



Adaptive Delta Management

Climate change threatens people living in delta areas all over the world. Climate change, land subsidence, increasing population and economic development increase the risk of floods and droughts. Through Adaptive delta management Deltares supports the assessment of impacts and the development and implementation of adaptation measures. Taking into account the uncertainties surrounding climate change and socio-economic developments, what are preferable and financially accountable investments in your area?

Why Adaptive delta management?

Delta areas require specific attention. Deltas around the world are threatened by sea level rise as well as extreme river discharges due to climate change. Often these areas are densely populated, urbanized areas and economic centres with sophisticated networks of water related infrastructure. Moreover, many deltas are sinking as a result of land subsidence and fresh water is scarce as a result of increased salt intrusion and competing water demands for food, industry and drinking water.

This complexity creates serious challenges for governments and planning- and water management authorities, that need to make decisions about long-term sustainable and climate proof investments. For instance, which of the possible infrastructural investments with regard to flood risk management and fresh water supply should be implemented, when climate change impact and socio-economic changes are uncertain? Is it urgent, or could investments be postponed? And can upcoming investments in urban planning, infrastructural maintenance renovation or replacement be used to reduce flood and drought risks and increase resilience?



The interdependence of the water system and economic system requires an integrated systems approach of the delta. The inherent uncertainties regarding the magnitude and rate of climate change and socio-economic developments require an adaptive approach. The need to invest in expensive water related infrastructure on the short term requires an approach that supports decision making under uncertainty. Adaptive delta management combines these aspects.

Through *Adaptive delta management*, Deltares can help you to assess climate change impacts, develop adaptation measures and calculate the effectiveness, analyse the robustness and flexibility of the adaptation strategy and design water management plans. Deltares and partners are leading the way in the international development of this approach. Though the prime focus is on delta areas, the approach can be applied to other areas than deltas as well.

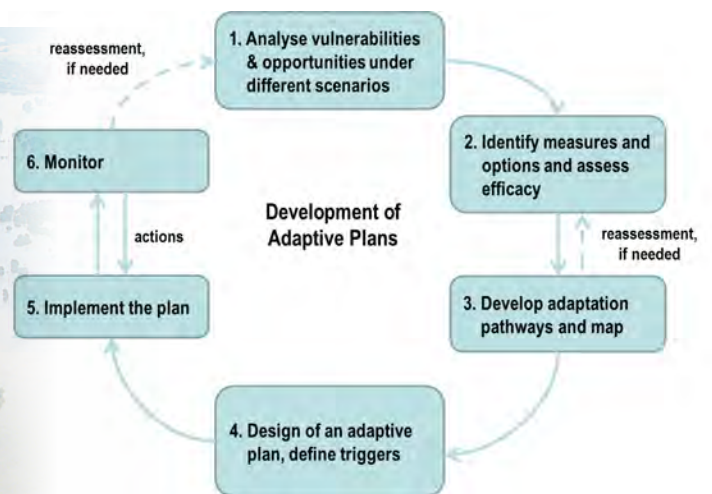
Dealing with uncertainties

Adaptive delta management is an approach to deal with uncertainties in a transparent and sensible way to support decision making with regard to water policy, planning and infrastructural investments. It links current decision making to future choices. It builds further upon years of Integrated Water Resource Management experience in developing and developed countries. Adaptive delta management consists of six steps. For each step, Deltares can contribute knowledge, skills and tools.

- The first step is the problem analysis, which provides insight into the urgency, nature, extent and timing of the occurrence of possible problems under different future developments.
- The second step is the identification of measures that might solve the problem and quantifying the effects.



- The third step is the design of multiple adaptation pathways consisting of the identified measures in step two. These paths show *when* decisions should be made and the possible measures to choose from. The paths generate insight into the consequences of the initial measure in terms of lock-ins and options that are still open. Opportunities arising as a result of other planned investments in the region may be considered to adjust timing of implementation.
- The fourth step is the design of an adaptive plan. This requires evaluation of the different adaptation pathways with regard to the economic and socio-cultural feasibility, governance,



Six basic steps of Adaptive delta management
(adapted from Haasnoot et al, 2013)

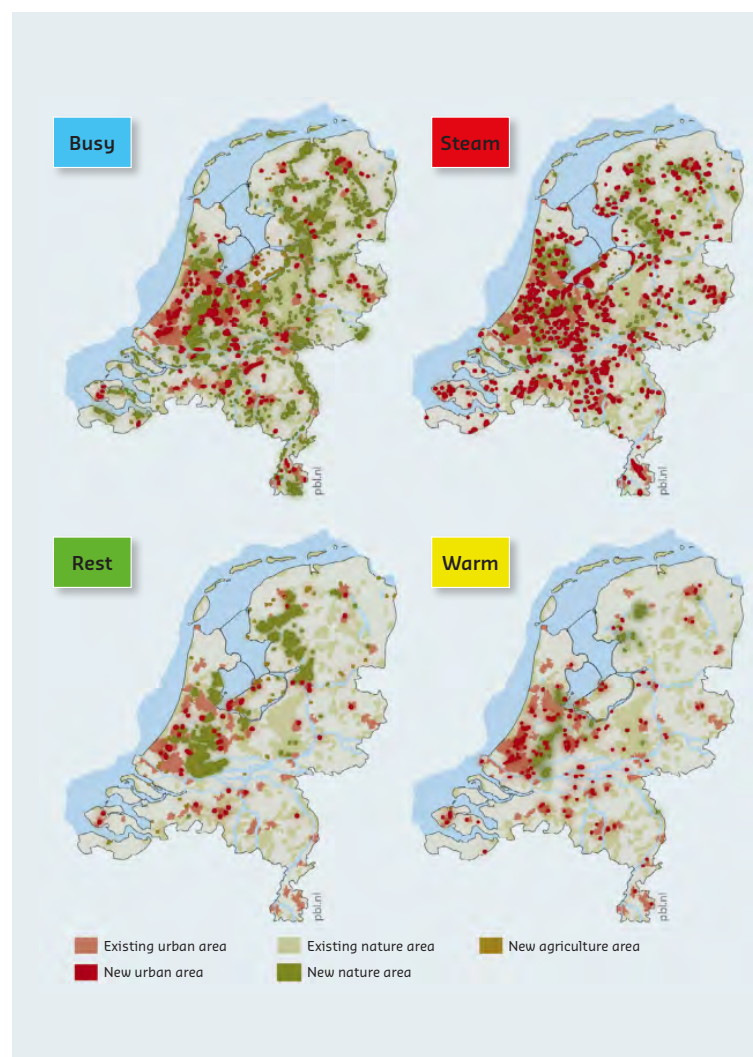
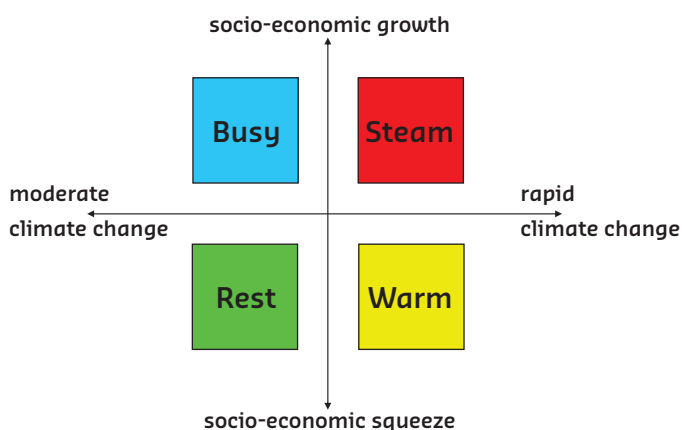
A policy is robust if the desired result can be reached under a variety of circumstances and assumptions. Flexibility in this regard is a key-quality of robust policies and can be understood as the relative ease by which a policy can be adapted to changing circumstances. Hence, flexibility contributes to robust policy in the sense that measures can be adapted, or may be implemented earlier or later than originally planned, while the result the policy aimed for will still be achieved.

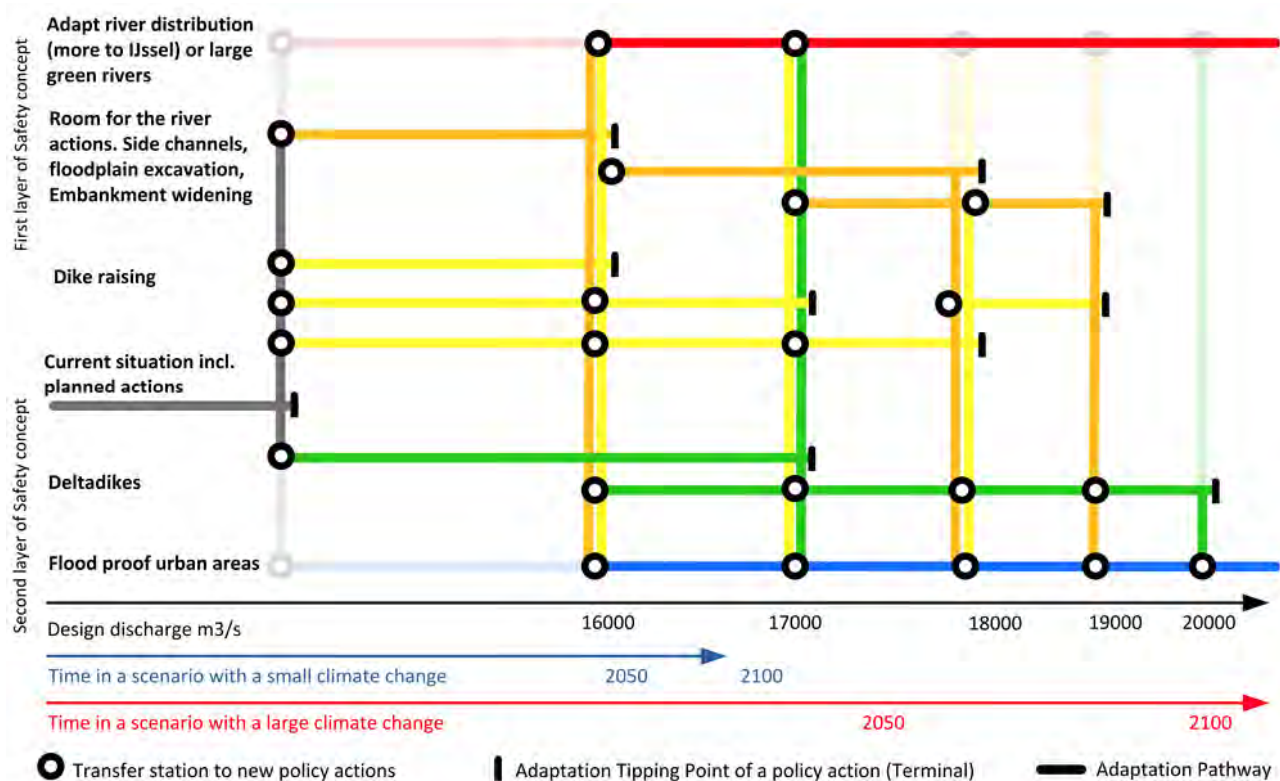
robustness and flexibility of the pathways. The adaptive plan might be considered robust if the desired result can be reached under a variety of circumstances and assumptions. In addition, it is necessary to identify critical values (triggers) beyond which adjustments need to be made.

- Step five is the implementation of the plan. This step is crucial as it requires not only the execution of infrastructural projects, but also the implementation of measures to keep options open that might be needed in the future.
- The sixth step is to stimulate adaptive capacity by setting up a monitoring system of the critical trends and the institutional mechanisms allowing adjustment of the adaptation strategy when needed.

Adaptive delta management is different from classic *policy analysis* in the sense that normally the starting points of the analysis are the (climate change) scenarios of which the impacts are calculated and the potential solutions developed. In contrast, the starting point in the Adaptive delta management analysis is the question: *how long the current water management strategies continue to be effective under different climate change scenarios?* Solutions are based on the analysis of multiple adaptation pathways instead of business-as-usual or worst-case-scenarios.

By building tailored *Scenarios*, Deltares develops *delta-scenarios* combining climate change scenarios and socio-economic scenarios. Qualitative storylines are combined with quantitative data as input for hydrological modelling. Deltares has prepared water scenarios for many regions in the world also on a global scale. We use information from global climate models accessible through the IPCC, or regional scenarios, either from high-resolution regional climate models or obtained through statistical downscaling. Scenarios are translated to a local context with help of experts and local stakeholders.





Example of adaptation pathways for flood risk. (Haasnoot et al 2013b)

Adaptation pathways approach

The basic idea behind *adaptation pathways approach* is to generate a wide array of pathways (consisting of a series of measures) through which policy objectives are achieved under changing climate and socio-economic conditions. Central to the adaptation pathways concept are adaptation tipping points (Kwadijk et al., 2010), which are the conditions under which an action no longer meets the clearly a-priori specified objectives. After reaching a tipping point, additional measures are needed to reach the objectives. In this way different pathways can be designed. Mapping the wide array of possible adaptation pathways provides a portfolio of adaptation options. Usually these pathways are used in the context of policy planning as they provide insights into the options, lock-ins and path dependencies and introduce the flexibility to adapt to a multitude of potential future changes.

Quantitative analysis

Deltares can draw on a variety of models for hydrology, floods, water scarcity, groundwater, subsidence on different scales to provide quantitative analyses of impacts and effects of different measures (needed to establish adaptation tipping points and benefits of measures). The Deltares (open source) software can be applied but also modelling systems provided by the client can be used.



Evaluation

Deltares can offer different tools for *evaluation of measures* under different scenarios

- Cost- benefit analysis – societal costs and benefits.
- Robustness analysis – performance under different scenarios and extreme events.
- Multi criteria analysis – including non-tangible effects by local and experts' panels.
- Implementation analysis – institutional and socio-cultural barriers for implementation.



Monitoring

Monitoring climatic and social developments is needed in order to know when to adjust measures. This includes climatic trends as well as less tangible social trends, such as privatization, scale, decentralization and internationalization. Deltares also has experience with forms of participatory monitoring systems.

Experience

Deltares is involved in various European scientific research projects on scenario development and adaptive delta management (BASE, RISES). Deltares is active worldwide in water related projects (Colombia, Thailand, Bangladesh, Vietnam, Indonesia



and Myanmar. Deltares is the key knowledge partner in the national policy programme on water management in the Netherlands (Delta Programme) in which Adaptive delta management is the leading concept.

Key competences

A specific strength of Deltares is the integration of specific disciplines (including geology, ecology, ground and surface water hydrology, morphology, geo-engineering, economics and policy analysis). In our projects, multidisciplinary teams work together to approach the issue at hand from different disciplinary angles:

- (Eco) Engineering
- Systems analysis
- Scenario and policy analysis
- Economic analysis
- Policy implementation

Major key competences are dealing with the uncertainties regarding climatic and socio-economic changes, quantifying the impacts on the water system from a local to a global level and quantifying the effects of (adaptation) measures and help to implement the solutions.

Clients of Deltares

Our national and international clients include government authorities, policy makers and administrations responsible for operational and strategic water management. In the private sector, our clients are consultants, contractors and insurance companies. Financing agencies such as national development aid agencies, the European Commission¹, the World Bank² and Asian Development Bank are also regular clients. Deltares is the primary advisor to the Dutch Ministry of Transport, Public Works and Water Management.



¹ The European Environment Agency has given considerable attention to the adaptation pathway methodology and green adaptation in their latest report: *Adaptation in Europe*.

² World Bank economists have invited Deltares to share knowledge on *Adaptation Pathways*.

Key publications

Haasnoot, M., J.H. Kwakkel, W.E. Walker, J. ter Maat. (2013). *Dynamic Adaptive Policy Pathways: A Method for Crafting Robust Decisions for a Deeply Uncertain World*. *Global Environment Change* 23 (2) 485-498 DOI: 10.1016/j.gloenvcha.2012.12.006

Haasnoot, M. (2013) *Anticipating change: sustainable water policy pathways for an uncertain future*. Thesis <http://dx.doi.org/10.3990/1.9789036535595>

Jeuken, A., M. Haasnoot, T. Reeder and P. Ward (2013), *Lessons learnt from adaptation planning in four deltas and coastal cities* *Int. Journal of Water and Climate* (In review)

Kwadijk, J.C.J., M. Haasnoot, J.P.M. Mulder, M. Hoogvliet, A. Jeuken, R. van der Krogt, N.G.C. van Oostrom, H.A. Schelfhout, E.H. van Velzen, H. van Waveren, M.J.M. de Wit. (2010). *Using adaptation tipping points to prepare for climate change and sea level rise: a case study in the Netherlands*. *Interdisciplinary reviews: Climate Change*. <http://onlinelibrary.wiley.com/doi/10.1002/wcc.64/abstract>

Deltascenarios for 2050 and 2100 (2013, in Dutch), Deltares, KNMI, PBL, CPB and LEI April 2013, available at <https://deltaprogramma.pleio.nl/file/view/20469432/deltascenarios-eindrapport-2012-2013>

Mens, M. J. P., Klijn, F., de Bruijn, K. M., & van Beek, E. 2011 *The meaning of system robustness for flood risk management*. *Environmental Science & Policy*, 14(8), 1121-1131.

Eijgenraam, C., J. Kind, C. Bak, R. Brekelmans, D. den Hertog, M. Duits, K. Roos, P. Vermeer and W. Kuijken, 2014. *Economically Efficient Standards to Protect the Netherlands Against Flooding*. *Interfaces* 44(1);7-21. <http://pubsonline.informs.org/doi/abs/10.1287/inte.2013.0721>

Van der Brugge, R., Roosjen, R (2014) *Institutional and socio-cultural analysis of adaptation pathways*. *Int. Journal of Water & Climate* (In review)

Related capabilities of Deltares

- Disaster risk reduction
- Integrated Water Resources Management
- Green Adaptation Scenario & Strategic studies
- Sinking Cities
- Asset management

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