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Using adaptation tipping points to prepare for climate change and sea level rise, a case study for in the Netherlands

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Abstract

Studies on the impact of climate change and sea level rise usually take climate scenarios as their starting point. To support long-term water management planning in the Netherlands a study was carried out that started at the opposite end of the effect chain. It was examined whether, and for how long, current water management strategies will continue to be effective under different climate change scenarios. This was done by applying the concept of “adaptation tipping points”, reached if the magnitude of change is such that the current management strategy can no longer meet its objectives. Beyond the tipping points an alternative, adaptive, strategy is needed. By applying this approach the following basic questions of decision makers are answered: *what* are the first issues that we will face as a result of climate change and *when* can we expect this. The results show, for instance, that climate change and the rise in sea level are more likely to cause a threat to the fresh water supply in the west of the Netherlands than to cause a threat from flooding. Expressing uncertainty in terms of the period that the existing strategy is effective (when will a critical point be reached) was found to be useful for the policy makers.

The need for adaptation to climate change is recognised more and more. Even if we would succeed in mitigation of the emission of greenhouse gases it will take at several decades for the global warming trend will be stopped. In the Netherlands adaptation of water management to climate change and accelerated sea level rise became a policy issue in the nineties with the publication of the Fourth National Policy Document on Water Management [1]. In 2000 the Committee Water management for the 21st century proposed three climate scenarios that could be used to design adaptation strategies: a Lower, a Central and an Upper estimate [2,3],. In a formal agreement [4] the water management community agreed to adopt the Central scenario to develop a series of adaptation measures. However, only four years later a new generation of scenarios was provided [5], based on new insights from the IPCC 4th assessment [6]. These scenarios showed a much wider range of possible climate changes. The new scenarios resulted in two important issues for water managers, namely:1) formalized agreements between different administrations and designed measures appeared to be insufficient already four years later, and 2) a central scenario was lacking as there were four provided, making it difficult to select a scenario as norm for the design of strategies. This experience pointed out the need to shift to an alternative approach to support the Dutch water management to prepare for climate change and sea level rise given the uncertainties about climate change and sea level rise.

Presently, two basic approaches are used to support climate adaptation policy on a regional and local scale. The predictive top-down approach and the resilience bottom-up approach [7, 9]. The top-down approach is the most widely applied and uses climate scenarios to assess impacts. The examples mentioned in the IPCC WGII chapter 17 [8, 9] follow this approach. Climate scenarios play a key role in this approach as they form the starting point to analyse impacts and prepare adaptation strategies. A limitation is the strong reliance on the climate projections, which may not be applicable for the scale or purpose for the decision maker. This was one of the difficulties the Dutch water managers had to deal with in the above example. Several other reviewers have also concluded that the results of this method was not immediately useful for adaptation policy.

Bottom-up approaches focus on vulnerability and risk management by examining the adaptive capacity and adaptation measures required to improve the resilience and robustness of a system exposed to climate change [9]. This approach is more independent of climate projections and can even be done without them. A successful example is the Thames 2100 study in which a bottom-up approach was used to identify flood defense measures along the Thames and prepare a flood defense plan in order to delay the replacement of the Thames storm surge barrier as long as possible [10]. However, critique regarding the bottom-up approach is also encountered, specifically regarding the applicability of the approach. The encountered critique is predominantly concerned with the lengthy time to perform an assessment and the perception that the system described is too complex for a proper comparison of all the drivers. It has been concluded, for example, that *“vulnerability assessment often promises more certainty, and more useful results, than it can deliver”* [11, page 411]. An other disadvantage of this approach is the greater reliance on expert judgment and qualitative results [12]

In order to enhance the transparency and reproducibility of the bottom-up approach and make it more applicable for decisions in water management adaptation, we developed the concept of “adaptation tipping point (ATP)”. The objective of our study was to apply and test the concept for the Netherlands and analyze whether support decision making on water management strategies. In the following sections we elaborate on the approach and illustrate ATPs from a historical perspective. ATPs in the Netherlands water management system that may be reached in the near future due to climate change are then identified.

Adaptation Tipping Points approach

In the context of climate change, adaptation refers to actions targeted at the vulnerable system in response to actual or expected climate change with the objective to either limit negative impacts or exploit positive impacts [13]. Adaptation involves dealing a.o. with predictability of climate change (some aspects of climate change can be predicted with reasonable confidence like temperature rise, while others are surrounded by more uncertainties); non climatic conditions (it occurs against the background of current and future use of the area); timing (proactive or reactive) and time horizon (short or long term actions) [14, 15]. Planned adaptation focuses on the use of information about current and future climate to review the suitability of current and planned management [12].

The term tipping point is introduced in climate change research literature to indicate the point where a system change initiated by an external forcing, no longer requires the external forcing to sustain the new pattern of change [14, 16, 17]. An example is the irreversible decay of the Greenland ice sheet [18]. In a slightly different sense, the concept also plays a role in greenhouse gas (GHG) emission policy to set a standard for GHG reductions. The reductions should be such that the global temperature rise at the end of this century should not exceed 2 degrees Celsius. Although many reviews in the scientific literature [19,20,21] suggest that 2°C cannot be regarded as harm-free or ‘safe’, beyond this limit, many believe that the behaviour of system earth will approach ‘terra incognita” and might lead to dangerous impacts [22]. Plus 2 degrees Celsius as an adaptation tipping point, is also adopted as a long-term EU climate target of limiting the global mean temperature in 1996, and recently (March 2005) reconfirmed by the European Council. In climate change communication, the use of tipping points often illustrates “points of no return” [23,17].).

We define ATP’s as points where the magnitude of change due to climate change or sea level rise is such that the current strategy will no longer be able to meet the objectives. This gives information on whether and when a water management strategy may fail and other strategies are needed.

An ATP analysis starts from the perspective that a water system provides the natural boundary conditions for living and working in this region, summarized as the boundary conditions for socio-economic activities. The system needs to be managed to maintain the proper conditions and achieve our objectives for living in the delta. In case of climate change and sea level rise these conditions change, resulting in the possibility of failure of the current water management strategy. At that moment an ATP is reached. Exceeding an ATP does not mean that water management is not possible anymore and that we might face catastrophic consequences. It simply means that alternative strategies are needed to manage the system. From this viewpoint adaptation to climate change in itself has no value; it is done to sustain our activities and preserve ecological values. Climate change only becomes interesting for policy makers if it would lead to other decisions about our water management strategies. In other words, the driver for taking action is not climate change, but failing to meet the objectives.

Reaching ATPs might have physical and ecological, technical, economic, societal or political causes [24]. An example of a physical boundary is the possible shift of habitats in case of sea level rise, limited by natural dunes or artificial barriers like dikes. Technological Economic ATPs may arise from lack of money either induced by large investments or by economic developments. Society may change its values and norms, resulting in different objectives, which may cause an ATP or may shift the timing of an ATP [25, 26].Political processes can make it unlikely to carry out a decision on time [e.g. 27]. Because of these different boundaries climate change should be considered as one of the issues (not necessarily *the* issue) to take into account in strategy development [e.g. 28, 29,30, 9]. Other socio-economic developments may, either in combination with climate change and sea level or on its self, result in (earlier) ATPs.

The moment in time when an ATP will occur according to different scenario’s, defines the moment that alternative adaptation measures will be needed.

The ATP approach differs from the classical top down approach and has elements from vulnerability bottom up approach. In the classical top-down approach to climate adaptation (see figure 1; left panel), the underlying question is: “*What if climate changes or sea level rises according to a particular scenario?”* This is followed by analyzing the cause-effect chain from pressures to impact (the PSIR concept [31]). If the impact is such that policy objectives are not achieved, adaptation measures are defined to overcome this problem. Then the chain is analysed again, answering the question: “*What if this particular scenario becomes reality and we implement measure x, are the objectives then achieved?”*

In the ATP (bottom-up) approach (see figure 1; right panel) the underlying question is: “*How much climate change and sea level rise can the current strategy cope with*?”, and the analysis starts at the other end of the cause-effect chain. Policy objectives for different sectors and areas are taken as a starting point. Then, the current measures to achieve these objectives are described. This is followed by a sensitivity analysis to determine the optimal and critical boundary conditions (state); e.g. for navigation, water depth is an important boundary condition. A water depth greater than 4m results in optimal conditions; at lower water levels, the suitability of the river for navigation gradually decreases to a critical minimum where no shipping is possible anymore. The state of the water system described in terms of relevant boundary conditions can be related to pressures in terms of climate and sea level. To do this, intermediate steps are sometimes needed. For example, in the case of river navigation, water depth needs to be related to river discharges.

ATPs in water management are thus the specific boundary conditions where technical, economic, spatial or societal acceptable limits are exceeded. The time at which an ATP will occur (which is dependent on the climate scenario considered) defines the moment that alternative adaptation measures will be needed.

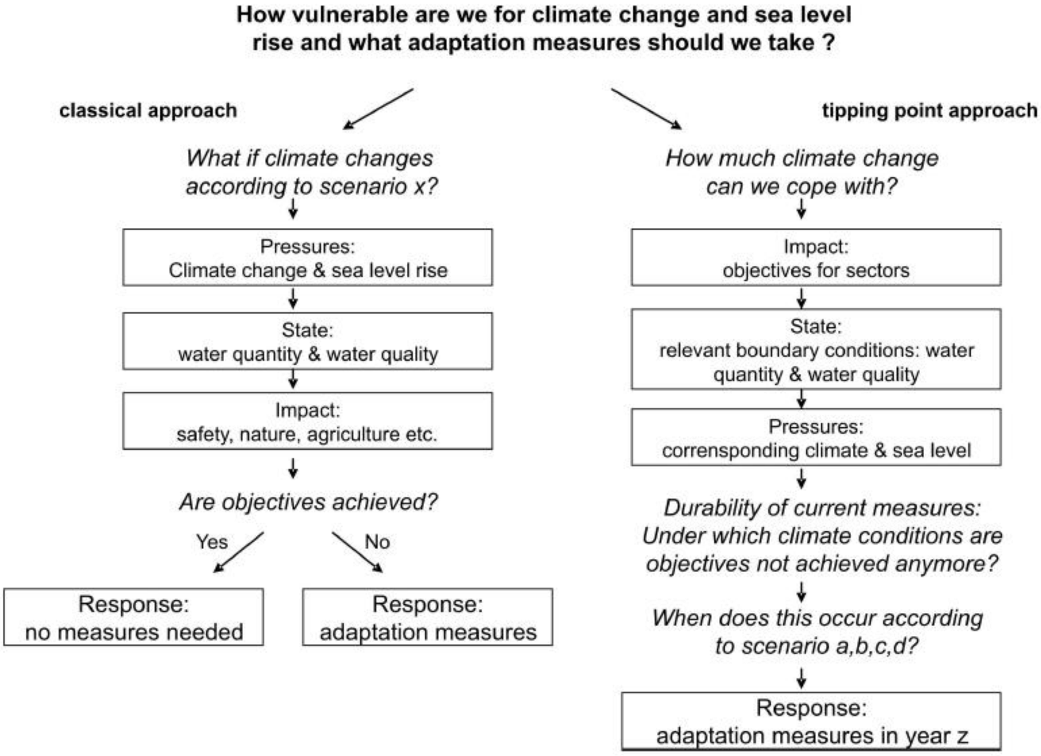

Fig. 1 Classical top-down approach and Adaptation Tipping-Point approach to develop adaptation measures.

The ATP approach thus focuses on defining if and when adaptation strategies are needed for policy makers to be able to plan the adaptation. The examples we give are from a physical and ecological point of view, which are considered as exogenous limitations. This does not mean that adaptation will succeed. There are other limitations which may result in failing of the adaptation. Adger et al [25] argue that climate change is not only limited by such exogenous forces, but also by endogenous forces within society. They identify four elements limiting the successful adaptive response of society. These limitations are due to a) ethics, in terms of divers objectives within society as what is successful for one may be a failure to the other; b) lack of knowledge about the future resulting in e.g. being to late; c) perception to risk, resulting in a low sense of urgency; and d) undervaluing of places and cultures as valuing method do not include cultural and symbolic values leading to a limiting range of actions.

Determining the natural boundary conditions in the Dutch case

In the case study for the Netherlands we focus on physical and ecological ATP's driven by climate change and sea level rise. For this purpose we used the results of simulations of studies using these hydrological, hydraulic, morphodynamic, ecological and impact models are used to determine the sensitivity of different sectors and associated objectives, to sea level rise and climate change.

To investigate morphological behaviour of the coast on the large scale associated with climate change, a large scale model of the Netherlands coastal system was developed, based on a combination of different model concepts [32, 33, 34, 35, 36, 37, 38, 39]. Sediment balance studies of the system were based on the national database for geological data and the geological mapping programme of Deltares / Geological Survey of the Netherlands [40]. In addition, for the active subsystems of the coast, bathymetric data were used from the database on bed level monitoring of the Directorate General for Public Works and Water Management dating back to beginning of the 20th century [41].

For the rivers and the estuaries, the tools include a hydrological-hydraulic system to simulate river discharges in the Rhine and Meuse basins [42, 43] as well as a weather generator to allow for generating synthetic discharge series [44]. A hydraulic modelling system allows for simulating water levels as well as water quality in the southwest estuaria and tidal areas [45, 46]. In the tidal area the assessment of the water levels and salt intrusion was carried out by executing a Monte Carlo analysis using a 1-D hydrodynamic model with different sea levels and upstream boundary conditions. A national groundwater and water distribution model is used to estimate effects on groundwater, agriculture and water level management of lakes and small ditches [47, 48, 49]. An ecological model is used to assess effects on the availability and quality of habitats [50].

Climate change projections were used to time the ATPs. For the Netherlands these projections were based on the IPCC 2007 4th assessment [6] are published by KNMI [5]. High-end scenarios, beyond the range the IPCC provides are published by [51]. These projections were used in the current study to establish linear temporal trends of temperature, rainfall, evaporation and sea level rise (Table 1). These linear trends were then used to force the various modelling systems; these results were then used to determine the earliest and latest date that a strategy is no longer effective Sensitivity of the Rhine Meuse delta to even higher sea levels has been studied [27]. Our study uses more recent estimates as this study [27] assumed a speed of rise which was not considered plausible by the more recent studies [51].

Table 1

Minimum and maximum climate change and sea level rise scenarios for 2100, based on the KNMI-G scenario (moderate change) for 2100 indicated with (1) [5]; the KNMI-W+ scenario (large temperature and circulation change over Europe) for 2100, indicated with (2) [5]; and the High-end Sea level rise scenarios for 2100, indicated with (3) [51].

	smallest		largest	
	winter	summer	winter	summer
Temperature change	+1.8 (1)	+1.8 (1)	+4.6 (2)	+5.6 (2)
Rainfall change	+8% (1)	+ 6% (1)	+28% (2)	-38 % (2)
Evaporation change	0% (1,2)	+6% (1)	0% (1,2)	+30% (2)
Sea level rise	30 cm (1)	30 cm (1)	105 cm (3)	105 cm (3)

Historical adaptation tipping points in the Netherlands

The long-term development of a low-lying deltaic area like the Netherlands (Fig. 2) is determined by a delicate balance between demand and supply of sediments [see e.g. 52]. This delicate balance may provide a system tipping point in deltaic formation [e.g. 53]. Sediment demand is dependent on the change in hydraulic boundary conditions (e.g. a rise in sea level) and on the initial topography of the coastal area, that together determine the (potential) accommodation space for sedimentation. Sediment supply is dependent on the availability of sediment resources and on the transport capacity of the hydro- and aerodynamic forces within the system. The coastal evolution of the Netherlands during the Holocene illustrates the role of the sediment balance [see 54, 55, 40]. During periods with a negative sediment balance, the coastline retreats;

when the balance is positive, the coastline extends. A lack of sediment supply is responsible for the retreating trend of the coastline during the last centuries.

Figure 1 The Rhine - Meuse delta

Through time, man has applied different strategies to cope with the ever changing physical conditions in the low lying grounds of the Netherlands. The history of human occupation of the country shows examples [e.g 56, 57, 58].

From ca. 2500 BP artificial dwelling mounds have been built in the northern, ‘swampy’ part of the country, in response to a rising sea level causing more frequent flooding. In fact this might be considered the first major adaptation tipping-point in occupation strategies: active interference with the physical conditions raising ground levels.

The era of water management started around 1200 – 1000 BP, when the population increased and dwelling mounds became too small to accommodate the people. In parallel, agriculture became an increasingly important activity. Techniques were developed draining the extensive peat areas in order to create agricultural land. Around 800 BP another major adaptation tipping point was passed, when the development started of dike systems and active drainage by pumping. During the following centuries this system of water management has been optimized by successive technical, organizational, and financial innovations.

A more recent major adaptation tipping point was reached towards the end of the last century. The Eastern Scheldt storm surge barrier, the final piece of the Delta Project protecting southwest Netherlands against flooding, originally designed as a pure flood defense structure, developed into an integrated design. An increased ecological awareness and social and political pressure resulted in the decision for an open barrier, not only serving safety against flooding but also ecological values and shell fisheries interests. The integrated approach that was developed to achieve this had to consider the entire estuarine system. During this process the importance of the sediment balance for long-term morphodynamic boundary conditions gradually became apparent [59, 60].

In 1990 this resulted in a strategy change, when in the Netherlands a coastal policy was adopted based on the principle of dynamic preservation of the sediment balance [61]. Sand nourishments to an amount proportional to the yearly sediment deficit must be guaranteed to achieve the objective [62]. Since 2000 the yearly nourishment volume is 12 Mm^3.

Adaptation tipping points in current Dutch water management

As typical examples of the evaluation results of current water management in the Netherlands, we will focus on flood defense, on the protection of Rotterdam Harbour and on fresh water supply.

Flood defense

To ensure safety against flooding, safety levels for all flood defences in the Netherlands, including the dunes, have been established by law [63]. Coastal dunes must be able to withstand a storm event with a certain frequency of exceedance. This frequency of exceedance should be 1 in 10,000 years for the Holland coast, and between 1 in 4,000 and 2,000 years for the Delta coast and Wadden islands. For dikes along the tidal rivers in the western part of the country, the frequency of exceedence should be between 1 in 2,000 and 1 in 4,000 years (Fig. 3).

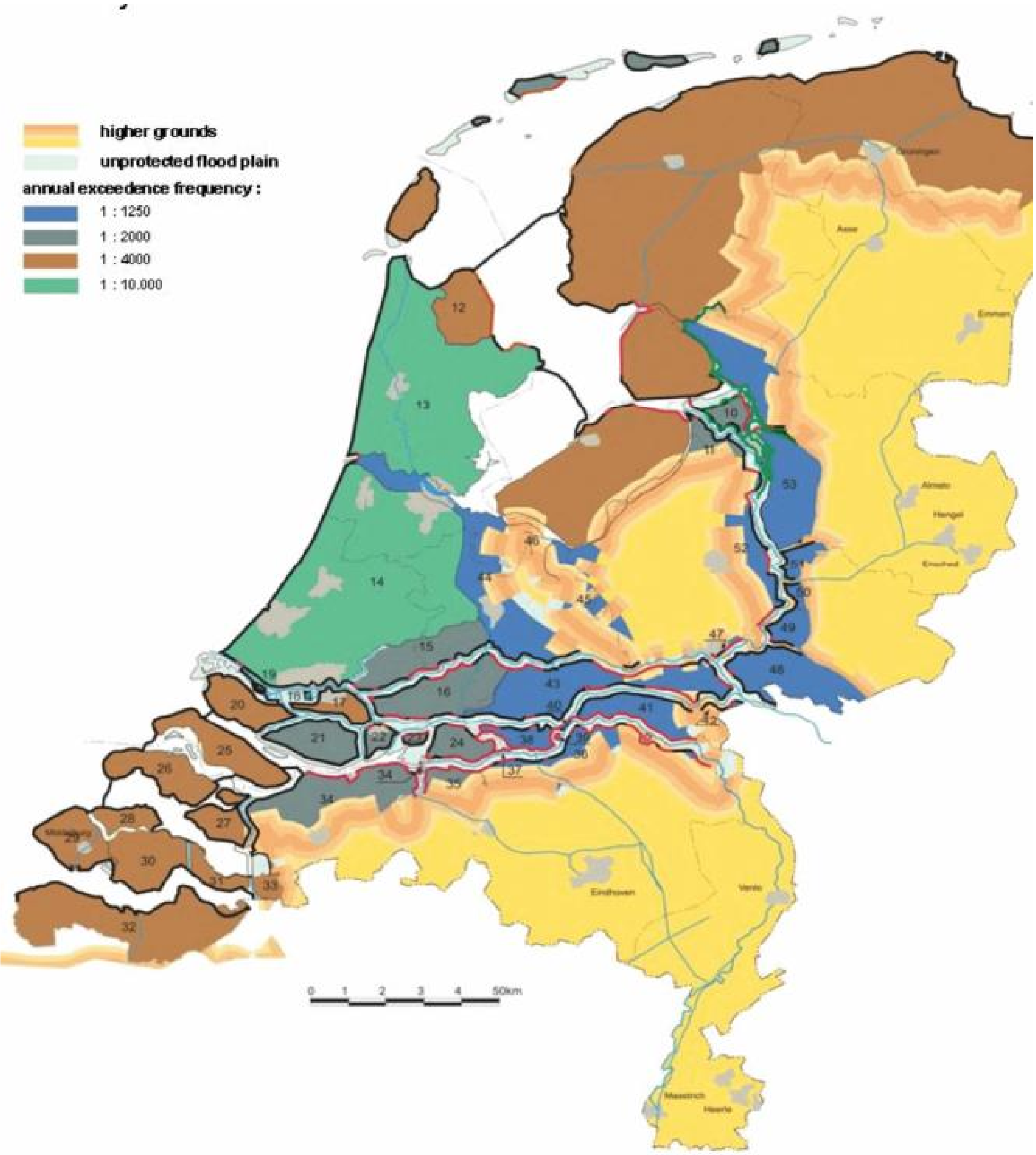

Fig. 3 Flood safety standards in the Netherlands

Additionally, for the coast the Water Act prescribes the preservation of the coast line at its 1990 position. This requirement ensures the maintenance of morphological boundary conditions for dune growth, and as such the sustainable preservation of safety levels. Preservation of the sand balance by sand nourishments started in 1990 and has shown to be effective at the present rate of sea level rise [33, 57].

For the coast, an increase in sea level rise might be compensated by a proportional growth of the yearly nourishment volume. An increase in rise from the present 2 mm/year to between 3.5 and 10.5 mm/year until 2100, would require a sand volume of 25 to 74 Mm3/year (i.e. between double and six fold the present yearly amount). Technically and financially this is regarded as feasible. Nourishments have been politically and socially accepted, and sand resources in the North Sea are abundant. Spatial reservations for future sand mining purposes must be able to safeguard ample availability. Optimization of both sand mining and nourishment must be able to meet ecological requirements. Thus even in the most extreme sea level rise scenario, the existing policy of protecting the sandy coast is not likely to encounter an ATP.

For dikes along the tidal river area in the western part of the country, technically and financially, no major adaptation tipping points are expected. Dike reinforcements and innovations must be able to cope with more severe hydraulic boundary conditions; expenses will grow, but remain feasible. Potential adaptation tipping points might arise on the social and political level. For example, the social acceptability of living behind giant dikes might decline, and increasing spatial claims of ever larger dikes might invoke innovations in governance arrangements.

Protection of Rotterdam Harbour

The Maeslant Barrier (Fig. 4) is essential in the protection of the Rotterdam harbour and tidal river area against flooding. In this region the levees are designed to withstand water levels that have a probability of occurrence between 1/10,000 and 1/4,000 annually. To meet this safety level, the barrier closes if the water level at the outlet of the Waterway exceeds 3m or exceeds 2.90m upstream at Dordrecht. The return period of such an event is approximately 10 years. Rising sea level implies that the barrier will close more often. However, closing the Maeslant Barrier hinders navigation to and from the Rotterdam Harbour. According to the Rotterdam Port Authority a maximum closing frequency of once per year is acceptable. This is considered an ATP. The closing frequency of the Maeslant barrier depends on the sea water level, the duration of storm events, and the discharge of the rivers. Once closed, the discharge of the rivers and the period the gate is closed determine the water level rise behind the barrier, causing a back-water effect and forcing parts of the river flow to follow a route more south into the southwest estuary. Figure 4 shows that a 85 cm sea level rise would mean that the barrier would close approximately once every year. Another ATP is the maximum sea water level rise the barrier has been designed for, which is 50 cm.

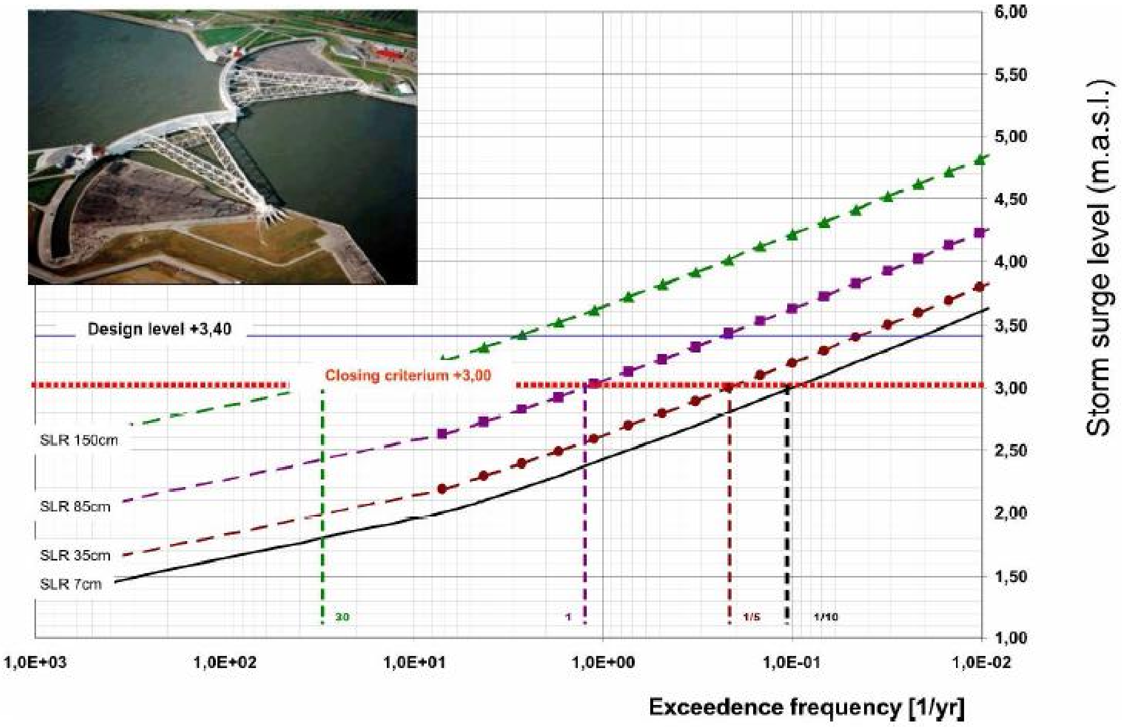

Fig. 4 The storm surge barrier (Maeslantkering) to protect the Rotterdam Harbour and exceedance frequencies (year^{-1}) of water levels in the Rotterdam Harbour assuming sea level rise between 0 and 150 cm [from 21].

Fresh water supply

The tidal river area is crucial for the freshwater provision (drinking water and agriculture) in the southwest of the Netherlands (Fig. 5). A rising sea level and reduced river discharge in dry summers is leading to extra salinization of the groundwater and surface water. An ATP for this sector would occur if the sea level rise in combination with lower river drainage results in an inability to maintain salt concentrations at a level low enough to maintain key functions. Water allocation has been established in a series of water agreements between the national and regional administrations. To meet the requirements, the maximum allowable chloride concentration in the inland water system is 250 mg/l. Under current conditions the inlet of fresh water needs to be closed between once every 5 and 10 years [65] to protect against saltwater intrusion. However, frequency and duration of necessary closure of fresh water inlets rapidly increases with rising sea levels and decreasing river discharges.

The present tolerable duration of a blocked water inlet due to elevated chloride concentrations varies between 12 and 48 hours at the main inlet points within the region. Model results show that within the range of the current climate scenarios, elevated chloride concentrations can be expected for much longer periods with a sea level rise of 35 cm. For a strategic inlet like Gouda, along the Hollandsche IJssel river, the number of days that the inlets must be closed in an average meteorological year will increase from 0 to 76 days. Discussions with the local water managers have indicated that this is such a dramatic change, that adaptive measures are considered insurmountable.

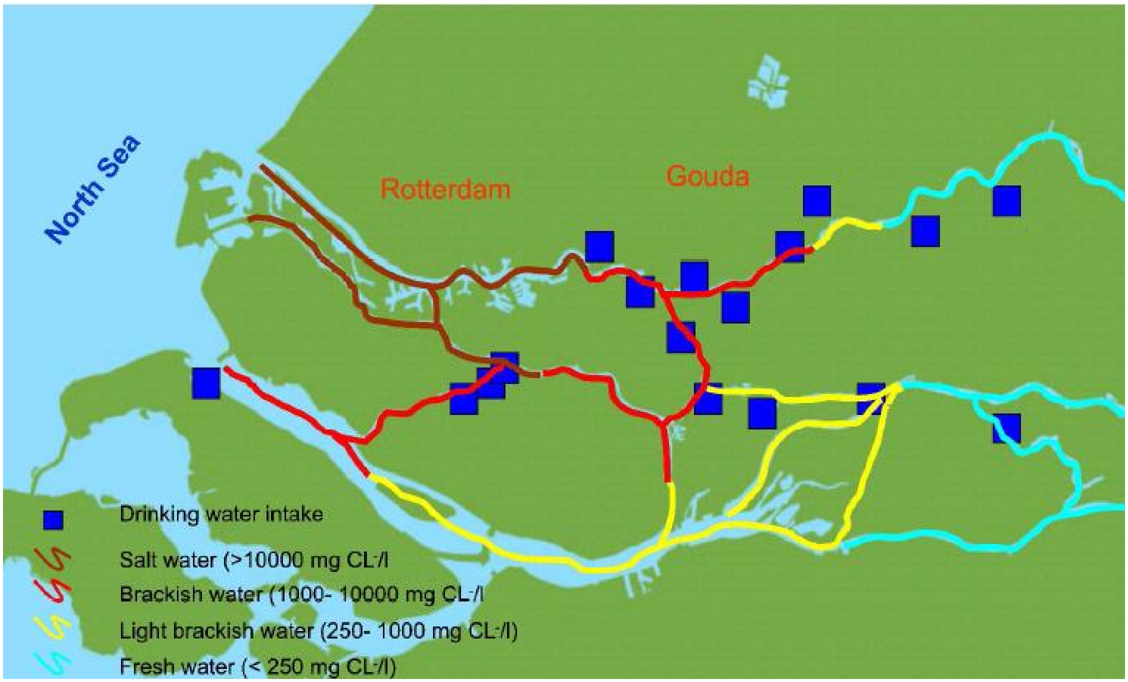

Fig 5. Chloride concentrations and drinking water intake points along the tidal rivers in SW Netherlands

Timing of an ATP: available time before adaptation measures need to be implemented

To estimate the maximum and minimum period available before decisions on adaptation measures in the Netherlands should be taken, we use the KNMI 2006 scenarios [5] as well as the High-end scenarios [51]: sea level rise until 2100 may vary between 30 and 105 cm (Table 1).

With respect to flood protection of the sandy coast and tidal river area, the current strategy can be continued within the evaluated range of sea level rise. This means that the current strategy is robust at least until the end of this century.

The Maeslant (storm surge) barrier can be used to protect the Rotterdam harbour up to a sea level rise of 50 cm. According to the upper limit of the considered range - a worst case of 105 cm SLR in 2100 relative to 1990 - this will be reached around 2050. Under the same worst case conditions, closing of the barrier would exceed a frequency of once a year only a few years later. Apparently, around 2050 sea level rise for the first time might present an ATP for the protection of Rotterdam Harbour. This ATP would lead to a re-consideration of the way the Harbour needs to be protected.

Fresh water supply in the western part of the Netherlands will be hindered to an unacceptable level if the sea level would rise by 35 cm relative to 1990. In the worst case, this ATP would occur around 2030.

According to the lower limit of the considered range of future sea level rise (35 cm in 2100), the Maeslant storm surge barrier would remain effective and fresh water supply in the Netherlands would remain acceptable until 2100.

Discussion

The classical approach for the development of adaptation strategies is to use one or more climate scenarios as a starting point for impact assessment and to define adaptation strategies based on the impacts. This top-down approach is useful to explore possible adaptation strategies. However, the results of such studies strongly depend on the chosen scenario(s) and the assumptions concerning scientific and socio-economic uncertainties related to these issues. Furthermore, as soon as there are new insights into climate change, the physical boundary conditions alter and may lead to other decisions on water management strategies. As an example in the water management in Netherlands, it has led to the pitfall that one scenario as best-estimate was taken. Consequently other scenarios and other possible futures which may have given useful information for the development of alternative adaptation strategies were ignored.

A bottom-up approach, i.e. vulnerability assessment of the management system, has received remarkably little attention so far. Nearly every study starts with one or more climate change scenarios and then tries to design strategies. In the vulnerability assessment using ATPs presented in this paper, we answer the basic questions of decision makers: *what* are the first issues that we will face as a result of climate change and *when* can we expect this?

Relating climate change directly to the current water management strategy, and expressing uncertainty in terms of the period that the existing strategy is effective (when will a critical point be reached), seems to give this valuable information about ‘what’ and ‘when’ for decision makers in a practical way, resulting in a better dialogue between the scientific and water management world.

The ATP approach stimulates the policy makers to look at sensitivity of sectors and the durability of a strategy under different conditions. The critical limits may be exceeded at a particular climate condition and sea level, resulting from either climate variability or climate change. In this way it may become clear that due to climate variability also in the current situation, there may be a reason to adapt the strategy. It also enables easier assessments to balance the risk of climate change with other risks.

Application of the ATP approach is relatively easy under the condition that the management objectives are clear and quantified. Particularly for flood protection this is often the case. Application becomes more difficult if well-defined standards are lacking. In these cases we propose two approaches to determine ATPs: (1) by presenting fuzzy objectives and a period in which an ATP may occur (2) by interviewing the responsible authorities or stakeholders (e.g. this approach was followed for the fresh water intake assessment) and (3) by comparing the expected climate or sea level change with the variation observed in history. The latter approach assumes that the current strategy is designed to cope with the current variation. This implies that as long as change remains small relative to the observed variation, in the near future climate change may not be the main reason to adapt the water management strategy, but that other (socio-economic) drivers will be at least as important.

The concept of ATP strongly depends on the objectives defined. These objectives may however change in the future as a result of different values and norms of future society, or maybe even within society. In this case the timing of the ATP may shift.

The method can be elaborated further to identify adaptation pathways into the future. After an ATP has been reached, a new water management strategy is needed. This strategy will have a new ATP. Analysing different options and ATPs may result in adaptation pathways. Adaptation pathways show different water management options and possible dead ends once a water management strategy has been chosen [66].

Conclusion

A bottom up approach to assess the vulnerability of the Netherlands water management system to climate change and sea level rise in terms of ATPs, has been successful in answering the basic questions for decision makers: what are the most urgent effects and when will these occur?

The results are less dependent on climate projections. In addition, it gives a lot of information about the system and its weaknesses. In case new climate projections will occur in the future, it is easier to say whether this has large consequences for the planned measures.

The method was considered clear and practical and more important it supports the decision makers in dealing with future uncertainties. The approach was therefore given as advice to the ministry concerned with water management issues by the Advisory Council for Transport, Public Works and Water Management [67].

The results of the case study have formed a basis of long term planning in the national water masterplan 2009-2015 [68]. Findings of the research also have been input to the authoritive study on future adaptation options by the 2nd governmental Delta Committee [69, 70]. The analysis concluded that the first sector to be affected by an ATP due to increased sea level will not be flood protection, but rather the fresh water supply in the western part of the Netherlands.

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Cross-References

CC-0032: Sea-level scenarios for evaluating coastal impacts

CC-0226: Communicating adaptation (vs. mitigation)