

A critical approach to some new ideas about the Dutch flood risk system

TIES RIJCKEN

Abstract

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Decisions on measures to improve a flood risk system are in part supported by general ideas about how the system works and should work. After the completion of the Dutch Delta Works around 1990, such new ideas regarding flood risk emerged. Some of these may be appealing at first, but appear debatable after a closer look. In this paper, fourteen such debatable ideas, familiar to most Dutch water professionals, are formulated and criticised, in order to find out what can be learned from them. The most important Dutch national flood risk policy documents since 1990 are reviewed for quotes that illustrate these ideas, complemented by scientific papers and other documents. These quotes present different expressions of these ideas, and their number can suggest whether they are broadly shared or marginal. In twelve of the twenty most important government documents, 47 quotes were found; in 26 documents of other types, another 39. Eleven quotes describe the idea that 'water should not be our enemy, but our friend'. Fifteen quotes were based on the idea that flood protection entraps us in a dangerous 'spiral of risk', which can be stopped, 44 quotes are related to the idea that flood risk reducing measures should be 'natural' or 'move with nature'. The remaining quotes illustrate other debatable ideas, such as 'water should lead spatial planning' and 'rivers should not be squeezed into a corset'. The frequency of such quotes suggests that ideas about 'water as a friend', the 'spiral of risk' and 'moving with nature' have not been marginal. It is however difficult to determine how influential they have been in decision-making, since general ideas are not the only factors leading to decisions. The general critique to the three ideas is that they present preferred measures as generally logical conclusions without a systematic comparison of alternatives for particular situations. Behind the new ideas lies increasing societal interest for objectives like an attractive water landscape (water as a friend), reducing our dependence on technology (spiral of risk) and nature conservation and development (moving with nature). This analysis further suggests a couple of final remarks, which are hard to prove and are open for discussion.

KEYWORDS

flood risk; water infrastructure; systems analysis; policy analysis; soft objectives; quality; aesthetics; meaning; storytelling

1. STUDYING DEBATABLE IDEAS ABOUT FLOOD RISK

The Dutch landscape may for a large part be seen as a gigantic highly man made water processing machine. A primary objective for this machine is to limit the probability that the seas and main rivers break through its elevations, the dykes, which protect 65 per cent of the country from flooding. Throughout the centuries, the Dutch water machine has continuously been improved and upgraded: the cross-section of a medieval sea dyke was at most 50 metres squared, reaching two or three meters above mean sea level, nowadays a dyke at the same location is easily four times as high and ten times as voluminous.

The water machine is never finished. Under the *Delta Plan* (1953–1997), over a thousand kilometres of dams and dykes along the coast and estuaries were newly built or upgraded. Between 1995 and 2015, about 500 kilometres of rivers were tackled in the projects *Delta Plan Large Rivers* and *Room for the River*. Currently, upgrades are being conducted under the *High Water Protection Program* prepared by the *Delta Program*. Since 1960, average yearly costs of flood risk system upgrades are estimated 400 million euro (in 2014); maintenance and operations cost about the same.

How are decisions for upgrades made, and which choices do decision-makers have? According to TAW (1998), Vrijling, Van Hengel and Houben (1998), Eijgenraam (2007), Kind (2013) and others, upgrades are viable when the benefits of an investment (primarily risk reduction) outweigh the costs (primarily building costs). The flood protection standards in the Dutch *Water Act* are derived from such a cost-benefit analysis. The system has to match up to the standards, but in practice, decisions for upgrades are often postponed and finally happen only after a flood or near-flood, or when times are right for other reasons.

When flood risk reduction is wanted somewhere, in a flood risk system that includes dykes, there are five types of measures available: (1) improved disaster management such as evacuation plans, (2) local measures behind the dyke, such as flood proof buildings and risk zoning, (3) dyke upgrades, (4) load reduction by river widening and deepening (spatial measures), (5) load reduction by control objects redirecting flows on a higher scale level for instance a storm surge barrier (Klijn et al., 2012). Figure 1 shows examples of types 2, 3 and 4. Each of these measures can impede or support a wide range of accompanying objectives related to shipping, freshwater supply, transportation infrastructure, ecosystems, and so on.

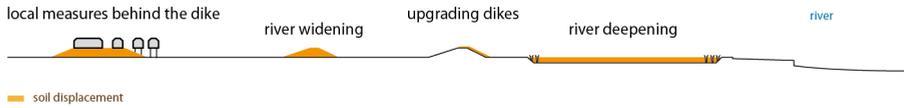


Figure 1 Three ways to reduce flood risk, next to disaster management and measures to redirect flows on a higher scale level (like a storm surge barrier or a spillway near a river bifurcation)

Decisions regarding which measure to take are made in an elusive process, one where ideas, beliefs and preferences among a large group of people converge (Rijcken et al., 2012). There are many theories about political decision-making, like the systems approach, revolving around system models, versus the network approach, revolving around actors and processes. Decisions may be rational or emotional, be comprised far-reaching blueprints or adaptive incremental steps or be pragmatic or appeal to a grand vision. In whichever way they are made, general *ideas* about how the flood risk system works and should work, play a major role. Someone may be in favour of a storm surge barrier because of the outcome of a *specific* cost-benefit analysis, but also because he or she believes in the *general* idea that a river mouth near a major port ought to be protected by a moveable barrier, regardless of the specific analysis.

In scientific discourse, most time is spent on elaborating good ideas and some time on dismantling bad ideas. Critical publications about flood risk ideas are usually personal opinionated essays (Boorsma, 2007; Rijcken, 2008; Vrijling, 2008; De Wit, Jongejan & Van der Most, 2010 and Jonkman, 2013), or comments on specific publications or policy proposals (Rijcken, 2007; Jongejan et al., 2008 and 2012 and Waterforum, 2013).

This paper is more extensive and makes an inventory of the major Dutch policy documents, looking for multiple ideas which can, carefully, be called *debatable*. Related quotes are collected, classified, dated and tallied in order to be able to make a conclusion whether an idea is marginal or more broadly shared. Three debatable ideas are scrutinised in terms of the reasoning used and the potential harm. The final general discussion considers what these debatable ideas have in common and suggests what can be learned about related preferences and perceptions in society.

The literature review begins around 1990, the final years of the Delta Works. In 1986, the famous Eastern Scheldt barrier was completed and a year

later parliament voted to build the Maeslant barrier. These feats of engineering marked the end of a technocratic mind-set, according to many (Van Rooy & Sterrenberg, 2000; DG Water, 2006; Meyer, 2012; Correljé & Broekhans, 2014), which the debatable ideas in this paper appear, at least in part, to rebel against.

Method

The research starts with a list of debatable ideas, collected in the years leading to this article. A *debatable idea* is an idea open to discussion because it seems to contain inconsistencies, logical formal flaws or otherwise present conclusions which do not logically follow from the premises. ‘Climate change forces us to improve our evacuation plans’, is debatable because improved evacuation plans are not the only possible response to climate change. ‘We prefer evacuation plans over other risk-reducing measures’, is a preference, not directly formally debatable.

A debatable idea is revealed in *illustrative quotes*. These quotes can similarly be debatable on formal grounds, or otherwise illustrate the debatable idea. ‘The main part of our organisation believes that climate change forces us to improve our evacuation plans’ is not formally debatable, but reveals the presence of the debatable idea.

A debatable idea is *not marginal* when related illustrative quotes are found in more than 10% of the twenty most important national policy reports, and furthermore in multiple scientific publications and other professional documents.

Of the list of debatable ideas, the three most prevailing and most controversial ones are elaborated. For each, the most illustrative quotes are selected and the idea is explained in pictures and drawings. Each idea is then explained and criticised both in terms of its reasoning and the potential harm. It is then made clear which types of risk reducing measures are supported by the idea. These are put together to support the final remarks in the general discussion.

“Until now, space in the Netherlands has primarily been facilitating human activities. Natural forces were tamed. Rivers were embanked, estuaries dammed and inland seas turned into polders. **Human functions lead in spatial planning.** Awareness increases that this approach knows not only advantages, but also yields more and more costs and is finite. The tamed natural forces will, sooner or later, be stronger than man. This can be avoided by no longer working against nature, but with nature, and adjust land use to the possibilities of the water: **water is leading.**”

Derde kustnota (V&W 2000)

“(…) a policy [is needed], where **water is less seen as an enemy that should be fought, but as an ally** with nature, agriculture and urbanisation.”

Rapport Commissie WB21 (2000)

“Historically we have restrained the water with pumps and levees, but that strategy is changing radically. According to the latest insights we should, in doses, let the water in, rather than **entrench ourselves behind ever higher walls.**”

magazine article (Metz 2012)

“Over the last centuries, a lot of space has been taken away from the river. As a result, **rivers have been sandwiched between dikes** which have, during the recent decades, become ever higher.”

PKB Ruimte voor de Rivier (V&W 2006)

“Large investments (...) ask for more protection and therefore more enforcements of flood defenses. **This makes us go around in a vicious circle.**”

Vierde nota waterhuishouding (V&W 1998)

“The shift boils down to the Netherlands having to adapt to the water. We have to give space to the water, in stead of take it away (...) Space not in height or depth by deepening channels, but in width. This costs space, but in return we get safety. (...) Only by giving space we can really get our house in order, because if we do not do that, the water will take the space, sooner or later, by force.”

Anders omgaan met water (DG Water 2000)

“Traditionally, flood management practices in Europe have focused on predominantly hazard control, or i.e. flood protection measures such as dykes or drainage systems to reduce the probability of flooding. However, in the past two decades **major flood disasters have created the need to shift** from flood protection to a more integrated approach in which flood risk is actively managed to also reduce flood impacts.”

scientific publication (van Herk 2014)

“(…) do we choose to **connect to natural processes, or will, on the contrary, the oppression of natural processes be our starting point?**”

policy vision report (Projectteam NW4 1995)

Figure 2 Examples of illustrative quotes. The ones related to *water is our friend* in blue, the *spiral of risk* in orange, *moving with nature* in green, other ones in grey. The captions give the document titles (for the major national policy documents) or the type of document (for other types of documents); between brackets () the reference

2. THREE DEBATABLE IDEAS

We conducted a survey, searching for quotes that illustrate the following fourteen ideas, each well known to most Dutch water professionals.

- Water is our friend, not our enemy.
- A focus on preventing flooding catches us in a spiral of risk, which should and can be reversed.
- We have to move along with nature and strive for natural solutions.
- Because of climate change, we have to innovate.
- Innovative solutions are better than traditional solutions.
- Spatial solutions are better than technical solutions.
- Precipitation should first be retained, then stored, and then discharged.
- Water should take the lead in spatial planning.
- Water problems should not be passed on to adjacent water systems.
- Rivers should not be sandwiched, laced up, or squeezed into a corset.
- We can't go on raising the dykes forever.
- Flood risk reducing measures are part of a safety chain with links that should all be strong.
- In a risk system, every layer of risk reduction has to be addressed with measures.
- Residual risks have to be addressed with measures.

To illustrate these ideas, the twenty major policy documents since 1989 are read or scanned (Ctrl-F in PDF files) for the words *leading*, *diverge*, *store*, *lace up*, *corset*, *forever*, *chain*, *vicious*, *residual risk*, *spiral*, *friend*, *enemy*, *moving along*, and *natural* (in Dutch). Figure 2 shows examples of illustrative quotes found in the survey.

Of these fourteen debatable ideas, numbers 4 to 14 are not further elaborated; ideas 4, 5, 6 and 7 favour particular measures in such an obviously general way that they are hardly controversial. Ideas 8, 9 and 10 are well-known, but few written quotes with logical flaws were found. A critique of 8 would be that when land use and water management are intertwined, it is not clear which of the two leads, and why this matters; regarding 9 it would be that water management is essentially about passing problems on towards the best locations to solve them; to 10 that rivers are not human bodies which can be squeezed in a corset, but volumes discharging precipitation, defined by a surrounding geometry of mostly sand and clay. Ideas 11, 12, 13 and 14 overlap with number 2. Ideas 1, 2, and 3 seem to be the most prominent and controversial. Figure 3 lists the document types scanned. Figure 4 shows when the debatable ideas were found. Quotes illustrating a struggle with the concept of nature are the most abundant.

	Documents	Quotes			
		Friend	Spiral	Nature	Other
Major national policy documents	15	2	4	25	8
State commission reports	5	2		3	3
Scientific publications	8	1	4	3	4
Other documents	18	6	7	13	1

Figure 3 The twenty most important national policy documents on the Dutch flood risk system were read and scanned for quotes like the ones in figure 2

	Documents	Quotes			
		Friend	Spiral	Nature	Other
1990 – 1994	5	1	2	2	
1995 – 1999	4		2	5	1
2000 – 2004	6	3	4	7	6
1005 – 2009	16	5	4	13	3
1010 – 2014	15	2	3	17	6

Figure 4 Most quotes were found in the 2000s and few before 1995

1 – *Water is our friend, not our enemy*

In his foreword to the final report of the (State) Committee Water Management 21st century, the chairman writes: *“there is no doubt that in the Netherlands, the sink of Europe, a different approach is needed. Too much we still deal with [only] technical management, while time is pressing for a different water policy [...], where water is less seen as an enemy who should be fought, but as an ally with nature, agriculture and urbanisation.”* (Commissie WB21 2000)

In 2006, the ministry wrote: *“[t]here is a growing awareness that living with water contains risks, but also offers opportunities, such as quality of life, economic profit, and roots for national identity”* (DG Water, 2006). This notion was a central theme in the 45 million euro knowledge program Living with Water, whose chairman wrote:

“Living close to the river doesn’t only entail flood risks but is also deeply connected to quality of life. [...] this idea is put to work in the design of river management that includes the local problematic aspects of making room for the river but also provides new opportunities for economic and social development. This expresses and supports the paradigm shift from ‘fighting the floods’ to ‘living with water’.” (Swanenvleugel, 2007)

World Wildlife Fund put it like this: “[w]e don’t stand a chance fighting the far reaching consequences of climate change, when we keep seeing the sea and the whimsical tides as the prime threat against which we have to arm ourselves” (Braakhekke et al., 2008). Figure 6 is taken from a Living with Water document.

The quotes were often practiced in a context of certain popular or preferred measures – see figure 7 for an indication.

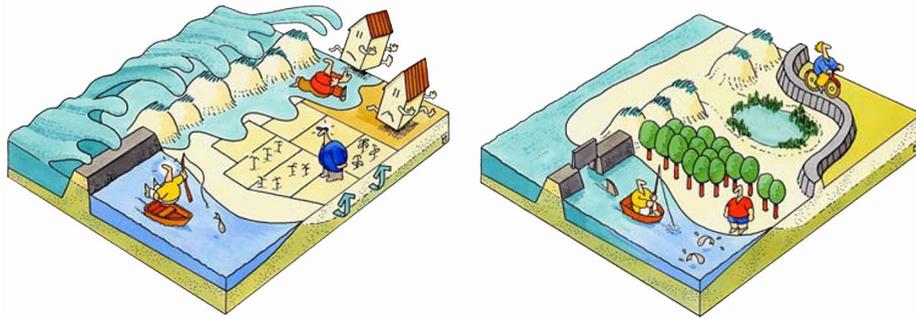


Figure 6 ‘From averting the water [...] to accommodating’ (Programmaorganisatie Leven met Water, 2006)

Types of measures

Disaster management

Water is our Friend, not our Enemy

not mentioned

In the context of the quotes, disaster management measures were not mentioned.

Local measures and risk zoning

some measures
favoured

Floating housing and water storage treat water as a friend.

Upgrading dikes

generally
disfavoured

Dikes consider water as an enemy. Dike heightening is worse than dike strengthening.

River widening and deepening

generally
favoured

River measures which reduce water levels treat water as a friend.

Redirecting flows on a higher scale level

some measures
favoured

Large engineering objects are hostile, but moveable barriers are favoured over dams.

Figure 7 A brief indication of the types of measures favoured and disfavoured in the context of the quotes illustrating the idea that *water is our friend, not our enemy*

"The battle has calmed down. Concerning levee enforcements the crisis in the culture-nature relationship will be heated just once again. Will we literally add another layer or is it time to take a different path? This much is sure: the ruler has won a great victory over the water. It is now time to **care about the exhausted waterwolf and try to become friends with him."**

essay (Kockelkoren 1994)



"People choose for attractive and healthy water around them for living, recreation and to enjoy. Direct involvement however, only occurs until they are threatened or experience nuisance and damage. Then the government is called upon, because they expect the government to take care of their safety and protects them from nuisance and damage. **Water as an ally again loses to water as a friend."**

Rapport Commissie WB21 (2000)

"In living with water, we see better guarantees for the generations to come, than solely technically restraining water."

"Slowly, more water appears in neighbourhoods, filled canals are reopened and more and more wet nature appears within our urban structure: water breaks through the hardness of concrete, stone and stress. In this state of mind, **water is not considered an enemy or prey, but rather a partner.** The properties of the water itself and the way it is experienced, should be starting points."

Anders omgaan met water (DG Water 2000)

"This long cherished self image of bold conquerors on a swampy subsoil needs a thorough revision for multiple reasons. **We don't stand a chance fighting the far reaching consequences of climate change, when we keep seeing the sea and the whimsical tides as the prime threat against which we have to arm ourselves.** (...) In the 20th century we learned important and expensive lessons about the limits to the ongoing canalisation of rivers, the neglect of the natural dynamics of flood plains; the challenge now is to rebuild our trust in the natural resilience of our own estuary. (...) **We have to work with water, play with it,** rebound with nature and dare to again profit from natural dynamics."

NGO report foreword (Braakhekke et al. 2008)

“Living close to the river doesn’t only entail flood risks but deeply connects to quality of life. In Freude am Fluss this idea is put to work in the design of river management that includes the local problematic aspects of room for the river but also provide new opportunities for economic and social development. This expresses and supports **the paradigm shift from ‘fighting the floods’ to ‘living with water.’**”

foreword to a research report (Swanenvleugel 2007)

“Building dykes ever taller is not the answer to increasing flood risks. The European project ‘Freude am Fluss’ proposes a new approach to flood risk management along embanked rivers: **‘live with water rather than fight it’** and ‘more room for the river’. This new way of thinking includes two main pathways which interact with each other: The first is technical innovation to adapt housing, land use and activities on the floodplain. In other words: land use has to become flood tolerant. [...] the second pathway focusses on developing a process of joint planning [...] Applying this new concept will fundamentally change the way we manage our river basins.”

documentary introduction (Freude am Fluss 2006)

“There is a growing awareness that living with **water contains risks, but also offers opportunities** (quality of life, economic profit, roots for national identity), which, however, can not be cashed, kept or used, without a struggle.”

Waterkoers 2 (DG Water 2006)



presentation (Adriaanse 2009)

“For a long time policy has been pledging to accommodate water by ‘space for the river’ and ‘space for water’, mostly combined with nature development. [This] policy aims at giving water the place in spatial development issues it deserves, and not always considers it an appendix. **Do not only reduce the probability of flooding, also create, here and there, some space for water.**”

scientific publication (van der Most et al. 2010)

Figure 5 Quotes illustrating the idea Water is our Friend, not our Enemy

The statement that water should not be our enemy but our friend makes a pledge for an attractive landscape and other 'soft' values on which the flood risk system can have an impact. Yet, the idea opposes two approaches that have always existed, and will always exist, side by side. Under the old paradigm perhaps, the aesthetic and emotional values of water were not acknowledged by policymakers (but they certainly were by others). Still, water has always had functions through which it is logical to consider water as an ally, like shipping, drinking water and agriculture. Under the new paradigm there will still be storms and heavy rainfall, at rare times, when the water surely feels like an enemy to all.

Furthermore, it is not clear exactly why this polarisation is made. It would be a clear standpoint to want to allocate a smaller part of the water management budget to fighting floods and more to increasing quality of life, or to obtain additional budgets to finance particular water-as-a-friend objectives, separate or integrated with flood risk. Instead of taking a clear defensible position like this, it is often claimed that when we treat water as a friend, its hostility will be reduced – a confusing idea that can never be true in general.

How could this idea be damaging? When it is unclear how enemy and friend-oriented objectives and budgets are connected, it matters which parts of the budget is directed to which issues, making it harder to make and explain decisions. The prerequisite that projects have to address water as an enemy and as a friend simultaneously, excludes packages of measures that meet both objectives separately against lower costs than their integrated alternatives (figure 8). In 2005 the Netherlands Bureau for Economic Policy Analysis (CPB), presented an alternative to the concept of 'making room for the river', with flood risk reduction projects and nature-orientated projects partly separated, generating lower total costs but with more total natural value (Ebregt et al., 2005). The recommendation was discarded, possibly influenced by the idea that 'water as a friend' should not be treated separate from 'water as an enemy'.

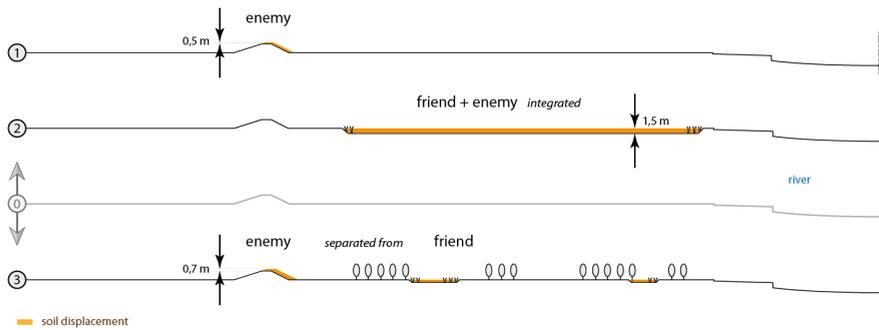


Figure 8 The idea that water should become our friend to reduce its hostility, favours certain measures without carefully considering the pros and cons of alternatives. In this figure, the three redesigns of the river profile give the same increase in discharge capacity. Option 1 treats water as an enemy. Option 2 is a typical *room for the river* floodplain excavation: water as a friend. Dyke heightening is avoided, but to achieve the same increase in discharge capacity as option 1, more than ten times as much soil than with option 1 has to be displaced. The resulting nature is high-maintenance; vegetation has to be cut frequently to keep roughness low. Option 3 treats water as friend and enemy separately. Vegetation can grow freely in the flood plains (water as a friend) because the increase in roughness is compensated by the dyke (water as an enemy). This option, if mentioned at all, has no support in the Netherlands

2 – The spiral of risk

In the cabinet’s decision on the fourth water plan, the ministry of public works and water management wrote:

“In the Netherlands we have been building levees and quays for many centuries. The higher and stronger these become, the larger the sense of safety. This makes the embanked land attractive for developers and investors. Large investments in their turn ask for more protection and therefore more enforcement of flood defences. This makes us go around in a vicious circle. [...] Extreme circumstances like storms at sea and high river discharges ask for extra space, space with which the spiral of land subsidence and raising dykes, of encroaching development and the call for flood protection, can be broken.” (V&W, 1998)

Two years later, a heavyweight report by multiple governments from the lower rivers region stated: *“upgrading levees alone is eventually a dead-end road, and will lead to increasing risks for consequential damages of possible floodings”* (de Jong et al., 2000). A scientific publication mentions that in the Netherlands *“the height of the dams will have to be increased for centuries to come [...] the chance of flooding is reduced, but the potential damage after a storm flood is enlarged: seawalls and dykes provide a false sense of safety against flooding.”* (Smits et al., 2006) Figure 10 was published in a national policy vision document. See figure 11 for an indication of popular or preferred measures found in the context of the quotes.

"Ongoing embankments and sedimentation of the floodplains forced the high river discharge in **an ever tighter corset**. In stead of dealing with the deeper underlying cause, solutions were sought in clearing natural obstacles in and along the river. Also the levee enforcements, which started around 1820 and are still going on, fits in an agrarian spirit of age, whereby of course also the increased economic importance of the embanked area plays a part. Looking back at 150 years of levee enforcements, we can not withdraw the impression that this is, in part, **a vicious circle, which can not be broken as long as intensive agriculture dominates the floodplains.**"

NGO report (Helmer et al. 1992)

"The historical traditions of large embankments and similar infrastructure are still being replicated (...). **This reliance and belief in large technological solutions is known as 'technological entrapment'**, and whilst new embankments may be appropriate in certain circumstances, a reliance on these and other 'big' solutions exclusively risks a loss of flexibility, adaptability and ultimately sustainability in flood-risk management."

scientific publication (Zevenbergen et al. 2010)

"Risk was defined as the product of the probability of being flooded and the scale of the consequences. In the Netherlands, it was argued, the reduction of this probability had allowed an ongoing expansion of the economic value and of land use behind the dikes, thus enhancing the vulnerability of the country, in case of another exceptional flood. Ultimately, the risk had not been reduced as much as was widely believed. Thus, the government was confronted with the paradox that **the smaller the probability of flooding, the higher the vulnerability.**"

scientific publication (Correljé & Broekmans 2014)

"The question is what counts: the safety behind the dike, or the safety of the dike itself. (...) The discussion we have had lately, is about the transition to **a new approach, to the safety behind the dike, the real safety for the people behind the levees.**"

parliamentary discussion (van Veldhoven & Sneep 2012)

"Our forefathers would **not for a moment have thought of building in the lowest parts of our country**, but our contemporary planners see no problems at all."

popular-scientific book (van Duijn 2007)

"(...) the height of the dams will have to be increased for centuries to come, because the land behind the levees cannot grow in elevation anymore with the rising of the sea. Maintenance of the civil-engineering structures, and mitigating their unpredictable impacts on ecosystems, involve very high recurrent costs. **The chance of flooding is reduced, but the potential damage after a storm flood is enlarged: seawalls and dykes provide a false sense of safety against flooding.**"

scientific publication (Smits et al. 2006)

"From a socio-economic point of view, the impression of safety bestowed by the dykes, invites people to invest money behind them. Towns and villages prosper and tend to grow. Although the frequency of a potential disaster has diminished, the potential damage to lives and goods increases: the impression is therefore false. Especially in times of poor maintenance of the dykes (war, recession) this becomes only too obvious.

(...) In the 50 years after 1953, huge investments in trade, industry, and infrastructure were made. The population increased very considerably. Individuals took many decisions to invest behind the dykes. The government not only did nothing to prevent this development but, on the contrary, favoured this development.

(...) Storms that do almost no harm in a natural situation, turn into catastrophes when dykes are breached. This has been the rule for a thousand years.

(...) The huge dams may be technical masterpieces for control of the tidal dynamics of the sea, but they fail to control the socio-economic processes they unleash, and their existence is irreversible. **The chance of flooding is reduced; the potential damage is enlarged, so the net result is zero or worse."**

NGO report (Saeijs et al. 2004)

"Costs for room for the river are higher than those for levee upgrades. But it has to be noted that **upgrading levees alone is eventually a dead-end road, and will lead to increasing risks** for consequential damages of possible floodings."

major regional policy document (de Jong et al. 2000)

"Ecologic recovery of our entire river system is possible. This recovery simultaneously offers great opportunities to solve other problems. Related to this I would like to mention, considering the political debate, **breaking the vicious circle of the river dike enforcements."**

foreword NGO report (Helmer et al. 1992)

"It is increasingly recognised that engineering responses alone cannot accommodate the future frequencies and impacts of flooding. Moreover, the mere use of **large infrastructure, particularly flood protection, has the risk for 'technological lock-in' or for 'investment trap'**, creating a path dependency that reduces the opportunities to take alternative or complementary measures."

scientific publication (van Herk 2014)

"Municipalities build in areas vulnerable to flooding, today and even more in the future: deep polders, regions with settling soil and groundwater seepage, or areas directly behind high levees. This is not only a consequence of the relatively short planning horizon common in current spatial policy-making. Also the repetitive emphasis on civil engineering measures contributes. Levees are raised step by step, surface water is pumped away ever deeper. This results in a slow increase between ground levels and maximum water levels, and slowly **we reach the limits of the system."**

policy research report (Pols et al. 2007)

Figure 9 Illustrative quotes to the idea of The Spiral of Risk.

The captions give the document titles (for the major national policy documents) or the type of document (for other types of documents).

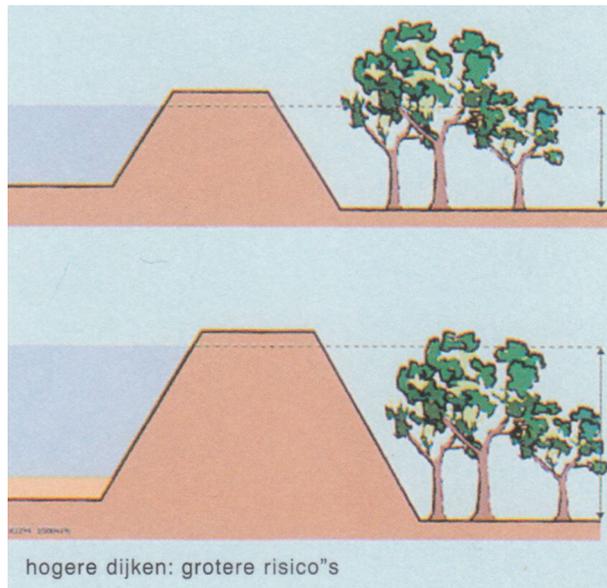


Figure 10 'Higher dykes, larger risks' (DG Water, 2000). See also figure 12

<i>Types of measures</i>	<i>the Spiral of Risk</i>	
Disaster management	generally favoured	<i>The related concepts 'Safety Chain' and 'Multi-level Safety' emphasise disaster management.</i>
Local measures and risk zoning	generally favoured	<i>Measures behind the dike are considered ways to break the Spiral of Risk.</i>
Upgrading dikes	generally disfavoured	<i>Higher dikes are core to the Spiral of Risk. Wider dikes are favoured over higher dikes.</i>
River widening and deepening	generally favoured	<i>Lower high river levels reduce inundation levels and substitute higher dikes.</i>
Redirecting flows on a higher scale level	generally disfavoured	<i>Storm surge- and river discharge distribution control objects are part of the dike system.</i>

Figure 11 A brief overview of the types of measures favoured and disfavoured in the context of the illustrative quotes to the idea of the *spiral of risk*

This concept of a vicious circle relates to a fear of relying too heavily on technology. It is sometimes called *technological entrapment* (Van Herk, 2014), or the *spiral of risk* (Rijcken, 2007). The idea has three parts: (1) investments to reduce flood probability and potential flood damage enhance each other eternally, (2) this should be stopped and (3) this can be stopped.

Flood probabilities often contribute to decisions to settle or invest somewhere, and settlers tend to want to further reduce flood probabilities when they develop. This can come to a halt for some time, for example when flood

protection is over-dimensioned and growth slows down. There will always be maintenance however, so when this is taken into account we may speak of being entrapped in never-ending effort. But should this really be avoided? The historic transition from hunting and gathering towards agriculture and industry is a tremendous entrapment, yet acceptable to most of earth's inhabitants.



Figure 12 Part of the *spiral of risk* idea is that dyke heightening provides a 'false sense of safety'; risks would increase because higher dykes lead to higher inundation depths. In this reasoning, damage is confused with risk. For Dutch rivers, roughly, a 40 centimetre higher water level has a ten times lower probability of occurrence. According to the *stage-damage curve* for an average dyke ring, a 40 centimetre higher inundation depth yields less than 10 per cent more damage. As risk is probability times damage, the new risk is $0,1 \times 1,1 = 0,11$ as large as the old risk. With dyke heightening, risk decreases more than ten times faster than damage increases. Safety is the inverse of risk. A sense of *absolute* safety may not be justified, but a sense of *increased* safety when a dyke is heightened, surely is

Several options have been presented to break out of the vicious circle of levee enforcements. For example, lowering high water levels – first by excavating the agricultural flood plains, then by relocating the embankments away from the river (Helmer et al., 1992; DG Water, 2006; PBR, 2013). In the Netherlands, if these types of measures would be implemented to the fullest there would still remain an average of 7 to 8 meter difference between the design water levels and the embanked land (Silva & Van der Linden, 2008). Slightly lowered water levels will not stop the spiral of risk from spinning.



Figure 13 New neighbourhoods on mega-mounds to avoid an increase in flood damage and thus flood risk (designed by landscape architects Stroming. Images taken from: Aerts et al. 2008)

A second way out of the vicious circle could be offered by additional flood risk reducing measures on scale levels lower than dyke rings, like risk zoning, abandoning areas, flood-resistant buildings, mounds (figure 13) or evacuation plans (Saeijs et al., 2004; Pols et al., 2007). This idea influenced two popular concepts: the *Safety Chain* (Ten Brinke et al., 2008) and *Multi-Layered Safety* (DGW, 2009; Hoss et al., 2013). Much can be said about which aspects of these concepts make sense or not, and which aspects are related to values and politics. The essence is that throughout the world a pragmatic approach to flood risk has always been to focus on the most effective measures, instead of spreading measures between scale levels as a goal in itself.

In the Netherlands, investments in prevention (mainly dykes) cover a small area and protect a large area, and when they work, they work completely. Measures inside the protected area (like flood-proof buildings) however, have to be applied in vast areas, and have a limited total effect when the preventive scheme fails (Jongejan et al., 2012; ENW 2012). Figure 14 illustrates some of these principles. When a country has arrived at a point where sufficient prevention requires no more than maintenance and occasional upgrades, this is from a pragmatic perspective, not an *entrapment*, but a safe haven. The illusion is not *complete safety*, but that the spiral of risk should and can be broken.

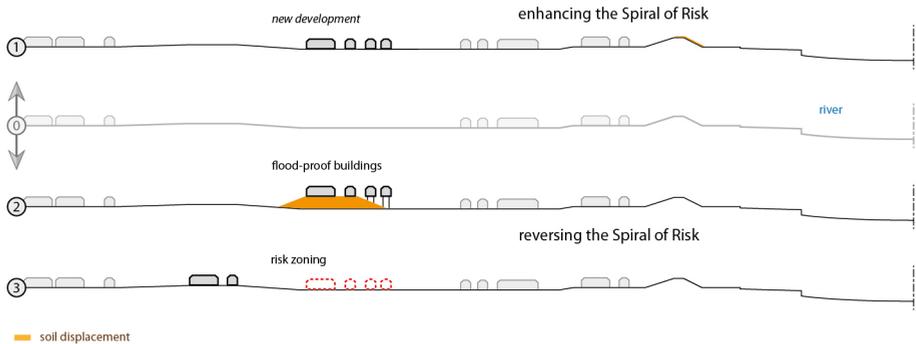


Figure 14 The *spiral of risk* idea suggests that the interdependency between flood protection and economic development is dangerous and can be reduced, for example by flood-proof buildings and risk zoning. Looking at properly scaled typical cross-sections, knowing that a Dutch dyke ring is easily 25 kilometres wide (on the scale of this drawing another *ten meters* to the left), it appears that flood-proof buildings (option 2) protect only new developments and quickly require much more soil displacement (or effort) than dyke heightening (option 1). The idea of *risk zoning* (option 3) is that higher areas are favoured for development over lower areas. This dyke ring floods, say, with a probability of 1:1000, and flood damage as a percentage of building costs may be 40 per cent for option 1, twenty per cent for option 3. Yearly flood risk relative to the building costs now differs between option 1 and option 2 by 0,02 per cent. In practice, the benefits of risk zoning will be crushed by other considerations for development, such as land value and proximity to infrastructure

The spiral of risk idea is potentially harmful in many ways: in an attempt to break the vicious circle, tax money earmarked for risk reduction is spent on projects while cheaper alternatives for more risk reduction are neglected; flood-proof building regulation and zoning add unnecessary red tape to city and landscape development, public awareness campaigns to change the behaviour of citizens end in vain, hammering on potential flooding deters foreign investors, etcetera. This is a sensitive topic in current Dutch policy-making – it is stressed that these are *potential* pitfalls.

3 – Moving with nature

In a report for the Fourth National Water Plan, a group of senior consultants write, “*the river fights back*”, referring to the swollen rivers of 1993. They ask: “*when we build, operate and manage infrastructure, do we choose to connect to natural processes, or will on the contrary, the oppression of natural processes be our starting point?*” (Projectteam NW4, 1995). The cabinet’s position on water management states that:

“*The natural coping capacity of the delta has largely been lost. With technical means like raising dykes and pumping alone we reach the limits of what is possible. (...) The restrained natural forces will sooner or later be stronger than man. This can be avoided by no longer working against nature, but working with nature.*” (DG Water, 2000)

An essay published by the ministry of spatial planning and the environment contains another example:

“*Moving with water means that where flows are too strong, we will give; where sediment accumulates, we will take. [...] The Netherlands will thus achieve its natural water order, and will no longer be a giant prosthesis.*” (Van Schuppen, 2007)

The Delta Commission of 2008 recommends that new developments should: “*move with natural developments, induced by climate change and other natural processes. We build and develop the country as much as possible in harmony with ecological processes.*” (Deltacommittee, 2008)

The recent annual Delta Program reports mention ‘moving with natural processes’ a few times, and use the term ‘natural flood defences’ more than ten times, especially in the 2013 report (Deltaprogramma 2010; 2011; 2012; 2013). Figure 16 shows a typical example of a natural flood defence. The quotes were often practiced in a context of certain popular or preferred measures; see figure 17 for an indication.

"[The Netherlands have to] develop along with climate change. Moving along with-, and making use of natural processes where possible, leads to solutions to which man and nature can gradually adapt. [...] Attempts to control nature will demand ever larger (and more expensive) effort. [...] We [should] **build and develop the country as much as possible in harmony with natural processes.**"

Deltacommittee (2008)

"(...) a natural stream is excavated, 60 meters wide and 1,2 meters deep"

web post (Coalitie Klimaatbuffers 2014)

"**The natural coping capacity of the delta has largely been lost.** With technical means like raising dikes and pumping alone we reach the limits of what is possible."

Anders omgaan met water (DG Water 2000)

"We are trying, less than we used to, to curb and restrain the forces of nature, but rather we try to better understand and guide them."

newspaper essay (Geldof & van Hilten 2006)

"(...) one might say that **Mother Nature**, old and wise, extends her hand to show us how we should and how we shouldn't interact with her.

All we have to do is listen and pay attention and follow her advice.

We must simply 'be her guest'. Let's not forget that she has 3 billion years more experience than we have, and was doing a wonderful job long before Man entered the scene. In fact she produced us!"

popular scientific book (Saeijs 2008)

"The Netherlands thought they had won the battle against the water: the Delta works are done [...] and the rivers have been laced up with dikes and dams. The water is caught in asphalt, steel, basalt and concrete, but maintenance costs increase day by day. At the same time, the Netherlands are sinking, because of the intense pumping and **natural processes like sedimentation and peat growth have been halted.**"

web post (Coalitie Klimaatbuffers 2014)

"Everywhere in the world, the reaction of people is the same: if something serious happens, you want to restore the old situation. For the consequences of Superstorm Sandy this is exactly the wrong reaction. **Working against nature is not a solution.**"

web post (Ovink & I&M 2013)

"In the policy concerning flood control and water management, 'hard core' civil engineering approaches are discussed and substituted by approaches which emphasize resilience and working with nature. (...) [This] approach has been applied predominantly in rural areas while in the urbanised western part of the country a more traditional combination of 'hard core' hydraulic engineering and urban planning seems to be the best option. (...) Two serious high-water situations in the river area in the mid-1990s enhanced **the idea that the era of controlling nature was finished.**"

scientific publication (Meyer 2012)

"The system is not capable to handle extreme circumstances (...), and it is therefore required that we give space to water and **restore natural processes.**"

Watervisie (DG Water 2007)

“Connecting to natural processes by restoring the resilience of water systems will provide important guidance for future water management”

Vierde Nota Waterhuishouding (V&W 1998)

“A delta without dykes is safer than a delta with dykes, because **natural processes will weaken the effects of extreme storm floods.**”

scientific publication (Smits et al. 2006)

“Water systems need playground to cope with unforeseen developments. For the rivers, this means water conservation in the entire catchment and expanding the flow profile, in stead of the next round of levee enforcements. (...) We have to **remove unnatural obstacles in the river bed. (...) for the coast sustainable safety means space for natural processes.** The less we fixate the coast by hard constructions such as levees, dams and permanent buildings, the less the effort to keep the coast at its place”

Vierde Nota Waterhuishouding (V&W 1998)

“Moving along with water means: where flows are too strong, we will give, where sediment accumulates, we will take. (...) **The Netherlands will thus achieve its natural water order**, and will no longer be a giant prosthesis. (...) Typical water infrastructure elements are the inlet and outlet for emergency storage areas, broad coastal defenses and room for the river. Housing in areas with ‘dynamic water management’ are historical typologies such as houses on mounds, on dikes, floating homes and – lest best – the drowning house. (...) It is a mentality of reversal, of paradox: dikes, quays and sluices built to keep the water out, can easily be transformed to function in a system aimed to let the water in.”

essay (van Schuppen 2007)



“The natural course of the river has been canalised by man. Now, the river reclaims its original space. Normalisation has, apparently, not been a sustainable solution. The maxim should be: **anticipate and move along with the natural dynamics of the water** and be prepared for the long-term consequences of climate change.”

Waterkoers 2 (DG Water 2006)

“(…) **building with nature offers a much better protection than the technical solutions that go against nature.** We are doing this along the coast, for example; sand nourishments so the coastline expands. I really believe in building with nature. (...) You get more stability when you implement both nature as well as technology. Insights about what works best are changing.”

newspaper article (Schultz et al. 2013)

Figure 15 Illustrative quotes to the idea of Moving Along with Nature



Figure 16 *Redesign of the Dutch Closure Dam* by landscape architect Hosper (Lammers, 2009). The green land to the left is currently not there; vegetation is to grow over artificial sand nourishments of several metres high. The concept is promoted by the NGO *Natural Climate Buffers*, in which the major Dutch nature conservation organisations collaborate. The NGO frequently uses the terms *natural safety* and *natural flood defences* in their communication, for example towards the Delta Program (SNK, 2014). Also see figure 19

Types of measures

Disaster management

Local measures and risk zoning

Upgrading dikes

River widening and deepening

Redirecting flows on a higher scale level

Moving Along with Nature

not mentioned

some measures
favoured

generally
disfavoured

generally
favoured

some measures
favoured

In the context of the quotes, disaster management measures were not mentioned

Prohibiting to build in certain areas (zoning) is sometimes called Moving Along with Nature

Dikes are considered acting against nature, oppressing natural processes, etcetera.

Measures in the river bed are called natural and often accompanied by nature restoration.

Open estuaries are natural, dams act against nature, movable barriers are in between.

Figure 17 Brief overview of the types of measures favoured and disfavoured in the context of the illustrative quotes to the idea of *moving with nature*.

These quotes reflect a strong interest in nature conservation and restoration, and in something transcending human interventions and technology, but the terms are not clearly defined. What does it mean to connect to a natural process or to give in when a flow is too strong? In the documents, this is not defined, but exemplified by measures, like ones that direct water sideways instead of upwards (figure 18). Other typical measures are coastal sand nourishments (figure 19) and excavated bends to de-canalise rivers. A term cannot be defined by examples however. In the Dutch dictionary, the word ‘moving along’ does not exist, and in the water literature, a working definition is nowhere to be found.

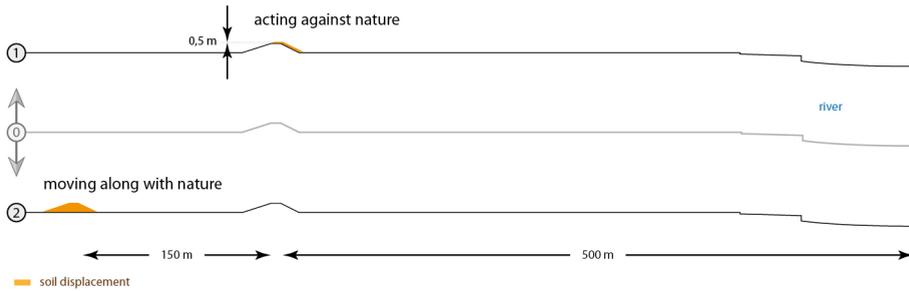


Figure 18 The idea that the flood risk system should *move with nature* favours additional horizontal space over extra space in a vertical direction. According to the formula $Q = C \cdot B \cdot H^{3/2}$, roughly 0,5 metre dyke heightening (option 1) and 150 metre river widening (option 2) give the same additional discharge capacity. Both result in highly man-made river profiles

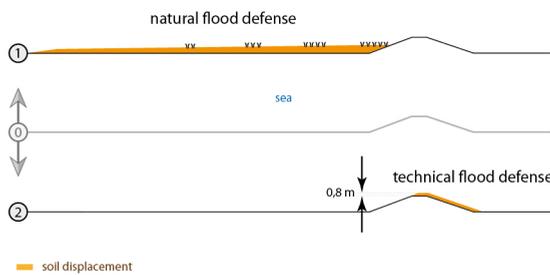


Figure 19 Artificially elevated foreshores along the coast are often considered *natural flood defences*. How much soil is to be displaced by machines does not determine how natural a measure is. There is currently no scientific agreement that option 1 can provide the same protection as option 2

The frequent use of ‘natural flood defences’ might be a serious indication that among water professionals the definition of the word ‘natural’ is changing. Most commonly, something is considered natural when its shape or place has been caused by a force other than induced by a conscious human decision. The forty-four quotes in figure 15 are all made in a context of human interventions: no one advocates making the flood protection system more natural by doing nothing. So what is meant by a natural measure or a natural system?

Let’s consider some contexts in which these terms are practiced. The concept *building with nature* is clearly defined: wind and currents distribute building materials (mainly sand), and/or building components are designed

such that they attract or facilitate flora, fauna and/or entire ecosystems (e.g. Waterman, 2008; Deltares, 2014). Nature is a force or a cause.

Most *room for the river* projects are about lowering or widening the river bed by turning agricultural flood plains into natural parks, digging bypasses and lakes for fish and birds or growing wild vegetation on excavated farmland (e.g. V&W, 2006; Q-team, 2008, 2012). Nature is an occupant of space.

Along the coast under the *dynamic coastal management* policy, twelve to twenty million cubic metres of sand is added to the coastal system each year to maintain a certain geographical base coast line and allow more sand to blow freely through the dunes. This contrasts to an alternative with less replenishments and more dunes fixed in place by planted grass or revetments, which would create a less diverse and smaller dune landscape (e.g. DGW, 2009).

It seems that a *measure* is called natural when it supports a native, diverse or attractive ecosystem. A *system* is natural by the same definition, or when it resembles the way it was before the interference of man. With this additional definition of *natural*, about half of the quotes in figures 13.3 and 13.4 could be removed. The other half refers to the poorly defined idea ‘moving with nature’. Both terms however are likely to arouse suspicion by an observant reader, and this suspicion is why an unclear definition is not only a linguistic flaw, but can represent a serious political issue.

According to epistemologists Collins and Evans the argument for the natural is “*about as unsophisticated an argument as one can find*” (Collins & Evans, 2007). People using the term *natural flood defences* may be suspected to not really know what they are talking about or not to express the real arguments. In the Netherlands, societal interest and political lobby for ecosystem conservation and restoration are strong. To many lobbyists the end justifies the means, and for the environmental lobbyists it is attractive to connect their cause to flood safety, a strategy publicly announced by World Wildlife Fund (Opmeer, 2013). Ambiguous and undefined terms can obscure the fact that a budget for an integrated project is primarily justified by providing safety, but is spent primarily on nature development.

3. DISCUSSION

The search for debatable quotes could have been more extensive but was sufficient to explain and discuss the debatable ideas and show that they are not marginal. More quotes and debatable ideas could be found with deeper searches in the same documents, other documents, or with web searches, possibly extended towards documents from international sources. A strict distinction between different types of illustrative quotes could help to reveal when an idea is formed, when it is taken for granted and when it might have disappeared.

A quoted author might say that he or she meant something else than what appears in this paper. It would be respectful and interesting to interview the authors of each quote or to take an entirely different approach and send a questionnaire about the same ideas to water professionals. This might yield additional debatable ideas or different interpretations of the fourteen selected ones. It would also be interesting to include the background of the authors, like engineering, geography or law, and see if there are correlations with certain ideas.

Still, many water professionals, engineers and others, will recognise the fourteen ideas, and acknowledge that it is healthy to discuss them. Achieving safety and related objectives require reasonings that are able to withstand critique.

After the Dutch Delta Works, new ideas about the flood risk system emerged among Dutch water professionals. These new ideas deserve a critical analysis. In this paper fourteen ideas that can be carefully called *debatable* but are also well known were formulated and scrutinised. Twenty of the most important national policy documents and 26 other publications were searched for quotes illustrating the ideas and to find out whether the ideas are broadly shared or marginal. The three most prominent and controversial ones were selected to elaborate further. Ten quotes were found related to the idea that ‘water should not be our enemy, but our friend’, fifteen to the idea that flood protection entraps us in a dangerous ‘spiral of risk’ which should and can be stopped, 45 were related to the idea that flood risk reducing measures should be ‘natural’ or ‘move with nature’. These numbers suggest that these three ideas have not been marginal.

The general critique to all debatable ideas would be that they present preferred measures as generally logical conclusions without a systematic comparison of alternatives for particular situations. Clearly negative effects such as reductions in safety, deliberate deception of the public or squandered tax money cannot be established, and general beliefs among the decision-makers are not the only factors leading to decisions. In this paper it was chosen not to delve into all considerations leading to the major decisions since 1990.

Behind these new ideas lies increasing societal interest in objectives like an attractive water landscape (water as a friend), reducing our dependence on technology (spiral of risk) and nature conservation and restoration (moving with nature). Some might argue that these worthy ends justify all means, even conceptual weakness in the underlying ideas. Others believe that the *content* of ideas is of minor importance, as long as a proper democratic decision *process* has been followed. This paper revolves around the idea that content matters, and that widely shared ideas about the system in one way or the other have had an impact on decisions. If arguments contain questionable ideas, this weakens the outcome of decision-making: the means justify the ends.

<i>Types of measures</i>	Friend	Spiral	Nature
Disaster management	not mentioned	generally favoured	not mentioned
Local measures and risk zoning	some measures favoured	generally favoured	some measures favoured
Upgrading dikes	generally disfavoured	generally disfavoured	generally disfavoured
River widening and deepening	generally favoured	generally favoured	generally favoured
Redirecting flows on a higher scale level	some measures favoured	generally disfavoured	some measures favoured

Figure 20 Favoured and disfavoured measure types in the contexts of the three debatable ideas. It seems they all favour river widening and deepening, and disfavour dyke upgrades

This survey leads to a couple of conclusions, presented as theses, open for discussion. Under almost all debatable ideas lies a general aversion towards dyke heightening – see figure 20. Throughout history, conceptual thinkers have always pointed out negative aspects of dyke heightening (Van der Ham, 2004), and dyke heightening has met fierce opposition by local habitants (Van Heezik, 2007). Perhaps after the River Delta Plan (1995–2000), avoiding dyke heightening became an objective in itself, and people were less critical towards the underpinning of available alternatives to dykes.

Studying ‘water as a friend’ and ‘moving with nature’ has suggested that people, by merging ecosystem restoration and nature development with flood risk objectives, conceal how important nature really is to them. Perhaps stakeholders are ready for ‘natural’ flood defences but do not dare to take a stand for nature development as an objective in itself, deserving a large national budget.

Perhaps people are attracted to debatable ideas because the flood risk system is not easy to comprehend. Grasping risk and probability is notoriously difficult (Ropeik, 2010; Taylor, 2011) and the interplay between flood risk-related objectives can be complicated. Nowadays more people are involved in the decision-making process than half a century ago, but many stakeholders have little time to learn about the system. It is fast and easy to hitch on to a simple grand idea that appears to have transcended the complexity of the system.

The topical concepts *storytelling* (Hajer et al., 2011) and *framing* (De Bruijn, 2011) explain, and in part support, the power of general ideas. An effective story creates meaning and engages a community; an effective frame wins a political dispute. Narrative persuasion is important to get things done, but

the flood risk system heavily relies on a complicated physical reality, well served by craftsmanship and custom-made solutions. The problems and budgets at stake are large enough for a systematic unravelling of objectives and an overview of the spectrum of possible solutions, before any decisions are made. General ideas distort a well-balanced overview, but they will always be around. New interactive information systems, like the SimDelta concept illustrated in figure 21, might lend the systematic approach a helping hand.

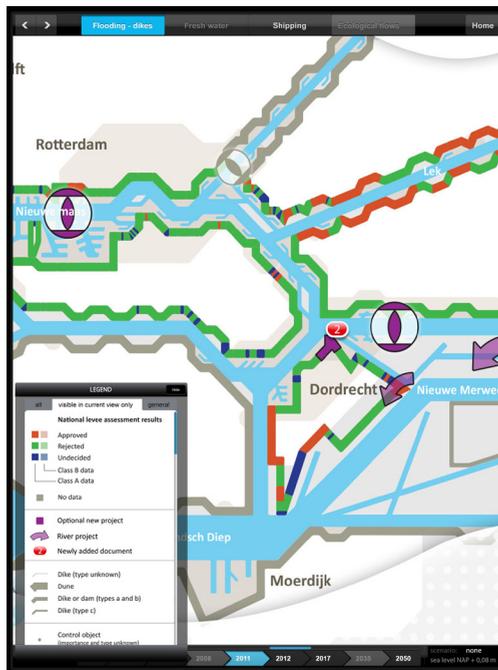


Figure 21 The SimDelta concept (Rijcken et al. 2012; Rijcken & Christopher 2013; DUT 2014) aims at representing the Dutch flood risk system in a clear consistent graphic language. Web technology enables insight and overview. There is room for general ideas, stories and framing, but these are subordinate to fundamental concepts about risk, objectives and solutions

ACKNOWLEDGEMENTS

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Not all quotes found are presented in figures 2, 3, 4, 5, 9 and 15. National policy documents in which no illustrative quotes were found, are not added in the reference list. In some documents, more than one illustrative quote was found.

REFERENCES

- Aerts, J. (2008) Dealing with uncertainty in flood management through diversification. *Ecology and Society* 13(1): 41
- Boorsma, K. (2007) *Deltaplan 2007*. Drachten, Ingenieursbureau Boorsma B.V.
- Braakhekke, W. et al. (2008) *Hoogtij voor Laag Nederland* (High Tide for the Low Lands), WWF/Stroming
- Brinke, W.B.M. ten, et al. (2008) The safety chain approach in flood risk management. *Proceedings of the ICE – Municipal Engineer* 161 (2), pp 93-102
- Bruijn, H. de (2011) *Framing, over de macht van taal in de politiek* (Framing, about the power of language in politics). Amsterdam, Atlas
- Collins, H. & R. Evans (2007) *Rethinking expertise*. Chicago, University of Chicago Press
- Commissie WB21 (2000) *Waterbeleid voor de 21e eeuw – Geef water de ruimte en de aandacht die het verdient; advies van de Commissie Waterbeheer 21e eeuw* (Water policy 21st century – give water the space and attention it deserves; recommendations by the Commission Water Management 21st century). Den Haag, Commissie WB21
- Correljé, A. & B. Broekhans (2014) Flood risk management in the Netherlands after the 1953 flood: a competition between the public value(s) of water. *Journal of Flood Risk Management* (Online Version of Record published before inclusion in an issue), pp 1-17
- Deltacommissie (2008) *Working together with water; a living land builds for its future – Findings of the Deltacommissie 2008*. Den Haag, Secretariaat Deltacommissie
- Deltaprogramma (2010) *Deltaprogramma 2011: werk aan de delta (working on the delta)*. Den Haag, Ministerie van Infrastructuur en Milieu a.o.
- Deltaprogramma (2011) *Deltaprogramma 2012: maatregelen van nu, voorbereidingen van morgen* (acting today, preparing for tomorrow). Den Haag, Ministerie van Infrastructuur en Milieu a.o.
- Deltaprogramma (2012) *Deltaprogramma 2013: de weg naar deltabeslissingen* (the road to the delta decisions). Den Haag, Ministerie van Infrastructuur en Milieu a.o.
- Deltaprogramma (2013) *Deltaprogramma 2014 – kansrijke oplossingen voor opgaven en ambities* (Delta Programme 2014 – promising solutions for tasks and ambitions). Den Haag, Ministerie van Infrastructuur en Milieu a.o.
- Deltares (2014) *Bouwen met de natuur in de praktijk* (Building with nature in practice). *Delta Life* 1, pp 14-15
- DG Water (2000) *Anders omgaan met water; waterbeleid in de 21ste eeuw* (A different approach to water management in the 21st century). Den Haag, Ministerie van Verkeer en Waterstaat
- DG Water (2006) *Waterkoers 2 – De visie van DG Water op het waterbeleid in Nederland* (The ministry's vision on Dutch water policy). Den Haag, Ministerie van Verkeer en Waterstaat
- DGW (2009) *Nationaal Waterplan (National Water Plan)*. Den Haag, Ministerie van Infrastructuur en Milieu a.o.
- DUT (2014) *SimDelta*. Retrieved from: <http://simdelta.tudelft.nl/> [Accessed February 27, 2014]
- Ebregt, J., C.J.J. Eijgenraam, H.J. Stolwijk (2005) *Kosteneffectiviteit van maatregelen en pakketten: Kosten-bate-nanalyse voor Ruimte voor de Rivier, deel 2*. CPB Document 83. Den Haag
- Eijgenraam, C.J.J. (2007) From optimal to practical safety standards for dyke-ring areas. *Water Science and Technology* 56 (4), pp 113-124
- ENW (2012) *Meerlaagsveiligheid nuchter bekeken* (A sober approach to multi-layered safety). Den Haag, Expertise Netwerk Waterveiligheid
- Ham, W. van der (2004) *Afleiden of opruimen* (Divert or clean up). Den Haag, Directoraat-Generaal Rijkswaterstaat
- Heezik, A.A.S. van (2007) *Strijd om de rivieren: 200 jaar rivierenbeleid in Nederland of de opkomst en ondergang van het streven naar de normale rivier* (Battle for the rivers, 200 years of river policy in the Netherlands). Haarlem, HNT Historische Producties
- Helmer, W. et al. (1992) *Levende rivieren* (Living rivers). Zeist, Wereld Natuur Fonds
- Herk, S. van (2014) *Delivering integrated flood risk management: governance for collaboration, learning and*

- adaptation*. Delft, UNESCO-IHE
- Hoss, F., Jonkman, S.N. & Maaskant, B. (2013) *A comprehensive assessment of multilayered safety in flood risk management – the Dordrecht case study*. Delft/Lelystad, Delft University of Technology/HKV consultants
- Jong, S.A. de, et al. (2000) *Advies Integrale Verkenning Benedenrivieren* (Recommendation Integral Exploration Lower Rivers). Rotterdam, Rijkswaterstaat Zuid-Holland
- Hajer, M., S. van 't Klooster & J. Grijzen (2011) *Strong stories: how the Dutch are reinventing spatial planning*. Rotterdam, 010 Publishers
- Jongejan, R.B. et al. (2008) A comment on 'Changing estuaries, changing views'. *Hydrobiologia* 605 (1), pp 11-15
- Jongejan, R.B., S.N. Jonkman & J.K. Vrijling (2012) The safety chain: a delusive concept. *Safety Science* 50, pp 1299-1303
- Jonkman, S.N. (2013) Veilig leven met water? (Living safely with water?). *Water Governance* 3, pp 37-39
- Kind, J.M. (2013) Economically efficient flood protection standards for the Netherlands: Efficient flood protection standards for the Netherlands. *Journal of Flood Risk Management* (Online Version of Record published before inclusion in an issue), pp 1-15
- Klijn, F., M. Kok & H. Moel (2012) *Towards climate-change proof flood risk management*, Knowledge for Climate, Report nr. KfC 57/2012
- Lammers, J. (2009) *Dijk en Meer – Eindrapportage verkenning Toekomst Afsluitdijk* (Final report of the exploration for the future of the Lake IJssel closure dam). Lelystad, The Netherlands, Rijkswaterstaat IJsselmeergebied
- Meyer, H. (2012) Urban design in a dynamic delta. *Proceedings of the ICE – Urban Design and Planning* 165 (2), pp 89-101
- Opmeer, A. (2013) Natuur in het nauw (Nature cornered). *Down to earth* 16 (4), pp 18-22
- PBR (2013) *Ruimte voor de Rivier* (Room for the River). Retrieved from: <http://www.ruimtevoorderivier.nl/> [Accessed October 2013]
- Pols, L. et al. (2007) *Overstromingsrisico als ruimtelijke opgave* (Flood risk as spatial planning task), Rotterdam/Den Haag, NAI Uitgevers/Ruimtelijk Planbureau
- Programmaorganisatie Leven met Water (2006) *Leven met Water – organisatie en werkwijze* (Living with Water-organisation and method). Gouda, Leven met Water
- Projectteam NW4 (1995) *Ruimte voor Water – visienotitie als aanzet voor discussie* (Space for Water – a vision for discussion). Den Haag, Projectteam NW4
- Q-team (2008) *Jaarverslag Q-team Ruimte voor de Rivier 2006-2007* (Annual Report Quality-team Room for the River). Utrecht, the Netherlands, Programmadirectie Ruimte voor de Rivier
- Q-team (2012) *Jaarverslagen Q-team Ruimte voor de Rivier 2009-2011* (Annual Reports Quality-team Space for the Rivers). Utrecht, the Netherlands, Programmadirectie Ruimte voor de Rivier
- Rijcken, T. (2007) Gevangen in de risicospiraal (Trapped in the spiral of risk). *Stedenbouw & Ruimtelijke Ordening (S&RO)*, pp 48-50
- Rijcken, T. (2008) The Ultimate Dyke Operator. *Volkscrant – Forum*, p 12
- Rijcken, T., J. Stijnen & N. Slootjes (2012) 'SimDelta' – Inquiry into an Internet-Based Interactive Model for Water Infrastructure Development in The Netherlands. *Water* 4 (4), pp 295-320
- Rijcken, T. & D. Christopher (2013) 'SimDelta global' – towards a standardised interactive model for water infrastructure development. *European Journal of Geography* 4 (1), p. 6-21
- Rooy, P. van & L. Sterrenberg (2000) *Het blauwe goud verzilveren; integraal waterbeheer en het belang van omdenken* (Cashing the blue gold; integrated water management and the need for rethinking). Den Haag, Rathenau Instituut
- Ropeik, D. (2010) *How risky is it, really? – Why our fears don't always match the facts*, New York, McGraw-Hill
- Saeijs, H. et al. (2004) *Changing estuaries, changing views*. Rotterdam/Nijmegen/Zeist. Erasmus University/Radboud University/Worldwide Fund for Nature
- Schultz, M., J. Hoedeman & R. Meerhof (2013). Interview Melanie Schultz, minister van Infrastructuur en Milieu (Minister for infrastructure and environment). *Volkscrant*, January 26

- Schuppen, S. van (2007) 'Meebuigen en combineren' (Bend along and combine), in: *Ontwerpen met water (Designing with water)*. Den Haag, Ministerie van VROM, pp 41-61
- Silva, W. & T. van der Linden (2008) *Van Lobith en Eijsden naar zee* (From Lobith and Eijsden towards the sea). Den Haag, Ministerie van Verkeer en Waterstaat, DG Water
- Smits, A.J.M., P.H. Nienhuis & H.L.F. Saeijs (2006) Changing estuaries, changing views (opinion paper). *Hydrobiologia* 565 (1), pp 339-355
- SNK (2014) *Klimaatbuffers 2.0 - Afsluitdijk*. Retrieved from: www.klimaatbuffers.nl/afsluitdijk-page [Accessed February 2014]
- Swanenvleugel, B. (2007) *Freude am Fluss (Joy at the River)*, Nijmegen/Gouda, Freude Am Fluss/Leven met Water
- TAW (1998) *Fundamentals on water defences*, Den Haag, Ministry of Water Management/Technical Advisory Committee on Water Defences
- Taylor, T. (2011) 'Risk and uncertainty', in: *Unexpected Economics*. Chantilly, Teaching Company
- Vrijling, J.K. (2008) Verloren in een zee van mooie plannen (Lost at a sea of plans). *Trouw* 12 September
- Vrijling J.K., W. van Hengel & R.J. Houben (1998) Acceptable risk as a basis for design. *Reliability Engineering and System Safety* 59 (1), pp 141-150
- V&W (1998) *Vierde Nota waterhuishouding - Regeringsbeslissing* (Government's decision on the fourth water plan). Den Haag, Ministerie van Verkeer en Waterstaat
- V&W (2006) *Planologische Kernbeslissing Ruimte voor de Rivier deel 4 (Key planning decision Room for the River part 4)*, Den Haag: Ministerie van Verkeer en Waterstaat
- Waterforum (2013) Discussieforum dossier meerlaagsveiligheid (Discussion forum multi-layered safety). *Dossier Meerlaagsveiligheid*. Retrieved from: www.waterforum.net/dossier/meerlaagsveiligheid
- Waterman, R.E. (2008) *Integrated coastal policy via building with nature* (2nd edition), Den Haag, Ronald Waterman/Building With Nature
- Wit, S. de, R. Jongejan & H. van der Most (2010) 'Niet bij preventie alleen - simulatie en analyse van een debat tussen voor- en tegenstanders van meerlaagsveiligheid' (More than just prevention - simulation and analysis of a debate between supporters and opponents of multi-layered safety), in: *Kijk op waterveiligheid*. Delft, Eburon, pp 74-96