tokyo and property developers	Municipality Tokyo and real estate owners

Figure 12: Water plaza

Example: Yokohama [17]

In Yokohama, the second largest city in Japan, the water flows into a basin when water levels are high. As soon as the level in the river falls, the locks in the dikes are opened so that the area can empty again. This basin has been designed as a recreational area with, among other things, a stadium that seats 72,000 people, which stands spectacularly on piles about five metres above ground level.

An added advantage is that the retention area is public property so a designation of private property as flood area is unnecessary.
As with the Step Dike and the Super Dike, there is evidence of an operational combination if urban functions are improved and the quality of the flood defences increases. That appears to be the case in Yokohama. By building everything at the same time, it is also a constructional combination, as with the Step Dike and Super Dike.

Figure 13: The stadium in Yokohama

Figure 14: Location of the Yokohama stadium in the basin

17 *Source: Rivieren & Inspiratie op cit.*

	Cost saving through constructional combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for the retention basins and urban functions	Retention basins create space for urban use, including recreation, sport and parking, whilst these urban functions contribute towards the function of the retention basins
Raw materials	Use of the same building materials for urban functions and retention basins	Use of the same building materials for upkeep of urban functions and retention basins
Shareholders	Public parties in the region	Public parties in the region

Example: DUIN plan, Almere

DUIN (dune) is a plan for a new residential, working and recreational area on the IJmeer in Almere, the Netherlands. The plan really lives up to its name as real dunes, up to ten metres high, will be created here along the coast, alternating with woods, creeks and a real dune valley. DUIN encompasses houses on the dunes, villas in the woods, apartments with views of the IJmeer, a promenade along the coastline, a marina and a plaza in the centre. The plan has already been approved, but some points in the design still need to be clarified. DUIN will be both a constructional combination and an operational combination because various functions will be mutually reinforcing.

DUIN should make an important contribution to the diversity of the landscape and also improve the quality of the water in the vicinity. The beach in the DUIN project, for example, will present a unique picture because there will be flowering plants alongside sand and marram grass. The freshwater of the IJmeer makes this combination of sand, water and greenery possible. The dunes also serve a water-purifying function for the area behind the beach. The dune sand filters the surface water and rainwater, so that clear water flows into the creeks. In this way, DUIN supports the intended sustainable future of the neighbourhood.

Figure 15: DUIN plan

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process, insofar as DUIN also functions as flood defence	Insofar as DUIN also serves as flood defence, this neighbourhood reinforces this. The other way round, the flood defence helps determine the value of the neighbourhood; the water-purifying function of the sand reinforces the ecological function of the neighbourhood, and the other way round; the diversity of the landscape reinforces the neighbourhood and also the quality of the water, whilst property development in the neighbourhood funds this diversity.
Raw materials	Use of the same building materials for construction of the whole DUIN area and elements of the flood defences	Use of the same building materials for upkeep of the whole DUIN area and elements of the flood defences; water purification and the development of nature.
Shareholders	Municipality, entrepreneurs, residents	Municipality, entrepreneurs, residents

Example: IJsseldelta-Zuid project [18]

Near Kampen, existing buildings form a bottleneck for future water drainage. In addition to this, damming up during north-westerly storms is a problem. For mainly financial reasons, the PKB (key planning decision) chose in 'Room for the River' to deepen the IJssel quite dramatically by lowering the summer bed of the river and by building a bypass. In 2009, the decision was made to perform the two interventions in combination. This was in anticipation of long-term climate change. At the same time, this constructional combination yields a massive cost saving. For example, the sand that is made available from lowering the summer bed of the IJssel can be used to build the 'climate dike' in the bypass. That lowers the transport and investment costs considerably.

Without a doubt, the most striking project in the IJsseldelta-Zuid development project is the construction of the bypass in combination with the climate dike, which is also suitable for house building. This means a constructional combination, but various operational combinations are also conceivable. This is because a large number

18 *Source: www.ijsseldeltazuid.nl*

of other developments are at play in the planning area. Things in the pipeline include construction of the Hanseatic Railway Line with a new railway station environment, the ecological connection between the River IJssel forelands and the four lakes, the Veluwerandmeren, reinforcement of the agricultural structure and the widening to 2x2 traffic lanes of the N50 and N307 roads.

Possible operational combinations are the improved access to and from the area thanks to the road, whilst the improved utilisation of the road will also speed up the development of the area. The mutual reinforcement between road and rail will also improve the way both function, and ecology and agriculture can also be mutually reinforcing (although the latter could also have the reverse effect).

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for lowering summer bed and bypass, and also for climate dike and house building	Climate dike gives housing a unique character and revenues from homes will contribute towards upkeep of the dike; mutual reinforcement between road and area, road and rail, ecology and agriculture
Raw materials	se of the same building materials for construction of the whole area; this includes sand from lowering summer bed for bypass, reduction in carbon emissions for transport	Use of the same building materials for upkeep of the different area elements, such as the bypass, the summer bed and the climate dike.
Shareholders	Municipality, Province, Water Board, Directorate-General for Public Works and Water Management, ProRail	Municipality, Province, Water Board, Directorate-General for Public Works and Water Management, ProRail

2.3 Sustainable energy

There is a relationship between flood defences and sustainable energy and this relationship is getting stronger all the time. As wind turbines are becoming taller and taller - some are already more than a hundred metres high - and are having an increasing impact on the landscape, locations on or along dikes are being considered increasingly often, for example in the Province of Groningen. In addition, room for future dike expansion, existing dikes and areas outside the dikes or which regularly flood can be interesting for the cultivation of bio-energy crops[19].

19 *Source, J.M. van Loon – Steensma op cit.*

The Energy Dike is the name of the concept used by a consortium of businesses, public authorities and knowledge institutions to draw attention to generating energy from osmosis and low tidal drop. The aim is to link Dutch know-how on dikes with the possibilities of taking measures immediately around the dike to generate energy. The Cabinet has set aside €20 million for the development of sustainable energy on the Afsluitdijk. Alongside solar energy, what is known as blue energy will be generated. Finally, it is starting to look very much as if permission will be granted for a tidal power station in the Brouwersdam.

Wind turbines

Wind turbines on dikes are becoming a normal sight. Is this a question of multifunctionality or simply land allocation and the multiple use of space? Do the turbines benefit from the dike and vice versa? That remains to be seen. After all, they are basically two separate functions with the wind turbine often even being seen as a risk to safety, the primary function of the flood defences. The location of many dikes is ideal for wind turbines, however, for example because they are much more easily accessible than turbines at sea and yet also catch a lot of wind. Also, few people usually live on or round dikes, so the turbines cause limited nuisance.

Is it the dike that benefits the turbine, or the location? The other way round, it is highly questionable if the turbine reinforces the dike. That could be the case if the foundations of the wind turbine were a bonus for the dike. Very large turbines certainly need large foundations, which could reinforce a dike. The turbine does cause the foundations to vibrate, however. Dike managers usually find that undesirable, although others claim that vibrations help soil to bed down and firm up. In other words, the operational combination is dubious, and limited perhaps to a financial payment from the turbine owner to the dike manager at the most. Nor is a constructional combination involved, because most turbines are erected afterwards. Perhaps a completely new dike could be designed in combination with wind turbines and then there would be evidence of a strong constructional combination. Of course, this is also possible with renovation work or major repairs, as presently with the Afsluitdijk and the Houtribdijk.

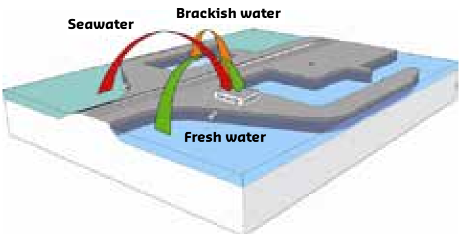
Figure 16: Wind turbines on the dike

Solar cells

A dike is also an excellent location for solar cells, although the salty seawater has a negative impact on the cells. Apart from the financial payment, there is no real evidence of strong multifunctionality. The dike does not improve the cells as such and nor do the solar cells make the dike better. As with the wind turbines, it is mainly a question here of the multiple use of space. And, as we know, that is not the same thing as multifunctionality.

Blue Energy

Blue Energy means that electricity is generated by mixing freshwater and seawater. In such a power plant, currently only at the experimental stage, the freshwater and seawater are brought into contact with each other by selectively permeable membranes, which separate freshwater and seawater. As the membranes and freshwater/seawater compartments are contained in compact modules, a massive working surface and massive potential energy difference are achieved. Scientists from Wageningen University and Wetsus have worked out that every cubic metre of fresh river water that flows into the salty sea every second represents, in theory, a power potential of one megawatt (a million watts), hence the name Blue Energy. According to these calculations, three gigawatts are going to waste in the Netherlands, or 12% of Dutch demand for electricity. A number of crucial upscaling steps do need to be taken, and researchers are working hard on these.
Now that the Afsluitdijk is due for a major overhaul, there is an ideal opportunity for a constructional combination with the Blue Energy power plant. Perhaps this will lead, like the constructional combination on Scheveningen Promenade, to a 10% reduction in the construction costs. In order to determine whether or not there is an operational combination, the question is, does the power plant for example contribute towards the discharge of water, or water quality, or definitely not? Here too there is the prospect of an interesting combination of functions. When the electricity is generated, the power plant has to discharge a large quantity of brackish water (mixture of freshwater and seawater) as ‘waste water’. This brackish water should be able to play a role in softening the ‘hard’ transition between the salty water of the Wadden Sea and the fresh water of the IJsselmeer, the large inland lake in the middle of the northern part of the Netherlands. Fish that want to migrate from seawater to freshwater, for example to spawn, would then suffer less from the state of shock they currently experience when the lock gates open twice a day. The brackish water of the Blue Energy power plant could, as it were, form a ‘decoy stream’ in an estuary strip that is built right through the Afsluitdijk. Research is currently being done on such a ‘fish migration river’



Figuur 17: Blue Energy

Example: Tidal Power Plant, Brouwersdam

The tidal power plant in the Brouwersdam will combine the functions of generating energy and damming. It is a constructional combination because the tidal power plant is being built as part of the flood defences. And it is an operational combination in its purest form because, after all, energy is generated at the same time as the function of damming is fulfilled. The plans for the Afsluitdijk do not include a tidal power plant, but a number of private parties have been experimenting with this for some time nearby Den Oever, and there are also ideas for a power plant in the Marsdiep.

Figure 18: Brouwersdam

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process, insofar as the Tidal Power Plant also functions as flood defence	Insofar as the Tidal Power Plant also serves as flood defence, this serves to reinforce it and, the other way round, the flood defence as location helps determine the value of the power plant
Raw materials	Use of the same building materials for the Tidal Power Plant and elements of the flood defence	Partial use of the same building materials for upkeep of flood defence and tidal power plant; generating energy
Shareholders	The Directorate-General for Public Works and Water Management, energy company	The Directorate-General for Public Works and Water Management, energy company

Bio-energy crops

A reasonable quantity of biomass can be produced through a combination with nature management. Trees, grass and shrubs grow and bloom along waterways. Once every now and then, this greenery has to be cut. That costs money and produces a huge mountain of green waste. This 'biomass' could also yield something. For example, green waste is definitely suitable for generating energy (biogas) via fermentation. Woody parts can be used as auxiliary fuel in a coal-fired power plant. Biomass is also increasingly becoming a useful raw material for new

products (biobased economy). That provides opportunities for the Directorate-General for Public Works and Water Management and other water managers.

In the river bed, legal regulations throw up obstacles to the large-scale cultivation of biomass in forelands. On the other hand, use of the wood that becomes available through the management/upkeep of the forelands seems very feasible for generating energy. After all, rough vegetation may not be allowed to hinder the free flow of water. In addition, new nature is increasingly being developed along the forelands. By managing this nature according to the concept of cyclical management, the production of biomass takes place as a sideline of nature management. That safeguards the discharge capacity of the rivers.

As part of sea defences, biomass plays a slightly different role. Insofar as dikes and dunes are mown, a lot of biomass is produced, as above, certainly in the dunes. In addition, the ground cover plays an important role in the sturdiness of flood defences. Just think of marram grass on dunes and eelgrass on the mud flats (see page 52). This eelgrass even helps create flood defences; a wonderful form of multifunctionality. Harvesting only takes place after some years. The grass first has to mature and fulfil its water-retaining function. Then the surplus can be harvested; see also page 48 on Building with Nature.

20 Source, J.M. van Loon – Steensma, op cit.

2.4 Green functions

Agriculture

The dike and adjoining areas are used for farming purposes in many places. Many dikes (in the river area) were even specially built in the past, sometimes first using groynes in the river, to make reclaimed wet areas suitable for agricultural use. The summer dike was also designed to make the area outside the dike between the major (winter) dike and the summer dike suitable for farming. These naturally fertile areas are used mainly for arable and grassland farming. The dike itself is usually only used for grazing. On some dikes, fruit is cultivated on the inner embankment and the inner verge. Trees in the dike profile can adversely affect the flood defence function of the dike due to erosion, for example, or if they are uprooted by the wind. For this reason, limits are often set on the height of the trees[20].

Figure 19: Dike combined with agriculture

Example: Overdiepse Polder[21]

Since the beginning of 2011, the Overdiepse Polder along the river Maas near Waalwijk has been undergoing complete redevelopment in connection with the project 'Room for the River'. The polder will be preserved for agriculture, whilst at the same time the river water can flow through it temporarily on average once every twenty-five years. Local residents and their animals live on terps (artificial hills) and the urban areas upstream of the Overdiepse Polder suffer less from flooding as a result.

As soon as creating more room for the river appeared on the agenda, the Overdiepse Polder came into the picture as an overflow area. At a very early stage, the local residents themselves came up with the plan to locate farms on terps. More than ten years later, this resulted in the demolition of all eighteen old farms. Nine of these will be rebuilt on terps and the other nine have been relocated or bought out. In addition to relocating and buying out, the measures consist of rerouting the primary flood defences and building nine terps. The current dike will be lowered and serve in this way as an inlet for the river water when water levels are high. There will also be an ecological zone with alternating elements, such as channels and higher sections with trees. The wide, open character of the polder will be preserved.

	New revenues from operational combination	**New revenues from operational combination**
Multiple use of space	Cost saving due to the same building process for terps, restructuring of agricultural area, rerouting and lowering flood defences, and ecological zone	Thanks to agriculture, the area remains suitable as overflow area, increasing safety and reducing inconvenience for urban areas upstream; the other way round, the overflow area ensures that farming can continue
Raw materials	Use of the same building materials for terps, flood defences and ecological zone	Use of the same building materials for upkeep of terps, flood defences and ecological zone
Shareholders	The Directorate-General for Public Works and Water Management, Province, farmers	The Directorate-General for Public Works and Water Management, Province, farmers

21 *Source: Waterstand februari 2011, quarterly publication from the Programme Board 'Room for the River'.*

The combination concerns the safety of the catchment area of the river Maas and the agricultural use of the Overdiepse Polder. This safety is not so much the result of a flood defence structure, but because the creation of an overflow area downstream makes it unnecessary to heighten the dike upstream. The farmland will not be lost and, when water levels are high, the cattle can simply go onto the terp, where the farms are already safe and dry. This combined use of the polder for farming and as overflow area is a true operational combination. The constructional combination creates the overflow area and restructures the farming area, incorporating the terps.

Figure 20: The tree dike in Wilp forms an ecological corridor

Landscape and nature

River areas and the areas of duneland have high scenic value and are home to a lot of flora and fauna. Large parts have already been designated Special Protection Area in the context of the European Birds and Habitats Directive. Nationally, many foreland areas (including summer dikes and levees) form part of the Ecological Main Structure. At the same time as managing nature and creating new nature, safety is often improved by giving rivers more room.

All 'line infrastructure' functions longitudinally as an ecological corridor and this applies equally to dikes and dunes. There are provincial requirements which stipulate that dikes are or must become corridors. If they have to serve this function, there is evidence of a constructional combination. In addition, with many dikes, one can speak of an operational combination of the functions flood defence and valuable nature reserve. It is crystal clear that dunes not only serve as flood defences but are also very important and often protected nature reserves and corridors

Example: Koopmanspolder project[22]

In the Koopmanspolder near Medemblik, the Province of North Holland is creating a sixteen-hectare nature reserve. It involves wet nature with reed-land, scrub and wet grassland as part of the Ecological Main Structure. In the design, landscape, nature and recreation are combined with a pilot for new water management. By experimenting with different water levels, the Directorate-General for Public Works and Water Management can learn more about water safety and that is important in connection with rising sea levels. The water managers measure the effects on nature, water quality and the surrounding area. As in the example from Yokohama, it is interesting to see which combinations are possible in such an area that is enclosed by flood defences.

The design for the Koopmanspolder, as a landmark, also enhances the cultural-historical landscape of the greater region. In this way, the province and region want to make this area more attractive for recreation and tourism. The differences in height and the variation in wet and drier areas make the polder an excellent habitat for various species of flora and fauna. To allow water in and out, a fish-friendly inlet is being created on the north-west side of the polder. It concerns an innovative tubular auger driven by a small wind turbine. This not only allows fish to enter the polder, but also return to the IJsselmeer, the large inland lake in the middle of the northern part of the Netherlands after spawning. A good flow and fish stock are also essential to limit insect populations, for example mosquitoes.

There is restricted public access to the polder. In the western part of the polder, you can walk over the 'rings of the whirlpool' via small dams or plank bridges. There is also a plan to use the polder as an ice rink during the skating season. The eastern section of the polder will retain an agricultural function, in part. Here, sheep can continue to graze, for example. The footpaths on the dikes around the polder will remain accessible. By realizing the many functions of this project simultaneously, it is certainly a constructional combination. If, following completion, these functions are mutually reinforcing, it will also be an operational combination.

Figure 21: Koopmanspolder project

22 Source: http://www.noord-holland.nl/web/Themas/Natuur-landschap-en-recreatie/Groenprojecten/Koopmanspolder.htm

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to simultaneous creation of functions involving landscape, nature, recreation, water management and agriculture	Landscape, nature, recreation, water management and agriculture are all closely related to each other and strengthening one function often means strengthening the other; that makes it easier here to make use of all these functions
Raw materials	Use of the same building materials for elements of landscape, nature, recreation, water management and agriculture	Use of the same building materials for upkeep of elements of landscape, nature, recreation, water management and agriculture
Shareholders	Province, Water Board, Municipality Province, Water Board, Municipality, residents,	the Directorate-General for Public Works and Water Management

Example: Dike rerouting, Westenholte

When the River IJssel is high and the level of the large inland lake IJsselmeer also rises, as a result of a north-westerly storm for example, the water ‘gathers’ around the city of Zwolle. The rerouting of the dike near Westenholte is one of the three measures to improve the safety of the city and surrounding area. By rerouting a dike, the river is given more room by moving the flood defence structure inland. This means that land that was originally inside the dike ends up outside the dike and the winter bed of the river is given some extra space. As a result, the river can discharge more water at high water without the water level rising.

To this end, the forelands near the Zwolle district of Westenholte are being enlarged and deepened. New channels will be connected to the existing channel. There will be a new 2.2 km long dike, about three hundred metres further inland than the current flood defence structure. A number of local residents will move to three new dike homes, two farms will be relocated and a new country estate will be created. Thanks to the rerouting of the dike, the level of the IJssel will be about fifteen centimetres lower near Zwolle at high water. The channels will join the flow during periods of high water. Due to the open connection with the IJssel, nature will have the chance to develop in the transition zone between wet and dry. On the country estate, there will be ‘boot paths’ so that people can enjoy this new nature. Such usage is, without a doubt, an operational combination, but in order to realize this, we first need a constructional one.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the simultaneous relocation of the dike, digging of new channels, building and relocating homes and creating the country estate and new nature	The main thing is to improve safety; this contributes towards the development of new nature, which will be accessible for the public
Raw materials	Use of the same building materials for dike, channels, nature and structures	Use of the same building materials for upkeep of dike, channels and nature
Shareholders	The Directorate-General for Public Works and Water Management, Province, Water Board, Municipality	The Directorate-General for Public Works and Water Management, Province, Water Board, Municipality

Climate buffers[23] and Building with Nature[24]

Rivers and brooks always used to flow freely through the Netherlands, depositing sand and silt in the delta and, in this way, forming new land. Nowadays, the canalized rivers carry silt directly to the sea. In the old days, peat formation kept pace with the water level. However, as a result of drainage operations, the peat bed has now been broken up and the soil is settling as a result of oxidation. Some parts of the Netherlands have sunk more than a metre in a century. By now allowing the Netherlands to grow along with the sea, rivers and peat where possible, our country's natural resilience will increase. Climate buffers, also referred to as natural climate buffers, can assist here because they can absorb and hold water like a sponge. Marshes were actually climate buffers before the term existed. But that's not all. Along the coast and riverbanks, the climate buffers use silting up to build up land and protect against flooding. Terminating or reducing drainage operations stops peat from settling and results in the growth of marshes. This allows the peat bed to grow again and prevents the land from sinking further.

Climate buffers combine a series of functions in an autonomous way. During wet periods, they reduce the drainage peaks in rivers, storage basin systems and brooks. The coast is also safer as a result. In drier periods, more good quality water remains

23 *Sources 1) Gerard Litjens, Keesjan van den Herik, Alphons van Winden, Wim Braakhekke, Natuurlijke klimaatbuffers, Adaptatie aan klimaatverandering, Wetlands als waarborg, Publisher: Stroming bv, October 2006. 2) www.klimaatbuffers.nl*

24 *Sources: 1) www.ecoshape.nl. 2) www.ark.nl*

available for farming, nature and urban areas. During periods of drought, the buffers also combat salinization. Furthermore, marshes are natural water purifiers and water reservoirs for dry periods. Retaining water for longer has advantages for the economy; enough water for the towns, agriculture and industry. Nature benefits from the preservation of biodiversity and safety is improved through the prevention of further sinking of peat polders and through the silting up of the water bed.

Such natural processes require space. And this is scarce outside the existing nature reserves. In order to use space efficiently, it is therefore logical to further increase the multifunctionality within climate buffers. Some buffers strongly resemble the ancient terps and can provide space for housing, work and recreation, which take on a sustainable and climate-proof character as a result. A green neighbourhood with a lot of surface water, for example, can be up to six degrees cooler during a hot summer than a neighbourhood without greenery, and can therefore combat ‘heat stress’ in the city. Levels of microscopic dust are also considerably lower in green neighbourhoods.

On the island of IJsselmonde, to the south of Rotterdam, there are plans for a climate buffer as a “natural sponge”. Literally just like a sponge, it will absorb water when it rains and then release it when necessary. In this way, the climate buffer can cushion the initial blows of climate change and market gardeners, for example, will suffer less from rivers becoming brackish during dry periods. The quality of the water system and the accompanying ecology are safeguarded better as a result. At the same time, it creates more possibilities for nature, recreation and spatial quality. With these and other forms of multifunctionality, climate buffers can play a role in coastal areas and river deltas.

Building with Nature (BwN), like climate buffers, makes use of the natural processes which served or serve as ‘master builders’ of the Dutch landscape, such as silting up, sand transport, peat growth and the formation of dunes. BwN sometimes involves a one-sided intervention, but often also encompasses some nice forms of multifunctionality, such as oysters helping to reinforce the coastal defences. At the same time, the oysters play a role in water purification, nature development and food cultivation. Two important social goals - safety and sustainability - can be combined well in the water sector by building with nature. They make a real contribution to the quality of the living environment and create room for different combinations with recreation and salty farming, among other things.

Climate buffers are in line with the concept of Building with Nature, but BwN is broader and goes further. Because it combines, among other things, coastal defences, water storage, land reclamation, nature

development, economic use, recreation and generating energy. BwN often means building with greenery, greenery that not only contributes towards binding carbon, but also leads to direct carbon reduction. Moreover, making use of plants and animals (including shellfish) helps in catching silt and binding nutrients and contaminants. In this way, building with nature contributes towards the quality of the surface water and combats climate change. As we mentioned, there is also a combination with agriculture and horticulture. After all, hydraulic solutions have an impact on groundwater levels, freshwater stocks, freshwater supplies and the salinization of farmland. A combination can also be made with sustainable energy. Just think of Blue Energy, algae as biofuel and energy storage in water.

Example: Oesterdam

The construction of the Eastern Scheldt Storm Surge Barrier has reduced the tidal difference. The tide is not strong enough to carry the sand and mud churned up during storms back to the sandbanks and the foreland of the Eastern Scheldt. The sand ends up in the channels and stays there. The destructive ecohydrological forces still operate, therefore, but there is no constructive capability. This process is known as “sand hunger”.

At the same time, the dikes along the Eastern Scheldt have to comply with the safety standards in the Delta Act. The dike of the Oesterdam – the longest dam in the Delta project – is one of the civil-engineering works that the Sea Defences Project Bureau is reinforcing in 2012. This work is being combined with the construction of a climate buffer, whereby the area just in front of the Oesterdam will be raised over a distance of two kilometres using 600,000 cubic metres of sand. The climate buffer is located on the eastern boundary of the Eastern Scheldt, to the west of Bergen op Zoom. This will reduce the effects of the ‘sand hunger’ and cushion the waves. Furthermore, it means that a major overhaul of the Oesterdam can be postponed for twenty years and that all regular maintenance work is cheaper.

The Oesterdam and the climate buffer ensure that water safety is improved in a natural way. Nature, sport fishing and recreation also benefit in this way. We can then speak of an operational combination, but this first has to be achieved through a constructional one.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to simultaneous construction for the benefit of flood defences, nature, sport fishing and recreation	The main thing is to improve safety; this contributes towards the development of new nature and places for anglers and other recreational visitors; the other way round, they do not reinforce the flood defences, but the new nature possibly will
Raw materials	Cost saving by using sand instead of other building materials	Lower maintenance costs by using sand; development of nature (biomass)
Shareholders	The Directorate-General for Public Works and Water Management	The Directorate-General for Public Works and Water Management, nature managers, anglers, recreational visitors

Example: Punt van Voorne

Another natural climate buffer can be found at Punt van Voorne (South Holland). By (artificially) reinforcing the natural sand transport, the dune zone there can cope better with rises in the sea level. New experience with this innovative approach is interesting, because it is expected to be applicable at many other places along the Dutch coast.

Due to the pointed shape, sand erosion at Punt van Voorne is particularly severe. For this reason, a large quantity of sand is being sprayed onto the beach between Punt van Voorne and Rockanje. The beach will finally be one metre higher. In addition, a 130-metre wide row of extra dunes will be created in front of the vulnerable point. In the course of time, this will slowly crumble away due to natural processes.

A bigger, higher and wider area of beach and dunes, and the restoration of old paths, will increase the recreational opportunities. With the dynamic and natural character of the sea defences and the plants and animals this attracts, the area will become richer in species and more exciting for nature lovers. In that case, it is a question of an operational combination, but here too a constructional combination is first needed; one that creates the sea defences and the nature reserve at the same time.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to simultaneous construction for the benefit of flood defences, nature and recreation	The main thing is to improve safety; this contributes towards the development of new nature and places for recreational visitors; the other way round, they do not reinforce the flood defences, but the new nature possibly will
Raw materials	Cost saving by using sand instead of other building materials	Cost saving by using sand instead of other building materials Lower maintenance costs by using sand; development of nature (biomass)
Shareholders	The Directorate-General for Public Works and Water Management	The Directorate-General for Public Works and Water Management, nature managers, recreational visitors

Example: Restoration of eelgrass in the Wadden Sea

From time immemorial, mud flats have been protecting the coast against the sea. Fields of eelgrass on these flats, which are alternately submerged and then re-emerge as the tide changes, are powerful silt catchers and, in this way, help silt sink to the bottom. As a result, the mud flats can grow along with the sea. Eelgrass (or seaweed) has almost disappeared from the Dutch Wadden Sea at the moment. Restoration of the eelgrass fields is possible by collecting ripe eelgrass seed stalks towards the end of the flowering season in Germany and taking them in floating sacks (nets) to the Dutch Wadden Sea. There, the seeds can germinate in the shelter of shellfish banks. They have already gained experience with this method in the United States. It concerns an experimental project involving around four hectares that is currently being implemented in the Netherlands.

Eelgrass fields which are located in the zone between the mud flats and the edge of the salt marsh not only help with the preservation and formation of salt marshes, they are also biotopes with a characteristic biodiversity. The simultaneous growth of sandbanks and eelgrass is expected to be a relatively slow process, but fortunately that also applies to the rising sea level. By simultaneously creating a sea defence and biodiversity, we have a constructional combination. This building process is a slow one. However, once built, it will serve both as a sea defence and a high-quality nature reserve, making it an operational combination.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to simultaneous construction of flood defences and development of nature (biodiversity)	Flood defences contribute towards the development of nature (biodiversity) and nature reinforces the flood defences
Raw materials	Cost saving by using eelgrass and silt instead of other building materials	Lower maintenance costs by using eelgrass and silt; development of nature (biomass)
Shareholders	The Directorate-General for Public Works and Water Management, Provinces	The Directorate-General for Public Works and Water Management, nature managers, anglers, recreational visitors

2.5 Tourism and flood defences

Flood defences

Dunes serve an important function for nature, are very important in water purification and also retain water. From way back, numerous opportunities involving dunes have been utilised to combine these flood defences with tourism, for example in the form of footpaths. Many structures, such as beach cafes, are temporary and do not form a true combination with the flood defences. It is a different matter with all the hotels and restaurants whose function is reinforced by the dunes. The same applies to specific facilities created for recreational purposes, such as car parks, viewpoints, works of art, picnic areas, special planting or cycle paths and footpaths. The other way round, they do not reinforce the dunes, except that money can be earned by exploiting them and this can go towards managing the dunes. Here we mainly have an operational combination and not a constructional combination, because the dunes were, of course, already there.

Figure 22: Hotel Huis ter Duin in Noordwijk aan Zee

Figure 23: A car park as a specific facility in the dunes

Example: Cadzand marina[25]

In 2005, the government designated the coast of West-Zeeuws-Vlaanderen as a priority weak link. This means that the coastal section will have to be reinforced within twenty years. One of the sub-projects concerns Cadzand-Bad, the aim of which is not only to guarantee the safety of the hinterland, but also to help improve the quality of living, working, recreation and nature on the coast. Partly on the basis of the Environmental Impact Assessment, the option 'Seawards Dunes' was chosen. A 200-metre long dike will be built, covered with sand, without any change to the toe of the dune. The dunes will also be widened by a maximum of sixty metres. A training wall on both sides of a drainage channel will be reinforced, raised and lengthened in the form of a hook.

Various parties have looked into whether or not this training wall could also serve as a harbour.

The construction of a new harbour could give the region a tourist/economic boost. A project group comprising representatives of the Municipality of Sluis, Scheldestromen Water Board and the Cadzand Promotion Foundation studied different variants. Finally, the choice fell on a marina with room for 110 boats. This variant will require an extra investment of €4.5 million, which is not considered feasible at the present moment.

This project is a constructional combination because, at the same time, work goes into safety and other functions, such as housing and nature. Furthermore, the project is an operational combination because living, nature and recreation will all improve. The other way round, these functions do not really make the flood defences stronger, except if living and recreation generate more tax revenues. The business case for the marina is not strong enough to justify the extra investment of €4.5 million.

Figure 24: Cadzand now

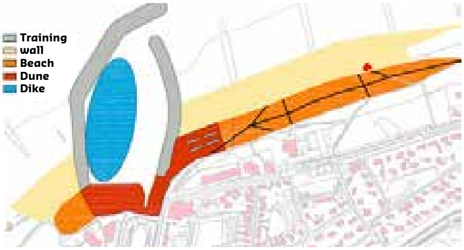


Figure 25: Cadzand marina

25 See: http://www.pzc.nl/regio/zeeuws-vlaanderen/10848672/Jachthaven-Cadzand-Bad-krijgt-ruim- honderd-plaatsen.ece.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for safety and the quality of housing, work, recreation and nature; this also involved looking for a variant to build the training wall as a marina too, but that is not feasible at the moment	The pursuit of safety contributes towards the quality of housing, work, recreation and nature; the variant of utilising the training wall as a marina yields too little to pay for its construction
Raw materials	Use of the same building materials for safety and the quality of housing, work, recreation and nature	Use of the same building materials for maintaining safety and the quality of housing, work, recreation and nature
Shareholders	Directorate-General for Public Works and Water Management, Municipality, Water Board, Stichting Promotie Cadzand	Directorate-General for Public Works and Water Management, Municipality, Water Board, Stichting Promotie Cadzand

Cultural history and archaeology

There is a lot of cultural history to be found around flood defences in the Netherlands. Well-known flood defences with value as monuments are the Westerscheldekering and the monument on the Afsluitdijk, but there are also several places where the route of an old dike is still visible in the current dike.

Features of flood defences with cultural-historical value often form characteristic elements of the landscape. Typical examples of this are mills and locks. Both historical defence lines, the New Dutch Water Line and the Line of Amsterdam, contain many elements that put their mark on the landscape, not infrequently with value as monuments. These elements influence the visual quality and scenic quality of an area. The book Rivieren & Inspiratie[26] speaks, in this context, of 'icons on the water/contact with the water'. The combination of a cultural-historical and damming function can be exploited with, for example, a visitors' centre. In such cases, we have an operational

Figure 26: A historical bunker

26 *Source: Rivieren &Inspiratie op cit.*

combination. It is not a constructional combination because a flood defence structure is seldom erected consciously as a cultural-historical feature.

2.6 Other water-related functions

Water purification, water storage, locks and inlets and outlets for water make it possible to combine various functions with flood defences. Not all examples in this 'residual category' are equally convincing cases of multifunctionality. Yet they do provide food for thought and are worth mentioning for this reason.

Water storage

The function of dunes in the context of water storage is clear, but the question is, does this involve multifunctionality? Are the flood defence and water-storage functions mutually reinforcing, or are these just two separate functions of the dunes? We can find an answer by looking at the new concept of 'unbreachable dikes'. These can flood, but the damage remains limited because they will not collapse. This requires that the land behind is made suitable for temporary water collection. This hinterland serves to give the dike its function, whilst, the other way round, the dike protects this land as much as possible. This is not the case with dunes, and the water storage behind the dunes has no function in the context of water safety. However, water purification often occurs in the dunes, and this earns money. That money partly benefits management of the dunes which serve as a sea defence. But it is not a strong example of multifunctionality\

Figure 27: Design of an unbreachable dike

Water purification / water storage

The combination of flood defence, water purification and water storage is not too convincing in the case of dunes, because water storage and water purification only make a financial contribution to the flood defence function, but do not directly reinforce it. This relationship is different in the example of Kristalbad in Enschede, which is therefore informative.

Figure 28: Water purification in the dunes

Example: Kristalbad

The development of the Kristalbad is all about the multiple use of space involving the two largest cities in the Twente region. Five functions have been combined, focusing on water storage and water purification:

1. Water storage

   There is too little room in Enschede and Hengelo to store excess rainwater. Furthermore, there is a considerable difference in height between Hengelo and Enschede. During heavy rainfall, the water runs too quickly, as it were, towards Hengelo. To guarantee dry feet in Hengelo, the water from Enschede has to be collected temporarily. Following the construction of the Kristalbad retention area, the water board will be able to store 187,000 cubic metres of water in times of excessive precipitation.

2. Post-treating water and making it biologically active

   Some of the water in the Kristalbad comes from the Enschede sewage treatment plant. The Regge and Dintel Water Board therefore came up with a design for the further treatment of this water. The Kristalbad is made up of compartments, which are filled, empty and run dry by turns. Under the influence of light, air and vegetation, the water bed does its purifying work: it breaks down and converts matter.

3. Spatial quality

   The area between Hengelo and Enschede is at its narrowest on a level with the project area. By bundling road, rail and canal, a fragmented landscape of residual spaces with limited value in terms of nature emerged. The construction of the Kristalbad provides the opportunity to preserve the scenic quality and reinforce it with its own identity. The Kristalbad forms a permanent green buffer between the two cities.

4. Ecological corridor

   In the new situation, the whole Kristalbad project area serves as an ecological corridor. There is great variation in biotopes for numerous species of flora and fauna. The biotopes vary from dry to wet and from woody via shrubs, reeds and scrub to open water.

5. Recreational use

   The Kristalbad offers extensive recreational possibilities. This mainly involves walking and cycling. Observation towers provide excellent views of the nature reserve between the Twente cities.

In contrast to dunes, the water-storage function of Kristalbad not only involves treating water, but also keeping people's feet dry. Although there is no direct relationship with a flood defence structure, by storing water the Kristalbad does serve a damming function. Furthermore, this example, like

Yokohama and the Koopmanspolder, shows what is possible within an area, even if it is enclosed by flood defences.

By means of a constructional combination, the Kristalbad project achieves five different functions simultaneously. These functions then reinforce one another in an operational combination.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for water storage, water purification, spatial quality, ecological corridor and recreation	Water storage, water purification, spatial quality, ecological corridor and recreation are all closely interrelated and reinforcement of one function often means reinforcement of the other; that makes it easier to exploit all these functions here
Raw materials	Use of the same building materials for water storage, water purification, spatial quality, ecological corridor and recreation	Use of the same building materials for upkeep of water storage, water purification, spatial quality, ecological corridor and recreation
Shareholders	Municipalities of Enschede and Hengelo, Water Board	Municipalities of Enschede and Hengelo, Water Board

Water work as flood defence structure

Naturally, the lock in IJmuiden serves in the first place as a lock. In addition, it forms a North-South link for cars and cyclists, as well as acting as a flood defence. The possibility of setting up an osmosis centre in the lock complex is also being investigated.

In Dalem, the lowest point in the Culemborgerwaard, steel sheetpile walls with concrete caps have been put in place, about 150 metres apart, right through the dike. The section between can be removed if necessary, so that the excess water can flow back to the river. The dike itself is of the same quality as the surrounding dike sections. By means of this example, the book Rivieren & Inspiratie wants to demonstrate that inlet and outlet structures can serve as flood defences[27]. The Eastern Scheldt dam is another strong example of this multifunctionality.

27 *Source: Rivieren & Inspiratie op cit.*

Figure 29: The locks at IJmuiden

Figure 30: The Eastern Scheldt dam

3

Three detailed case studies

3 Three detailed case studies

In this section, three case studies are looked at more extensively. Consequently, we highlight the approach to the parking problem in Katwijk, the construction of the Zuidelijke Randweg near Gouda and the measures to combat flooding in the city of Den Bosch. The reason for the detailed description is that these three projects are all explicit attempts to achieve multifunctionality. We discuss the task of multifunctionality, how this is expressed in design and execution, and the cost and profit centres. As already referred to above in many examples, we point to the difference between constructional combination and operational combination. For the distinction between cost centres and profit centres, we refer the reader to Chapter 1, which provided an explanation of the multiple use of space. The proposition is that every form of multifunctionality begins with the multiple use of space, i.e. with two or sometimes more functions sharing the same square metres.

Functions not only share space, but also the costs of this space. By looking at cost centres in the case studies below, we investigate where these cost savings go within a project. We indicated earlier that multifunctionality was only complete if the multiple use of space not only saved costs but also that new revenues were generated by combining functions. For example, water storage and water purification, as in Kristalbad (see page 57), can generate extra revenues from recreation. By looking at profit centres, we attempt to discover where these revenues go within a project

3.1 Coastal defences, Katwijk

The flood defence structure in Katwijk is included in the High Water Protection Programme (HWBP) as a non-priority weak link. With the tightening of the safety requirements as a result of the rise in sea levels and the increased frequency of storms, weak links must be reinforced within fifty years. In Katwijk, the retaining structure is not on the coast but in the centre of the village. This means that around three thousand people are living outside the dike. In January 2008, the Province of South Holland, the Rijnland Water Board, the Municipality of Katwijk and the Government joined forces. They signed a declaration of intent to reinforce the coastal defences in Katwijk, with the Water Board driving the process. The aim is to guarantee the safety of the hinterland. The flood defence structure must be able to cope with a water level that could lead to flooding once every 10,000 years..

The task

One of the starting points is to bring the old village within the dike. As part of it is currently located outside the dike, building restrictions apply, thereby limiting the space available for development. A second

starting point is to look at what to do about parking needs in Katwijk. A plan has been forged to combine the construction of the new flood defences with that of a multi-storey car park. An important trigger for this combination of functions is that 192 parking spaces along the coastal strip have to make way for the new flood defence structure. As the parking facilities cannot simply be created somewhere else, combining is an interesting alternative. The relocation of the retaining structure to the coast appears to create opportunities for this. The combination yields savings in terms of (shared) research and design, and everything will integrate better with the landscape. This is significant because, in addition to the building work, the sea views and access to the beach are important. Fired with this ambition, the project group Coastal Defences Katwijk was formed, consisting of the Directorate-General for Public Works and Water Management, Rijnland Water Board and the Municipality. The project group presented its preliminary memorandum/EIA back in 2009.

Design and execution

Before arriving at the idea of combining the functions of flood defence and car park, a number of alternatives for the dune structure were investigated, including the design 'High, sandy dune'. This design was based on the principles robust, sober and effective, and concerns a structure 120 metres long and 10 metres high (to be referred as 'reference alternative').

In 2010, the Municipality of Katwijk commissioned a study into the possibility of combining the flood- defence structure with a multi-storey car park. This proved possible if the flood defence structure took the form of a 'dike-in-dune'. This quickly became the preferred option of the project group, also referred to as the HWBP variant (High Water Protection Programme). At the same time, what is known as the 'Multikering' (multifunctional flood defence) variant, which integrates various facilities (underground parking and hospitality) into a sea defence, was also looked at.

At first glance, the HWBP variant appears to be €7.5 million more expensive than the reference alternative, although this does not include the costs of an alternative to the car park. Another salient point is that the Rijnland Water Board's policy up to then did not allow for any combinations. For this reason, the Water Board modified the policy to make the multi-storey car park possible in combination with the coastal defences. Damming water might still be the primary function, but priority is also given to how it all fits into the landscape.

As a compromise, it turned out that the 120-metre long 'High, sandy dune' could be designed for other purposes, but that there always had to be a separation of functions. This means that, in the ultimate design, the construction of the car park does not strengthen the dike-in-dune, but is immediately behind it. The choice for

this solution was set down in 2011 in an administrative agreement between the parties involved. The additional costs of the dike-in-dune solution (€7.5 million) will be divided among the Province, the Water Board and the Municipality. The Municipality of Katwijk will also cover all the costs of building the multi-storey car park.

Cost and profit centres

Although, due to the Water Board's policy, the decision was made to physically separate the flood defence structure and the multi-storey car park, there is still evidence of a constructional combination. Thanks to the modification in the policy of the Water Board, the multiple use of space is possible for damming and parking. By building the flood defence structure and car park at the same time, it is a question of creating 'work with work'. The joint performance of EIA procedures, research and design saves costs and time and creates synergy between the structures. There is another, not unimportant, advantage for local residents. By combining the construction, the surrounding area will only suffer the inconvenience once. In addition, it is not necessary to look for an alternative location to cater for parking needs in Katwijk.

Another benefit for the area is the disappearance of parked cars from the streetscape, and the choice of the (lower) dike-in-dune variant is a concession to the public. The lines of vision towards the sea are preserved to some extent. There are also disadvantages to the multi-storey car park, however. In order to cover the construction costs, both the parking charges for the multi-storey car park and for on-street parking will increase substantially. Financially, the combination mainly produces costs, as the design is €7.5 million more expensive than the reference alternative. This will not be recouped in operating the parking spaces, because the forecast shows that the Municipality will subsidise this.

Apart from the constructional combination, there is also an operational combination and this will yield financial returns in time. Also, the fact that part of Katwijk will then be within the dike produces operational advantages, although these have not yet been calculated. After all, the location within the dike means that the current building restrictions will no longer apply and the area will increase in value. Furthermore, the solution is robust and durable, because no further interventions will be needed in the coming fifty years. The design fits into the landscape better, so the lines of vision towards the sea are preserved. Nature benefits because the planned dunes will form a wonderful connection between the nature reserves to the north and south of Katwijk. These advantages stemming from an operational combination are even stronger in the Multifunctional flood defence variant. This option also scored better on other points.

Multifunctional flood defence variant

A comparison between the HWBP variant and the Multifunctional flood defence variant produces a very different picture.28 The realization of the Multifunctional flood defence with development possibilities is about €24 million cheaper than a more traditional (HWBP) approach to the primary flood defence. This is due to cheaper investment, lower management costs and higher expectations of the economic developments surrounding the Multifunctional flood defence structure. The cheaper investment and the higher revenues are attributable to the fact that the multifunctionality in the Multifunctional flood defence variant is better organised than in the HWBP variant. In other words, this €24 million is earned by the constructional combination and operational combination. It is not actually clear if a 'hard' flood defence structure, as with the multifunctional flood defence variant, is an adequate solution; this technology still has to prove itself. In addition, the Multifunctional flood defence variant could (drastically) change the appearance of Katwijk aan Zee. For this reason, no decision has yet been made, despite the fact that the Multifunctional flood defence structure would be considerably cheaper than the HWBP variant.

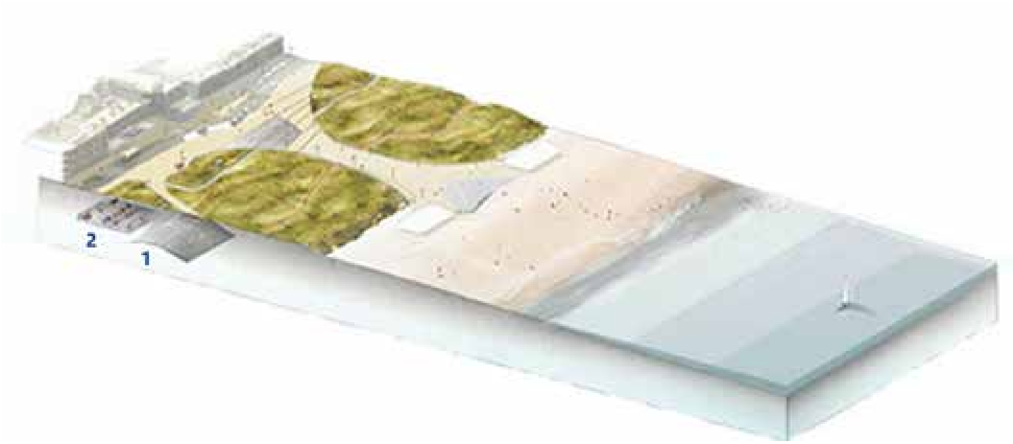


Figure 31: Design of coastal defences, Katwijk

The cost and profit centres of the Multifunctional flood defence variant are represented in the figure below.

	New revenues from operational combination (cost centre)	**New revenues from operational combination** (profit centre)
Multiple use of space	Cost saving due to the same building process for flood defence, spatial quality, parking and tourism	Flood defence, spatial quality, parking and tourism are closely interrelated and reinforcement of one function often means reinforcement of the other; that makes it easier to exploit all these functions here
Raw materials	Use of the same building materials for flood defence, spatial quality, parking and tourism	Use of the same building materials for upkeep of flood defence, spatial quality, parking and tourism
Shareholders	The Directorate-General for Public Works and Water Management, Province, District Water Control Board, Municipality, residents, tourists	The Directorate-General for Public Works and Water Management, Province, District Water Control Board, Municipality, residents, tourists

3.2 South-Western Ring Road Gouda

Near Gouda, part of the new embankment is being built on a levee outside the dike. At the same time, the levee forms the new primary flood defence structure, to replace the old dike which is no longer fit for purpose. This combination yields savings in terms of both the construction and upkeep of the road and flood defence structure.

The task

For twenty-five years, discussions have been held about improving access to and from the southwest side of Gouda. In 2008, the Province of South Holland presented the definitive design for the new South-Western Ring Road Gouda to residents of the area. This ring road will provide a better and faster connection with the Krimpenerwaard and good access within Gouda, particularly via the local road to Rotterdam and vicinity. The integration plan for this was adopted by the Provincial Council in 2009. The new ring road runs around the built-up area and forms part of the N207 road. Part of the embankment of the new SWR will be outside the dike and will run parallel there with the Hollandsche IJssel. The opening of the South-Western Ring Road is planned for the end of August 2012.

In the same area, the District Water Control Board of Schieland and the Krimpenerwaard (HHSK) manages the primary flood defences (known as category C flood defence structure). This flood defence structure has steep inner embankments. The buildings are close to the toe of the dike. In order to be able to maintain these buildings, revetments were erected in the embankment in the past. Provisional test results on the flood defence structure show, however, that this structure no longer meets the standards. It is not possible to make improvements inwards, in connection with the buildings. An investment to the tune of €10 million per kilometre is needed to create a structure that complies with all the standards.

The new ring road and the improvements to the dike came together when a policy official from HHSK had to make a decision regarding the laying of low-noise asphalt on the part of the dike that will experience a greater intensity of traffic due to the pull effect of this new road. The man wondered how it could be explained to the public that an embankment without a flood defence function will be built in front of the dike whilst the existing flood defence structure will shortly be rejected. The Province and the District Water Control Board then met to discuss the matter. They decided to investigate the possibility of building the South-Western Ring Road as a primary flood defence. A precondition for the Province is that the schedule for the road may not be delayed. The multifunctionality is discovered quite late during the preparations. At the request of HHSK, the Province asked the Ministry of Infrastructure and the Environment to include the measure in the High Water Protection Programme and make funds available for this.

Design and execution

It was the Province that commissioned the combination of functions. It put the combination out to tender as a Design & Construct. The first advantage of combining the design of the dike and road is immediately obvious; it is easier to resolve a number of technical issues together than separately. The embankment of a road is usually made of sand, but it can also be of clay, which is commonly used as flood defence. That makes the embankment suitable for two functions; in short, the multiple use of space.

With a view to operations, a dilemma did arise at this stage: who is charged with the maintenance work? Three parties appeared to be responsible: the Province, the Municipality of Gouda and the District Water Control Board. If the road becomes a dike, the whole structure is primarily a dike. As a result, the District Water Control Board should bear the most responsibility, whilst the Province is the major investor. This was solved cleverly by making the service road next to the secondary road the actual flood defence structure. The upkeep of this service road is also the responsibility of the District Water Control Board, whilst the secondary road on the same embankment remains within the jurisdiction of the Province.

The Province and the District Water Control Board work together on the basis of trust. The HHSK handed responsibility for the design and construction of the dike fully to the Province. Only functional requirements were put forward. The discussion about where exactly the boundary lies between service road and road was still ongoing when the parties reached agreement

Figure 32: The South-Western Ring Road near Gouda

Cost en profit centres

From the above description, it appears that the task initially involves a constructional combination. In this constructional combination, a road embankment will be built that will also serve as a primary flood defence structure. The Province of South Holland and HHSK will execute the ring road project. No calculation was ever made of precisely which costs and benefits would go to each party, because the advantages are more than clear. The starting point that the constructional combination is fundamentally the right thing to do is enough here. Both parties laid all their cards on the table, financially. The decision in favour of the combination was based on the choice of the option with the lowest social costs. A calculation such as that above with the HWBP variant and the Multifunctional flood defence structure was not appropriate.

The explanation for this is the patently obvious benefit and the confidence that the parties will not let this advantage go to waste. The half a kilometre along which the road forms a combination with the dike requires an investment of around €800,000. This involves replacing half a kilometre of dike that does not pass inspection. The costs of the separate construction of a new dike would be in the region of €5,000,000. The combination means a saving of €4,200,000; 84%! HHSK is pre-financing the necessary extra investment without knowing for certain that the government will grant the requested subsidy. An additional large, non-financial advantage is that the HHSK is not compelled to go through the procedures of the Flood Defences Act. After all, the Province already did its best to provide enough publicity and opportunities for public participation during the procedure for the construction of the road.

But the combination of road and dike also yields various advantages for the vicinity in the exploitation of the area. For example, the relocation of the flood defence structure will turn the old dike into a dead end, thereby giving rise to a residential area with restricted traffic on a stretch which used to have a maximum speed limit of 60 kph. The flow of traffic on the new ring road will also improve, which will improve safety and reduce delays. Furthermore, less land is needed for infrastructure and, finally, the ring road can be integrated better into the landscape. The area that is bound by (outside-the-dike) water safety rules will move towards the river and, as a result, more will be possible in part of the area, for example house building. The main benefit for the surrounding area, however, lies in the decision not to carry out the original, unavoidable dike reinforcement. The homes on the old dike would have suffered a lot of inconvenience from this in the form of noise nuisance and reduced accessibility. Together with the other advantages for the vicinity already referred to, the multifunctionality is also an operational combination.

The *cost* and *profit centres* of the Multifunctional flood defence variant are presented in the figure on page 70.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for flood defence, road and spatial quality	Flood defence, road and spatial quality mean that the area can be exploited much more favourably than before
Raw materials	Use of the same building materials for flood defence, road and spatial quality	Use of the same building materials for upkeep of flood defence, road and spatial quality
Shareholders	Province, Municipality of Gouda, District Water Control Board and, without wishing it, the Ministry of Infrastructure & the Environment; also residents who will experience less inconvenience	Province, Municipality of Gouda, District Water Control Board; also residents whose residential quality will improve

3.3 HoWaBo: High Water Approach, Den Bosch

To protect the city and the nearby A2 motorway from flooding, a large area is being designed as a retention zone near Den Bosch. A simultaneous approach to achieve nature-related objectives will yield savings in the soil balance and create added value for nature and the enjoyment of nature in the area.

The task

In 1993 and 1995, large areas of Limburg flooded as a result of high water levels in the river Maas. In order to prevent such inundations, the Maaswerken (Maas Project) was and is being implemented in the Province of Limburg. This might well prevent the risk of the Maas flooding in the south of the country, but the Maas Project has negative consequences for the regional water system to the south of Den Bosch. This is because the water level of the Maas rises here at high water a day earlier, so the small rivers Dommel and Dieze have one day less to drain into the Maas. In turn, that causes too high water levels with the chance that regional flood defence structures will be breached with the subsequent inundation of the urban area, starting with Den Bosch. In short, temporary storage is needed for this excess water. When the water level in the Maas has fallen again, this water can be discharged into it.

Calculations suggest that about 4.5 million m^3 of extra water storage will be needed by 2015. It is possible that even more capacity will be necessary for the subsequent period.

In order to cater for this massive storage need, the Aa and Maas Water Board is making the whole area to the west of Den Bosch into a regional water storage area. The project soon took on the name HoWaBo, or the High Water Approach Den Bosch. It concerns the polder Vughtse Gement and the vicinity of the Engeler lake, together covering an area of 750 ha. This new water storage area will be allowed to fill up once every 150 years. The location of this area is ideal as a temporary 'parking place for water' as it is lower than Den Bosch. In a certain sense, they are going back in time, because in the olden days this area (together with the Bossche Broek) was flooded to protect Den Bosch from enemies, such as the Spanish during the Eighty Years' War.

A nice thing about the plan is that, at the same time as setting out the area for water storage, the nature-related values in the area will also be restored, so that rare flora and fauna will be able to thrive. This will enhance the beauty of the area and make it more accessible for the public. The new water storage area even overlaps the Ecological Main Structure for a large extent. This structure is the robust network of nature reserves where priority is given to the development of flora and fauna. This requires intervention in the area. Due to years of agricultural use, large parts of the area are dry and the soil has become too fertile for nature. So that nature can recover, the Aa and Maas Water Board will be digging up plots so that the nutritious top layer disappears and the groundwater comes closer to ground level.

Figure 33: The planned retention area near Den Bosch

Design and execution

In 2011, the formal consultation procedure took place. The municipalities involved (Vught, Heusden and Den Bosch changed their land-use plans in 2012 to accommodate HoWaBo. The preparatory work then began. Various interventions were aimed at making the area suitable for water storage. To start with, an inlet structure by the Drongelen Canal was built in 2012, so that the water storage area can fill up in a controlled way at high water. Execution of the other operations will follow at the beginning of 2013 and will continue in subsequent years; the whole project is due for completion in 2015.

In the polder Vughtse Gement, redevelopment of the current agricultural landscape will also make water storage possible. In the area around the Engeler lake, the current

recreational function will be preserved and the modifications for water storage will be largely invisible. Levees will be built around the whole area, which will spare the existing farms. For the construction of the levees, the Water Board consciously looked for ways of using the large quantities of soil excavated for the creation of the nature reserves. As a result, massive savings were made in the soil balance.

The question still remains of how to connect the polder Vughtse Gement and the Engeler lake, which are currently separated by the A59 road, with each other. A 'chiffon' to allow water through is among the possibilities. A more large-scale modification by setting the A59 on 'legs' provides more opportunities for connecting both water and nature in the two areas with each other and, at the same time, working on viaducts and roads in need of repair. Furthermore, such a solution would prevent possible extra investments if, in the future, more water has to be let through as a result of more far-reaching consequences of the Maas Project. A decision will be made in this connection in the course of 2012.

As the soil in the area is too sandy and too peaty for the construction of steep 1 in 3 embankments, a modified gradient of 1 in 6 was chosen for the new levees. This is possible as enough space is available for the flood defence structures in the area. Due to the relatively low, gently sloping levees, the open lines of vision in the area will be preserved. Furthermore, nature can develop on the low levees, including rare species of fauna such as the Scarce Large Blue (butterfly), which will contribute towards the recovery of nature in the area. Finally, there will be meadowland management on the levees.

There was hardly any need to purchase land, and claim settlements also proved unnecessary. This is because the area is largely owned by nature organisations, which cooperated in redeveloping the area for temporary water storage. The advantage for them is that the nature-related objectives in the area will be achieved, planned levees will also be given a nature-related function and the use of the area for nature is guaranteed. After all, incidental water storage does not clash with nature-related objectives. The majority of the remaining land had already been bought up by the Province in connection with the Ecological Main Structure. The adjoining Municipality of Heusden cooperated by situating the necessary land in the water storage area via the exchange of plots.

In the region, there is much support, both administrative and social, for HoWaBo. For instance, the municipalities have agreed to the construction of a green buffer between the municipal boundaries. The project plan and the EIA were carried out in collaboration with the Province of North Brabant, the

Dommel Water Board, the Municipality of Vught, the Municipality of Den Bosch, the Municipality of Heusden, the regional farmers' organisation (ZLTO), the National Forest Service in the Netherlands and the Society for the Preservation of Nature in the Netherlands. Cooperation with local residents and farmers is also very important in the project. Landowners have to agree to their land being flooded once every 75 years.

In addition to HoWaBo, there are other area processes under way within the planning area that will provide opportunities for reinforcement and combinations of the intended functions. Examples include the Area Development Oostelijke Langstraat (headed by the Province of North Brabant), the eastern access to Vlijmen (Municipality of Heusden), the Climate Buffer project in Vlijmen (National Forest Service) and the exchange of plots in the Municipality of Heusden. When choosing the location of the water storage, these other area processes were taken into account. HoWaBo supports these processes and is not inconvenienced by them. As a result, the project plan does not involve any costly and spatially intrusive measures which will have to be reversed if there is more far-reaching area development.

Cost and profit centres

It appears from this description that the task concerns both a constructional combination and an operational combination. The constructional combination consists of levees made of soil dug from the area itself in connection with the nature-related objectives and also involves coordination with other area processes. In the operational combination, there is water storage, the development of nature, agriculture and recreation in the same area. At some distance from HoWaBo, residential functions also benefit.

The Aa and Maas Water Board is executing the HoWaBo project. The total costs were estimated at around €20 million. The costs of the project will be covered, according to agreements, by the Maas Project, because, after all, it is because of this latter project that water storage is needed at Den Bosch. This alone results in substantial savings. Compensation for water storage within the planning area of the Maas Project would have cost around €500,000,000, twenty-five times as much!

The combination of functions also yields various other cost savings. Using the excavated soil for the nature reserves means substantial savings in the soil balance. The construction of the levees requires 100,000 cubic metres of soil. By using material from the area for this, a saving of around €12.50 per cubic metre, or €1.25 million, can be made. Furthermore, the fact that the excavated soil does not need to be carried away and no newly purchased soil brought in saves a lot of money and carbon emissions. Given good coordination between the development of nature and levee building, the Water Board can make both financial and environmental profits from the soil excavation, as well as the construction of the levees. Finally, the combined upkeep of the dikes will yield savings.

The combination of functions also provides added value for various other aspects. For instance, residential safety is improved due to the protection against flooding and people's enjoyment of where they live increases due to the proximity of nature and recreational opportunities. An increase in recreational use will generate more revenues in this sector. Investment in the nature-related objective will give rise to greater biodiversity and the characteristic landscape with the accompanying flora and fauna will make a recovery. And last but not least, the layout of the retention area will prevent regional flood defence structures from being breached and result in better protection against flooding.

As in the case of the South-Western Ring Road near Gouda, no calculation was made here comparable to that for the HWBP variant and the Multifunctional flood defence variant. However, an inventory was made, on the basis of the Mutual Gains Approach (MGA), of the interests of actors in the area, such as local farmers (via their regional organisation, the ZLTO), the Dutch Butterfly Conservation, the Municipalities of Den Bosch, Heusden and Vught, National Forest Service in the Netherlands, the Society for the Preservation of Nature in the Netherlands, the Water Board and the Province of North Brabant. Unique to the MGA is that the disadvantages come into view first, and how these disadvantages (such as those of the roads) can possibly be prevented. Another unique thing about the MGA is that the advantages of multifunctionality are presented (not calculated, but reasoned out).

For example, through extensive reasoning, arguments were presented for the important levees in the area on how reinforcement was possible between the levees and the landscape, agriculture and nature. The levee can function as a boundary between the Ecological Main Structure and agriculture, so that not only a physical barrier is created, but the landscape is also better designed. This and other combinations were not calculated with the MGA. That is largely unnecessary, because, as in the case of Gouda, it is clear to all parties concerned that they will benefit by allowing their sub-project to be part of the larger whole of the combination. In short, the business case is 'felt' and that is enough for agreement and participation.

	New revenues from operational combination	New revenues from operational combination
Multiple use of space	Cost saving due to the same building process for levees, the development of nature and diverse area processes, including a climate buffer, the opening up of the area and the exchange of plots	Flood defence with levees, the development of nature, water storage, agriculture, housing, landscape and recreation are mutually reinforcing in their usage
Raw materials	Use of the same building materials for levees, the development of nature and diverse area processes; reduced carbon emissions	Use of the same building materials for upkeep of levees and development of nature; more biodiversity
Shareholders	Province, Water Board, Municipalities of Vught, Den Bosch and Heusden, the regional farmers' organisation (ZLTO), National Forest Service in the Netherlands, the Society for the Preservation of Nature in the Netherlands, residents, farmers and other landowners	rovince, Water Board, Municipalities of Vught, Den Bosch, Heusden, ZLTO, National Forest Service in the Netherlands, the Society for the Preservation of Nature in the Netherlands, residents, farmers and other landowners, and Dutch Butterfly Conservation

Figure 34: Kristalbad, Regge and Dinkel Water Board

4

Conclusions

4 Conclusions

What if….? What would have happened in Gouda if there had been no combination of functions? A new high dike would have been built in front of an old levee, with an empty space between. It would have been a lot more expensive to build, required more raw materials and led to the inefficient use of space, with fragmentation and suboptimal social integration.

To the south of Den Bosch, there would have been no HoWaBo if, in accordance with current policy, compensation for the Maas Project had taken place at the location itself. The decision to relocate to Den Bosch yields massive direct savings. If, on top of this, no multifunctionality had been realized, all municipalities involved would have implemented their own sub-plans, soil would have been brought in for the levees or the levees would not have been developed as part of the landscape element with nature-related values.

In the case of Katwijk, the 'What if?' question is even more exciting, because the choice has not yet been made. The ostensibly suboptimal choice of the HWBP variant, or even the reference alternative, is still up in the air. It is difficult to understand why, in the HWBP variant, the multi-storey car park may not be allowed to help reinforce the flood defence. Perhaps the explicit responsibility for water security leads to a division of functions.

It can be deduced from Chapter 1 of this book that combining functions remained out of the picture for a long time, because people staunchly chose to separate functions. We argue that this is no longer financially viable. The organisation of a joint building process, whereby the costs of raw materials are shared, leads directly to savings. This is on condition, however, that two or more mutually re-inforcing functions are coordinated. As a result, new revenues can arise in the operational stage. Furthermore, this calls for fewer raw materials or it sometimes even generates energy or raw materials.

The condition that the parties involved in the multifunctionality are shareholders also formed part of the analysis in Chapter 1. These are stakeholders who benefit from an initiative and, vice versa, can also strengthen the initiative. In Chapter 2, this analytical framework was used to look at more than twenty-five examples. In Chapter 3, three case studies were examined in more detail. Finally, here, we draw a number of conclusions. This is followed first by extracting a number of main points from the examples and case studies. Then, a few obstacles to multifunctionality are discussed.

Lessons from the examples and case studies

1. On the basis of the examples, multifunctionality involving flood defence structures is usually a question of building and then

operating. They create for themselves the advantage of the constructional combination, including the lower costs for raw materials, and they also benefit in the operational stage. Just take the Gouda case study, where the constructional combination yields a substantial financial advantage and then its operation offers numerous further opportunities for earning money. There are also a few examples of just a constructional combination and also examples of just an operational combination, but these exceptions form a small minority. The overall conclusion is that making combinations with flood defence structures is usually a question of building and operating together.

2. The examples studied show that the parties involved have to be aware of the advantage of both a constructional combination and an operational combination if they are to reach agreement. In most cases, multifunctionality is linked with a new investment and only rarely arises from the use of an existing structure. It follows from this that it is not a question of a split incentive. That is when parties who basically can combine do not have the incentive to do so because the advantages of the combination do not accrue to the party that has to bear the costs. As a result, the combination does not go ahead and the parties which did have the incentive do not benefit either. Just think of a water board that, unlike a nature manager, does not feel any incentive to develop a dike in an environmentally-friendly way. If there is an advantage to be gained from both the construction and operation, that helps a lot in preventing the split incentive. A party that only benefits from the construction or only from the operation will be less inclined to combine due to the split incentive. This perhaps plays a role in Katwijk, because the Directorate-General for Public Works and Water Management there will not benefit from the economic advantages which the town of Katwijk will enjoy from the Multifunctional flood defence.

3. Stakeholders who, at the same time, feel the incentive to build and operate a structure in combination expose a unique relationship between the internal and the external supply chain integration as described in Chapter 1. Multifunctionality is a form of external supply chain integration that arises from cooperating with another party. It is interesting that internal supply chain integration then also takes place. In Chapter 1, this was described as the process of forward and backward supply chain integration. Both take place if the building process and the usage phase (operation) are bound together. Then, nothing is built without thinking about its use (forward supply chain integration). And nor is a structure used without learning from this for future retrofit, renovation or conversion (backward supply chain integration). This error is avoided with the promenade in Vlissingen. This leads to another main conclusion, i.e.

that, in this way, raw materials are used in a careful and sustainable way. In short: multifunctionality is sustainable due to the integration of construction and operation.

4. The examples studied, and the case studies in particular, reveal a unique phenomenon that occurs if agreement is reached on the combination: often, the business idea is enough for agreement to be reached. To put it more strongly – and that sounds counter-intuitive – there seems to be a relationship between the degree of detail with which a business case is worked out and the delay in the relevant decision making. The Katwijk case study, for example, came with extensive calculations, while the decision making here is very slow. Probably it is just a question of indecisive administrators, who therefore decide to conduct extra studies. With the Gouda and HoWaBo case studies, there is ostensibly no evidence of this. As they featured far fewer calculations, the decision-making went more smoothly. It is not possible to trace whether other, completely different factors also play a role in Katwijk. With some caution, we therefore draw the conclusion that the advantage of multifunctionality must be evident to all parties involved. As soon as a party starts to doubt and make calculations, it is not evident and the basis for the combination is lost.

5. Equally counter-intuitive is the negative correlation there appears to be between the extent to which combinations are planned in advance and their ultimate realization. In Gouda, for example, the combination arose in the course of the project and there seems to be a relationship between such a coincidence and spontaneity, and the success. Is a combination created on the drawing board or does it emerge from the dynamics of area partners who come together at times when they themselves feel tension surrounding their own activities? It is precisely then that these partners realise how the combination with another party can help them.

6. Even though multifunctionality is not seldom the result of coincidence, there are also examples of successful planned combinations: the soil balance with the Beatrixsluizen is a combination that was consciously sought[28]. It is therefore definitely possible to bring area partners together in a planned way, to let them feel the tension in a planned way and, in this way, to make combinations. In order to couple area partners in this way, you must use the right method for organising the process[29]. This can help in enabling area partners to discover from each other how they can be mutually reinforcing. Examples such as those collected in this book can serve as inspiration for this.

28 *See Future value now! The power of multifunctionality, op cit. page 31 et seq.*

If area partners discover, in this way or coincidentally, that they can come up with wonderful combinations together, the insights in this book, such as the DBFMORE model in Chapter 1, will help them further.

Obstacles

With the aid of the examples and, in particular, the case studies, we can identify a number of obstacles to the development of multifunctionality. The split incentive, the lack of incentive to combine with a party that could be an interesting partner in a combination, has already been discussed. The lack of scope for policy-making on the part of the water manager can also form an obstacle to multifunctionality[30]. This plays a role for example in the case study in Katwijk. For reasons of safety, but also for other motives, it is not permitted in policy terms to combine flood defences with other functions, for example. Achieving multifunctionality calls for a willingness and the leeway for those involved to look beyond these limits.

For multifunctionality, the budgets for two or more projects are often combined. An initial obstacle occurs if the budgets are inadequate to fund the investment. A second obstacle can be that a budget has been earmarked, for example for dike reinforcement, and then cannot be used for other purposes such as water storage or the development of nature. A third obstacle can be that the advantage of the combination is not clear enough. For instance, it might not have been demonstrated convincingly that a multi-storey car park will strengthen the sea defences. A fourth obstacle can arise from the risks that can accompany multifunctionality, for example because a competent administrative body is unwilling to accept responsibility for a combination. Responsibilities are by definition 'simple'. Joining together in a multiple solution is not something that every organisation dares to do, or may do legally.

In the case of water safety, a dike manager cannot and may not make concessions regarding the stability of the sea defences in order to make things fit together better. Particularly when a large organisation with a strict division of responsibilities is involved, there seems to be a good chance that an individual employee will feel no incentive to combine. There is a good chance that he will act only in accordance with the authority vested in him and choose a separation

29 See Ireen Röling, Ingrid Roos, Rosalie Franssen, Rutger van der Brugge, Bouke Ottow, Jurgen van der Heijden, Rob Prins, Slim combineren met de meerwaardescan, the Directorate-General for Public Works and Water Management 2011.

30 See also: Tromp E., Ellen G., Borgers H. and Rengers R. (2012). Case Study. Multifunctioneel ruimtegebruik van waterkeringen: Wat houdt ons tegen? Water Governance 1: 50-55. van der Heijden, Rob Prins, Slim combineren met de meerwaardescan, The Directorate-General for Public Works and Water Management 2011.

of functions. Without the backing of his superiors, he will never choose a combination. The Gouda case study, on the other hand, shows how an employee can be successful by taking a risk.

Synchronisation between the initiatives of various stakeholders can form a stumbling block. For instance, a combination of soil balances is highly dependent on whether or not the movement of soil can be allowed to occur more or less simultaneously. Non-synchronous money flows can also lead to problems. Money comes from a variety of sources, such as the the Multiyear Programme for Infrastructure (MIRT) of the Directorate-General for Public Works and Water Management and the Delta Fund. Such funds have a planning cycle and it is possible that a golden opportunity to combine cannot be funded simply because no money was set aside for this flood defence structure. For this reason, the Water Board in the Gouda case study advanced a sum that will have to come from the government at some point. The Water Board shows courage here, because there is no certainty that this sum will ever be paid. In addition to a shaky planning cycle, the fact that various decision-making processes do not link up with each other can be a further obstacle to multifunctionality. If such processes fail to connect with each other, no *window* of *opportunity* can be found to realize the combination.

Finally

Flood defence structures are there to keep water out and protect the area behind the structure from flooding. Yet the presence of water can also yield added value for such functions as living and working. It is therefore important with flood defences to look for opportunities to benefit from the presence of water. Water is no longer an enemy that has to be kept out, but the opposite: the water actually yields added value! That is possible through combinations with nature, roads, housing, energy, tourism and much more[31]. This short book provides numerous examples and hopefully the inspiration to create many more examples.
Safety was always what legitimated the use of hard structures such as dikes and other hydraulic structures which had to be suitable for exercising strict control over the water system. The consequence of this is a transformation in the Netherlands of the river delta and the coastal area, and a disturbance of nature, up to now often without any effort to limit this disturbance. That has been changing gradually in recent years, under the influence of sustainable development and climate change. In hydraulic engineering, a paradigm change is taking place: more and more projects are embracing the dynamism of nature and water and relinquishing the strict control of the system. Multifunctionality fits into this seamlessly and can start to play an increasingly important role. Hopefully, this short book will make a contribution towards this.

31 *Sybrand Tjallingii, Jos Jonkhof, Synergie in stromenbeheer, meekoppeling van water met andere stromen bij klimaataanpassing in de stad, Deltaprogramma Nieuwbouw en Herstructurering, October 2011, p.40.*

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Figure 32: With thanks to the Schieland and Krimpenerwaard Water Board
Figure 33: With thanks to the Province of North Brabant
Figure 34/35: With thanks to the Regge and Dinkel Water Board

4 Conclusions

Figure 35: Kristalbad

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