Neo-Atlantis: Dutch Responses to Five Meter Sea Level Rise

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Abstract. What would happen to the Netherlands if, in 2030, the sea level starts to rise and eventually, after 100 years, a sea level of five meters above current level would be reached? Two socio-economic scenarios are developed from a literature review and by interviews with researchers and practicionersin the domains of social sciences, economics, civil engineering, and land use planning. One scenario describes what would happen in a future characterised by a trend towards further globalisation, marketisation and high economic growth, while the other scenario happens in a future under opposite trends. Under both scenarios, the Southwest and Northwest of the Netherlands – already now below seal level - would be abandoned because of

sea level rise. Although most experts believe that geomorphology and current engineering skills allow to largely maintain the territorial integrity of the Netherlands, there are some reasons to assume that this is not likely to happen. Social processes that precede important political decisions – such as the growth of the belief in the reality of SLR and the framing of such decision in a proper political context (policy window) – evolve slowly. Although a flood disaster would speed up decision-making, the general expectation is that decisions would come too late in view of the rate of SLR and the possible pace of construction of works.

Keywords: Extreme sea level rise, The Netherlands, flood defences

1. INTRODUCTION

A possible effect of the ongoing change in the climate system would be the disintegration of the West-Antarctic Ice Sheet (WAIS). Such event would lead to a 5 to 6meter (m) sea level rise (SLR). Although chances are small, the consequences are enormous. Obviously, communities in low elevation coastal areas would be threatened. However, what more is there to say about this risk? What could actually happen under such 5 m SLR? This question – the topic of the present paper – is relevant, for instance when considering policies to avoid and adapt to climate change.

We present the description of the risk in terms of scenarios, narratives about what could happen under certain exogenous developments (i.e. under a scenario of SLR). We do not discuss the probability of the 5m SLR itself (see Kasperson *et al.*, this volume; Nicholls *et al.*, this volume, Hansen, 2005; Oppenheimer and Alley., 2005)). The assumption is that the SLR will start in 2030 and occur in period of 100 years. The subject matter under influence of SLR is nothing less than “the Netherlands as a whole”. As the endpoints of this concept (i.e. the dependent variables), we have in mind items such as the geography of the Netherlands (about half of the

Netherlands is at risk, without any adaptation of the current flood defence system), the flood defence system and associated institutions, the demography and the economy of the Netherlands.

The structure of this paper is as follows. The next section "Methodology" describes the approach and sources of information. Section 3 presents an overview of concepts and topics that appeared to be relevant to the subject of the study. Section 4 gives a brief overview of current flood safety in the Netherlands, a country of which major parts are located below sea level. The scenarios are presented in section 5. Finally, section 6 discusses and concludes.

2. METHODOLOGY

The information used to write the scenarios was collected from literature, from a series of interviews among researchers and professionals who are either in the field of water management or are knowledgeable in other relevant science and policy domains.

Literature. In the Netherlands, in the domain of policy discussion and design, there is awareness about the possible consequences of climate change for the SLR. Strategic planning in the area of water management and flood safety is based on the assumption of up to 1m SLR from climate change (and tectonic subsidence) in the coming century (WB21, Tielrooij 2000). Numerous studies of flood safety under climate change have been made in the last decades in the context of developing flood safety strategies in The Netherlands. For instance, the National Institute for Public Health and the Environment (RIVM) recently evaluated the Dutch flood security policy (RIVM-NMP, 2004) from various angles and with respect to different types of risk(but also see Van Asselt 2001; Middelkoop *et al.* 2001; Van den Brink *et al.* 2003; Bouwer and Vellinga in press).

From the literature mentioned above and from discussions within the ATLANTIS project we identified a series of issues, which we used to structure interviewing and support scenario writing. These issues were, in summary:

- Analogues: are there historical developments that would be informative to considering possible response to the assumed sea level rise?
- Options: what response options are there (e.g. migration and abandoning land and associated problems, heightening dikes)
- Actors: what people would initiate processes of response and what would these responses be (e.g. political processes such as coalition formation among actors that share interests that evolve from the SLR).
- Processes: what processes would be seminal to eventual happenings?
- Trends: what current and expected trends in thinking and acting might be important to eventual societal responses

Interviews. In order to further identify and specify what is actually considered important in society and what processes or trends are thought to be determining possible future responses to an accelerated sea level rise, we interviewed professionals in domains assumed to be directly affected by SLR or to be of influence in societal responses to extreme sea level rise. A number of potential interviewees were identified and approached which resulted in fifteen in-depth interviews, which were conducted over a time-span of six months. The interviewees were briefed by sending them a checklist of issues that were thought to be relevant by us (see above) and they were invited to consider those issues that were familiar to them. Space was left, however, to discuss items deemed relevant to the interviewees. During the interviews, groups of questions were discussed one by one in an open way. This created a certain structure, whilst leaving enough space for the development of creative thought.

About a third of the interviewees were social scientists (mainly from academia), about a third were civil servants engaged in strategy and policy development. The other included a former politician, water management engineers and representatives of major industries.

Workshop. Eight of the interviewees participated with four other scientist (See table 1), in a one-day workshop that was intended to elicit ideas about the scenarios. Each participant is a senior in his field of expertise and used to thinking about the future.

Insert Table 1

The structure of the workshop mostly resembles the procedure of a "policy exercise" (See Hizsnyik and Toth, this volume). Workshop participants were asked to contemplate – interactively - possible events in the Netherlands during a 100-year SLR to 5m. This process was structured. Participants were first briefed about the scenario assumptions. Then the participants were asked to consecutively discuss possible events in three periods (2030-2050, 2050-2070 and 2070 2130). Finally, the results and the process were evaluated.

3. GEOGRAPHY, SOCIAL PROCESSES AND ACTORS IN SOCIETY

Thinking about the Netherlands in the far future requires to first delimit the scope of the scenarios: what topics could be addressed; what is felt to be important? In other words, what should be the indicators that would inform today's decision making? Answers are related partly to our audience, i.e. EU and national policy making. So, for instance, a major indicator is the geography of the Netherlands as a whole; will there be parts of the Netherlands submerged? Other indicators that are relevant to policy making at a National/EU level are, for instance, (opportunity) costs of possible responses, or the Gross Domestic Product of the Dutch economy, or the size of the Dutch population. Clearly, our subject is Dutch society as a whole.

Insert figure 1

Figure 1 shows how we conceptualise the relations between SLR, geography and society. The extreme sea level rise is considered the ultimate driver. Disasters strike with chance events such as storms coinciding with spring tide or high river discharges. The future physical shape of the Netherlands – "geography" in the figure – is a major part of the subject matter of the study. SLR prompts "the Netherlands" to react, i.e. to develop and decide on policies to address issues that arise from SLR and that are socially embedded.

Below we present, in brief, a series of topics that emerged from the interviews and the workshop and which topics the scenarios should touch.

Water culture. Water is important to current Dutch society and in Dutch culture. In the Netherlands, the large sea level rise and its dangers is not something that is remote and outside the scope of imagination. For instance, in 1991 the well-known writer Evert Hartman (1991) published a youth novel, with nine reprints, that takes place in the 22nd century, after a SLR due to climate change. A large part of the Netherlands is submerged and the former heart of the Netherlands – the Amsterdam, Rotterdam, the Hague triangle – has become an island polder, linked to the main land by tunnels. Extreme sea level rise has also been a topic in Dutch institutions concerned with flood safety policy making; in 1986 the Dutch State Water Management Authority performed an in-house study (Rijkswaterstaat-DGW, 1986) that looked into the possibility to adapt to a 5m SLR to occur in a period of 200 year (twice the time span considered in the present study). It must be said that the aim of this (in-house) study was to demonstrate the capabilities of the organisation rather than to conclude on policy making. Bye the way, this early study assumed it possible to preserve Dutch territorial integrity.

The Dutch are proud of their water management and of their ways to turn water into an endowment. This makes the Dutch differ from other people, in their own opinion, but also in the opinion of others (see e.g. Schama, 1987).

It might be conceivable that somehow this awareness – including a sense of urgency about hydrological risk - is exploited to create a political will to address problems once recognized. Two trends might reduce public awareness of "water". Firstly, to paraphrase Anthony Downs (1971): the capacity of the Dutch public to become bored by the topic or to forget events can not be overestimated. This is a consequence of the passage of time, but also a matter of other issues coming to the forefront. Take the last sea flood. The number of people with personal experience of the 1953 storm surge disaster is already decreasing and will decrease even more, weakening the public memory of that disaster. Floods, such as the one that occurred in 1916 has all but evaporated from the public mind. Along similar lines, the momentum for dike construction that was there after several (near-) floods of the large rivers in the 1990s has already waned. The restrictions that were posed on developments in flood prone areas are once again starting to become contested, which is indicative of the replacement of water concerns with new items on the public agenda. Secondly, immigration from countries where the public water awareness is very different from the current Dutch awareness (e.g., Morocco), will also lead to a dilution of this memory. On the other hand, a single experience with some flood (or a near flood)–might enhance awareness enormously.

With respect to water management culture, floods are not perceived as a natural hazard, entirely outside human control. There is a strong belief in the technological and financial possibilities to control and create flood safety according to plans. In relation with this belief, people expect from their governments to protect them, similarly as they expect the government protection to industrial hazards (Wissink and Bouma, 2002; Huysmans and Steenbekkers, 2002; De Boer , Goosen and Huitema, 2002)). This characteristic is one of the defining elements of risk society (Beck, 1990).

Perception of sea level rise.

The very first signs of an accelerated sea level rise will be broadcasted by individual scientists. Later on, probably, an international organisation such as the Intergovernmental Panel on Climate Change (IPCC), will be the channel through which these signs will reach a wider public. However, whether these signs are picked up, resulting in an awareness of accelerated sea level rise, depends on earlier experience of people. For instance, the belief in extreme SLR will relate to personal experience with hydrological threats and disasters. One mechanism is that SLR will obstruct river flow and pumping away excess water after periods with high precipitation, therefore experiences of near floods and nuisance from excess water will become increasingly frequent. Of course, if an ever-possible major disaster strikes, public belief (i.e. societal urgency of the problem) in SLR will increase stepwise. Another mechanism through which the social perception of the problem will increase would be the advancement of the WAIS science and the dissemination of its results by (peer) scientist to the mass media.

Politicians and political decision making.

Flood safety levels and assets-at-risk are unevenly distributed over the country (See figure 3 and its explanation). Under sea level rise the differences in risks will increase, and may lead to political conflict, since resources for flood safety policies are likely limited. Adaptation to such increasing risk will have to address such differences and might require major political decisions to resolve the conflicts. The opinions gathered from interviews and the workshop suggest that such major political decisions are made only if politicians can frame them as win-win options. As noted in the workshop, for politicians it is important that, to the public, they appear successful and to be high achievers. Being perceived as successful depends also on the prevailing political feelings in society, such as about solidarity, nationalism or globalisation. Big political decisions must fit into such moods (See e.g. Kingdon, 1984).

A second consequence of the working conditions of politicians is that they will not bring bad news (of accelerated sea level rise). Governments will continue to radiate trust and adequacy in

flood protection structures. The central and local governments will not easily think of abandoning any territory and forcing people to migrate. Governments are inherently conservative because they must account for their actions. Lonsdale *et al*, this volume, make similar observations about the limits of political decision making in the context of lon-term planning of flood risk management.

As a rule, politicians will be more responsive to public opinion than to warnings of scientists. Rather than taking the lead in reaction to announced threats of SLR, politicians will see SLR as a problem once floods or near floods occur. In contrast, other actors, e.g individuals, firms, investors - may respond faster to changing circumstances and therefore, are the initiators of new developments. Thus, actors peripheral to mainstream governance often initiate new developments and precede a governments' decision making.

European Union and the wider context

Accelerated sea level rise might prompt a reaction at the European level and the European Union might set up some legislation to channel adaptation, for instance a mechanism for financial assistance to implement adaptation measures. To the Netherlands, such EU policies might not necessarily beneficial to the scope of possible adaptation strategies, since the idiosyncrasies of the Dutch problems (e.g. related to the existence of polders and the firmly established institutions to cope with flood risks) might not match "average" European problems.

Flood safety in the Netherlands might or might not be considered an issue with implications for the whole of the European Union.

On the other hand, in the middle of the century, the Netherlands will have been a net contributor to the EU budget; and will have transferred substantial sums of money to other EU member states. Therefore, the Netherlands will be able to legitimately claim financial support from the EU. Nonetheless, other countries are likely to make similar claims at the same time.

Private industry

SLR will generate business opportunities. The Dutch coastal engineering industry will benefit from an increasing market for flood protection schemes across the world. On the other hand, some sectors will loose, in particular land-based activities than cannot be moved to safe areas. A major looser would be agriculture. This sector will also suffer from groundwater becoming brackish due to increasing hydrostatic differences between sea level and in-polder ground water levels.

Companies can decide to retreat from the western and northern parts of the country, including from the "core area" with Rotterdam, Amsterdam and The Hague and 80% of the economic assets. They close down or reinvest abroad or in the higher parts of the country. Once a critical mass of economic activity is moving away from the "core area" other companies may follow suit. Workers will tend to follow.

Company managers may also lobby with politicians to take timely initiatives and protect the "core area" against the upcoming sea level rise. Crucial in this process is the opinion formation among top managers about SLR and the relative costs and benefits of protection versus retreat.

It also is possible that conflicts arise between companies that opt for defence and retreat. Their disagreement will be reflected in the informal lobbying with politicians, who in the process may engage in conflict about defence or retreat as well.

Regions

A future sea level rise may divide the Netherlands economically and politically into three parts. The eastern and southern parts will remain dry. Their inhabitants may be less willing to share costs at the national level for defence of the other regions. They may resist mass immigration to their regions or, on the other hand, lobby among companies to shift their investments to the east and south. The second part would be the economic "core area" in the west, with 80% of the national assets. This part would be inundated without extra defence constructions. This core

area is essentially constituted by the Amsterdam-The Hague-Rotterdam metropolitan conglomeration, including the international hub Amsterdam airport and the world's largest harbour of Rotterdam. The third area at stake is constituted by the other sub-sea level parts in the west and north of the country. These areas are considered as somewhat economically "marginal" and are populated relatively thinly. The costs of extra flood defences might greatly exceed their benefits.

Regional conflicts

Whilst initially confusion and a lack of response may dominate, in the next stage thinking and action with regard to the defence of interests may arise, not only among firms but also among regions in the country. The interests may differ and lead to regional conflicts that can be reflected in political struggles. "Highlanders" and "lowlanders" may start conflicts. People in the sub-sea level marginal areas may engage in struggles with the sub-sea level core area.

Migration

In the near future, in general, people might become less migration averse, as the result of many people having visited foreign countries, speaking foreign languages – at least English. Internet and other electronic networks provide new ways of communications, which may at least partly be a substitute for face-to-face contacts between friends and family members. Today a substantial part of the Dutch population – about 15% - is already from foreign origin (CBS, 2003). These are signs that society becomes more "footloose". Migration, as a response to signals of enhanced risks, might easily start spontaneously, by small and medium sized firms to safer parts in the Netherlands, immigrants returning to their home country and retired people to the European sunbelt. Such developments might trigger further "natural" migration. However, migration could lead to the creation of refugee camps if – after disasters – large groups of people would have to move elsewhere on short notices. Eventually, the existence of job opportunities elsewhere will de decisive to outcome of migration (or flight) from areas at risk.

Nature conservation

In current flood safety policies environment is an important element. One of the justifications of selecting the "room for water" strategy (See next Section) is that creating room/space for water simultaneously creates natural areas (nature conservation areas) (Tielrooij, 2000). An earlier study (Rijkswaterstaat-DGW, 1986) of a 5m SLR (to occur, however, in 200 years) discussed the possible effects of sea level rise on ecology and nature conservation extensively[1]. Our interviews and workshop did not bring forward environmental issues – i.e. conservation of natural areas – as a very important topic vis-à-vis other issues.

Narrative structure of the scenarios

Finally, with respect to the structure of the scenarios we mention that we decided to structure these stories along two lines. The first line is chronological order: four periods are distinguished. The first period is 2000-2030, the period that precedes the discovery of the WAIS being in process of disintegration. The second period is 2030-2050. The first signs of disintegration are detected in 2030 and scientists start to warn. The third period is 2050-2070. By the end of this period, the sea level would have risen with about 2 m, and doubts about the origin of the SLR (and its prospects) disappear. In the final period 2070-2130, society must somehow respond to the reality of the sea level rising with another 3 meter.

The second line of structuring the stories is based on Kingdons' model of political agenda building and decision-making (Kingdon, 1984). One key element of that model (see figure 2) is the distinction of three social streams in time: streams of problems, of solutions and of political moods. The problem stream refers to the evolving public opinion about the relevance or urgency of some issue. Processes such as risk amplification or risk reduction relate to this stream. The solutions stream describes the evolvement of strategies to address such issue, as discussed among those participating in the policy making process. Finally, the political stream refers to the rise and fall of political moods (e.g. in the election cycle). Kingdon suggests that

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[1] These were the days of an extensive public discussion about the closure of the Oosterscheldt estuary (resulting in the loss of ecologically valuable wetlands), leading to the political decision to build a

the rise of problem-solution combinations is an important step in political decision-making, one that is sometimes accomplished by the hard work of policy brokers in the solution stream. Such couplings - i.e. solutions thought to be appropriate to solve problems - are, however, not enough for political decision. For that, political support must also be gathered. Political support can become unavoidable by major events, such as a tidal surge flood, but may also arise as a result of continuous monitoring data and as a result of elections that bring politicians to power with their particular agenda. Political support, when coupled, with a problem/solution combination creates the policy window enabling decision making. This model of the dynamics of decision making is in line with the observations about political decision making (see above) made by the workshop participants.

Insert figure 2

4. FLOOD RISK IN THE NETHERLANDS

In order to better understand possible responses to accelerated SLR in the Netherlands it is useful to briefly characterise the current situation with respect to flood safety policies in that country.

Geography

Figure 3 shows a map of the Netherlands in its current shape. The grey area of this map represents the part of the country that is not at risk to river or sea floods. The non-grey are is divided into so-called dike-ring areas. A dike-ring area is a juridical concept – part of the Flood Protection Act of 1996 - that refers to a region for which a maximum acceptable flood return

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moveable dam.

period (or flood probability) is established that flood safety management authorities must pursue. The boundaries of these areas are constituted by flood defence structures, mainly man-made (dikes) but also natural (e.g. beach barriers and dunes). The standards that these structures must meet are derived from assumptions on the probability of dangerous water levels and structural properties of the defence structures. There are 3,558 km of primary flood defence structures in the Netherlands, of which, by 1st January 2002, about 50% met the statutory requirements (DWW, 2003).

Flood risks vary with dike-ring area. Dike-ring areas 13 and 14 are best protected - storm surge risk - with a probability of once in 10,000 year. The less populated areas areas in the southwest and in the north are protected to once in 4000-year weather events. Along the rivers (e.g. dike ring areas 40, 41 and 43), flood probability is highest (probability once in 1250 year). The dike that connects area 12 with are area 6 – the Afsluitdijk – was built in the twenties/thirties of the last century, after a serious flood in the area just north of Amsterdam in 1916 (see Huitema, 2001, Huitema and Kuks, 2004).

The disastrous storm surge in 1953 (nearly 2000 fatalities) prompted the building of the dikes that close the arms of the estuary in the southwest of the Netherlands. These works were carried out under the so-called Delta Act that embodied the decision to improve the flood defence structures. The above mentioned flood safety standards date back to this law. They relate to political decisions informed by historical probabilities of extreme water levels and a cost-benefit analysis (Van Dantzig, 1956; See also Eijgenraam, 2003) that took account of the variation of the assets-at-risk across the Netherlands (RIVM, 2004).

Dike-ring areas 13 and 14 – which comprise the big Dutch cities and industrial areas – are of major economic importance and efforts to reach a safety level of once in 10,000 year are

economically justified[2]. Another justification is that a flood in these areas would result in many casualties. This is in contrast with a flood along the big rivers, since the relatively slow temporal evolution of flood risk allows evacuation of areas at risk. For instance, in 1992 100,000s of people were evacuated before water levels peaked; in the end, dikes were not overtopped and did not collapse. The possibility of effective contingency planning is one of the reasons that justified the "high" accepted flood probability in these dike ring areas.

For the sake of clarity, floods from overtopping of dikes do occur only during high river discharges or at spring tide when gale winds may additionally push up water levels. Current flood defences are designed to withstand surges of 5 m. One may think overtopping of dikes might lead to a flood. This is true. However, in reality most floods occur before dikes are overtopped, from dike breaches, which events in turn can be caused by processes such as sliding of the inner or outer dike slope; erosion of the dike revetment; and 'piping', causing water to flow under the dike and to erode the dike body (TAW 2000). For instance, in the summer of 2003 a local flood occurred when a dike (made of peat) failed due to drying – a real 'surprise' as nobody had thought of this failure mechanism.

Flood risk management institutions

Accepted statutory flood probabilities are not established for eternity. The Flood Protection Act stipulates that these standards are subject to revision each five years.

Until the 19th century, flood safety was a local concern; it became a national concern with the economic, administrative and political developments in the 19th century, notably the French occupation (Kuks, 2004; Tol and Langen, 2000; Bressers *et al.*, 1995). These developments and all corresponding engineering works have resulted in a large part of the Netherlands – such as the dike-ring- being "man made"; in a way, much of the geography of the Netherlands is a

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[2] Since the fifties economic growth at a rate of –on average – 3.8% did result in an increase in the assets-at-risk. Since flood probabilities did not decrease, the risk has grown considerably, and for this reason cost benefit analysis of flood safety, suggest currently safety levels are too low (Brinke *et al.*, 2004).

"technological" artefact. Polders, dikes, and systems for pumping water are amongst the best-known elements of the Dutch landscape.

Insert figure 3

Next to preserving flood safety, there is a second statutory driver to maintain the geographical integrity of the Netherlands. By law, the government has stipulated that the 1990 position of the coastline should be preserved. This is in reply to erosion losses along the coastal dunes that became a concern[3].

Flood control policy

In the last half of the 20th century, a shift occurred in approaches to flood risk management from "building ever higher and stronger dikes to contain water" to "designating areas for temporarily storage of excess water" (room for water). The source of this development was concern about the impact of traditional approaches (building ever higher and massive dikes) on the environment, landscape and cultural heritage and the notion that climate change would implies greater probabilities of greater river discharges. Expected SLR (of limited magnitude) is another concern that prompted rethinking of flood control policy, at least in institutions engaged in policy development. Already in 1986 the State Water Management Authority (*Rijkswaterstaat)* conducted an (in-house) study of possibilities to cope with 5m sea level rise (Rijkswaterstaat - DGW, 1986). The new approach – laid out in the Fourth National Water Policy white paper of 1998 - has serious implications for strategic land use planning in the Netherlands. For instance, a direct implication is that some (low-lying) areas must be designated to serve as excess water storage basins in case of extreme high river discharges, so preventing uncontrolled flooding elsewhere. Decision-making on concrete plans involves the

[3] Mainly done by beach nourishment, at an annual cost of about € 30 million (in 2000).

consideration and trading-off of impacts with respect to endpoints of different nature. See for instance Brouwer *et al*. (2004). So-called integrated assessment of the various pro and contras of policies involves stakeholder consultation in order to identify what is felt important.

Costs of flood defences

The amount of assets-at-risk and financial resources delineates the space of possible responses to SLR. Table 2 presents an economic assessment of the current policy to cope with expected climate change and SLR (not including the effects of the disintegration of the WAIS). This table – after Stolwijk and Verrips (2000) - shows economic assessments of five major plans, of which the first three relate to flood safety in the upper Rhine area, and the other to flood safety in the Western part of the Netherlands (where potential damage is orders of magnitude larger). They concluded that the total annual costs (loss of welfare) of protection against foreseen climate change, sea level rise and land subsidence, are in the order of magnitude of € 600 million, while the benefits (avoided annualised damage) exceed the costs by a factor of about 5. Note that the Dutch Gross National income (GDP) in 2000 was about € 400,000 million. So, costs would be about 0.15% of the GDP. This is about the level of the current expenditures on structural flood safety.

Insert Table 2

One may already wonder whether these figures would give an indication of the costs of a programme to protect the Netherlands against a 5m SLR (if technically feasible). A very rough assessment would follow from the rule that the volume of material needed to construct a dike relates quadratic to its height. This rule to extrapolate the data of Table 2 would indicate that costs of protection against 5m SLR would exceed its benefits by an order of magnitude. Annualised costs would be in the range of 3%-4% of GDP (20%-30% of national investments),

a major cost. In the fifties, the Delta committee deemed an amount of 0.5% of GDP to spend on flood safety acceptable (Eijgenraam et al, 2003). The actual costs – relative to GDP - turned out to be lower (due to high economic growth). The earlier study of DGW (1986) presented costs – indicative only - associated with three scenarios of flood safety responses to a 5m SLR to occur in a period of 200 year. The strategy that assumed abandoning the North and South-western part of the Netherlands would cumulatively require expenditures in the order of magnitude of the GDP in 1986, over a period of N years. Preserving the territorial integrity would cost about four times more. The latter figures, turned into annualised cost, would compare to the 3%-4% of GDP figure. In conclusion, costs are very high, bringing a burden to the governments' budget, and hampering other investments that would be economically more beneficial.

5. THE SCENARIOS

5.1 Introduction

This section develops two scenarios as were laid out in the workshop. The workshop participants decided to delineate two futures by distinguishing two possible social trends. One social trend would be a continuation of the current trend that is characterised by key words such as "globalisation", "individualisation" and "liberalisation". Under such trend, there is only a limited role for the government in activities such as land-use planning, public health system, retirement payments, and economic policy. This trend or scenario is called "markets prevail". We named the other scenario "public institutions"; this scenario foresees less globalisation (and less economic growth but a more equal income distribution) through a greater role of the government in societal development. This distinction is inspired by a scenario study of the Dutch Bureau for economic policy analysis for the development of the European economy in the period 2000-2040 (Lejour, 2003).

Table 3 shows what interviewees and workshop participants did associate with this distinction in trends.

Insert Table 3

5.2 Developments 2000 - 2030

Economy and demography. We assume that under the "markets" scenario there is an 2.0% annual growth rate in GDP, while in their "public institutions" scenario the growth rate will be 1.0% (Lejour, 2003). The GDP would have risen by 58% respectively 29% over a period of 30 years.

By 2030, there will about 18 million people living in the Netherlands (today 16 million). Roughly 9 million people live in areas below sea level, of which about 6.5 million in the central urban part of the country and 2.5 million in peripheral areas.

The share of elderly (retired) people will be high: it almost doubles from 22% in 2000 to somewhere between 35% and 52% in 2035 (CBS, 2003). In particular, well-to-do retired people increasingly have second homes in countries with a favourable climate (e.g. France, Spain). Also, some of the elderly immigrants from Turkey and Morocco tend to return to their homelands.

SLR and flood risk. In line with the expectations in the end of the 20th century, sea level rises with about 10 cm in the period 2000-2030. By the year 2030, most of the 3,558 kilometres of primary flood defence structures in the Netherlands, along the coast, the Lake IJsselmeer area and along the rivers, will meet technical standards established by law (See preceding section).

The problem stream 2000-2030. In the public mind, the issue of flood risk will remain at the background, which is tantamount to saying that there will be no serious (other than giving only

local nuisance) flood events. Actually, the most important events that will feed public opinion are the efforts of the public authorities to enhance and at least preserve the discharge capacity of the big rivers. For instance, the national governments would want to prevent developments (e.g. housing developments in river forelands) that would obstruct river flows. In addition, at certain bottlenecks in the river channels, the national authorities might want to enlarge discharge capacities. The latter would certainly lead to conflicts of interest between authorities and local stakeholder (e.g. real estate owners that would be exposed to greater flood probabilities).

Awareness of specific risk among people depends on, among other factors, individual experience with the hazard (Zwick and Renn, 2002; de Boer, 2005). With respect to flood hazards (i.e. drowning), one may assume that personal experience of swimming, enhances somebody's awareness. If true, groups of people that are not able to swim are expected to be less receptive to warnings of flood risk. In contemporary Dutch society immigrants often are unable to swim, unlike the majority of the other Dutch. It is conceivable that other idiosyncratic cultural properties of immigrants are also relevant to developments in "water awareness" of the Dutch population.

The solutions stream 2000-2030. Among the community that is informed about flood safety and where ideas are created about policies to pursue, the sense of urgency increases over the years. The focus of the policy-making community is on ways to overcome local resistance against designating areas as potential excess water storage areas, or against areas as potential water discharge areas in rare occasions (*overloopgebieden*). With respect to storm surge defences, some development is going on with respect to alternatives to conventional dike reinforcement.

The political stream 2000-2030. Politics continues more or less to develop without major alterations. No major political decisions are taken on serious (i.e. having profound political and economic impacts) flood safety policies. In 2020, after a period of relatively high economic

growth, the government budget allows financial compensation for inhabitants of areas designated as water excess storage areas are designated.

5.3 Two scenarios unfold.

Below we present two scenarios in the form of two timetables, for, respectively the periods 2030-2050, 2050-2070 and 2070-2130. The first period is characterised by uncertainty. Scientists start to empirically support their worries about the disintegration of the WAIS and the consequences for sea level. After 20 years, there is at least scientific consensus about the phenomenon, while, after minor floods or near-flood disasters, there will be public concern about SLR by the middle of the 21st century. The period 2050-2070 is the period of discussions and political debate about what to do vis-à-vis the SLR, which by now scientists are able to predict.

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6. DISCUSSION AND CONCLUSION

The central question of the present study was “what would happen to the Netherlands and Dutch society during a century of sea level rise of, eventually, 5m?”. We tried to answer this

question by first identifying characteristics of and processes in Dutch society that can be considered as constitutive to possible responses of Dutch society to such sea level rise. Next, we combined the results of this inventory into two scenarios of possible events. Interviewing experts and a scenario-building workshop were important elements in the methodology of constructing these scenarios.

Our interviews with experts confirm that experts in flood defences feel that technically (i.e. without any financial or organisational constraints) it would still be possible to bye and large maintain the territorial integrity of the Netherlands under a 5m seal level rise. Their opinion and also the opinion of experts in other fields is, however, that social (and political) processes make it unlikely that decisions to carry out such policy can be made timely: the rate of sea level rise is faster than the rate of social processes that enable such decisions. For example, sea level rise will bring about conflicts of interests, for instance among those who areas exposed to high risks – to control only against very high costs - and those who are not – and are not willing to pay for risk control elsewhere. Windows of opportunity to make major decisions on enhancing flood safety that would resolve such conflicts are only possible in a brief period after a disaster or other chance events. A window of opportunity exists if the problem as perceived in society and the solutions to this problem – as being discussed in policy-makers circles - are in line with the political mood (Kingdon, 1984). Next to decision making by governments there are processes that are outside of the control of governments, such as migration (of individuals and firms) away from risky areas and that have profound influence on the eventual “state” of the Netherlands.

Eventually, after a 5m SLR in 100 years, the geography of the Netherlands will probably be quite different from its current shape, according to the outcome of the workshop. This conclusion was assumed to hold under two quite different socio-economic futures. For both futures, we wrote a story about possible and plausible events. Of course, the more detailed the

scenario the less the probability it will come true. On the other hand, each added detail contributes to the persuasiveness of the scenario. Scenarios have the purpose to sensitise the public to the message conveyed by the scenario. The message of our scenarios is that under a fast 5m sea level rise, the territorial integrity of current the Netherlands will likely be lost and many people will live in other places than they would without such SLR.

Article 2 of the U.N. Framework Convention on Climate Change requires countries to avoid "dangerous anthropogenic interference with the climate system". This could mean that we must try to avoid that the climate system changes in such way that conditions for human life are at risk. If millions of people will have to leave their residences, the latter could become reality, at least in the low elevation areas.

Our scenarios are useful in two ways. Firstly, the community of coastal zone and hazard management may come to reflect on the implications of 5 m sea level rise in their area and take account of such future in policy discussion development; after all, it is not at all certain that the scenarios would come true, and foresights might counter worst-case scenarios.

Secondly, these scenarios can be used in climate change policy (i.e. greenhouse gas emissions abatement) analysis. In that context, it is assumed that there are possibilities to avoid a 5m sea level rise and the questions is then to what extent it makes sense to exploit such possibilities (e.g. greenhouse gas emission reduction). In other words, the question is what is at stake with the assumed 5m sea level rise vis-à-vis the possibilities for climate change policies.

Obviously, however, the very first conclusion from our results is that they provide grounds to further investigate the physics of the WAIS, and other potential sources of important climate events such as the melting of the Greenland Ice Sheet (GIS), in order better assess how such "events" might evolve over time. In addition, given the expectation that the rate of social processes (e.g. social learning) would limit adaptation, the study of the latter is at least equally useful.

Acknowledgement

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Table 1. Workshop participants and their discipline

- Civil servant Ministry of Transport and Water management. Strategic planning.	- Social psychologist; public reactions to environmental risk.
- Civil engineering company; consultant to water management development.	- Professor of political science; stakeholder analysis.
- Former politician and secretary of state of the Ministry of Transport and Public Works. Geography background.	- Economist of Dutch Bureau for economic policy analysis. Long-range economic scenario construction.
- Senior civil engineer of major dike engineering firm.	- Landscape architect of a major consulting firm for land use planning.
- Professor of environmental economics. Climate change policy analysis.	- Civil servant of the Rotterdam Harbour Authority. Strategic planning.
- Environmental social scientist; stakeholder analysis (chair).	- Environmental sciences; climate change risk analysis.

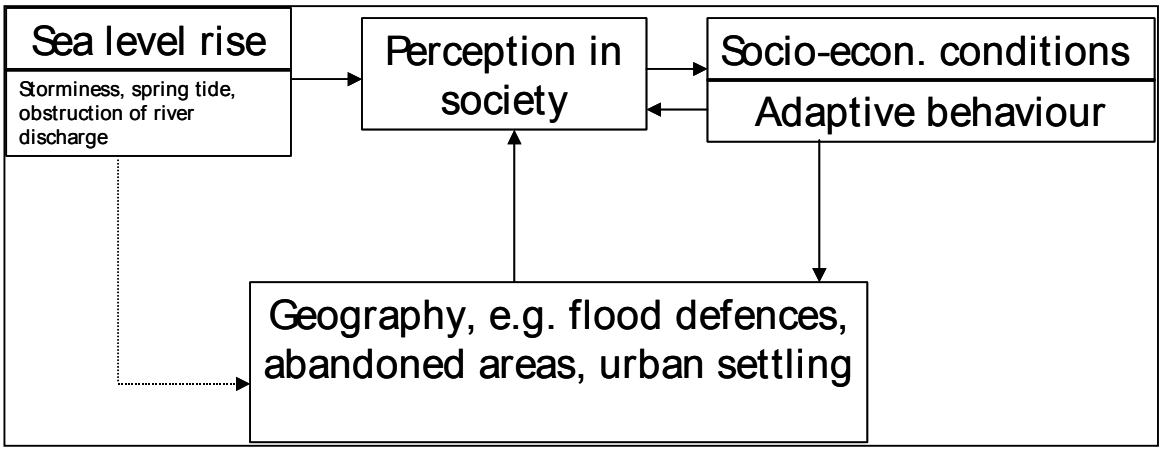

Figure 1. A conceptual model of "the Netherlands as a whole" under sea level rise.

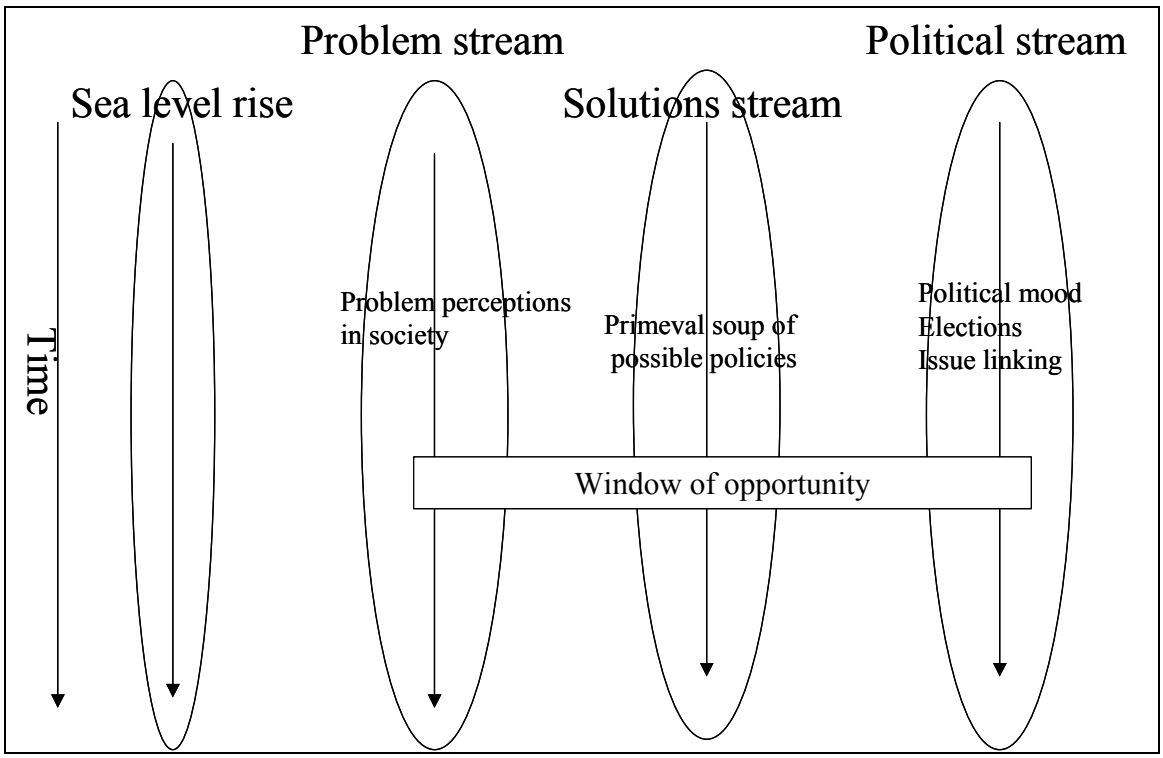

Figure 2. The Kingdon model as a guide for scenario building.

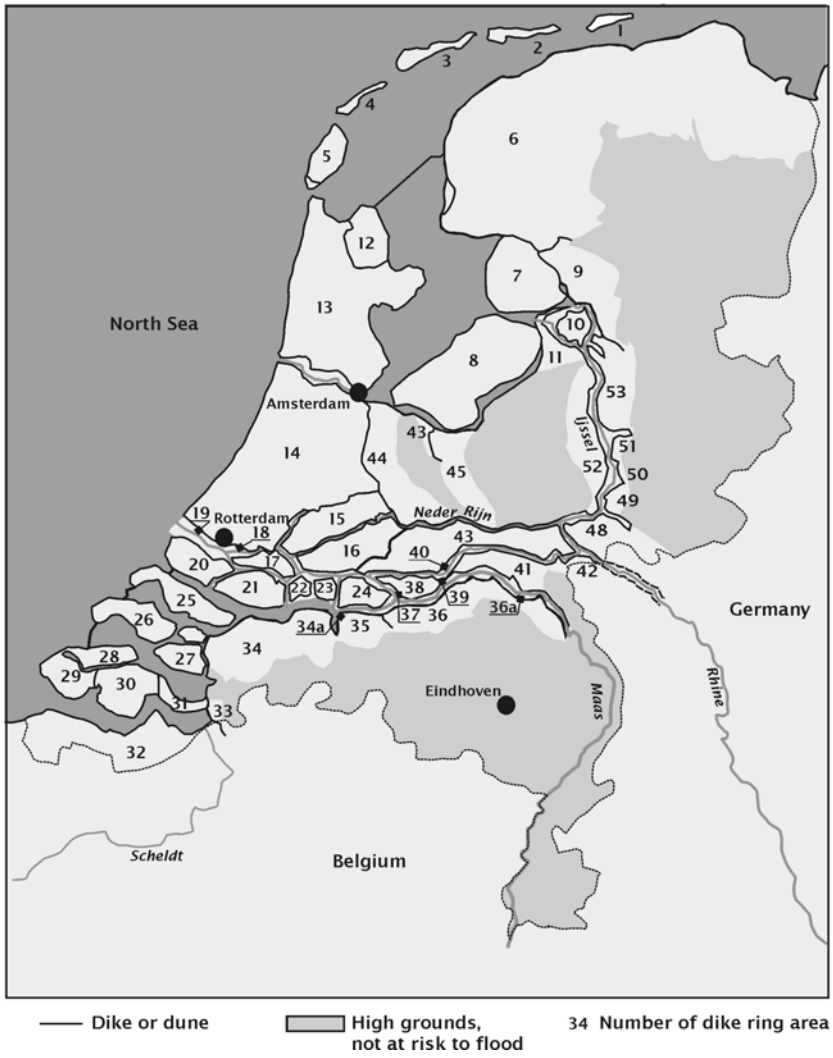

Figure 3. Distribution of flood risks across the Netherlands.

Table 2. Costs, benefits and avoided damage of six major flood control works (all in million €)

Projects to enhance flood safety at currently foreseen climate change and sea level rise (1m)	Annual costs* (M€)	Annual benefits (M€)	Potential damage (M€)
Retention basins (excess water storage) (Upper Rhine)	11	118	
Dike heightening and reinforcement (Upper Rhine)	23	118	
Moving river embankments/dikes (widening floodplains)	16	27	136
Heightening and reinforcing coastal defences	369	1,739	480,018
Enhancing discharge capacity lower Rhine delta	152	908	1,090

*) Annualised capital costs (4% interest rate) and annual maintenance costs.

Table 3. Two opposing trends in socio-economic developments

Markets prevail	**Public institutions**
Emphasis on decentralised co-ordination	Emphasis on centrally led co-ordination.
Directed at economic efficiency	Directed at equitable distribution of resources.
	Income redistribution.
Preference for the market as a means	Centralised co-ordination of public services
distribution of "public services"	
People and business do migrate relatively	People (and business) are attached their
easily. Footloose society.	surroundings and do not migrate easily
Public services privatised. The Night-watch	Strong influence of governments on public
state.	services
Values of self-enhancement are predominant.	Self transcendence is a dominating value
Individualism	
Development of international institutions for	National sovereignty prevails
economic policy co-ordination	
Role of government limited to safeguarding the	Strong role of the public sector in
working of markets.	redistributing welfare

Table 4 Sea level rise starts to accelerate. 2030-2050.

	2030 to 2050	
	Markets	Public institutions
Geography	Serious near floods do occur. Elsewhere in the world serious disaster occur. In 2049, the heart of Holland narrowly escapes from a major flood disaster after a coincidence of high discharge of the river Rhine, spring tide and strong gale from the West.	Serious near floods do occur. Elsewhere in the world serious disaster occur. In 2049, the heart of Holland narrowly escapes from a major flood disaster after a coincidence of high discharge of the river Rhine, spring tide and strong gale from the West.
Economy and demography	Population growth from immigration. Share of elderly decreases. GDP increases from 1.60 to 1.98 of its 2000 level. Globalisation continues. Firms easily move around.	Population does not alter. Share of elderly decreases a bit. GDP increases from 1.29 to 1.48 of its 2000 level.
Problem stream	Initially little public belief in warnings of scientist. By the end of this period it is accepted that there is accelerated SLR, without consensus of its rate and level. After the 2049 event, flood safety is high the political agenda.	Somewhat more belief and support to at least discuss the problem. Relatively more fear. By the end of this period it is accepted that there is accelerated SLR, without consensus of its rate and level. After the 2049 event, flood safety is high the political agenda.
Solutions stream	After the near-flood, measures proposals will be presented to protect the industrious heart of Holland (Rotterdam, The Hague, Amsterdam). In addition, there are Peripheral (non-governmental) initiatives. Discussion about wide range of solutions (including giving up). Cost-benefit approaches dominate. Little expectation about (financial) "Brussels".	Government tend to say problems are manageable. Research of technical solutions. Resistance to the idea of giving up land. Environmental implications of approaches – loss of "nature" - prompt public debate. Start of a "*Maatschappelijke discussie*" (national discussion) in order to mobilise support to a new Delta plan. "Brussels" (i.e. other European countries) is sympathetic but little money is available.
Political	Political confusion and arguments. Political	Political confusion and arguments. Political

stream	stratification along geographically distributed interests. A decision, after the near flood incident, to protect the high assets-at-risk areas.	stratification along notions of solidarity.

Table 5 Accelerated sea level rise becomes a major concern

	2050 to 2070.	
	Markets	Public institutions
Geography	In a lifetime, SL will have risen to 1 or 2 m above former SLR. Frequent problems with rivers. In 2068, there is a serious dike breach north of Amsterdam (near Petten). A large part of the province of North Holland is flooded. There are many victims.	In a lifetime, SL will have risen to 1 or 2 m above former SLR. Frequent problems with rivers.. In 2068, there is a serious dike breach north of Amsterdam (near Petten). A large part of the province of North Holland is flooded. There are many victims.
Economy and Demography	GDP will augment to 2.5 times the level of 2000. The sector "Water management and water defence engineering" flourishes.	GDP will accrue to 1.6 times its level in 2000.
Problem stream	Problems will be manifest. Frequent floods and transport interrupts. Flood safety in the front of the public mind. The WAIS is now well understood. Doubts about feasibility of protection starts. The possibility of abandoning land (polders) vis-à-vis the great sea level rise enters the public mind. Blaming starts. Some fatalism. Economic paralysis is seen as a danger. The frame of mindsets, however, is European. Only few see the problem as being "the Netherlands as a culture" at risk. Serious flooding of Venice. Venice is abandoned. Entrepreneurs of the tourist industry buy what is left of Venice and start flood protection schemes.	Problems will be manifest. Frequent floods and transport interrupts. Flood safety in the front of the public mind. The WAIS is now well understood. The possibility of abandoning land (polders) vis-à-vis the great sea level rise enters the public mind. There are public calls for concerted action, with reference to the Delta plan of 1960 and Dutch identity, after all in the second half of 20th century dikes were heightened with about 5m. Local resistance against abandoning land gains strength. Venice becoming uninhabitable becomes a public item all over Europe. The public asks for European approaches and European solidarity.
Solutions stream	Strategies being discussed will be based on agreed-on predictions of SLR and now include the possibilities of permanent evacuation. Research	Strategies being discussed will be based on agreed-on predictions of SLR. Strategies aim at protecting most of the Netherlands as a whole. Constitutional

	after finding solutions elsewhere, e.g. using the Quattara Depression in the Egyptian desert (140m below SL) as a spillover basin (similar basins elsewhere). Private sector reacts. Firms seek commercial opportunities vis-à-vis the prospect of climate change. Civil engineering firms propose solutions. Other individuals/firms react by leaving areas at risk. Emigration. Uncertainty and paralysis prompts demand for strong leadership. Technical once-and-for-all solutions prevail.	law saying the government must protect its inhabitants is more important rationale than welfare (i.e. cost-benefit considerations). Programmes are started to enhance the civil engineering capacity. Strategies include new concepts for urban areas that occasionally might be flooded and consider the option of temporary evacuations. Roads will be elevated and become functional to flood protections and places for emergency evacuations. New development schemes to be constructed on mounds. The possibilities of permanent evacuation are hardly discussed.
Political stream	Being at risk to flood hazards becomes an important element in politics. Lowlanders and highlanders become political groups and divide. After the 2048 flood disaster of 2048 the government decides on a cost-benefit guided strategy to re-engineer flood defences. The southwest and the north of the Netherlands will experience lower safety standards. Cities will be protected; agriculture must be abandoned.	After the flood disaster of 2048 the government decides for a patch work of projects to preserve as much as possible of the Netherlands, with reference to the Dutch history of dealing with "water". Catch word: The Dutch Archipelago.

Table 6. Sea level rise is completed 2070-2130

	2070-2130	
	Markets	Public institutions
Geography	At the start of this period, the geography of the Netherlands is not very different from before. At the end of this period the currently scarcely populated areas are submerged.	At the start of this period, the geography of the Netherlands is not very different from before. Later on some areas become less safe, and some nasty floods occur.
Economy and demography	Agriculture has become a minor sector. After the floods and with a view of further SLR investments in the vulnerable are affected. People start to emigrate out of fear for flood. House market is affected. Economic development starts to lag behind average development across the world. Economic resources diminish.	Agriculture and other rural activities is still an important sector, politically.
Problem stream	There is little belief in the possibilities of flood defences anymore after the disaster of 2068 (which put the flood safety in front of the public mind). Since businesses stop to invest in the areas at risk, the problem becomes associated with economic policy issues. Conservation of nature competes requirements of new housing schemes in safe areas.	There is still belief in the possibilities of flood defences anymore after the disaster of 2068. Insurance is believed to reduce the problem. Examples of foreign projects to preserve vulnerable areas, e.g. Venice, support the opinion that structural solutions are possible. As time progresses, disasters elsewhere in the world undermine confidence. Some floods in the Netherlands undermine belief in structural safety.
Solutions stream	Economic efficiency (cost-benefit) is and important concept and used to analyse options of responses. Solutions that allow high flood probability, but little loss of personal safety by contingency planning are considered as well.	Solutions are being discussed that comply with the will/vision to preserve Dutch identity. Given the expected fast rise of the seal level and the time required constructing adequate flood defences, it is accepted to construct works that only give limited

	Abandoning areas as a strategy is increasingly put forward as an option. Agriculture is considered less important. Arrangements to compensate SLR-refugees sought in Brussels.	structural safety. Vulnerable areas become fragmented by works. Contingency planning becomes an important part of flood safety. Evacuation and, eventually abandoning of areas, become solutions that are proposed.
Political stream	The victims of economic depression and "lowlanders" form a strong political coalition. They are able to postpone major decisions on abandoning. Eventually, the lowlands become less powerful and decisions are made to abandon the less valuable and vulnerable areas.	The high costs of structural works become a political issue. Eventually, after floods that have impact because of failing contingency planning, decisions are made to abandon vulnerable areas.

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Research Unit Sustainability and Global Change

Hamburg University and Centre for Marine and Atmospheric Science

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