The Netherlands: Challenges for the 21st century

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Summary

A paradigm shift in the approach to water and coastal management represents a major challenge. This shift is needed to implement some of the far-reaching recommendations of the Second Delta State Committee (2008). It is using integrated planning and cross-sectoral strategies based on the two pillars of safety and sustainability.
The principle of 'Working with nature' is used for flood protection in coastal environments. Annual sand nourishment is standard in the Netherlands since 1990 and an economically viable way to protect the mainly sandy coast. It increases coastal resilience and provides a flexible response to the uncertainties of future sea level change.
Implementing a 'Working with nature' approach in areas protected by dikes is also possible but more complex.
The Second Delta State Committee has also developed a vision for water management beyond 2100. This is needed to prepare adaptive measures dealing with increasing risks related to increased population and capital investments, and the envisaged impacts of climate change.
Long term, adaptive measures ask for special institutional arrangements and reserve funding. The key to enable future livelihood for the inhabitants is to combine management plans for rivers, sea, coast and land, based on a dared and comprehensive vision.

1. Introduction

Recently a government State Committee (Second Delta State Committee, 2008) was chaired by former Minister Veerman, see CCC Statements. The Committee made recommendations for making the Netherlands flood proof over the next 100 years and beyond. In response to the potential impacts of climate change, to keep the country an attractive place to live, work, recreate and invest there was a need for a new vision. This involves an integrated approach with a strategy based on the two pillars of safety and sustainability. Fresh water and adequate drainage issues were also addressed. This chapter highlights the main triggers for concern and the paradigm shift needed to implement some of the far-reaching recommendations.

2. Triggers for concern

About 9 million inhabitants, 60 % of the Dutch population, live directly behind dunes and dikes. Most live on land that is below Mean Sea Level (the lowest polder is 6.7 m below MSL, located in the densely populated Province of South Holland). The deltaic plain has high levels of productivity. It provides about 65 % of GDP (Gross Domestic Product). Holland is the second largest exporter of agricultural produce in the world. Large infrastructures, like sea- and airports, situated close to the North Sea are vital hubs for international transport. Rotterdam harbour and the international Schiphol airport deliver 13 % of GDP. The airport is located at 4.5 meter below Mean Sea Level (MSL). These factors pose challenges to economic sustainability and effective space utilisation. Climate change, notably sea level rise, will increase the threat to these low-lying areas.

Socio-Economic pressure

The GDP, US$ 860 billion in 2008, ranks the Netherlands as the 16th largest economy in the world. The GDP per capita, an indicator for economic wealth, is growing considerably and constantly over a long period of 45 years with an average rate of more than 4% per year (Figure 1) and requires a high level of capital investment. Population and economic growth increases the demand for space for housing and industry. Given the low-lying nature of the densely populated land and the high level of capital investment, preventing erosion and flooding is a major concern.

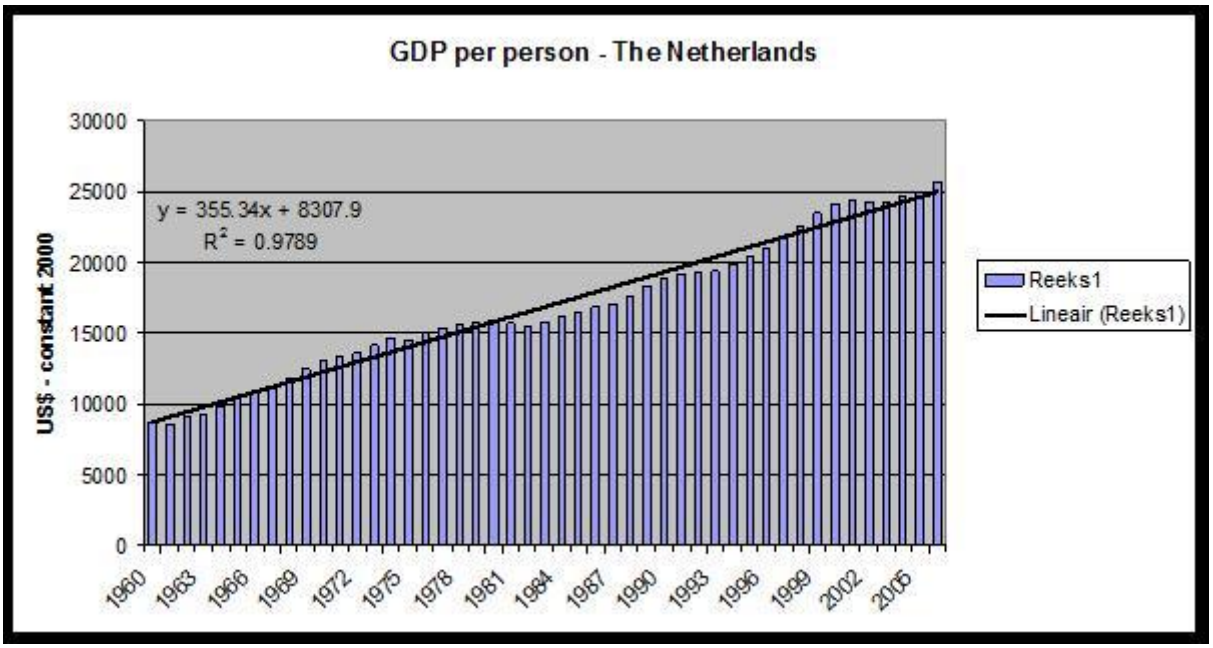


Figure 1: ***Time series of GDP/capita*** *in constant 2000 US$. (source: R. Misdorp based on WRI - Website).*

Population density in the Netherlands is among the highest of the world.
The most densely populated region of the Netherlands is the province South-Holland (2,800 km^2) with an averaged density of more than 1200 inhabitants/km^2 (Figure 2). The areas with the highest density have 75% of the inhabitants living in an urban environment. The rate of increase in the population has been about 1% per year, over a relative long period: 1950 – 2008 and continues to grow.

A strong and growing demand for houses has an increasing spatial footprint. The population increased by a factor 3 during the period 1921 – 2008, while national housing stock increased tenfold (CBS - Statline) in the same period. By 2008, there were 7 million houses with a roughly estimated capital value of about 1,5 € trillion being three times GDP.

Figure 2: ***Population density in the 12 provinces of the Netherlands,*** *inhabitants/km^2 in 2008. (source: CBS - StatLine).*

Climate change, notably Accelerated Sea Level Rise (ASLR) and increased storminess will enlarge coastal erosion and the frequency and severity of coastal and river flooding. Increased salt-water intrusion and changes in rainfall effecting river discharges will also affect the coastal areas. The rates of ASLR estimated by IPCC (mid SLR scenario: 45 cm by 2100, IPCC-Fourth Assessment Report 2007) may be conservative. Results of ongoing glaciological research particularly in Greenland suggest that higher ASLR estimates should not be excluded.

To establish a long-term view the 2008 Delta Committee has based its advice on the most recent scientific findings. The Committee asked a team of national and international climate experts (including IPCC authors) to provide the best estimate of expected global and regional sea level rise and rainfall intensity. Their updated results suggest a rate of sea level rise varying from 0.65 to 1.3 m by the year 2100 and 2 – 4 m by 2200.

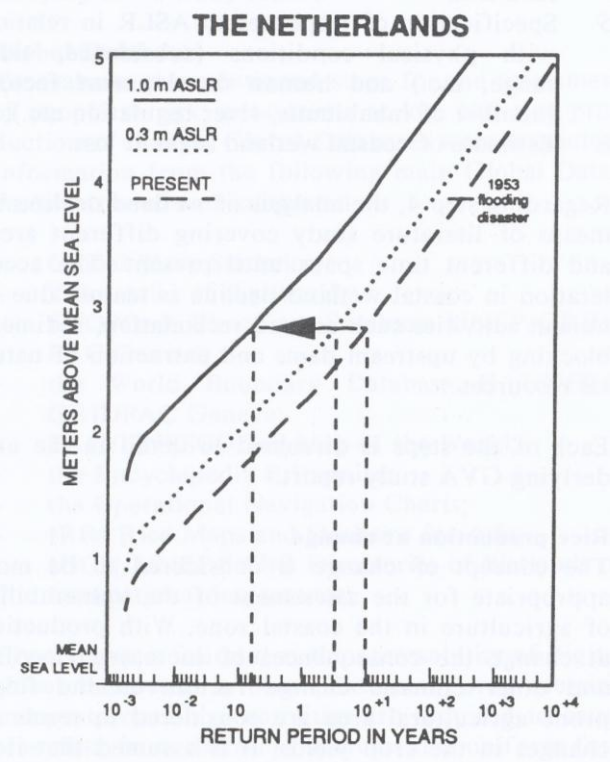


Figure 3: ***Frequency of high water*** *levels (Hoek van Holland tidal gauge station) at the year 1990, and with 0.3 and 1.0 m sea level rise. (source: IPCC-CZMS, 1992)*

A rough assessment of high-risk impacts of sea level rise for the Netherlands coastal zone suggests that the increase in frequency of high water levels due to a 1m ASLR can be considerable :
The rate of occurrence for giving 2.8 m above MSL at Hoek van Holland could increase from once in the 10 years in the years 1990 to 4 times per year under a 1 m ASLR scenario (Figure 3).
Because of the present uncertainties the Committee found it prudent to explore and adopt the upper limits of the impacts of climate change. This to prepare decision-making on long-term adaptations to sea level changes aiming to achieve 'no regret measures' while increasing resilience of the coastal system.

Increasing temperatures and changes in atmospheric circulation will alter precipitation patterns. Warmer drier summers will decrease river discharges affecting navigation and together with Accelerated Sea Level Rise, increasing salt-water intrusion. The expected summer drought conditions can also affect the supply for drinking water, agriculture, horticulture and industrial processes. Wetter winters may on the other hand increase discharge from the main rivers and with it the risk of flooding. The adaptive measures needed to counteract these effects require integrated planning (see also CCC I-2-1).

3. Paradigm shift

The paradigm shift in the approach to water and coastal management, observable over the last few decades, represents a major challenge. This focuses on adopting principles of 'Working with nature' using integrated planning and cross-sectoral strategies. The following section illustrates some of the issues and dilemmas involved.

'Working with nature'
In a critical evaluation of the morphological, ecological and socio-economic effects of the Delta project, following the 1953 flood disaster, Saeijs *et al.* (2004) advocate "Working with nature" in any flood protection project in estuarine and coastal environments. They provide a number of recommendations:
(1) If there is a choice, leave undeveloped estuaries and deltas alone;
(2) If there is a history of human intervention, adopt the most flexible approaches to delivering safety and development;
(3) Apply reversible and local measures taking account of natural processes.

The recommendations of Saeijs *et al.* (2004) based on the principles developed by Waterman (CCC III-3-3) are largely in line with today's policy. Annual sand nourishment is applied in the Netherlands since 1990 and is an economically viable way to protect the mainly sandy coast. This increases coastal resilience and provides a flexible response to the uncertainties of future sea level change.

Implementing a "Working with nature" approach in areas protected by dikes is more complex. Sea dikes may hamper natural processes, but intentionally breaching sea defences, however environmentally desirable, is difficult from sociological or economic viewpoints. This 'reintegration with the sea' has taken place in some areas; however, it is a time-consuming activity. For example, along the Western Scheldt, opening a polder to increase the natural values of the estuary as a compensation for the increased dredging regime of the navigation channel to Antwerp, demands extensive and in depth consultations with local stakeholders.

On the other hand, the fact that the present protection standards are over 40 years old and have not evolved with the increase of economic values of areas requires a fundamental debate on the safety levels and risks especially for those areas with high population densities. (Jonkman, 2007; Ten Brinke and Bannink, 2004) .
Such debates are not trivial (Saeijs *et al.* 2004).

4. Recommendations of the Second Delta State Committee (2008)

The Second Delta Committee made recommendations on protecting the Netherlands from flooding over the next century and beyond. Unlike earlier committees, established after flood disasters such as in 1916 (Committee Lely) and in 1953 (the First Delta Committee) this Committee was not established in the wake of a disaster. However, there are serious issues requiring urgent action, due to:

- The need for increasing safety levels up to the new standards as demanded by the changing society;
- The increase in capital investment and growing population in low-lying areas;
- The growing awareness of the potential effects of climate change, especially the acceleration of sea level rise.

The Second Delta Committee underpinned the premise introduced by the First Delta Committee (1953) that a risk-based approach is appropriate.

Figure 4: ***A water management vision*** *for the low lying Netherlands: rivers, lakes & coast, with coherence between the regions (source: the Second Delta State Committee - 2008).*

The Second Delta Committee has developed a vision beyond 2100 for water management of the entire country. Such a long-term vision is needed in order to prepare Dutch society for the impacts of climate change. In the short term, the Committee has recommended specific actions, notably to increase the level of safety against flooding and subsequent adjustment of coastal defences.

Risk approach

The hydraulic mega-structures introduced by the First Delta Committee are impressive. One of the most visionary aspect of the Delta Works, however is the statistical approach that guided the designs. How high should one build the levees? How strong should a surge barrier be? The Dutch decided to base their answers not merely on the premise that storms are destructive and the Netherlands low-lying, but also on economics. With the help of the Dutch mathematician David van Dantzig, the 1953 task force calculated safety levels using an equation sealed into the minds of Dutch engineers:

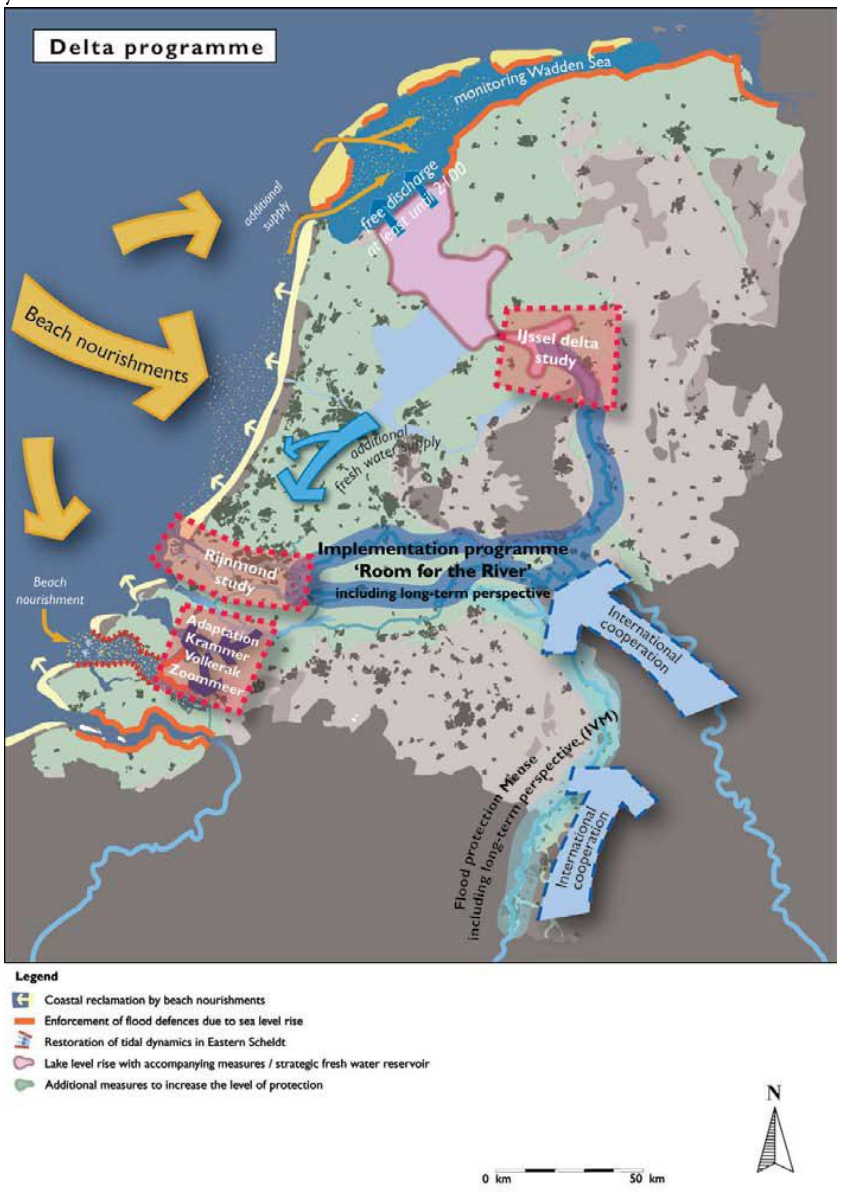
risk = (probability of failure) x (projected cost of damage)

This kind of risk analysis is so common today in fields like nuclear power, aerospace, and chemical manufacturing. In the 1950s, accounting for the projected cost of damage when developing flood protection was novel. The power of this formula is that it produces a simple cost - benefit analysis. Dutch law now requires the use of this principle to determine the strength of flood defences throughout the country.

An example is the dune area at Ter Heijde located SW of The Hague (see Figure 5), between the sea and a vulnerable, but economically vibrant area

Figure 5: ***Air-photo of the coastal zone*** *of Westland near Ter Heyde with settlements, greenhouses directly behind the protecting dunes. (photo: //beeldbank.rws.nl)*

with a high level of capital investment, towns, horticulture (green houses) where a protection from a 1:10,000 year flood event is called for.



In more pastoral parts of the country, much lower standards are required.

Updating the standards

The standards for assessing flood risk needs adjustment (Jonkman et al., 2003). The Second Delta Committee recommended an increase in protection level by a factor of ten. This new level will be a minimum for densely populated areas, facing increasing levels of risk as the population and capital investment continue to grow.

Figure 6: ***Adaptive measures under the Delta Programme*** *of the Second Delta State Committee: Rivers, lakes, sea and coast combined in an integrated vision with concrete measures safeguarding livelihood in the future.*

(source: the Second Delta State Committee - 2008).

Climate change

The main message from the Committee is that the Netherlands can withstand the higher rates of sea level rise and changes to river discharges resulting from climate change. The proposals from the Committee are feasible and there is enough time, knowledge, finance and legal instruments to achieve them. The measures in the river flood plain for instance are built on the long term perspectives, the concepts and results of the "Room for the River" programme (see "Room for the River" website).

Moreover, the adaptive measures proposed will also result in a richer natural environment and higher socio-economic values. If the rate of sea level rise is lower than expected, there is flexibility to delay or temper measures and adjust expenditure.

Three examples of adaptive recommendations:
provided by the Delta Committee in the Delta programmme, are:

I. Raise the water level of lake IJsselmeer

IJsselmeer is the largest lake in the Netherlands and fed mainly by the river IJssel, a tributary of the Rhine (see Figure 4). Regulation of the water level of this fresh water lake is by gravity flow through sluices. The excess water flows through the sluices to the Wadden Sea, which has an open connection to the North Sea. Presently, at low tide, there is enough height to allow gravity to drain excess water from Lake IJssel. This will cease to operate as sea levels rise. A plan to increase the enclosure height will raise the lake water level by up to 1.5 m by 2050. This will ensure gravity-driven drainage from IJsselmeer into the Wadden Sea beyond 2100. It will also provide the Netherlands with an extra reserve of fresh water for irrigation in times of summer droughts. In the mean time, this extra water will help combat salt water intrusion resulting from ASLR. Moreover, a feasibility study will provide more insight whether sustainable 'fresh-salt' energy can be generated in the fresh-salt water system near the 1932 Closure (IJsselmeer) Dam (see box).

Figure 7: ***The 32 km long Closure (IJsselmeer) Dam*** *separating the salt Wadden Sea water from the fresh IJsselmeer water.*
(photo: // beeldbank.rws.nl)

Box: Fresh-Salt sustainable electric energy generation (Second Delta State Committee's full report)

A new development, combining sustainable energy with increased fresh water reserve, generates energy from the difference between salt and fresh water. This can generate electricity uses a membrane to separate fresh from salt water. Two basic conditions are needed:
1) Both fresh and salt water must be present;
2) A guaranteed, adequate supply of fresh water (the plant needs about 2 m3/s of fresh water per MWh).
If these preconditions are satisfied, then this sustainable source of energy in principle offers the great advantage of a continuous, on-demand electricity supply. A study is now being conducted into the possibility of a future 'fresh-salt' generator (200 MW max.) near the Closure (IJsselmeer) Dam. If this were to be built, it would supply approximately 1% of all power generated in the Netherlands. This, would be enough to cover the electricity demand of the entire water management sector in the Netherlands. It is an inviting prospect: the flood defence as a source of energy .

II. Extend the coast seawards

Off the coasts of Zeeland (South western Delta area), Holland and the Wadden Sea Islands, flood and erosion protection will continued to consist of sand nourishment. This approach may include land reclamation extending the coastline by as much as 4 km, adding about 1000 km^2 to the country. This will require a considerable volume of sand to be extracted from the North Sea. The ecological, economic and energy implications of the extraction of such large volumes must be investigated at short notice.

III. Create an 'open-closable' water system in Rijnmond

For the Rijnmond, the mouth of the rivers Rhine and Meuse an open system, which can be closed in emergencies offers good prospects for combining unhindered shipping, protection against flooding, urban and nature development.

An extensive network of dams, dikes, and dunes protects Rotterdam, Europe's busiest port (CCC I-2-2). The new plan would strengthen this system, raising the height of existing structures and adding four giant flood barriers to improve fresh water management (see Figure 8: #2).

Rerouting extreme discharges from the Rhine and Meuse will be via the South western part of the delta. Fresh water for the Western Netherlands will be supplied from the IJsselmeer during summer. The necessary infrastructure has yet to be built. Space must also be created for local water storage in polders (see Figure 8 in CCC I-2-1). Further research into the design of the new 'open-closable' Rijnmond system will take place soon.

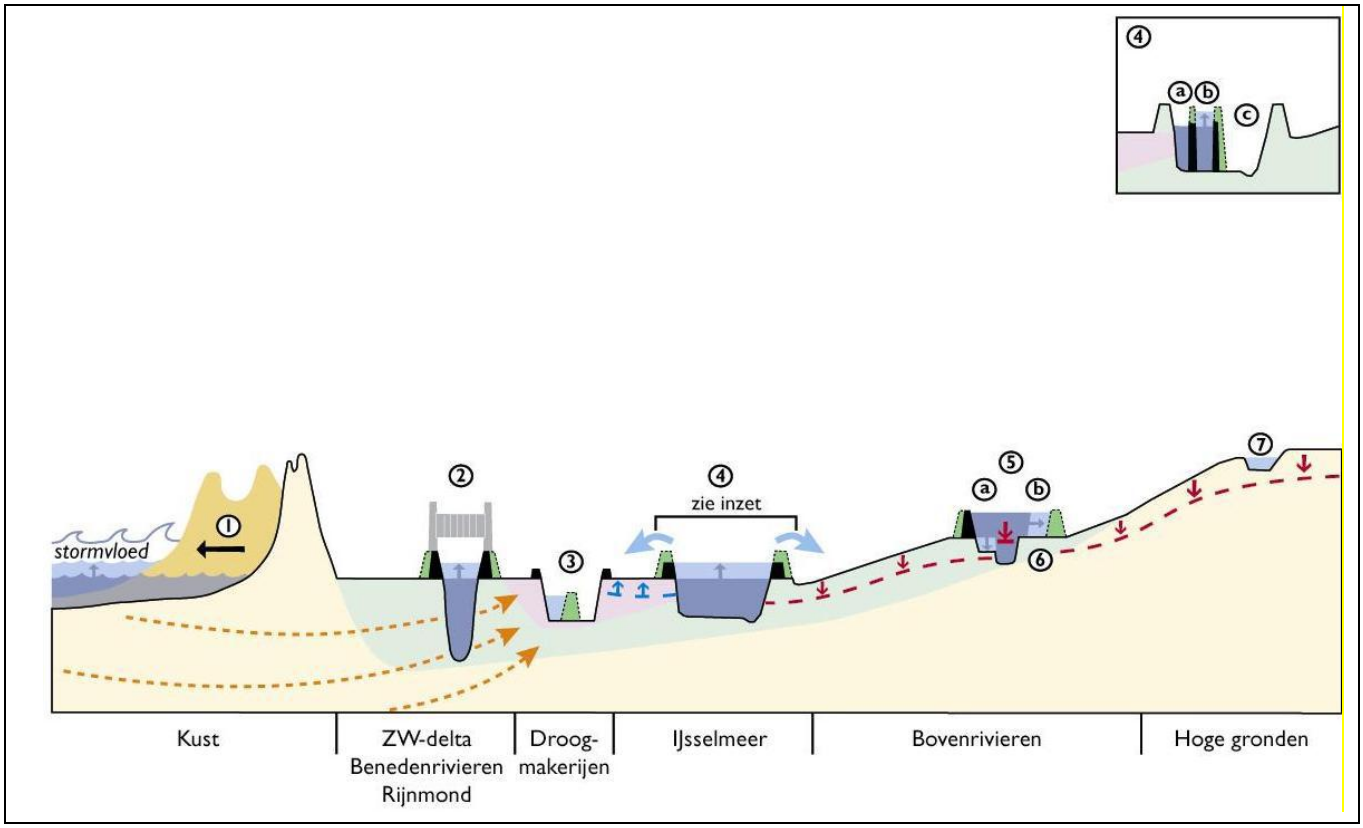


Figure 8: ***Some of the proposed adaptive measures for the Netherlands*** *:*

- *Sea ward extension of the dune areas as an offensive defence (#1),*
- *Heightening of hard structures and adding flood barriers in the lower part of the Netherlands #(2),*
- *Heightening the level of the IJsselmeer in order to safeguard enough irrigation water during periods of droughts (#4), combating increased salt water intrusion - red dotted arrows in the coastal zone.*

(source: the Second Delta State Committee - 2008).

Special institutional arrangements will help keep the government's attention in offering realistic, short and long term, sustainable solutions. Such arrangements include the establishment of one over-arching organisation to consider the response to more extreme flooding and droughts.

A *Delta Act* will anchor the political-administrative organisation and funding, within the present system and the current legal framework. Arrangements should encompass the organisation of long-term financial commitments whatever government is in power. The Committee has addressed this important concern in its last, 12 th Recommendation: a *Delta fund* (estimated at 1.5 billion € per year) should be reserved until 2100 to execute the *Delta program.*

For more information, see the website of the Second Delta Committee.

5. Conclusions

The Dutch take the threat of global warming seriously. The proposed adaptive measures will probably withstand future impacts of sea level rise and changes in river regimes. However, special additional arrangements will be required to increase the resilience of the coastal zone:

- Because of the increased risks the Second Delta State Committee is of the opinion that the society should be prepared for a worst case scenario, e.g. 1.3 m ASLR during the 21 st century and 2- 4 m rise during the 22nd century;
- Increased flooding risk can be counteracted by extended beach nourishment and seaward land reclamation. This also provides greater protection and creates more space in the densely populated coastal zone;
- Increasing the level of the largest lake of the Netherlands, the Ijsselmeer, will help combat flooding and salt-water intrusion, and provide irrigation water in future and may generate sustainable electric energy;
- For realisation of the long-term vision, there is a strong need for special institutional arrangements and long term reserved funds;
- The continuation of systematic monitoring of natural coastal processes and socio-economic development is a prerequisite for sound decision making to ensure flood protection and sustainable development of the Dutch resources.

6. References

- **Ten Brinke W.B.M., Bannink B.A., 2004**: *Risico's in bedijkte termen, een thematische evaluatie van het Nederlandse veiligheidsbeleid tegen overstromen*, (English translation: Dutch dikes and risk hikes. A thematic policy evaluation of risks of flooding in the Netherlands); RIVM rapport 500799002; Beleidsmonitor Water, 242 p ; (http://www.rivm.nl/bibliotheek/rapporten/500799002.html)
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- **Saeijs, H.L.F., Smits, A.J.M., Overmars, W, & Willems, D., 2004**: *Changing Estuaries, Changing Views.* Erasmus University Rotterdam, Radboud University Nijmegen
- **WB-21, 2000:** *Water policy for the 21th century* (In Dutch); Advies van de Commissie Waterbeheer 21 e eeuw, Ministry of Transport, Public Works and Water Management and the Association of Water Boards, The Hague, 118 pp.

PDF Reports:

- **Second Delta Committee's Summary report:**
  www.deltacommissie.com/doc/deltareport_summary.pdf
- **Second Delta Committee's Full report:**
  www.deltacommissie.com/doc/deltareport_full.pdf

Website links

- **Room for the River-Programme Directorate, Rijkswaterstaat, Ministry of Infrastructure and the Environment:**
  http://www.ruimtevoorderivier.nl/meta-navigatie/english/

- **RWS/RIKZ – coastal aerial photography – the Netherlands:** http://www.rws.nl/rws/rikz/projecten/kustfoto/kustvak.html
- **Second Delta Committee** : www.deltacommissie.com/en/advies www.deltacommissie.com/en/film
- **Second Delta Committee - Additional information: "Before the Levees Break: A Plan to Save the Netherlands"**, via Wired Magazine 17.01**:** www.wired.com/science/planetearth/magazine/17-01/ff_dutch_delta?currentPage=all#
- **CBS - Centraal Bureau voor de Statistiek, Statline :** http://statline.cbs.nl/StatWeb/dome/?LA=NL)
- **WRI - World Resource Institute**: http://earthtrends.wri.org/searchable_db