



Experiment / pilot / Implementatie / in gebruik

> Delta scenarios and Adaptive Delta Management

IDEE/VERKENNING



PROOF OF CONCEPT



EXPERIMENT/PILOT



IMPLEMENTATIE/IN GEBRUIK

INHOUD

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INTRODUCTION

Adaptive Delta Management is a term coined by the Delta Programme for 'addressing uncertainties in a transparent way'. While it is recognised that there are significant uncertainties about the rate and extent of climate change and socio-economic developments, there is also an urgent need to make decisions about (small or large scale) infrastructure investments. Achieving this objective, however, requires an approach that takes into account different investments from the perspective of the uncertainties, but is flexible enough to adapt the strategy to unexpected challenges and opportunities in the future.

This dilemma about long-term uncertainties versus making urgent decisions also plagues the water boards. They have much to contend with - climate change, urbanisation, changes in agriculture and the natural environment, as well as governance, scaling up of water boards, regional cooperation, privatisation of purification plants, and the recovery of energy and commodities from purification. Although these developments will take time to materialise, the time is now ripe to prioritise the decisions that need to be made.

This fact sheet covers Adaptive Delta Management and the Delta Scenarios, explaining how they can be used in the strategic decisions of the water board, as well as applications in practice and knowledge gaps.

RELATED TOPICS AND DELTA FACTS

Keywords: Adaptive Delta Management, Scenarios, Adaptation pathways, Uncertainties

Delta Facts: **Robustness**, **Effects of climate change on agriculture**, **Effects of climate change on nature**.

SCHEMATIC

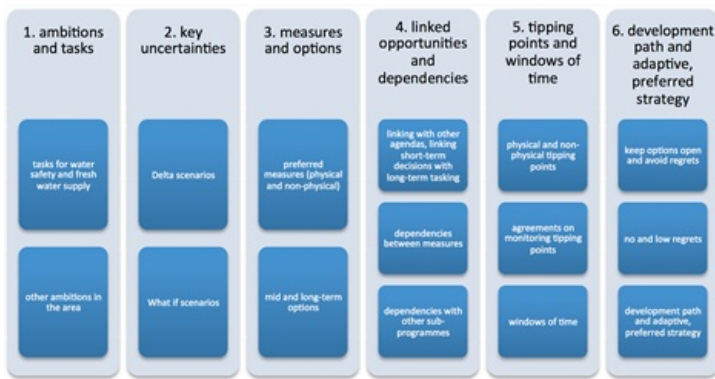


Figure 1 Components of Adaptive Delta Management within the Delta Programme (Morselt, 2013).

(TECHNICAL) SPECIFICATIONS

What is Adaptive Delta Management?

Adaptive Delta Management (ADM) is an approach (still in development) that seeks to develop common-sense measures to deal with uncertainties by linking short-term decisions with options for adaptation in the future (Delta Programme, 2014). Adaptive Delta Management involves making investment decisions that take into account the large uncertainties in future developments (Bloemen, 2012).

Key points of ADM (Delta Programme, 2013):

1. Linking short-term decisions with long-term tasking
2. Incorporating flexibility in possible solution strategies
3. Working with multiple strategies that can be applied alternately depending on developments
4. Linking different investment agendas.

Thus, Adaptive Delta Management differs from the 'classical' approach where a robust solution is often chosen based on business-as-usual and worst-case scenarios.

The first key point – linking short-term decisions with long-term tasking - is important for two reasons; the approach helps to better anticipate events so that future measures can be accomplished in a simpler or more cost-effective manner, and it helps to prevent certain adaption measures from becoming obsolete in the future in case a pathway has been chosen that makes certain solution strategies impossible.

This also explains the importance of the second key point, which boils down to maintaining flexibility in solutions in order to respond to climatic and social changes, and to use new knowledge as it becomes available. Flexibility, be it in terms of implementing measures in the immediate term or somewhere down the line, or be it other measures, can prevent the risk of making over or underinvestments. An overinvestment in this context, for example, is dike elevation while climate change does not pose an imminent threat. An underinvestment, on the other hand, is failure to invest in elevating a dike to adequately protect against a growing flood threat arising from climate change.

The third key point suggests that different strategies are developed and when combined, cover the wide range of plausible future situations. Adaptive Delta Management is characterised by the ability to alternate between strategies as required by current developments. To explore this flexibility, so-called adaptation pathway cards are used. Adaptation pathways show the measures that may be successively implemented. The different adaptation pathways are incorporated into a diagram, illustrating the transition options, i.e. the circumstances under which a transition can be made from one pathway to another (see Figure 2). The transition options indicate the time at which a decision may be made about the choice of measures to be implemented. They also show which strategies are flexible and which are not.

The fourth key point is the linking of investment agendas of other local authorities or private parties for the purpose of sharing costs, reducing impediments, or creating added value. This means that ambitions in areas other than water management, such as agriculture, nature, shipping and recreation must be taken into account during planning, choosing locations, designing phase and the assessment of the investment needs. This too requires flexibility.

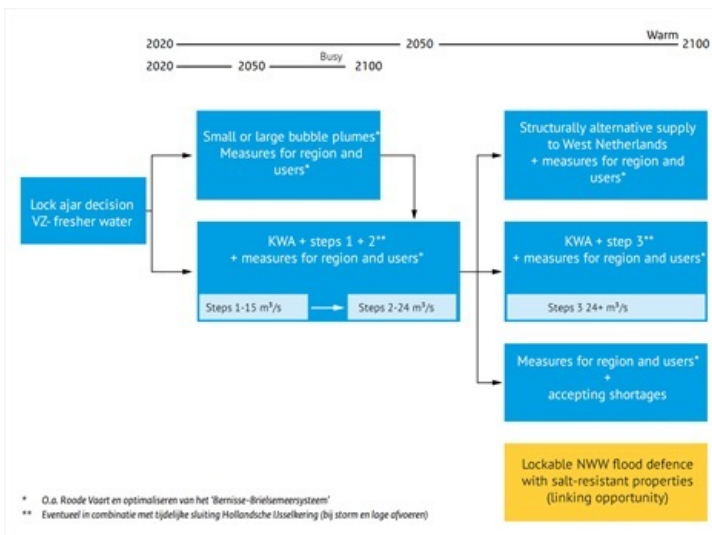


Figure 2. Adaptation pathways for the sub-programme fresh water supply (Delta Programme, 2014).

The Delta Scenarios

The Delta Scenarios explore four different types of future situations, which can be used to determine where and when alternative (water) measures will be required in the future. The four Delta Scenarios are called: *Steam*, *Busy*, *Warm* and *Rest*. The scenarios are based on two factors of significant impact on water issues, which are simultaneously highly uncertain and beyond the direct control of water managers, i.e. climate change and socio-economic development (see Figure 3). It should be noted that the Delta Scenarios are neither predictions nor target scenarios. Rather, they are context scenarios that show how climatic and socio-economic context may change for water management by 2050 and 2100. They describe a modest, plausible bandwidth of possible, autonomous developments. It is therefore possible that the next century will see developments that fall outside this bandwidth. The Delta Scenarios can be used to identify future water-related issues, assess measures and trigger more insights to inspire new strategies. They are part of the Adaptive Delta Management cycle.

The scenarios provide qualitative and quantitative information on the climate, water systems, and water and land use. The qualitative information consists of storylines and maps, which describe the backgrounds and identify the links among them. The quantitative information is presented as figures, covering time series for temperature, precipitation, river discharges and geospatial land use databases, land subsidence and salinisation in the Netherlands. The databases are specifically designed for use in quantitative modelling tools for long-term policy decisions (Delta model) and the Netherlands Hydrological modelling Instrument (NHT).



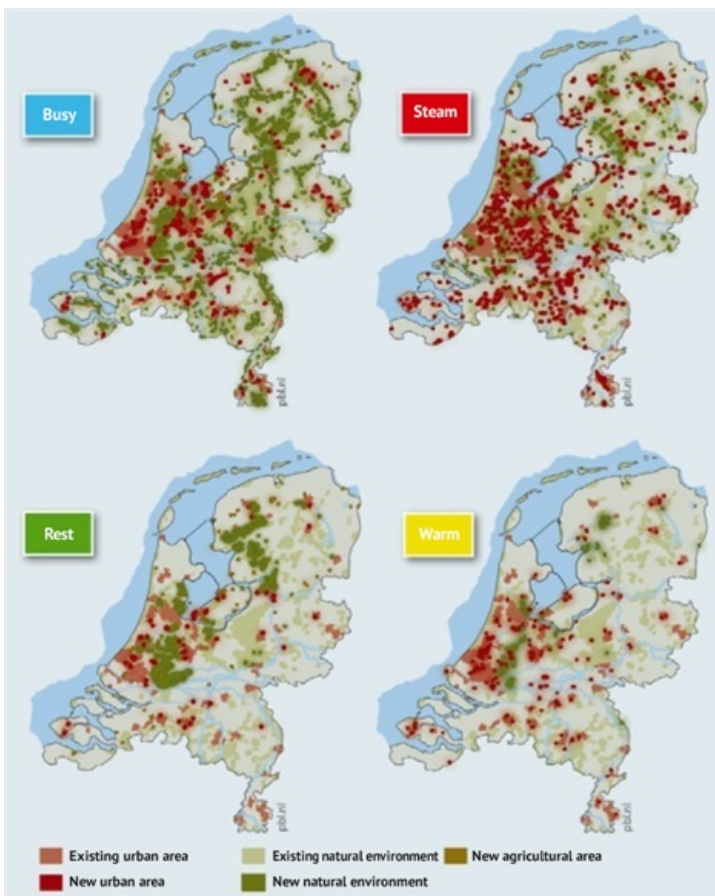


Figure 3. Changing land use in the four Delta Scenarios, publication year 2100

The Delta Scenario study, conducted by Deltares, the Netherlands Environmental Assessment Agency [Planbureau voor de Leefomgeving (PBL)], KNMI, LEI Wageningen UR and the Netherlands Bureau for Economic Policy Analysis [Centraal Planbureau (CPB)], was commissioned by the Ministry of Infrastructure and the Environment (Bruggeman, Dammers et al., 2013).

The KNMI'06 scenarios are used as basis for the hydrological conditions. The bandwidth for climate change is also in line with recent findings by the IPCC. The possible impact of socio-economic developments on land use, water and space until 2050 is derived from the Welfare, Prosperity and Quality of the Living Environment [Welvaart en leefomgeving (WLO)] study from 2006. The WLO scenarios are prepared by the Netherlands Environmental Assessment Agency and the Netherlands Bureau for Economic Policy Analysis. The low and high economic growth bandwidth chosen at that time can still be used to project long-term future developments until 2050. A description is provided for the second half of the 21st century using the growth and shrinkage scenarios. The Delta Scenarios are part of the Adaptive Delta Management cycle.

Adaptive Delta Management cycle

Adaptive Delta Management is a cyclical process consisting of six iterative stages (which largely coincide with the policy cycle) (see Figure 4). Each stage offers the possibility to adjust elements of the strategy, thereby creating an adaptive capacity (adaptability). This capacity is necessary because we are dealing with uncertainties - we don't know which scenario will unfold - and so we don't know which investments (when do which measures have to be taken?) are the right ones. But one thing is for certain: decisions need to be made. The different stages are described below. The components in Figure 1 will be developed in stages 1 to 3.

The first stage of Adaptive Delta Management involves conducting a problem analysis: where and when will problems occur in the different scenarios. A problem occurs when policy objectives, such as safety, flooding, water quality or water level standards, are no longer met. This is called a tipping point (Kwadijk et al., 2010). It provides insight into the nature, extent and time scales of the problems occurring in the different scenarios.

The second stage involves exploring possible adaptation pathways, which is often done using the method developed by Haasnoot et al. (2012, 2013). Adaptation pathways consist of possible series of measures that provide a solution to the problem. It is important to estimate the duration of the solution - i.e. how long the measure will remain effective - which by and large is determined by the rate of climate change. It is also important to know whether and, if so, which other measures are subsequently possible. Preparing different pathways makes it possible to explore what adaptation options are available.

In the third stage, an evaluation is made of different adaptation pathways. This evaluation is not about choosing the most optimal pathway, but rather about determining which measures need to be taken now and which measures should be deferred. In other words, what needs to be decided now and what does not. The objective is to pursue a robust policy (see also the fact sheet on robustness). A robust policy ensures that the desired policy results can be achieved under very different circumstances (Mens et al., 2012). Flexibility is an important tool for achieving a robust policy. Having the option to adapt or implement measures as and when required provides the flexibility to respond to changes and still achieve the intended results. Flexibility is therefore a key term in the evaluation of adaptation pathways. The transition points on the

adaptation pathway card show the circumstances under which it would be possible to move from measure to another.

The fourth stage is policy formulation. The previous stages can be used as the basis for formulating the adaptation plan on which a decision can be made. The measures from the adaptation plan, including the triggers for modifying the measures, are central to the decision-making process. Incidentally, a decision can also be made to rule out certain options.

The fifth stage involves implementation of the policy. Short-term measures, including the measures necessary to keep options open in order to maintain flexibility over the long term, are implemented at this stage.

In the sixth stage, a monitoring system is set up, which allows for tracking climatic and social developments relevant to adapting the strategy or expediting or delaying implementation of the measures. If, for example, climate change occurs at a faster rate than expected and the tipping point is reached earlier, then the measure will also be implemented earlier than projected. If it evolves more slowly, however, then the measure can be delayed. Socio-economic developments can also be monitored. Sometimes these are less tangible trends, such as privatisation, upscaling, decentralisation or internationalisation. Thus, besides monitoring, it will also be necessary to set up a system or platform where the rate and direction are indicated in relation to what this means for (adjusting) the policy. Policy adjustment requires adaptability, or adaptive capacity, of the organisations involved. Adopting participatory forms of monitoring (Ellen et al., 2013) gives parties a better understanding of why policy should be adjusted.

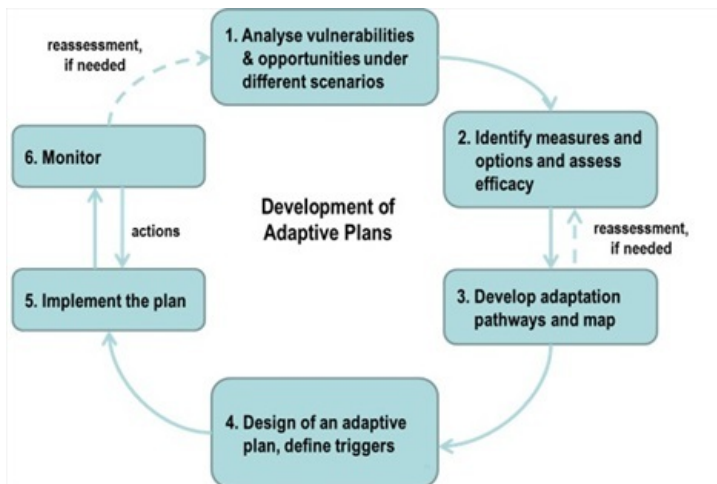


Figure 4. Adaptive Delta Management cycle

COSTS AND BENEFITS

It is still not possible to specify the extent to which Adaptive Delta Management will lead to cost reductions. Solutions to a number of shortcomings in the current cost-benefit analysis methods are however being sought within Adaptive Delta Management. These shortcomings could lead to suboptimal investment decisions based on the lack of full identification and valuation of uncertainties in social cost-benefit analyses (SCBAs) (Morselt and Gersonius, 2011). The added value of flexibility is still rarely valorised. Currently, research is being undertaken by Morselt, Reitsma and Van Rhee and Van Aalst et al. (in preparation), and others, into methods for valuing economic flexibility. One of the methods that is receiving much attention is the **real options method**. Unlike conventional SCBAs, the **real options analysis** does not rely on average values, but on bandwidths. The method can include uncertainties by including delay or adjustment options, where the conventional cost-benefit analysis cannot. This could eventually lead to better investment choices. The drawback of this method is that the likelihood of different scenarios needs to be assessed in advance (thereby partly ignoring the inherent uncertainty that creates the need for flexibility). Moreover, the method requires relatively detailed information and is too complex to explain to decision-makers.

In the Rijnmond-Drechtsteden sub-programme, a software tool (Blokkendoos DPRD [box of building blocks]) has been developed for calculating each year's costs and expected losses. It can also be used to calculate the present value of different adaptation pathways in different delta scenarios to obtain the best possible comparison.

FIELD EXPERIENCE IN THE DELTA PROGRAMME AND WITH THE WATER BOARDS

The Delta Scenarios and Adaptive Delta Management are used in the Delta Programme. Water boards have shared experience in conducting strategic explorations in preparation for the Water Management Plan 2016-2021. A number of examples are listed below.

Delta Programme

In 2012, the Delta Scenarios were used in the nine sub-programmes of the Delta Programme to explore the water safety and fresh water supply issues that are projected to occur in the future. These have led to the development of strategies. Insights from Adaptive Delta Management have been used in the Rijnmond-Drechtsteden, Southwest Delta, Rivers, Coast, Wadden, IJsselmeer and Fresh Water sub-programmes. While each sub-programme has different objectives, they share multiple strategies and underlying adaptation pathways. The options that need to be kept open and how this can be done were also examined (<http://www.rijksoverheid.nl/onderwerpen/deltaprogramma>).

Adaptive Delta Management handbook

Stratelligence has compiled a handbook based on existing material provided by the Delta Commissioner's staff, the results of application of Adaptive Delta Management in the development of the possible strategies of a number of sub-programmes (including Southwest Delta and the IJsselmeer area), the results of the Adaptive Delta Management work sessions for the Rijnmond-Drechtsteden sub-programme, and the contributions and input from the advisory group.

Adaptive Delta Management pilot

In 2011/12, the Rijnmond/Drechtsteden Delta Programme explored how the term Adaptive Delta Management should be employed, thereby qualitatively determining the tipping points of the current policy and developing interrelated packages of measures (strategies) in the various Delta Scenarios. The strategies were then subjected to a stress test to locate the vulnerabilities and determine how they can be anticipated in the short term. The steps are completed in two half-day workshops with field experts, designers and strategists.

Delfland

In preparation for a new Water Management Programme for the 2016-2021 period, the Delfland Water Board explored possible future situations based on the Delta Scenarios and what this might mean for Delfland's policy. The aim of this strategic exploration was to identify long-term administrative issues for early-stage discussions with external partners. Elements of Adaptive Delta Management were used to develop strategies. The project served as the starting point for dialogue with Delfland's partners in the region in the spring of 2013. In this study, governance proved to be an important topic, particularly in respect of aligning responsibilities and cooperation with government partners and private parties in response to the changing expectations from society.

Strategic positioning of Aa en Maas

In preparation for the new Water Management Plan (2016-2021), the Aa en Maas water board explored possible future situations and what these might mean for future policy directions. The aim of the strategic positioning is to identify long-term administrative issues for early-stage discussions with administrative departments within the water board as well as with partners. This process has shed light on a number of different administrative dilemmas, such as administrative legitimacy, citizen engagement, scale, internal efficiency, cooperation and funding, all of which have been assessed in the light of regionally specified Delta Scenarios. Governance proved to be an important theme here as well.

CURRENTLY ACTIVE RESEARCH

National - Network Adaptive Delta Management

Various establishments, including TU Delft, WUR, Alterra, Utrecht University, Deltares and the Ministry of Infrastructure and the Environment have joined forces in the knowledge network, Adaptive Delta Management. Network meetings are held every three months for sharing new research, among other things. A number of research results were published in 2014 in a special issue of the scientific Journal of Water and Climate. The research themes featured in the journal include:

- Marcela Riquelme Solar, Erik van Slobbe, S.E. Werners: Inland Waterway Transport in the Rhine River Basin: Searching for Adaptation Turning Points
- Maarten van de Vlist, Saskia Ligthart: Replacement of hydraulic structures in the Dutch national water system; an adaptive approach
- Ad Jeuken, Marjolijn Haasnoot, Tim Reeder, Philip Ward: Lessons learnt from adaptation planning in deltas and coastal cities
- Farhana Ahmed, Berry Gersonius, William Veerbeek, M. Shah Alam Khan, Flip Wester: Role of Historical Tipping Points in Flood Risk Management of Dhaka
- Nadia Koukoui, Berry Gersonius, Paul P. Schot, Chris Zevenbergen, Ellen Kelder : Adaptation Tipping Points for the Management of Urban Flood Risk - Case Study in Dordrecht, the Netherlands
- Art Dewulf, Katrien Termeer: The governance implications of Adaptive Delta Management
- Astrid Offermans, Valkering: Towards socially robust water management strategies; the role of perspective dependent acceptability thresholds
- Rutger van der Brugge, Ronald Roosjen: Institutional and sociocultural analysis of Adaptation pathways

International

BASE (Bottom-up climate Adaptation Strategies towards a Sustainable Europe) is a project within the EU 7th Framework Programme, which researches sustainable bottom-up and top-down climate adaptation strategies. Within BASE, various local case studies are analysed or evaluated to obtain insight into local climate adaptation strategies and options. One of the cases in the Netherlands is Rijnmond-Drechtsteden. An attempt is also made to quantify the costs and benefits of adaptation pathways. The project started in late 2012 and is set to continue until 2016.

RISES (Responses to coastal climate change: Innovative Strategies for high End Scenarios) is also part of the EU 7th Framework Programme. The research focuses on the (economic) impact of climate change on coastal zones and the development of adaptation measures. The focus is on the benefits of flexible management methods, whereby the tipping points of adaptation pathways are identified and quantified.

KNOWLEDGE GAPS

Adaptive Delta Management is still in development with many knowledge gaps to overcome. To date, knowledge development has largely taken place within the Delta Programme, predominantly in regard to determining tipping points and identifying measures and adaptation pathways in relation to climate change. With the shift from the problem analysis phase to preferred strategies and decision-making, most of the focus has shifted to the evaluation of adaptation pathways

and governance.

The evaluation has raised questions about how flexibility should be valued and what its costs and benefits are. The methods to be used in the regard are still unclear. The CPB is currently exploring the options at the request of the Replacement Tasking for Hydraulic Structures programme [Vervangingsopgave Natte Kunstwerken (VONK)] and the Delta Programme. Furthermore, attention also needs to be given to the changing institutional and socio-cultural conditions and the extent to which they affect the supposed flexibility of adaptation pathways ([van der Brugge et al., submitted](#)).

As for governance, the crucial question is: how should policy arrangements be organised to enable adaptation? On the one hand, this involves agreements made between the parties about who does what and the conditions under which policy and monitoring should be adapted. On the other hand, it involves ensuring that options are actually kept open if and when required. In addition, there is a knowledge gap in relation to the changing institutional and administrative context in the future. The Delta Scenarios touch on this very briefly.

LITERATUUR/LINKS

- Bruggeman, W., et al., (2013). [Deltascenario's voor 2050 en 2100. Nadere uitwerking 2012-2013](#). Eindrapport, 65 p. Deltares/PBL/KNMI/LEI-WUR/CPB, 2013.
[Delta Scenarios for 2050 and 2100. Further development 2012-2013]
- Bloemen, P. van Alphen, J. (2012) [Adaptief deltamanagement](#). Presentatie
[Adaptive Delta Management. Presentation]
- Deltaprogramma (2014) [Werken aan de Delta. Kansrijke oplossingen voor opgaven en ambities](#).
[Delta Programme (2014) Working on the Delta. Promising solutions for tasking and ambitions]
- Deltaprogramma (2013) [Werk aan de Delta. Maatregelen van nu, voorbereiding voor morgen](#).
[Delta Programme (2013) Working on the Delta. Acting today, preparing for tomorrow]
- Haasnoot, M., Kwakkel, J.H., Walker, W.E., ter Maat, J. (2013) [Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world](#). Global Environmental Change 23, 485-498.
- Haasnoot, M., Middelkoop, H., Offermans, A., Van Beek, E., van Deursen, W.P.A. (2012) [Exploring pathways for sustainable water management in river deltas in a changing environment](#). Climatic Change 115, 795-819.
- Kwadijk, J.C.J., Haasnoot, M., Mulder, J.P.M., Hoogvliet, M.M.C., Jeuken, A.B.M., van der Krogt, R.A.A., van Oostrom, N.G.C., Schelfhout, H.A., van Velzen, E.H., van Waveren, H., de Wit, M.J.M. (2010) [Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands](#). Wiley Interdisciplinary Reviews: Climate Change 1, 729-740.
- Kennisinstituut voor mobiliteitsbeleid (2013) [Stappen naar Adaptieve gebiedsagenda's](#). Ministerie van Infrastructuur en Milieu
[Knowledge Institute for Mobility Policy (2013) Steps to Adaptive regional agendas. Ministry of Infrastructure and the Environment]
- Mens, M. J.P., Kwakkel, J.H., de Jong, A., Thissen, W. A. H., van der Sluijs, J.P. (2012) [Begrippen rondom onzekerheid](#). Rapport Kennis voor Klimaat.
[Uncertainty Terminology. Knowledge for Climate report]
- Morselt, T. (2013) [Adaptief programmeren](#), essay, Blueconomy
[Adaptive programming]
- Morselt T en Gersonius, B., (2011). [Flexibele maatregelen in het waterbeheer zijn economisch aantrekkelijker](#).
[Flexible measures in water management are more attractive economically]
- Te Linde, A., Jeuken, A. (2011) [Werken met knippunten en adaptiepaden](#). Deltares report.
[Working with tipping points and adaptation pathways]
- Ad Jeuken, Teun Morselt, Robert Vos. [Adaptief deltamanagement, Ten behoeve van besluit Voorkeursstrategie DPRD](#). Powerpoint 17 oktober 2013
[Adaptive Delta Management, For the DPRD preferred strategy decision. Powerpoint October 17, 2013]
- Roosjen, R., Van der Brugge, R., Morselt, T, Jeuken, A. (2012) [Adaptief deltamanagement. Pilot voor deelprogramma Rijnmond/Drechtsteden](#). Rapport Deltares en Blueconomy.
[Adaptive Delta Management. Pilot for the Rijnmond/Drechtsteden sub-programme. Deltares and Blueconomy report]
- Reitsma, R., Van Rhee, G. C. [Real Options Analyse: Kansen voor het Ministerie van Verkeer en Rijkswaterstaat](#). Stratelligence Notitie.
[Real Options Analysis: Opportunities for the Ministry of Transport and the Ministry of Infrastructure and the Environment. Stratelligence Note]
- Van Rhee, G. C. [Handreiking Adaptief deltamanagement](#). Stratelligence Rapport.
[Adaptive Delta Management handbook. Stratelligence Report]
- Van Aalst, M. Haasnoot, M. (in preparation). Comparing economic evaluation tools for evaluation adaptation pathways to support decision making under deep uncertainty
- Van der Brugge, R., Roosjen, Morselt, T, Jeuken, A. (2012) [Adaptief deltamanagement](#). Water governance, 2, 35-40.
[Adaptive Delta Management]

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The Delta Fact is in part based on interviews with Ad Jeuken and Marjolein Haasnoot and input from Peter Bloemen, Teun Morselt, Rob Ruijtenberg, Robin Engel, Birgitta van der Wateren.

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