The Climate Proofness of "the Netherlands Water Country"

"Tipping points" in water policy and management

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Cause for concern

Studies into the effects of climate change usually take climate scenarios as their starting point. In this Deltares/Rijkswaterstaat study we started at the opposite end of the effect chain and examined whether, and for how long, current water management will continue to be effective. This has shown, for instance, that climate change and the rise in sea level are more likely to cause a threat to the freshwater provision in the West of the Netherlands than to cause a threat from flooding. Also, environmental management that aims at maintaining certain species is not feasible in a changing climate. These are a few of the results thrown up by the research by Deltares into the consequences of climate change for Dutch water management. The results have been used by the Delta Commission, which in the Netherlands launched an advise to the national government about how to cope rising sealevel and climate change for the next 100 years.

Introduction

Adaptation of the water system to a changing climate is the primary focus of low-lying Deltas like the Netherlands. Even with the most far-reaching restriction on the worldwide production of greenhouse gasses, the climate will change in the course of the coming century and the sea level will continue to rise. The biggest direct effects, e.g. likely increase of winter precipitation and likely increase of the summer precipitation-deficit and temperature, on the Netherlands will have consequences for the water system. This realisation has directed attention to the development of measures in the water system in order to control the changes.

We must adapt our water system but the question is how and when. The approach up until now for the development of adaptations, alternative strategies, was to develop one or more possible climate scenarios and then use these to calculate their effects. Designs were made for the purpose of water management strategies based on, for example, hydraulic conditions.

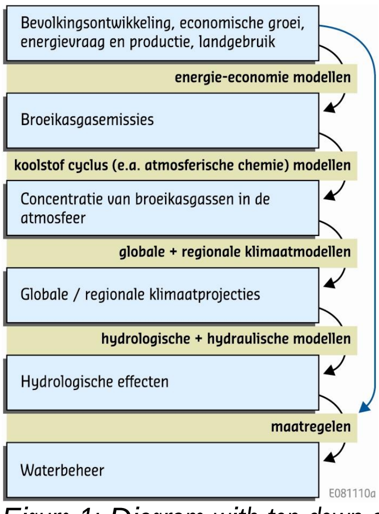

Figure 1: Diagram with top-down approach.

However the scope, speed and even the direction of climate change are surrounded by uncertainties. The additional disadvantage of this traditional approach is that as soon as there are new insights into changing climate, the conditions change and with that the starting points for the strategy previously designed. Examples of such a change in insight are the differences between the first generation climate scenarios used in the Netherlands, the so called WB21 Low, Medium and High scenarios and the Royal Dutch Meteorological Institute (KNMI) G, G+, W and W+ scenarios published in 2006. The first generation could be characterised as wet, wetter and wettest, whilst the current generation shows a more diverse picture of the uncertainty in future developments. The scenarios include combinations of very diverse wetter and dryer conditions. Therefore the KNMI '06-W scenario leads to wetter conditions in the winter and much drier conditions in the summer. However despite a drying out in the summer, the infrequent extreme rainfall in the summer will increase in scope according to the KNMI'06-W scenario. In 2012 the KNMI will produce new scenarios that will probably be a further readjustment of the earlier scenarios. Robust design is very difficult using the traditional approach because of such uncertainties.

Approach using tipping point analysis

In a joint project the Ministry of Waterways and Public Works and Deltares have used an alternative approach. The research has been focussed on the issue to what extent the climate can change before the current water management and water policy are no longer adequate. This can be considered as a sensitivity analysis of the water system.

Therefore we asked ourselves questions such as how much the sea level could rise before the Maeslant Barrier (*Maeslantkering*) is no longer adequate. We interpret this rise in sea level as a so-called tipping point for management. A tipping point is only dependent on the magnitude of the change and not on time. Thus the results are independent of the acceptable climate scenarios at that time.

Additional explanation of the term tipping point

We use the following definition for this term: A tipping point is a point in time when the current policy is revised. Tipping points can have social causes or be the consequence of natural developments. The following types can be differentiated:

- The maintenance of the management strategy is up to its physical, spatial and technical limits;
- The maintenance of the management strategy is considered too expensive;
- The maintenance of the management strategy is coupled with socially unacceptable interventions;
- The maintenance of the management strategy is up to (international) organisational-management limits (this type of tipping point is not investigated here); or lastly (somewhat variably)
- An occurrence where large social pressure will arise which will cause a rethink in policy (this in itself is not a tipping point but can hasten a tipping point)

The timing aspect will be introduced through taking existing scenarios in order to establish the earliest or latest point that a similar sea level rise can be expected. Therefore, the KNMI scenarios, the so-called high-end scenarios which the Delta Commission made use of, are the starting point.

This approach gives insight into which sections (themes) of water management will be affected first through climate change and above all in which part of the Netherlands. This gives a picture of which effects of climate change need measures most urgently and which less. When applied to questions of spatial planning, the method's starting point is not climate scenarios; it begins by establishing under which physical conditions the intended layout of an area is manageable. In other words, how much does the climate have to change before we have a problem. Therefore the climate scenarios are taken in order to research when the conditions have changed so much that adjustment is essential.

In fact we interpret the range in the scale of climate change as the range between the earliest or latest point in time when preparation/implementation of an alternative strategy must begin.

The tipping points were calculated by researching the main water system for the sensitivity of safety against flooding, water provision and the aquatic ecosystem to a change in climate parameters. Modelling results have been used and the literature has been consulted for this purpose.

Examples of the methodology and results

Sand nourishment and dike reinforcement are not a technical problem
If the current management of sand nourishment for coastal protection are continued, no tipping point will be reached for the foreseeable future. There is sufficient sand available in the North Sea, the costs are not too high and the nourishment is socially acceptable. However there are points of concern: there are also other functions concerning the North Sea (for example, the environment, windmills) that make use of the sand, and there are areas, such as the eastern part of the Wadden Islands where sand nourishment is not the right solution for rising sea levels. Alternative strategies such as islands off the coast or the building of different kinds of hard constructions instead of sand are unnecessary from a safety perspective. Other possible arguments for the construction of islands off the coast (space, innovation, export) are not included in this study.

We could continue to strengthen dikes; from a technical perspective there would be no tipping point in the long term. However there are also other factors that dictate the appearance of tipping points: the point at which the space for dike reinforcement is too restricted, the costs become too high or the landscape is affected by it to an unacceptable level. These tipping points will be reached first where all these factors occur at the same time and where the sub soil is weak and susceptible to subsidence; this is the case in the Rotterdam-Gouda region, as well as elsewhere.

Several tipping points for the rivers Rhine and Meuse between now and 2200
The tipping points for the rivers are the moments in time where there are higher design discharges than the dikes were designed to cope with (i.e. higher than the standard probability of 1/1250 per year). For the Rhine and Meuse the design discharges are now respectively 16,000 m^3/s and 4,000 m^3/s. The probability of reaching these discharges is increased by climate change. As soon as the probability of this becomes greater than 1/1,250 per year, new (higher) design discharges will be established. At this point a tipping point will be reached and additional measures will become necessary. Measures for higher design discharges from the Rhine and Meuse of respectively 18,000m^3/s and 4,600 m^3/s have been anticipated upon in current plans. Exceeding these discharges also results in a tipping point. All of these tipping points will eventually be reached, because of climate change. As a result, the level of design discharge of 3,800 m^3/s for the Meuse established in 2001 was increased in 2006 to 4,000 m^3/s after the high river discharges of 2002 and 2003 were included in the statistics.

For the Rhine a design discharge of 18,000 m^3/s could be reached at the earliest between 2040 and 2045. However here it must also be explained that because the dikes in the Lower Rhine in Germany are relatively low, the discharge at Lobith, also with climate change, cannot be higher than 17,500 m³/s. The situation could change if the Germans adapt their dikes more than presently anticipated, for example as a reaction to a large scale flood (a social tipping point). However the chance that a similar social tipping point appears before a physical discharge tipping point is reached is small.

For the Meuse the tipping points with critical values for design discharges will be reached at the earliest (thus by the most extreme climate scenarios) between 2050 (4,200 m³/s) and 2100 (4,600 m³/s). However these tipping points could be much further in the future, even up to two centuries away for the discharge of 4,600 m³/s.

Replacement of the Maeslant Barrier will be needed at the earliest between 2050 and 2060
The Maeslant Barrier, the storm surge barrier that protects the harbor of Rotterdam, is essential in the protection of the tidal river area against flooding. The barrier has been designed for a sea level rise of maximum 50 cm. In the most extreme climate scenario this will be reached in approximately 2060. Up until this time a rising sea level will be able to be dealt with by the current safety standards by closing the barrier more often. Closing the Maeslant Barrier more often is recognised as a tipping point, because the barrier was designed for a closing frequency of once in 10 years. With a sea level rise of 50 cm the estimated closing frequency will be approximately once in three years. More frequent closing means that the barrier loses its function, because the entrance to the harbour will be seriously obstructed. With a sea level rise of 85 cm the frequency will increase to once or twice a year, and with a rise of 1.5 m it would have to be closed roughly 30 times a year if there are no additional measures taken in the tidal river area.

Lake Ijssel will be able to drain for the first half of this century using gravity
The sea level rise that would mean that it is no longer possible to drain using gravity can be considered as a tipping point. Thanks to the anticipated increase in the locks' capacity in the 'Afsluit' Dike (*Afsluitdijk*) this will be reached by a sea level rise of 35 cm. In the most extreme scenarios this tipping point for Lake Ijssel will not be reached in the first half of this century. Thereafter with a sea level rise of 1.5 m, the level in Lake Ijssel can also rise but this has consequences for safety and the environment. Thus, unless further measures are taken, shallows that are very important for many species will be flooded and dike reinforcement will be necessary. With a sea level rise of 1.3 m and a Rhine discharge of 18,000 m³/s at Lobith, the water level at the mouth of the Ijssel at Kampen can increase by 0.6 m.

The water provision in the South West of the Netherlands will become problematic before 2050
The tidal river area is crucial for the freshwater provision (drinking water and agriculture) in the South West of the Netherlands. A rising sea level and reducing river discharge in dry summers is leading to extra salinization of the ground and surface water. A tipping point in this area will occur if the sea level rise in combination with lower river drainage means that the normal salt levels for key functions can no longer be maintained.

The normal salt levels appear to be exceeded with a sea level rise of 35 cm. According to current KNMI'06 scenarios this will happen at the earliest in approximately 2040 (and at the latest in approximately 2100) at the inlet points on the New Meuse, the Old Meuse (up as far as the Spui) and the Dutch Ijssel (*Hollandsche Ijssel*). Alternative strategies must therefore be operational at the earliest in 30 years.

First tipping point in biodiversity and nature conservation already reached

Current biodiversity and nature conservation management is aimed at the maintaining of existing species. There is a high probability that the change in conditions caused by climate change will result in policy goals not being reached and therefore a tipping point will be reached. Other effects of human intervention also appear to be as important for habitats and ecosystems, as the results of climate change. The fact that some tipping points have already been passed is not because of climate change but through the influence of man such as emissions, rigid water level management, drainage, and physical boundaries in the landscape.

For Lake Ijssel and Lake Marker the water level management is the most critical factor: for the natural environment a tipping point will be reached when the water level rise in the spring and the summer leads to the flooding of shallow habitats. Regarding the concentration of algae, a tipping point has already been reached: in the current and future circumstances with climate change the environmental goals for algae concentration will not be reached. A reduction of 25 to 50% in the silt content marks, above all in combination with a reduction of the nitrogen load, a positive tipping point for the water quality. Depending on the type of animal, a tipping point for the water temperature is reached between 20º and 26ºC.

For the coast a tipping point will be reached when flats, silt beds and salt marshes can no longer grow with the rise in the sea level and are swamped. This tipping point is not reached by all morphological units at the same rise in sea level; for flats this can occur with a 3-10 mm rise in the sea level per year whilst salt marshes can tolerate a rise of 10-13 mm per year. The sea level rise according to the current KNMI'06 scenarios (30-85 cm this century) is critical; if there is an even faster rise a tipping point will definitely be reached for the flats, silt beds and salt marshes.

After the tipping points have been defined, what is the following step?

The results of this study have been used, among others, by the Delta Commission in order to establish the urgency of the various consequences of climate change. The next stage is to set up alternative strategies that could be used after the current management and policy is no longer feasible.

There are various possible strategies to cope with the expected changes. With respect to water safety the Veerman Commission has chosen over-dimensioning as a strategy. This is a robust strategy that is appropriate for major uncertainties. They have assumed the most unfavourable situation imaginable in terms of a sea level rise and on the basis of this have formulated a series of measures. In addition the Commission has ordered the Lake Ijssel area to prepare for a maximum rise of 150 cm. This is to make the water provision in the lower Netherlands safe and to regulate the level management by means of sluices to the Wadden Sea. Given the robustness of this measure the Committee appears to see also the water provision as a safety problem.

Over-dimensioning as a solution strategy in order to deal with uncertainty in the climate has the disadvantage that it could lead to large expenditure that ultimately turns out not to have been necessary. Given the risk of flooding this disadvantage is less serious. In the event that the sea level rises less, the measures would lead to a reduced probability of flooding. This is also advantageous even without climate change because the economic growth could be reduced by the results of flooding. In addition there is a trend in society whereby fewer and fewer risks are accepted. Over-dimensioning is the answer to this trend.

Have we dealt with the Delta Commission's recommendations?

Because of the chance of high, possibly ultimately unnecessary expenditure, over-dimensioning based on the worst possible scenarios is generally unacceptable for other sectors. Therefore alternative water management strategies are being inventoried for other sectors at the moment. The various alternative strategies are being analysed in a comparable way as described earlier. Research will be carried out for each strategy to find out within which climate change boundaries it will still be workable. In order to make this meaningful, we have made use of the so-called Evaluation Strategy sheets. Figure 2 gives an example of a similar figure for safety against flooding in the outer dike area of the city docks area (*Stadshavensgebied*) in Rotterdam.

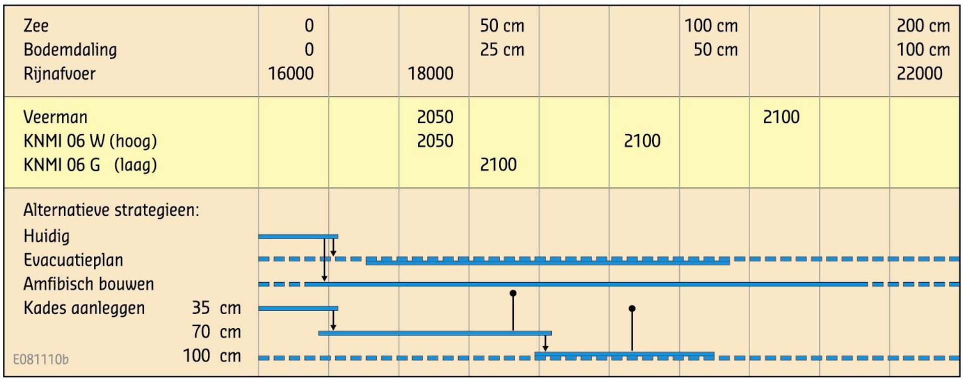

Figure 2 Sample illustration

Ultimately this creates a picture about how we can deal with climate change that is reasonably irrespective of new scenarios. The advantage of this is that the policy can more easily anticipate new scenarios. Possible policy adjustments will be brought forward or postponed depending on whether the changes appear to be occurring more quickly or more slowly over the course of time.

References

Delta Commission (*Deltacommissie*), 2008. Working together with water (*Samen werken met water*) Findings of the Delta Commission 2008 (*Bevindingen van de Deltacommissie 2008).*

Deltares, 2008. The climate resistance of Nederland Waterland: Tipping points in the management and policy for the main water system (*Klimaatbestendigheid van Nederland Waterland: Knikpunten in beheer en beleid voor het hoofdwatersysteem*). Compiled by J.Kwadijk, A.Jeuken and H. van Waveren; 2008. Interim project report T2447 The climate proofness of Netherlands Water Country (*De klimaatbestendigheid van Nederland Waterland*) by Deltares.

Deltares, 2008. Three perspectives for a climate-resistant Netherlands. Adaptation measures for the Dutch water management (*Drie perspectieven voor een klimaatbestendig Nederland. Adaptatiemaatregelen voor het Nederlandse waterbeheer*). Compiled by Ad Jeuken (Deltares) and Harold van Waveren (RWS Waterdienst). Interim report on behalf of the Delta Commission the climate proofness of Netherlands Water Country (De *klimaatbestendigheid van Nederland Waterland*). Deltares.

KNMI, 2006. Climate in the 21st century. Four scenarios for the Netherlands (*Klimaat in de 21e eeuw. Vier scenario's voor Nederland*).

Netherlands Environmental Assessment Agency (*Milieu- en Natuurplanbureau*), 2007 (with cooperation from WL|Delft Hydraulics), The Netherlands Later; Second Sustainability Investigation, section Physical Surroundings in the Netherlands (*Nederland Later; Tweede Duurzaamheidsverkenning, deel Fysieke leefomgeving Nederland*), MNP publication number 500127001/2007, Bilthoven..

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