

Working together with **water**

A living land builds for its future

Findings of the Deltacommissie 2008 | SUMMARY AND CONCLUSIONS



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SUMMARY AND CONCLUSIONS

DELTA  **COMMISSIE**



Foreword

One cannot conceive of the Netherlands without water. Through the centuries, and still today, the inhabitants of our delta have made great efforts to struggle out of the grasp of the rivers and the sea and it is this that sets our country apart. Situated at the mouths of four major, navigable rivers with access to all the seas of the world, in many respects our country is supported by the water. The sea and the rivers have shaped our identity and the country itself: its nature and landscape, its prosperity and economy, and the way it is governed (water boards; the polder model).

The disastrous floods of 1953 are still etched into our collective memory; in the very same month the Minister of Transport and Public Works set up a committee to examine, ‘which hydraulic engineering works should be undertaken in relation to those areas ravaged by the storm surge, (and) also to consider whether closure of the sea inlets should form one of these works.’¹ In their advisory report the first Delta Committee introduced the concept of risk-based flood protection, i.e. to consider the probability of flooding as well as the consequences when determining the optimum level of safety. In addition the implementation of the recommendations radically altered the appearance of the south-western Netherlands and secured its long-term safety. Construction of the ‘first’ Delta Works thus laid a solid foundation upon which to base the present recommendations. In recent decades considerable investments have also been made in the defence of the coastline of Holland, the Wadden Sea coast and the construction of river dikes. In the years to come, work will continue on the ‘weak links’ in the coastal defences and on the measures to create more discharge capacity for the rivers Rhine and Meuse through the implementation of the *Maaswerken* [Meuse Works] and *Ruimte voor de Rivier* [Room for the River] programmes.

A new Delta Committee

Climate change is now forcing itself upon us: a new reality that cannot be ignored. The predicted sea level rise and greater fluctuations in river discharge compel us to look far into the future, to widen our scope and to anticipate developments further ahead. For that reason the Cabinet appointed a ‘new’ Delta Committee, the Sustainable Coastal Development Committee, with the mandate to formulate a vision on the long-term protection of the Dutch coast and its hinterland.

Our mandate is broader than that of our predecessors in the first Delta Committee. At that time they were primarily concerned with ‘hydraulic engineering works’ to counter an acute threat. For us, the second Delta Committee, the threat is not acute, but our mandate is nevertheless urgent. There is absolutely no reason for panic, but we must be concerned for the

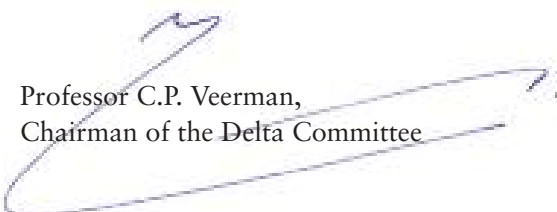


future. If we are to be well prepared for the expected consequences of climate change, we shall have to strengthen our flood defences and change the way our country is managed, both physically and administratively. Our Committee's mandate is therefore unusual: we have been asked to come up with recommendations, not because a disaster has occurred, but rather to avoid it. The nature of the advice requested is also unusual: to present an integrated vision for the Netherlands for centuries to come.

The challenge to the Netherlands in the coming centuries is not primarily a threat; it also offers new prospects. Changing the way our country is managed creates new options; working with water may improve the quality of the environment and offers excellent opportunities for innovative ideas and applications. Where there is water, new forms of nature can arise. Water can be used to produce food and generate energy. Flood defences can be used for roads.

The country we want to live in

The fundamental question, central to this report, is 'How can we ensure that future generations will continue to find our country an attractive place in which to live and work, to invest and take their leisure?' This advisory report sets down the conditions required for that desired future to become a reality. If these conditions are fulfilled, then as far as the Delta Committee is concerned we proceed right away, in both word and deed. After all, 'A living land builds for the future'.



Professor C.P. Veerman,
Chairman of the Delta Committee

1. Rapport Deltacommissie. Eindverslag en Interimadviezen. Deel 1, blz. 15 (1960) [Delta Committee Report, Final Report and Interim Advice, Part 1, p. 15]

Summary

The mandate ...

The government asked the Delta Committee to come up with recommendations on how to protect the Dutch coast and the low-lying hinterland against the consequences of climate change. The issue is how the Netherlands can be made climate proof over the very long term: safe against flooding, while still remaining an attractive place to live, to reside and work, for recreation and investment.

... and its interpretation

The task at hand, then, involved looking further than just flood protection. The Committee's vision therefore embraces interactions with life and work, agriculture, nature, recreation, landscape, infrastructure and energy. The strategy for future centuries rests on two pillars: flood protection and sustainability. The report also emphasises the opportunities for Dutch society/ the Netherlands as a whole.

Water safety

Water safety is at the centre of this report, and includes both flood protection and securing fresh water supplies. Achieving water safety prevents casualties and social disruption, while avoiding damage to our economy, landscape, nature, culture and reputation.

In their report, the Delta Committee assumes that a safe Netherlands is a collective social good for which the government is and will remain responsible. The level of flood protection must be raised by at least a factor of 10 with respect to the present level.

Opportunities for sustainability

The Committee's recommendations place emphasis on development along with climate change and ecological processes; thus, they are cost effective and produce additional value for society. The recommended measures are flexible, can be implemented gradually and offer prospects for action in the short term. Their implementation will allow the Netherlands to better adapt to the effects of climate change and create new opportunities. The recommendations made must be sustainable: their implementation must make efficient use of water, energy and other resources, so that the quality of the environment is not merely maintained but even improved.

Implementation: *The Delta Programme*

The Delta Committee has drafted the *Delta Programme* to implement its recommendations for a climate-proof Netherlands. The programme will be embedded, financially, politically and administratively, in a new *Delta Act*.

The mission is urgent

Implementation of the recommendations is a matter of urgency. The Netherlands must accelerate its efforts because at present, even the current standards of flood protection are not being met everywhere. Moreover, the current standards are out of date and must be raised, the climate is changing rapidly, the sea level is probably rising faster than has been assumed, and more extreme variations in river discharge are expected. The economic, societal and physical stakes in the Netherlands are great and growing still; a breach in a dike has seriously disruptive consequences for the entire country.

The Delta Committee concludes that a regional sea level rise of 0.65 to 1.3 m by 2100, and of 2 to 4 m by 2200 should be taken into account. This includes the effect of land subsidence. These values represent plausible upper limits based on the latest scientific insights. It is recommended that these be taken into account so that the decisions we make and the measures will have a lasting effect, set against the background of what can be expected for the Netherlands.

For the Rhine and the Meuse, summer discharge will decrease and winter discharge will increase due to the temperature increase and changed precipitation patterns. Around 2100 the maximum (design) discharges of the Rhine and Meuse are likely to be around 18,000 m³/s and 4,600 m³/s, respectively. Present design discharges are 16,000 m³/s and 3,800 m³/s.

A rising sea level, reduced river discharges in summer, salt water intrusion via the rivers and ground water, all put pressure on the country's drinking water supply, agriculture, shipping and those sectors of the economy that depend on water, for cooling or otherwise.

Scientific basis

The Delta Committee sought scientific advice on a number of aspects, which form part of the present recommendations. In summary, these are the findings of a group of national and international experts, including those close to the IPCC and Dutch experts on flood protection and water management. This group of experts has supplemented the latest insights into climate scenarios, and come up with new estimates of extreme values.

Cost

Implementation of the *Delta Programme* until 2050 involves a cost of 1.2 to 1.6 billion euros per annum, and 0.9 to 1.5 billion euros per annum in the period 2050–2100. Coastal flood protection in the *Delta Programme* is mainly achieved by beach nourishments. If this method is intensified so that the coasts of the Netherlands grow say 1 km in a seawards direction, thus creating new land for such functions as recreation and nature, it will involve an additional cost of 0.1 to 0.3 billion euros per annum.

Indicatie extra annual costs [billions of euros]	Period		Average
	2010 - 2050	2050 - 2100	2010 - 2100
<i>Deltaprogramme</i>	1,2 to 1,6	0,9 to 1,5	1,0 to 1,5
<i>Deltaprogramme</i> , with additional coastal space for other functions	1,3 to 1,9	1,2 to 1,8	1,2 to 1,8

Amounts in euros at 2007 price levels, including Dutch Value Added Tax (BTW).

Twelve recommendations for the future

The Delta Committee has developed an integrated vision for the future extending to 2100 and beyond. A long-term vision like this depends on national, European and global developments. Concrete recommendations for the short and medium term must be made, however, since direct action is needed now to raise the level of flood protection and to secure fresh water supply. The Delta Committee has formulated the following twelve recommendations for the short and medium term.

Twelve recommendations for the future

Recommendation 1 Flood protection level	Until 2050	The present flood protection levels of all diked areas must be raised by a factor of 10. To that end, the new standards must be set as soon as possible (around 2013). In some areas where even more protection is needed, the Delta Dike concept is promising (these dikes are either so high or so wide and massive that the probability that these dikes will suddenly and uncontrollably fail is virtually zero). With regard to specific or local conditions, this will require a tailor-made approach. All measures to increase the flood protection levels must be implemented before 2050.
	Post 2050	The flood protection levels must be updated regularly.
Recommendation 2 Plans for new urban development		The decision of whether to build in low-lying flood-prone areas must be based on a cost-benefit analysis. This must include present and future costs for all parties. Costs resulting from local decisions must not be passed on to another administrative level, or to society as a whole. They must be borne by those who benefit from these plans.
Recommendation 3 Areas outside the dikes		New development in unprotected areas lying outside the dikes must not impede the river's discharge capacity or the future water levels in the lakes. Residents/users themselves are responsible for such measures as may be needed to avoid adverse consequences. Government plays a facilitating role by giving information, setting building standards and warning for floods.
Recommendation 4 North Sea coast	Until 2050	Build with nature. Flood protection of the coasts of Zeeland, Holland and the Wadden Sea Islands will be continued by beach nourishments, possibly with relocation of the tidal channels. Beach nourishments must be done in such a way that the coast can expand seaward in the next century. This will provide great added value to society.
		Sand extraction sites in the North Sea must be reserved in the short term. The ecological, economic and energy requirements needed to nourish such large volumes must be investigated.
	Post 2050	Beach nourishments need to be continued with more or less sand, depending on sea level rise.
Recommendation 5 Wadden Sea area		The beach nourishments along the North Sea coast contribute to the adaptation of the Wadden Sea area to sea level rise. The continued existence of the Wadden Sea area as we know it at present is by no means assured, however, and depends entirely on the actual rate of sea level rise in the next 50 to 100 years. Developments will have to be monitored and analysed in an international context. The protection of the island polders and the North Holland coast must remain assured.
Recommendation 6 South-western delta: Eastern Scheldt	Until 2050	The Eastern Scheldt storm surge barrier fulfils the safety requirements. The disadvantage of the barrier is the reduction of flood and ebb volumes going in and out of the tidal basin and, as a result, the loss of the intertidal zone. This is to be countered by additional sand nourishment from outside (as from the Outer Delta).
	Post 2050	The life span of the Eastern Scheldt storm surge barrier will be extended by technical interventions. This can be done up to a sea-level rise of approximately 1 m (to be reached in 2075 at the earliest). If the Eastern Scheldt storm surge barrier is no longer adequate, then a solution will be sought that largely restores the tidal dynamics of its natural estuarine regime, while maintaining the desired level of flood protection.
Recommendation 7 South-western delta: Western Scheldt		This must remain an open tidal system to enable navigation to Antwerp and to maintain the valuable estuary. Flood protection must be maintained by enforcement of the dikes.
Recommendation 8 South-western delta: Krammer-Volkerak Zoommeer	To 2050	The Krammer-Volkerak Zoommeer, the Grevelingen and possibly also the Eastern Scheldt must be re-arranged to provide temporary storage of excess water from the Rhine and Meuse when discharge to the sea is blocked by closed storm surge barriers. A salinity gradient (a natural transition between fresh and salt water) in this area is a satisfactory solution to the water quality problem and can offer new ecological opportunities. In this case an alternative fresh water supply must be provided.

Recommendation 9
The major rivers area

- Until 2050 The *Ruimte voor de Rivier* [Room for the River] and *Maaswerken* (Meuse Works) programmes must be implemented without further delays. Subject to cost-effectiveness, measures must be taken already now to accommodate discharges of 18,000 m³/s for the Rhine and 4,600 m³/s for the Meuse. In this context negotiations with neighbouring countries have to be conducted under the *European Directive on the assessment and management of flood risks* in order to harmonise the measures. Furthermore, room must be reserved and, if necessary, land purchased so that measures can be taken in the future to safely discharge the 18,000 m³/s of Rhine water and 4,600 m³/s of Meuse water.
- 2050 - 2100 Completion of measures to accommodate Rhine and Meuse discharges of 18,000 m³/s and 4,600 m³/s, respectively.

Recommendation 10
Rijnmond
(mouth of the river Rhine)

- Until 2050 For the Rijnmond an open system that can be closed when needed ('closable-open') offers good prospects for combining flood protection, fresh water supply, urban development and nature development in this region. The extreme discharges of the Rhine and Meuse will then have to be re-routed via the south-western delta.
- The fresh water for the Western Netherlands will have to be supplied from the IJsselmeer lake. The necessary infrastructure will have to be built. Room must be created for local storage in deep polders. Further research into the 'closable-open' Rijnmond system should be initiated soon.

Recommendation 11
IJsselmeer area

- The level of the IJsselmeer lake will be raised by a maximum of 1.5 m. This will allow free discharge from the lake into the Wadden Sea beyond 2100. The level of the Markermeer lake will not be raised. The IJsselmeer lake retains its strategic function as a fresh water reservoir for the Northern Netherlands, North Holland and, in view of the progressive salt water intrusion in the Nieuwe Waterweg, for the Western Netherlands.
- Until 2050 The measures to achieve the elevated water level can be implemented gradually. The aim must be to achieve the largest possible fresh water reservoir around 2050. The measures needed to adapt the lower reaches of the river IJssel and the Zwarte Water to a 1.5 m higher water level in the IJsselmeer lake must be investigated.
- Post 2050 Depending on the phased approach adopted, follow-up measures may be needed to actually implement a maximum water level increase of 1.5 m.

Recommendation 12
Political-administrative,
legal, financial

1. The political and administrative organisation of our flood protection must be strengthened by:
 - ~ providing cohesive national direction and regional responsibility for the implementation (ministerial steering committee chaired by PM, political responsibility lying with the Minister of Transport, Public Works and Water Management, the Delta director for cohesion and progress and regional administrators for the implementation of the (individual) regional assignments);
 - ~ initiating a permanent Parliamentary Committee on the theme.
2. The financial means must be secured by:
 - ~ creating a Delta Fund, managed by the Minister of Finance;
 - ~ supplying the Delta Fund with a combination of loans and transfer of (part of) the natural gas revenues;
 - ~ making national funding available and drafting rules for withdrawals from the fund.
3. A *Delta Act* will embed the political and administrative organisation and funding within the present political system and the current legal framework. This must in any case include: the Delta Fund and its supply; the Director's tasks and authority; the provision that a *Delta Programme* shall be set up; regulations for strategic land acquisition; and compensation for damages or the gradual loss of benefits due to the implementation of measures under the *Delta Programme*.



Future-proof advice: conclusions

The Committee's mandate

The Committee was asked by the government to come up with advice on how to go about the planning and development of the Netherlands so that our country can be protected against flooding over the very long term, while still remaining an attractive place in which to live. Furthermore, the Committee was asked to look at consequences extending further than safety alone. It was also asked to investigate possible synergy with other societal functions, such as living and work, agriculture, nature, recreation, infrastructure and energy. The Committee can see an ocean of opportunities for combining different functions and interests with an approach to water safety.

The Committee has interpreted 'the coast' in very broad terms as comprising the entire low-lying area of the Netherlands. The Committee's advice concerns mainly the principal water system, in relation to and co-operating with spatial planning throughout the entire country.

An urgent matter

Given the state of a number of diked areas, the safety issue is urgent right now and, with rising sea levels, greater variation in river discharge, and a further growth of interests that need protecting, it will only become more so. A disastrous breach in a dike anywhere in the country would disrupt the entire country.

The current legal standards date from the 1960s. Currently about a quarter of all flood defences do not comply with the present standards, while we do not know whether a further 30%, roughly, are in compliance.

In the Delta Committee's view we should anticipate a sea level rise of 0.65 to 1.3 m in 2100 and from 2 to 4 m in 2200. This includes the effects of land subsidence. These values represent possible upper bounds; it is sensible to work with them so that the decisions made and the measures adopted will be sustainable over the long term, set against the background of what we can possibly expect.

Rising temperatures and possible changes in air circulation will lead to declining summer discharges and increasing winter discharges in the Rhine and the Meuse. There is a limited discharge capacity for the Rhine in Germany, which means that the upper Rhine discharge limit that the Netherlands can expect around 2100 may reach 18,000 m³/s. For the Meuse we should anticipate a design discharge of at most 4,600 m³/s around 2100.

Water intake and with it the country's fresh water supply come under pressure when the sea level rises and salt water penetrates further inland via the rivers and ground water. Dry summers, like that of 2003, will occur more frequently, leading to damage to agriculture and shipping. Other economic sectors will also be harmed as a result.

A coherent vision and a national perspective

It is the Committee's view that all of the Netherlands must remain an attractive country in which to live, work, invest and take leisure. The two pillars on which the strategy must rest in the coming centuries are safety and sustainability. The best strategy to keep the Netherlands safe and a pleasant place in which to live over the long term is to develop along with climate change and other ecological processes.

Water safety is of utmost importance to the whole of the Netherlands. A safe delta is a collective societal good for which the government is and will remain responsible. It is upon this collective societal interest that the principle of solidarity is based: everyone contributes to water safety since everyone has an interest in a safe Netherlands, both now and in the future.

Innovative approach to risk

The Committee has remained true to the risk management approach upon which the first Delta Committee based its actions. On top of this, however, the new Delta Committee has paid explicit attention to reducing the probability of fatalities, while maintaining a broad definition of the concept of safety, where damage involves more than just economic harm.

Assessment of the safety level of various diked areas must be based on three elements:

- ~ The probability of fatality due to flooding. A human life is worth the same everywhere and the probability of a fatality due to a disastrous flood must therefore be assessed on a common basis, to be agreed throughout society. The Committee proposes a probability of one per million, which is comparable with other (external) safety risks, such as those associated with industrial plant and the transport of hazardous materials.
- ~ The probability of large numbers of casualties in a single flood episode. This probability is currently far greater than all other external safety hazards combined. The Committee finds this unacceptable. There is as yet no measure for the 'societal (group) risk' due to flooding. It is the Committee's urgent advice that such a measure be developed as soon as possible.
- ~ Possible damage, involving more than economic harm alone. It is the Committee's view that damage to the landscape, nature and cultural heritage assets, societal disruption and a harmed reputation must be explicitly incorporated.

In combination, these three elements result in a single, amended standard for water safety.

Water safety highest priority

Our understanding of the way these three elements can be combined into a new standard is not yet complete. It needs further refinement. The Committee believes, however, that safety levels should not be determined purely on the basis of calculations. After careful consideration, it is the Committee's judgement that the present safety level for all diked areas must be improved by a factor of at least 10. In the Committee's view, further refinement leading to a factor lower than 10 can be justified only on very substantial grounds. In view of the considerable likelihood of large numbers of casualties, the Committee rather expects that further refinement will lead to a still higher factor for a number of diked areas, to improve safety yet further. The Committee has considered the concept of Delta Dikes for such diked areas.

A sustainable strategy ...

The Committee considers that safety comes first. The solutions that the Committee proposes, though, make a substantial contribution to the physical quality of the Netherlands and thereby to its attractiveness as a location to live and work. The Committee's proposals:

- ~ are to harmonise as far as possible with natural processes: 'building with nature and other ecological processes';
- ~ are as far as possible integral and multifunctional; solutions deliver added value to society;
- ~ are cost-effective;
- ~ are flexible and can be implemented gradually to take advantage of long-term developments;
- ~ contain prospects for action in the short term;
- ~ are rooted in Dutch tradition and can serve as a beacon to the rest of the world.

The Committee emphasises that government must remain responsible for climate-proof planning and development. The recommendations made also offer room for active market involvement: where possible, private parties may be invited to co-invest in sustainable planning and development for the Netherlands, especially where investments in water safety are accompanied by the reinforcement of other interests and values, such as nature, recreation, industry, agriculture, infrastructure, energy and housing.

... for the entire Netherlands

The Delta Committee has arrived at a number of recommendations for a *Delta Programme*, which demands a coherent, comprehensive package of investments running over more than a century. These recommendations ensure that the Netherlands can absorb the effects of climate change while still remaining an attractive, safe country over the long term. In this regard the Committee has made choices based on a view of the nation as a whole, tested against an overarching national interest, to which factional interests are subservient.

The Committee's point of departure is our present, interlinked water system, which is organised in such a way as to allow it to serve a variety of functions. At the same time, the short and medium-term recommendations we make have been chosen so that different options remain open over the longer term. This will allow future generations to form their own judgements, based on their own insights and values. Flexibility is essential: it is important to stay abreast

of developments, to keep our knowledge up to date, continually assessing our plans and modifying them where necessary.

The Committee distinguishes between three time horizons and has set its recommendations in that context:

- ~ concrete measures out to 2050;
- ~ a clear vision out to 2100;
- ~ opinions on the very long term, beyond 2100.

Safety level

The backlog of work needed to make the flood defences in the Netherlands comply with present safety standards must be remedied quickly. This also holds for setting new water safety standards, so that the present safety level will be improved by a factor of 10. New standards can be set before 2013. The measures needed to increase the safety level must be implemented before 2050. These must take account of the predicted sea level rise and increased river discharges, as well as the Delta Committee's long-term vision. The Committee stresses the importance of combining water safety with the exploitation of opportunities for nature, housing, agriculture and other activities.

Plans for the construction of new buildings

The Committee does not recommend an unequivocal ban on building on physically unfavourable locations. Space is scarce, after all. Decision-making on planned new building in these areas (on soft peat lands, for instance) must be based explicitly on an integral cost-benefit analysis. The costs arising from local decisions must not be passed on to another administrative tier, or to society as a whole; rather, they must be carried by those who profit from them.

This principle must be incorporated into the wider context of decision-making on climate policy, which can be applied regionally and locally. Water managers must become involved in this process at an early stage.

Areas outside the dikes

New development in areas outside the dikes must not impede the river's discharge capacity or the future levels of water in the lakes. Residents/users themselves are responsible for such measures as may be needed to avoid adverse consequences. Government plays a facilitating role in such areas as public information, advice and warnings.

North Sea coast

For the North Sea coast (Holland, the Zeeland headlands and the Wadden Islands), the accent lies on maintaining coastal safety by continuing the practice of beach nourishments, which will offer permanent safety until far into the next century. The Committee advises that nourishments must be carried out in such a way that the coast can grow in the next century to meet the needs of society. This vision should allow the 'weak links' to be dealt with. A growing coast in fact creates extra space for nature and recreation (including seaside resorts). Islands off the coast have a beneficial effect on coastal safety, albeit only a limited one compared with that of beach nourishments. They can be constructed for other functions, but coastal expansion is more cost-effective for nature and recreational functions.

Wadden area

Large-scale beach nourishments along the North Sea coast will have a beneficial effect on the Wadden area, allowing it to grow with rising sea levels. Developments in the Wadden area must be observed with care. The sea defences in the Northern Netherlands and the Wadden Islands will be brought up to strength and maintained.

South-western Delta

The Committee can see good arguments – primarily ecological ones – for completely restoring the tidal dynamics in the Eastern Scheldt when the life-span of the Eastern Scheldt storm surge barrier can no longer be extended, which is expected between 2075 and 2125. A solution must be chosen in good time, because if a completely open variant is selected, the flood defences around the Eastern Scheldt will then have to be brought up to strength. To maintain the estuarine character the sand starvation in the Eastern Scheldt must be tackled by sand nourishments in the short term.

The Western Scheldt must remain open to preserve both the valuable estuary and the navigation to Antwerp. Safety must be maintained by dike reinforcement.

Provisions must be made so that the Krammer-Volkerak Zoommeer lake, combined with the Grevelingen, can store large quantities of river water temporarily when river discharge is high. A freshwater-saline gradient in the lake will rapidly improve water quality. The water supply from the South-western Delta for agriculture and industry must be guaranteed by fresh water supplied from the Hollands Diep. When the details of this plan are developed further, the Committee's advice is to investigate whether water pricing may be applicable.

Rivers region

In the short term it is imperative for the river basin that the programmes *Room for the River* and *Maaswerken* be implemented. For the time being, the Committee assumes that the maximum discharge that can reach the Netherlands via the Rhine is 18,000 m³/s. The design discharge for the Meuse is 4,600 m³/s in 2100. It is essential to harmonise measures with neighbouring countries under the European *Directive on the assessment and management of flood risks*. It will be necessary to reserve the space needed to accommodate these maximum flows, possibly by establishing a permanent preference right and, if necessary, by strategic land acquisition. The peak discharges expected in 2100 must be anticipated, if possible, before 2050 for both the Rhine and the Meuse.

Rijnmond

The Committee recommends that a study be made of the ‘closable-open’ variant for the Rijnmond area immediately: the area can be closed off by barriers when faced with extremely high water levels. This offers safety, while at same time allowing the development of attractive living environments (city water fronts) and nature reserves. A ‘closable-open’ variant will need the Maeslant and Hartel Barriers, and the Haringvlietdam with its sluices (all of which will need replacing between 2050 and 2100), possibly supplemented with other closable barriers on the Spui, Oude Maas, Dordtse Kil and Merwede.

Salt intrusion via the Nieuwe Waterweg will no longer be counteracted with large quantities of river water. The fresh water supply for the Western Netherlands will be drawn mainly from the IJsselmeer lake and local storage where possible. The Committee recommends that this be implemented before 2050. The fresh water supply to the Rijnmond area, including possible innovative water management options, must be incorporated into studies of the ‘closable-open’ approach.

IJsselmeer area

The Committee has opted for a water level rise of at most 1.5 m in the IJsselmeer lake. The importance of the strategic fresh water reserve and the need to be able to discharge into the Wadden Sea without pumping for as long as possible are more important, in the Committee’s view, than the disadvantages (extra costs) of the increased water level. Related to expected climate change, from 2050 onwards, a ‘water slice’ of 1.5 m will be needed in the IJsselmeer lake in years of extreme drought. A water level rise of more than 1.5 m would have significantly adverse effects on safety in the lower reaches of the IJssel and the Zwarte Water, which is why the Committee advises a maximum 1.5 m water level rise to afford the greatest possible flexibility. A phased approach may be adopted, but the aim must in any case be to have the largest possible fresh water reserve available around 2050.

The water level in the Markermeer lake will not be raised. A clearly defined water level offers clarity for urban development in Amsterdam and Almere. After the safety backlog has been remedied, the flood defences, with their prized landscape along the coast of North Holland, will not need to be reinforced again.

Cost

Implementation of the *Delta Programme* will require a sum of 1.2 to 1.6 billion euros per annum until 2050, and 0.9 to 1.5 billion per annum between 2050 and 2100. Under the *Delta Programme* coastal safety will be maintained by means of beach nourishments. Extra nourishments to expand the coasts of Holland and the Zeeland area into the North Sea by 1 km, for instance, and thus to create space for such functions as nature and recreation, will require an additional 0.1 to 0.3 billion euros per annum. These sums are merely an indication. New insights may lead to different measures, with cost implications.

Funding and implementation

The Delta Committee points out that the measures it advises will impact on the planning, development and use of physical space throughout large areas of the country. The Committee's proposals will have consequences at a variety of scales and will thereby have an impact on many functions and interests. Improving water safety – protection from flooding and water nuisance, and securing the fresh water supply – forces choices about land use and therefore affects the development of agriculture and nature, urban development, infrastructure, shipping, ports and other sectors of the economy. Implementation of the Delta Plan, therefore, demands an integral, harmonised interface with other facets of spatial planning, touching on such aspects as the economy, energy, nature and landscape, etc. The need for such an integrated approach leads the Committee to urge the appointment of a ministerial steering committee led by the Prime Minister. Final political responsibility for implementation and execution remains with the minister of Transport, Public Works and Water Management.

The political and administrative organisation can be further reinforced by the appointment of a Delta Director who can serve as secretary to the ministerial steering committee and thus assure horizontal and vertical communication. The Delta Director will translate the national task into regional ones. Responsibility for development and implementation of the regional tasks would generally rest with the regional administrators. In practical terms, the Committee advises the use of the water managers' experience and expertise. Finally, the Delta Committee proposes that a permanent, dedicated Delta Theme committee be instituted in the Parliament to assure parliament's supervision of the *Delta Programme's* implementation and execution.

The measures the Committee proposes are so important for our nation's water safety and fresh water supply that their financing must be independent of short-term political priorities and economic fluctuations. The Committee advises, therefore, the establishment of a Delta Fund, to be supplied from (part of) the natural gas profits and long-term loans.

Those political-administrative and financial recommendations that are not already set down in current legislation will be embedded in a new *Delta Act*.

The Delta Committee emphasises the importance of society's close involvement with the water safety in our country. Only if the general public – residents and industry – is careful with and aware of the way it uses water can the necessary approach to flood protection and a sustainable fresh water supply be realised.

The *Delta Programme* must be a sustainable one, which the Committee interprets as an enduring attempt to use water, energy and other basic materials as efficiently as possible to preserve and even improve the quality of the living environment. The Committee can see innumerable opportunities, the key concept being multifunctionality. Biodiversity can flourish if we offer more room for the dynamics of the sea and rivers. Residential environments (suitably adapted) can be created in water storage areas, on new land or on Delta dikes. Development and utilisation of sustainable energy supplies near to or using the water can simultaneously cut greenhouse gas emissions while combining functionalities.

Future-proof advice

The Delta Committee's report consists of integral recommendations, with a clear direction indicated. However, this report is not intended to be a cut-and-dried blueprint of what the Netherlands will look like in a century or two. Our recommendations are based on the latest scientific knowledge of the consequences of climate change; they tie recommendations for water safety and fresh water supplies to solutions that will permanently improve the physical quality of the Netherlands.

Assuring water safety demands a long-term approach and considerable stamina. For that reason, the Committee believes it is essential that its recommendations must be future-proof. This the Committee has achieved with its combination of a flexible, partly multifunctional package of suggested solutions for planning and developing the Netherlands, coupled with a sturdy package of guarantees: political-administrative, financial and legal.

In the Committee's view, one important source of uncertainty for the future is prosperity and, related to it, the willingness to invest in the protection and quality of our country. We recommend the creation of a Delta Fund to survive less prosperous times and to avoid the danger of non-investment. Furthermore, the political-administrative and legal components of the report are aimed at maintaining the necessary focus on the *Delta Programme*: a powerful role for a ministerial steering committee chaired by the Prime Minister; a Delta Director, tying in both horizontal and vertical communication while also being responsible for progress and co-ordination; strong regional responsibility; legislation embedded in a *Delta Act*; and a Theme Committee in the Lower House. This future-proofs the recommendations against uncertainties arising from political, economic and societal developments.

Another important factor is pressure on space. Despite uncertainties about demographic developments, the Committee expects that pressure on space in the Netherlands will persist. The Netherlands will remain densely populated, come what may, while agriculture, water storage and other functions will demand a great deal of space. The Committee's proposed solutions bear a close relationship with spatial planning. Coastal expansion offers extra space. Multifunctional solutions, such as wide Delta dikes combined with dwellings and infrastructure, aim at an efficient redistribution of space. Water safety costs space, but the space is regained, with better quality. Under any and all circumstances, it is vital to reserve space now.

International co-operation plays a part in the recommendations, certainly for the rivers area. Cross-border co-operation within the European Union is increasingly commonplace. Even if matters were to change in the future, the recommendations are future-proof with provision in the major river basin for 18,000 m³/s for the Rhine discharge and 4,600 m³/s for the Meuse discharge, and the strategic fresh water supply in the IJsselmeer lake.

The recommendations here do not anticipate future technological advances, which will certainly be significant. The development and utilisation of new materials, for instance, will permit the construction of new types of dike. New forms of energy and food production will undoubtedly become possible, with consequences for the use of space. Information and communication technology

will come to offer new facilities for risk monitoring, allowing the population to be informed and brought to safety when disaster threatens. Developments like these will only be beneficial to the execution of the recommendations.

Now suppose that the sea level rises by 4 m in the year 2200: will the Committee's recommendations still stand? What is important here is that we adopt no measures in the coming centuries that leave us with no way out. In this respect, too, the recommendations are future-proof. It will be possible at any time to erect a barrier in the Western Scheldt, or to close off Rijnmond with a lock, as at IJmuiden. The choice will be made at any moment to pump excess water from the IJsselmeer lake, while over the long term, the decisions made for the Krammer-Volkerak Zoommeer can all be reversed. Continuing beach nourishments along the coast and strengthening the flood defences – whether in the form of Delta dikes or not – can continue to protect us, even if the sea level rises by 4 m. If investments continue beyond 2100 in the order of magnitude proposed by the Committee, then our country will remain a safe place to live for many, many years.

And now to work!

The challenges facing the Netherlands are immense and it is no use closing our eyes to the task ahead. But we have the means, the knowledge and the time to take up the challenges and grasp the opportunities. That we have the time does not mean that we can wait. Using the Delta Committee's recommendations, the Netherlands must set to work today: not just on the coast and along the rivers, but also around the seat of government in the Hague and everywhere in the country where politicians, administrators, professionals and scientists are working on water safety and shaping the Netherlands.

The recommendations in this report are devoted to the issue of water safety in its entirety and impact on the spatial planning of the Netherlands. In that regard they offers prospects for other areas of policy and create preconditions for developments in these areas. It goes without saying, then, the possibilities for co-operation offered by the *Delta Programme's* implementation must be utilised to the full. In this regard, the Committee has in mind ties with the national Adaptation Space and Climate programme, with the future of the coastal conurbation of the Randstad, with the policy for the rural area and the countryside, with the achievement of nature goals, with the work on a sustainable energy supply, and with the further development of the Netherlands as a transport country and a business location.

Implementation timetable
Working together with water

A start can be made on this timetable during the present Cabinet's term of office; in the Delta Committee's view this is an ambitious agenda. The very short-term needs are:

- ~ the installation of a ministerial steering committee chaired by the Prime Minister, the secretariat to be headed by a Delta Director;*
- ~ drafting a Delta Act and setting up a Delta Fund so that the Delta Programme can get under way.*

The Committee would like to see at least the following items on the agenda before 2020:

- ~ Continue to cut the backlog in reinforcing the primary flood defences. Anticipate future sea level rises and changes in river discharge as investigated by the Committee and according to the Committee's long-term vision;*
- ~ Implement the programmes Room for the River and Maaswerken in full. Where cost-effective, anticipate a Rhine discharge of 18,000 m³/s and a Meuse discharge of 4,600 m³/s;*
- ~ Reserve space with a permanent preference right and/or acquire strategic land positions that will in time be needed to increase the discharge capacity of the Rhine and Meuse to 18,000 and 4,600 m³/s, respectively;*
- ~ Tackle the 'weak links' accordance with the Delta Committee's vision;*
- ~ Set down new standards for water safety in a new Water Act, in accordance with the Delta Committee's proposal;*
- ~ Develop instruments that can be used to create climate-proof spatial planning at local and regional scale. These must not be voluntary in respect of building on unfavourable locations and the early involvement of the water managers;*
- ~ Make a start on:*
 - ~ expanded, gradual beach nourishments along the North Sea coast, looking always for innovative concepts;*
 - ~ sand nourishments in the Eastern Scheldt to compensate for sand starvation in the area;*
 - ~ admitting salt water into the Krammer-Volkerak Zoommeer lake and constructing alternatives for areas that depend on the lake for their fresh water supply;*
 - ~ preparing the Krammer-Volkerak Zoommeer and the Grevelingen so that they can be used for water storage at times of high river discharge.*

The Committee believes it is important that before 2050:

- ~ measures will have been implemented to improve the water safety of the Netherlands according to the Delta Committee's proposals: i.e. by a factor of at least 10;*
- ~ the Rijnmond will have been developed in such a way that the area is no longer exposed to the influence of storms and extreme river discharges in an uncontrolled manner;*
- ~ fresh water transfer will have been made possible from the IJsselmeer to the Western Netherlands;*
- ~ arrangements will have been made for a 1.5 m higher water level in the IJsselmeer lake.*

Grasping the challenges offered by climate-proofing the Netherlands demands the development of integrated knowledge: knowledge that ties in ‘green’, ‘blue’, and ‘red’. Moves towards this sort of integration are already afoot in the academic world and the Delta Committee’s recommendations only serve to increase the need. The Netherlands forms an ideal test bed for experiments in this area, even from a global perspective. The Committee envisages an explicit, structural role for Dutch research institutions, assessment agencies and universities in support of the *Delta Programme*.

Knowledge timetable
Working together with water

The following knowledge timetable is needed to get the Delta Committee’s recommendations off to a good start:

- ~ building with nature; innovative ways to carry out large-scale, gradual sand nourishments on the coast and in the Eastern Scheldt;*
- ~ monitoring developments in the Wadden Sea and the intertidal zones;*
- ~ necessary modifications to the Krammer-Volkerak Zoommeer lake, including a realistic price-fixing for water;*
- ~ innovations in water treatment and water use by industry and agriculture; experiments with sustainable energy, linked to the possibilities offered by water;*
- ~ realisation of a ‘closable-open’ Rijnmond, including the fresh water supply to the Rijnmond area;*
- ~ taking the necessary measures to enable raising the water level in the IJsselmeer lake;*
- ~ the Delta Dikes concept, including possible multifunctionality, in relation to diked areas where the new standards specify a more than 10-fold improvement in their safety level.*

Finally, the work is never done. That is characteristic of living in a delta. Circumstances and outlooks will always change. For that reason it will be necessary to keep knowledge up to date and to modify the plans continually in light of the latest developments and insights. In the meantime, it will remain sensible to be prepared for possible disastrous floods and, as a society (government, the public and business), to have our disaster planning and crisis management in order, no matter how small the chance of a catastrophe may be.

We can master the long-term challenge of keeping the Netherlands a safe, attractive country. Moreover, we have many opportunities and new prospects, particularly to make our country more sustainable, to expand our knowledge and expertise yet further, spreading it and putting it into practice in the rest of the world. Given the Delta Committee’s ambitious timetable for implementation, the Netherlands can and must start work today. In our interaction with the water we, the country’s residents, can ourselves shape the Netherlands of the future – just as our forefathers have always done throughout the centuries.

Colophon

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Further information:
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A DVD with background reports
and a movie is available as part
of this advice

Printer:
Hollandia Printing

First edition September 2008
Second edition November 2008