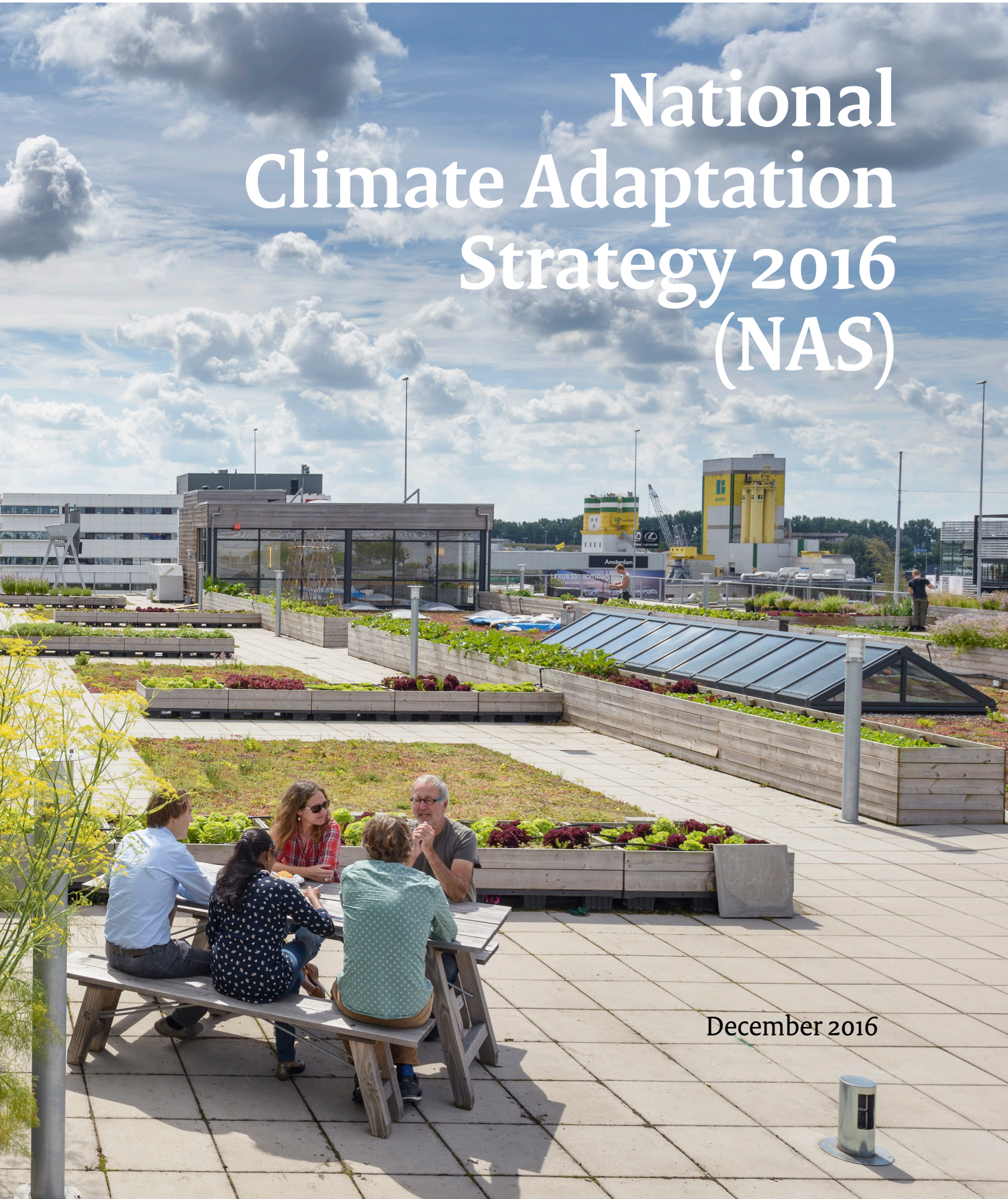


Adapting with ambition

National Climate Adaptation Strategy 2016 (NAS)

December 2016



Background and status

This document sets out the Netherlands' national climate adaptation strategy. It has been produced under the responsibility of the Minister for the Environment, acting on behalf of the Minister of Infrastructure and the Environment, the Minister of Health, Welfare and Sport, the Minister of Economic Affairs, the Minister of Agriculture, the Minister of Security and Justice, and the Minister of Overseas Trade and Development Cooperation.

The National Climate Adaptation Strategy – NAS – is the result of a participative process involving public sector authorities at regional and local level, water management authorities, knowledge institutes, private sector companies and societal organizations. Important input was derived from three workshop sessions. A review group comprising representatives of the relevant ministries, knowledge institutes and societal organizations was appointed to monitor progress and create the necessary grassroots support. Interim results were discussed at meetings attended by the directors of ministry departments, the Delta Programme Commissioner, the Royal Netherlands Meteorological Institute (KNMI), the National Institute for Public Health and

the Environment (RIVM) and the Netherlands Environmental Assessment Agency (PBL). On 15 September 2016, proposals were discussed at a consultation meeting attended by the Minister for the Environment and senior representatives of the Association of Provinces of the Netherlands (IPO), the Association of Netherlands Municipalities (VNG) and the Association of Regional Water Authorities (UvW). A draft version of the NAS was produced with the assistance of external experts in various disciplines.

Several organizations* have made a significant contribution to the current document. They include the provinces of Noord-Holland, Noord-Brabant, Overijssel and Zuid-Holland, the municipalities of Amersfoort, Amsterdam, Arnhem, Delft, Gouda, Rotterdam, The Hague, Tilburg, Utrecht, Venlo and Zwolle, the regional health authorities of Gelderland Midden, Haaglanden, Amsterdam and Rotterdam, the Delfland Water Authority, IPO, KNMI, PBL, the Midden-Holland metropolitan region, Rijkswaterstaat, RIVM, the Zeeland Safety Region, Waternet, Rijn en IJssel Water, Rivierenland Water, DNB, Climate Alliance Netherlands, Natuur en Milieu Overijssel, Natuurmonumenten

(Dutch Society for Nature Conservation), RIONED, Stadswerk, UvW, the Dutch Association of Insurers, VNG, World Wildlife Fund, Centraal Beheer Achmea, Amsterdam Rainproof, Atelier Groenblauw, Bureau Stroming, Bureau ZET, Climate Adaptation Services, CLM Onderzoek en Advies B.V., De Betekenaar, Deltares, Movares, HKV – Lijn in Water, Amsterdam University of Applied Sciences, CROW, ORG-ID, ProRail, Royal HaskoningDHV, Sweco Nederland B.V., Synergos Communicatie, Twynstra Gudde, VisNed, Wageningen University and Research Centre, Alterra, WING, and Zegge & Schrijve.

The 2016 NAS project team: Stef Meijs (project manager, Ministry of Infrastructure and the Environment, IenM), Ytsen Deelstra (WING) Annemarieke Grinwis (IenM), Paul van Hemert (IenM), Kim van Nieuwaal (CAS), Tis Solleveld van Helden (IenM), Hilde Westera (Rijkswaterstaat) and Berend van Zeggeren (Synergos Communicatie).

* This list is as complete as possible. It is nevertheless possible that some names have inadvertently been omitted, for which we apologise.



Workshop session in Utrecht.

Contents

Foreword 2

Executive summary 3

1. Necessity and purpose 5

1.1. Climate change in the Netherlands 5

1.2. Climate-proofing the Netherlands 6

1.3. Structure of this document 6

2. The effects of climate change 9

2.1. Positive effects 9

2.2. The effects at a glance 9

2.3. Notes on the diagrams 11

3. Challenges 20

3.1. Effects demanding urgent action 20

3.2. Measures already in place 25

3.3. Aspects demanding special attention 29

4. The approach 31

4.1. Raising awareness 31

4.2. Climate adaptation in practice 31

4.3. Using and expanding existing knowledge 34

4.4. Addressing the urgent risks 35

4.5. Embedding health within policy and legislation 38

4.6. Monitoring 39

5. From strategy to implementation 40

Appendix 1 Climate effects by impact and urgency 42

Appendix 2 Crossovers 44

Foreword

by the Minister for the Environment

“Bring Paris Home!” This was the message of the National Climate Summit held in October 2016, referring to the international agreement to limit global warming to less than 2°C. This is likely to prove a major challenge, as is the task of preparing the Netherlands to face the effects of climate change. As the Delta Programme Commissioner Wim Kuijken remarked during the Summit, mitigation and adaptation are two sides of the same climate coin. This National Climate Adaptation Strategy will help the Netherlands to meet the challenges ahead. It introduces various new initiatives and will help to push forward those already in progress.

The Netherlands is particularly susceptible to the effects of climate change. At the same time, our knowledge and expertise enable us to play a prominent role in climate adaptation. Much is happening in terms of research, policy development and practical projects by private sector companies, civil society and engaged individuals. Even so, there is room for improvement in several areas, including public awareness. Everyone can – and indeed must – do their bit to ensure that the Netherlands is better protected against heat, drought, flooding and other extreme weather conditions. This is a joint responsibility for us all.

In a report published in October 2016, the Scientific Council for Government Policy (WRR) noted that Dutch climate policy must be based on a long-term perspective. The Council stressed the importance of consistency and coherence: climate policy must be coordinated with that in other domains. Climate adaptation and mitigation measures should form a prominent component of spatial planning and infrastructural development, in accordance with the principles presented in this National Climate Adaptation Strategy.

This document is based on the latest research and a comparison of various possible scenarios. It represents the combined input of experts in a wide range of disciplines. Among the likely effects of climate change are some which must now be addressed as a matter of urgency. The proposed approach encourages everyone to contribute. The government will provide all necessary support. Climate change brings challenges but it also creates opportunities. We must exploit those opportunities to the greatest extent possible.

Sharon Dijksma

Minister for the Environment

Executive summary

The negative effects of climate change must be minimized or at least made manageable. Those effects include damage to property, nuisance or inconvenience, disease, increased mortality and a decline in environmental and ecological quality. This National Climate Adaptation Strategy (NAS) introduces various new initiatives and will accelerate the progress of ongoing initiatives. It builds upon a decade of climate adaptation policy and, in combination with the Delta Programme, sets out the Netherlands' response to climate change. One important component of the strategy is the desire to unite all parties in pursuing common objectives. The NAS answers the European Commission's request for member states to produce a climate adaptation strategy no later than 2017.

Analysis of effects and policy

The NAS uses four diagrams ('Hotter', 'Wetter', 'Drier' and 'Rising Sea Level') to visualize the effects of climate change within nine sectors: water and spatial management; nature; agriculture, horticulture and fisheries; health and welfare; recreation and tourism; infrastructure (road, rail, water and aviation); energy; IT and telecommunications; public safety and security.

Six climate effects which call for immediate action have been identified:

1. Greater heat stress leading to increased morbidity, hospital admissions and mortality, as well as reduced productivity.
2. More frequent failure of vital systems: energy, telecommunications, IT and transport infrastructures.
3. More frequent crop failures or other problems in the agricultural sector, such as decreased yields or damage to production resources.
4. Shifting climate zones whereby some flora and fauna species will be unable to migrate or adapt, due in part to the lack of an internationally coordinated spatial policy.
5. Greater health burden and loss of productivity due to possible increase in infectious diseases or allergic (respiratory) conditions such as hay fever.
6. Cumulative effects whereby a systems failure in one sector or at one location triggers further problems elsewhere.

Attention must also be devoted to climate effects which are not expected to emerge until somewhat later this century but which call for urgent attention due to their high impact. They include the failure of the electricity supply grid due to extreme weather, restriction of shipping due to unusually high or low water levels, the loss of habitats and species due to extremely low water in river systems, large-scale failure of IT systems due to problems experienced by crucial IT service providers elsewhere in the world, large-scale failure of IT services due to overheating, and changing migration patterns of various migratory animal and bird species. There may also be ground subsidence causing damage to buildings and infrastructure, safety risks further to the fracture of pipes and cables, and increased CO₂ emissions due to peat oxidation.

Positive effects

Rising temperatures might also have positive economic and societal effects. Warmer weather could increase yields of some crops or allow the cultivation of new crops. The Dutch weather might become more attractive – or less uncomfortable – than that elsewhere in Europe and this could have a positive effect on tourism. Morbidity and mortality due to freezing temperatures in winter will decrease, and the milder winters will also reduce the energy requirement for heating homes, business premises and glasshouses.

Approach ‘Climate-proofing’ our country is a joint undertaking for which every member of Dutch society is responsible. The National Climate Adaptation Strategy (NAS) sets out the course. The government will initiate specific projects and programmes in order to:

1. increase awareness of the necessity of climate adaptation
2. encourage the implementation of climate adaptation measures
3. develop and exploit the knowledge base
4. address urgent climate risks
5. embed climate adaptation within policy and legislation
6. monitor the progress and effectiveness of the adaptation strategy.

Confirmed projects include a study to determine the current status of government buildings and sites, the organization of a dialogue about the insurability of climate risks, a study of chain dependencies and possible points of failure (‘weak links’) in the rail infrastructure, and the production of a climate adaptation handbook to accompany the Multi-Year Programme for Infrastructure, Spatial Planning and Transport (MIRT).

Implementation programme The NAS forms the precursor to a Climate Adaptation Implementation Programme which will build upon ongoing activities such as those of the Delta Programme. Where necessary, the implementation programme will fast-track the existing initiatives by providing additional manpower and resources. The Delta Programme forms an intrinsic component of the overall strategy and is the context within which the Delta Plan for Spatial Adaptation is to be produced. The Ministry of Infrastructure and the Environment and the relevant knowledge institutes will design a system which enables central government, regional and local authorities, water management authorities and other stakeholders to monitor the progress of the overall implementation programme and their own contribution. The monitoring programme will be fully coordinated with that of the Delta Programme.

Learning by doing The necessity of climate adaptation can only increase in the years ahead, as will the urgency with which measures must be implemented. We are already experiencing the effects of climate change to a greater degree than had been expected. It is not possible to plan everything in advance; there remain too many unknowns. It is a question of ‘learning by doing’ and this concept underpins the NAS. The role of the Ministry of Infrastructure and the Environment is that of coordinator.

Climate adaptation entails expenditure. Certain important choices must be made by government departments, the business community and individual households. Adapting to climate change requires everyone to make investment decisions. Putting off those decisions, or making the wrong choices, is likely to prove far more expensive in the longer term.

Participation The government is to present the Climate Adaptation Implementation Programme during the second half of 2017, following due consultation with the ministries, the Delta Programme Commissioner, local and regional authorities, private sector organizations, knowledge institutes and societal organizations. Preparations are already well in hand. Everyone in the Netherlands has been invited to contribute to the process and, more especially, to participate. We can then make joint investments in policy, research and the practical measures needed to prepare the Netherlands to counter the negative effects of climate change.

1. Necessity and purpose

On 12 December 2015, no fewer than 195 countries ratified the Paris Agreement, a global convention on climate change which establishes various objectives. For example, signatories are expected to restrict global warming to less than two degrees Celsius (compared to pre-industrial levels). To achieve the aims will call for major efforts in terms of climate mitigation: the prevention of further climate change – see below – and the reversal of climate change that has already taken place. Climate adaptation is also required to diminish our susceptibility to the negative effects of climate change and to reduce the associated costs. This document sets out the National Climate Adaptation Strategy 2017, which answers the European Commission's call for all member states to produce a formal plan no later than 2017. The NAS will be presented to the European Commission. In 2017, the Commission will evaluate the progress of the European Adaptation Strategy adopted in 2013, based on the reports prepared by each member state in accordance with Regulation (EU) No. 525/2013 ("on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level"). The Dutch government will actively support the Commission's assessment by reporting the Netherlands' experiences following due consultation with regional and local authorities.

1.1. Climate change in the Netherlands

The effects of climate change are extremely diverse. Their exact nature will depend on geographic location. Reports published by the Intergovernmental Panel on Climate Change (IPCC) suggest that the most severe negative effects will be felt by those countries and populations which are already under pressure, and in particular the small island states, delta regions and areas that are affected by drought. By comparison, the countries of northwestern Europe – which include the Netherlands – have somewhat less cause for concern. Indeed, an increase in average temperatures could have a positive effect in some economic sectors. The Dutch have a long history of successful water management and are well versed in dealing with one of the most serious climate effects: flooding. Even so, further action is required and is being taken under the Delta Programme.

In our country, climate change will bring about higher temperatures, more extreme rainfall at certain times and longer periods of drought at others. Summers are likely to be drier. As a coastal country, the Netherlands is also affected by the rising sea level (see insert on page 8). Some changes will be gradual, others less so. Weather extremes such as heatwaves, heavy rainfall and hailstorms will become more frequent and will cause even greater damage and personal injury than in the past. In 2012, the Deltares research institute calculated that the financial losses sustained by the Netherlands due to flooding, drought

Mitigation and adaptation

Mitigation refers to a reduction in the emission of greenhouse gases to ensure that the increase in average temperatures remains limited. The 2015 UN Climate Change Conference in Paris formulated long-term emissions targets intended to restrict global warming to less than two degrees Celsius (compared to pre-industrial levels), with 1.5 degrees as the working target.

Alongside mitigation, climate **adaptation** measures are also required. Here, the aim

is to reduce susceptibility to the negative effects of climate change, to minimize those negative effects wherever possible, and to take advantage of any positive effects. This calls for the right measures to be implemented in the right place at the right time. Climate adaptation is given a prominent place in the Paris Agreement.

Failure to restrict greenhouse gas emissions will lead to rising global temperatures. In simple terms, the smaller the reduction in emissions, the greater the

increase in global warming and the greater the need for adaptation measures.

Adaptation and mitigation are complementary approaches; both are essential. Some measures contribute to both. For example, designing towns and buildings to reduce their energy consumption will also increase their resistance to heat and heat stress.

The effects of climate change will continue to be felt for decades to come, even after emissions have been reduced to the target levels.

and heat stress during the period to 2050 would be in the order of 71 billion euros. It is now apparent that climate change is even more rapid and intense than had been anticipated. The amount must therefore be revised upwards. In June 2016, hail and rainstorms in the southern Netherlands alone caused damage totalling over 700 million euros.

1.2. Climate-proofing the Netherlands

The effects of climate change must be minimized or at least made manageable in the longer term. The negative effects include damage to property, nuisance, disease, early mortality and a decline in environmental and ecological quality. The National Climate Adaptation Strategy will help to 'climate-proof' the Netherlands by introducing new initiatives and by building upon those already under way. It is essential that climate adaptation permeates all sections of society and that all citizens are aware of the joint responsibility they bear for its success.

The NAS encourages public sector authorities, knowledge institutes, private sector companies, societal organizations and engaged individuals to play their part in offsetting the negative effects of climate change and taking advantage of the opportunities it brings. An important component of the strategy is the desire to unite all parties and promote a joint approach.

The NAS builds upon a decade of climate adaptation policy (see below) and, in combination with the Delta Programme, will guide the Netherlands' efforts in this field. The contents of the NAS are fully in keeping with the risk inventory and capacity programme of the National Safety and Security Strategy.

1.3. Structure of this document

Chapter 2 sets out the most significant effects of climate change. Those which demand immediate action are identified in Chapter 3. The steps needed to ensure that the Netherlands is less susceptible to the negative effects of climate change in 2050 and beyond are described in Chapter 4. The final chapter paves the way for the Climate Adaptation Implementation Programme which is to be published in late 2017.

A decade of climate adaptation policy in the Netherlands

2007: Publication of the first National Climate Adaptation Strategy. Preparations for the 'Knowledge for Climate' research programme.

2010: Launch of the Delta Programme to address the most urgent challenges in connection with flood safety, fresh water provision and spatial adaptation.

2012: Publication of the report 'Adapting to Climate Adaptation: strategy and policy' (Netherlands Court of Audit) calling for attention to be devoted to effective policy development to address all aspects of climate change.

2013: The government adopts the report's recommendations in its Climate Agenda, which states that the economic and social risks posed by climate change are to be identified in detail. This is the first step in meeting the European Union's call for all member states to produce a formal climate adaptation strategy.

2014: Ratification of the five 'Delta Decisions', including those on Flood Safety, Fresh Water Access and Spatial Adaptation, and their incorporation into the National Water Plan. The Delta Decision on Spatial Adaptation sets out objectives intended to create a robust, climate-proof spatial structure by 2020. By 2050, the entire spatial structure of the Netherlands should be significantly less susceptible to the risks posed by climate change.

2015: The Netherlands Environmental Assessment Agency (PBL) and the Knowledge for Climate programme publish the joint report *Aanpassen aan klimaatverandering; kwetsbaarheden zien, kansen grijpen* ('Adapting to climate adaptation: recognizing risks, seizing opportunities'). This forms important input for the forthcoming National Climate Adaptation Strategy.

2016: Publication of the National Climate Adaptation Strategy (NAS).

2017: Publication of the Climate Adaptation Implementation Programme and the Delta Plan for Spatial Adaptation.

Climate adaptation in practice



Amsterdam Rainproof takes advantage of rainwater.
PHOTO: MERLIJN MISCHON
FOTOGRAFIE

Making the most of sudden downpours

Amsterdam Rainproof is a partnership which aims to reduce the negative impact of the increasingly frequent heavy rainfall in the city. Rainwater represents a free resource. Rather than allowing it to simply run off into the drainage system, Amsterdam Rainproof wants to put it to good use.

In some places, the drainage system is simply not up to the task. In the urban environment, much of the surface area is covered by buildings, asphalt or concrete whereupon water accumulates and can cause significant damage.

Amsterdam Rainproof collates information, initiatives and ideas. Everyone can help it to achieve the aims. While installing a rain barrel in the garden may not seem to make much of a difference, the 'rainproofing' of Amsterdam will be the combined result of all efforts, large and small. Every drop counts! The project involves close cooperation between various partners, from water management authorities and research institutes to small companies and individual households.

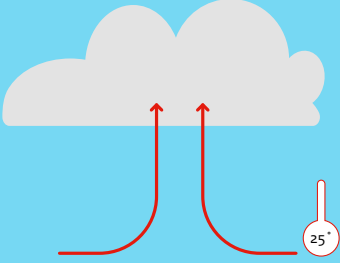
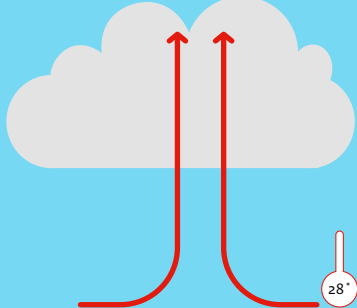
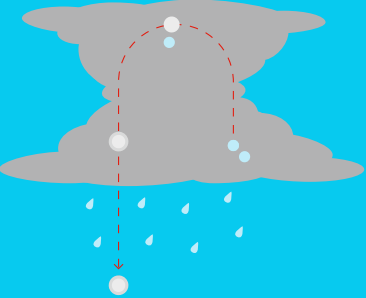
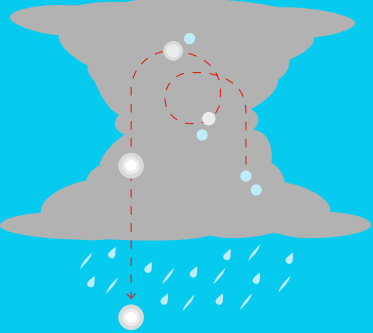
Climate change in the Netherlands, today and tomorrow

The climate is definitely changing. In 2015, the average temperature worldwide was approximately one degree Celsius higher than during the period 1850-1900. The Netherlands has seen an even greater increase, with temperatures now some 1.8°C higher. Between 1910 and 2015, annual precipitation increased by 27%, while the incidence of heavy showers capable of causing flooding has risen by over 20%, as have both the frequency and intensity of hailstorms. Extended dry periods are more common than they were prior to 1951. Changes in the incidence of storms and high (gale force) winds fall within the bounds of natural variability.

The climate will continue to change in the centuries to come, although it is impossible to predict either the rate or the

extent of change. This is partly because we do not (yet) understand all contributory factors, and partly because other developments such as population growth and global climate agreements will play a role. For these reasons, climate researchers and policy-makers base their deliberations on alternative scenarios. In 2014, the Royal Netherlands Meteorological Institute (KNMI) published four detailed scenarios, the salient points of which include:

- an increase in temperature of between 1.0 and 2.3°C and a rise in sea level of between 15 and 40 centimetres by 2050 (compared to the period 1981-2010)
- annual precipitation will increase by 2.5%, possibly by up to 5.5%
- the frequency and intensity of extreme precipitation will increase in all scenarios and in all seasons of the year
- the intensity of heavy rainstorms and hailstorms will increase by 10 to 15% for each degree of temperature increase, as will the number of lightning strikes and winds capable of causing damage or personal injury
- drought (defined as a shortage of rainfall of an order that may be expected to occur only once in ten years) will be between 5% and 25% more prevalent by 2050 than in the period 1981 to 2010.

Why hailstorms will become more common	
The climate today	The climate of the future
 <p>Storms occur when warm air rises and meets cold air, whereupon moisture condenses.</p>	 <p>Because average temperatures will be higher in future, the upwards flow of warm air will be greater in volume, creating bigger clouds.</p>
 <p>Hail begins as water droplets which become supercooled and freeze on contact with condensation nuclei. A cross-section through a large hailstone shows an onion-like structure, the number of layers indicating how many times the hailstone has fallen and been carried back into the cloud in the updraft.</p>	 <p>The vertical movements will be greater and hailstones will rise and fall more frequently. They will collide with super-cooled raindrops on each movement and could grow to become very large before eventually falling to the ground.</p>

For further information, see KNMI '14: Climate scenarios for the Netherlands.

2. The effects of climate change

The Netherlands will be affected by four main climate trends: Warmer, Wetter (in terms of total rainfall) but with Drier summers. There will be a Rising Sea Level. Some changes will be gradual. The average temperature may rise quite slowly year on year, for example. However, the frequency and intensity of weather extremes, such as heatwaves, could also increase.

It is generally the negative effects of weather extremes that come to public attention, as when a festival site is transformed into a mudbath by a freak thunderstorm which might even claim lives. We read reports of damage to roofs and glasshouses caused by extreme hailstorms, or of a motorway becoming impassable when heavy rainfall caused the embankment to collapse in a miniature landslide. Such incidents may prompt response measures, such as the Bad Weather Fund for Cultural Events announced by the Ministry of Education, Culture and Science in June 2016.

The gradual changes attract less attention but their effects are no less serious. They can erode the resilience of nature whereupon crops are exposed to pests and disease. Human health may also be placed at risk by new pathogens or allergens.

2.1.

Positive effects

The effects of climate change are not necessarily all negative (see insert on page 10). Rising temperatures in northwestern Europe could have positive economic and social effects. Dutch agriculture is likely to benefit from climate change more than in countries farther to the south or east. Higher temperatures may allow the introduction of new crops. If the effects of climate change elsewhere in Europe prove less propitious, the Netherlands will gain a competitive advantage.

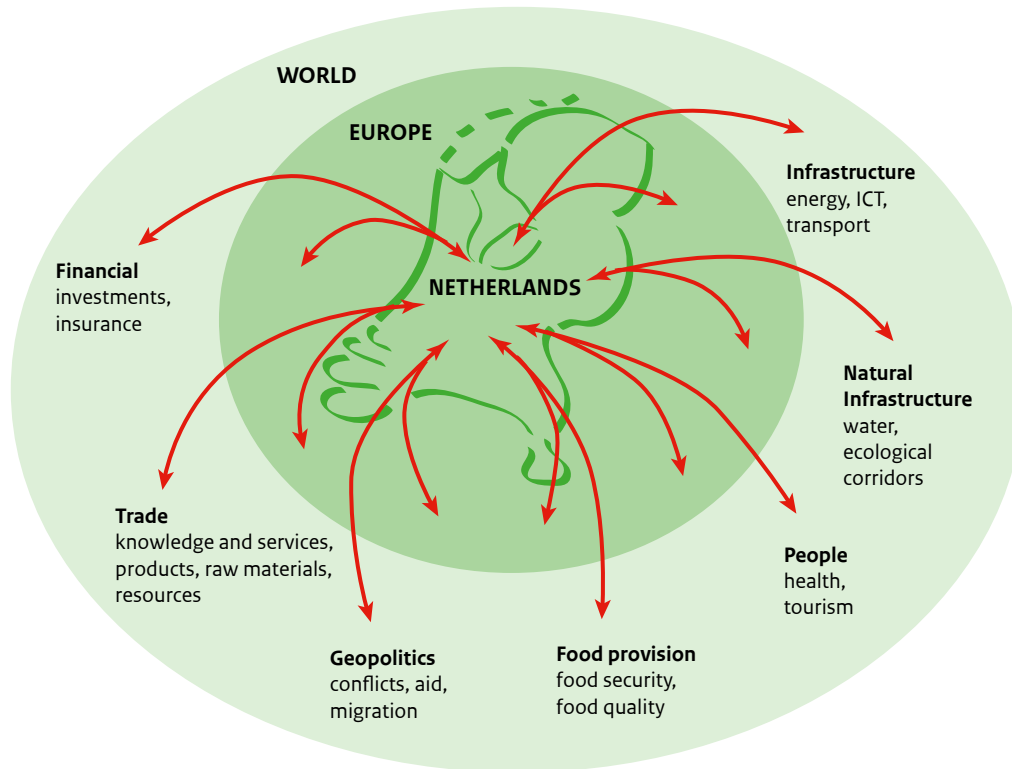
It is possible that the weather in the Netherlands will become more attractive, or less uncomfortable, than that elsewhere in Europe and this will have a positive effect in terms of tourism. Moreover, there will be less morbidity and mortality due to freezing winter weather. Milder winters will also reduce energy consumption and the costs associated with heating homes, business premises and glasshouses.

2.2.

The effects at a glance

An effective response to the effects of climate change demands a good understanding of those effects. For each of the climate trends, we have produced a diagram showing how it could affect nine economic and social sectors: water and spatial management; nature; agriculture, horticulture and fisheries; health; recreation and tourism; infrastructure (road, rail, water and aviation); energy, IT and telecommunications; safety and security. The frameworks are based on the report *Aanpassen met beleid* ('Adaptation with policy') published by the Environmental Assessment Agency in 2013, and the follow-up report *Aanpassen aan klimaatverandering* ('Adapting to climate change'), published in 2015. See also Appendix 1.

We see a very broad range of effects which will occur at various levels of scale. Some effects will be far-reaching, others will be less marked but perhaps more frequent. Some will become apparent relatively quickly while others may be seen only after several decades. There may also be cumulative and knock-on effects, both within and between sectors.



Source: adapted from PBL (2005)

The international context

Climate change does not respect national boundaries. The Netherlands has a very open economy and a high degree of interdependence with the rest of the world. Climate effects at home and abroad could weaken our competitive position or, conversely, strengthen it. Increasing international cooperation in areas such as energy provision, IT, funds transfer and other vital infrastructure makes the Netherlands increasingly susceptible to developments elsewhere. Climate change is likely to affect our country in other ways. It may bring about changes to the food production chain. It may affect ecosystems and hence the flora and fauna to be found in the Netherlands, such as migratory birds at certain times of the year.

Climate change could also affect international stability. Drought is already a motive for people to leave the region in

which they were born. In time, new migration flows are likely to develop. Climate change is an issue within the economic and social domains, including the interests of international security. Its effects will inevitably be felt by Dutch society. It is essential that solutions to the challenges are sought at the European and global levels. Attention must be devoted to all aspects, including energy security and new health risks.

As noted above, climate change could also create new opportunities. There might be even greater demand for Dutch expertise in water management, flood safety, water distribution systems, renewable energy and innovative agriculture. The impact of climate change in the southern and eastern regions may well create competitive advantages for Dutch agriculture. Central government,

knowledge institutes and the private sector can all play an active role in helping to climate-proof the world, a process which will further increase the export of Dutch knowledge and expertise. The Netherlands will continue to form an important part of the European network of nature areas and will actively promote climate-related investments – both public and private – in the developing countries. The Netherlands will also play a prominent part in projects intended to achieve the UN Sustainable Development Goals, thus helping the developing countries to implement climate adaptation and mitigation measures. Some activities fall within the Sendai Framework for Disaster Risk Reduction 2015-2030, as endorsed by the UN General Assembly in the 2015, which recognizes the correlation between climate change and disaster management.

2.3.

Notes on the diagrams

The primary effects of each climate trend are shown in black and white. The effects for the specific sectors are shown in colour, whereby the diagrams present the following information:

Circles

- The relevant sector is indicated by the circle's outer edge.
- The colour of the centre of the circle indicates whether the effect is a risk (red) or an opportunity (green). Where it is not yet certain whether the effect is predominantly positive or negative, the centre is grey.
- A continuous black outer edge indicates a moderate or marked effect that can already be seen or is expected to become apparent within the next ten years. A dotted black edge indicates a marked effect which is likely to emerge at some point this century. All other bullets represent categories with a lesser impact.
- Symbols are used to indicate whether measures have already been implemented (where known).

The diagrams are simplified representations of the actual situation and are, of necessity, incomplete. They nevertheless provide a good indication of the complexity of the various issues and offer a useful starting point for the proposed joint approach. It should be noted that these diagrams relate specifically to the situation in the Netherlands. Interactive versions are to be published online. A complete overview of all climate effects within each sector will be produced at a later date.



National Climate Adaptation Strategy Climate trends effects at a glance

Impact, opportunities and threats

- Generic climate effects
- Medium to marked effect: this decade
- Marked effect: this century
- Effect is an opportunity
- Effect is a threat
- Unclear whether effect is an opportunity or a threat

Implication for sectors

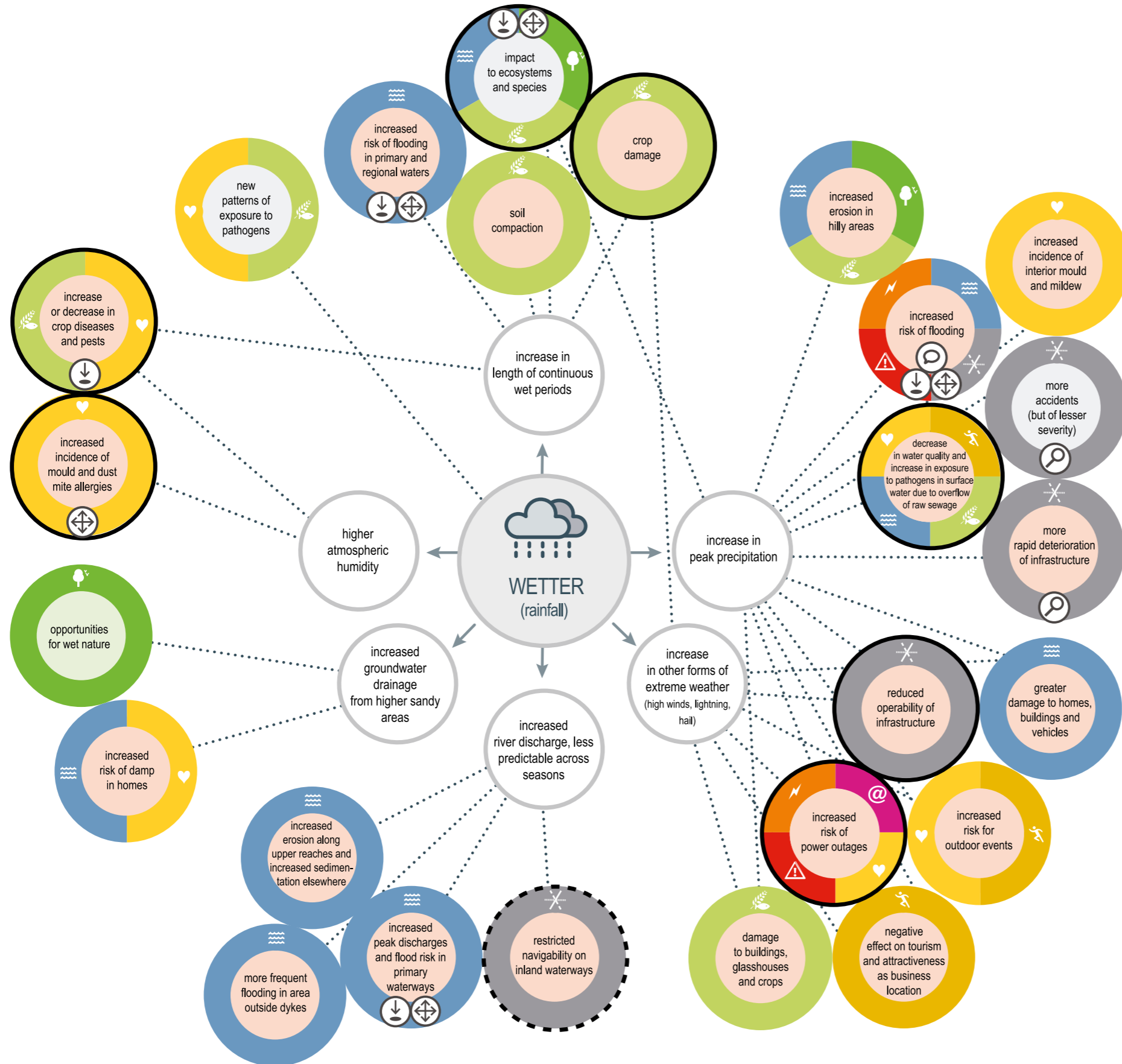
- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT en telecommunications
- Safety and security

Current measures (incomplete)

- Research
- Measure specific to effect
- Process approach
- General action plan or measure

bron: - PBL, *Aanpassen met beleid* ('Adaptation with policy'), 2013
 - PBL, *Aanpassen aan klimaatverandering* ('Adapting to climate change'), 2015
 - NAS workshop sessions, 7 June, 1 September and 12 October 2016

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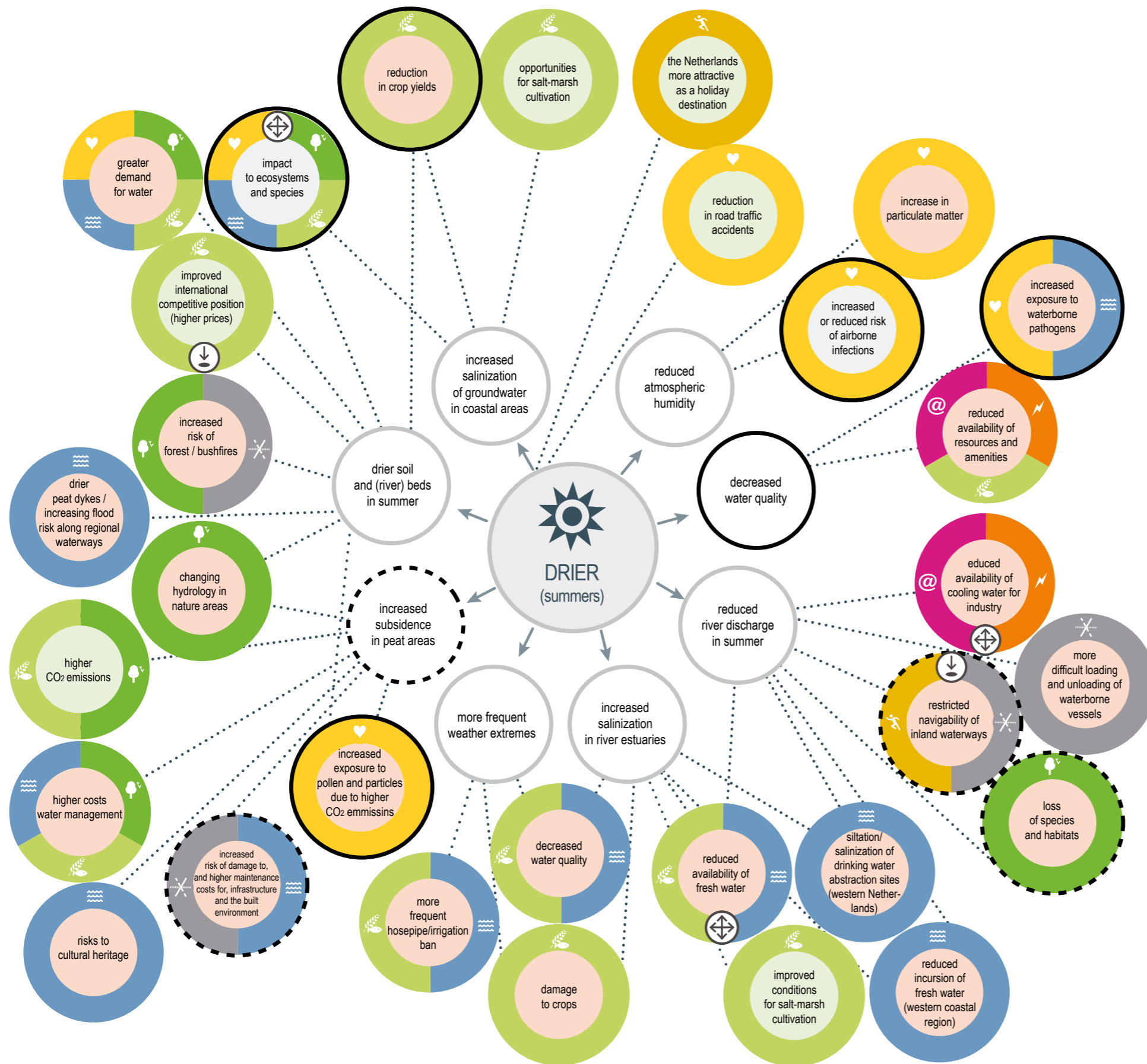
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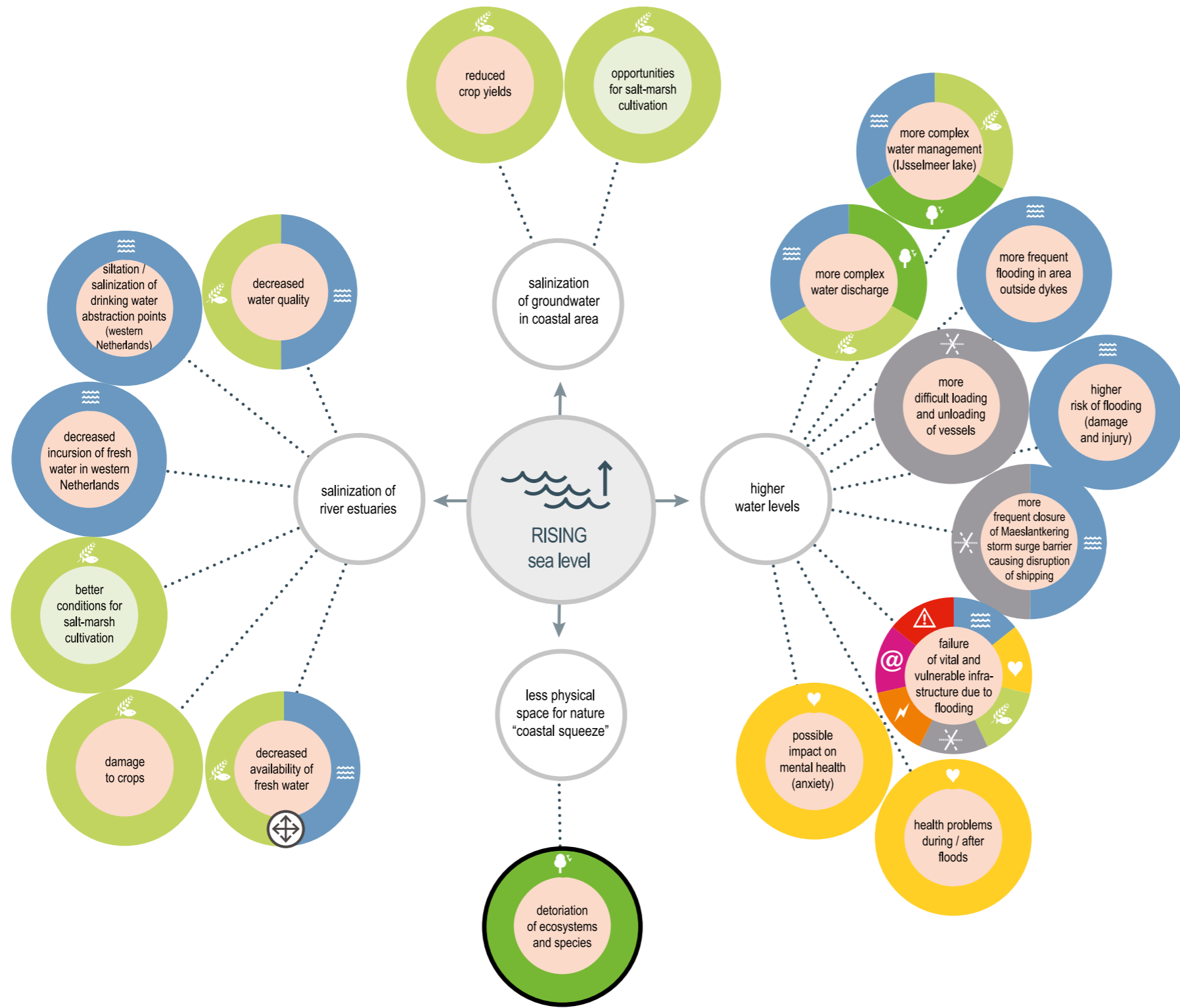
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- General action plan or measure

bron: - PBL, *Aanpassen met beleid* ('Adaptation with policy'), 2013
 - PBL, *Aanpassen aan klimaatverandering* ('Adapting to climate change'), 2015
 - NAS workshop sessions, 7 June, 1 September and 12 October 2016

Disclaimer: These diagrams offer a simplified and incomplete representation of the actual situation. In the interest of clarity, not all components of the known causal relationships are shown.



National Climate Adaptation Strategy Climate trends effects at a glance

Impact, opportunities and threats

- Generic climate effects
- Medium to marked effect: this decade
- Marked effect: this century
- Effect is an opportunity
- Effect is a threat
- Unclear whether effect is an opportunity or a threat

Implication for sectors

- Water and spatial management
- Nature
- Agriculture, horticulture and fisheries
- Health
- Recreation and tourism
- Infrastructure (air, road, rail, water)
- Energy
- IT en telecommunications
- Safety and security

Current measures (incomplete)

- Research
- Measure specific to effect
- Process approach
- General action plan or measure

bron: - PBL, *Aanpassen met beleid* ('Adaptation with policy'), 2013
 - PBL, *Aanpassen aan klimaatverandering* ('Adapting to climate change'), 2015
 - NAS workshop sessions, 7 June, 1 September and 12 October 2016

Disclaimer: These diagrams offer a simplified and incomplete representation of the actual situation. In the interest of clarity, not all components of the known causal relationships are shown.

3. Challenges

3.1. Effects demanding urgent action

The Netherlands Environmental Assessment Agency (PBL) applies five criteria to determine the urgency of action to address the effects of climate change. Three criteria relate to the risk profile of the effect itself: the likelihood that the effect will occur (this decade or this century), its likely impact (high, medium or low) and the degree of uncertainty. Two criteria relate to the sector(s) which will be affected: the adaptation capacity and the lifetime of the necessary investments.

Within the PBL's standard methodology, these five criteria are used to identify those climate effects to which extra attention should be devoted, over and above those designated under the Delta Programme. The National Climate Adaptation Strategy focuses on climate effects with a particularly marked impact, those which are already visible or which will become visible in the short term, and those which affect sectors that are sensitive to weather extremes or have limited adaptation capacity.

This assessment results in the following list of climate effects which should be addressed as a matter of urgency. (In the diagrams on pages 12 to 19, these effects are indicated by a circle with a solid black edge.)

Climate effects demanding urgent action:

**1. More heat stress caused by extreme weather conditions:**

- Greater morbidity and mortality, more hospital admissions, reduced productivity.
- Increase in incidence of skin cancer.

**2. More frequent failure of vital and vulnerable functions due to extreme weather conditions:**

- Energy, telecommunications, IT and the water supply system.
- Transport: the main infrastructure.

**3. More frequent damage to crops or production resources due to extreme weather conditions:**

- Lower crop yields and/or reduced quality due to rain, storms, hail or saturated soil.
- Damage to production resources such as glasshouses and buildings caused by hail, storm or lightning.
- Lower crop yields and/or reduced quality due to extended periods of drought and in the absence of adequate irrigation.
- The more extreme the weather conditions, the more difficult it will be to anticipate and take precautionary measures.

**4. Shifting climate zones further to gradual climate change: the resilience of nature under strain:**

- Changes to the composition of flora and fauna: native species will be lost while new species will establish themselves.
- Some new species may pose a threat to economic activity, to human or veterinary health, or to biodiversity.
- There may be 'mismatches' within the food chain.
- The rise in sea level will place the existing nature of the estuary (delta) region under pressure; habitats will be eroded or lost altogether.

**5. Increased health burden, lost productivity and higher costs due to potential increase in allergies and infectious diseases:**

- Possible increase in the prevalence of allergies such as hay fever and other respiratory conditions.
- Possible increase in exposure to waterborne pathogens due to growth in water recreation and deterioration of water quality.
- Possible increase in vector-borne infectious diseases.

**6. Cumulative effects:**

- Effects whereby failure or disruption in one sector or at one location leads to further failures or disruption elsewhere.

Attention must also be devoted to climate effects which are not expected to emerge until somewhat later this century. In the diagrams they are shown as circles with a dotted black border. All have the potential to cause significant adverse impact, especially if global mitigation efforts remain inadequate. The impact will be considerably less – and within acceptable limits – if the current mitigation agreements are observed.

**Effects which will demand action
in the longer term:**

- Higher risk of electricity grid failure due to extreme weather conditions.
- Restricted movement of shipping due to extreme high or low water.
- Loss of species and habitats due to extremely low water levels in river systems
- Changing migration patterns of migratory birds.
- More frequent or more widespread subsidence causing:
 - damage to buildings and infrastructure
 - safety risks (e.g. fractured cables and pipelines)
 - extra CO₂ emissions due to peat oxidation
- Salinization of agricultural land in the west of the Netherlands due to a combination of rising sea level and soil compaction.
- Large-scale failure of IT services due to problems experienced by crucial IT service providers in other countries, or to overheating.

**Explanatory remarks
to climate effects
demanding urgent action**

1. Heat stress

The Netherlands Environmental Assessment Agency (PBL) has identified heat stress as a climate effect which is likely to have a marked impact on human health and wellbeing within the foreseeable future. High temperatures are only one contributing factor. Heat stress is exacerbated by atmospheric pollution (high levels of ozone and summer smog) and it is this combination which can trigger various respiratory conditions. Among vulnerable groups, heat stress is likely to lead to illness requiring time off work (and hence lost productivity) and even increased mortality. During the unprecedented high temperatures of August 2003, the Netherlands reported 1,400 more deaths than usual. In Europe as a whole, the heatwave claimed over twenty thousand lives.

According to the World Disasters Report produced by the International Federation of Red Cross and Red Crescent Societies (IFRC) the 2015 European heatwave was the second most deadly natural disaster of the year (after the Nepalese earthquake), claiming 3,275 lives in France alone. Heatwaves in Belgium, Pakistan and India are also among the ten most serious disasters listed in the report.

2. Failure of vital and vulnerable functions

The vital and vulnerable functions which could succumb to extreme weather include:

- energy, IT, telecommunications and the water supply system
- transport: the main infrastructure.

More frequent and intense weather extremes will lead to greater disruption of the vital functions, and in some cases to outright failure. Heavy rain, especially when accompanied by high winds and lightning, is likely to cause much damage and inconvenience. Unless additional measures are put in place, the availability of the vital functions will be far below the desired level.

The effects may include direct economic losses. There could be an increase in the number of road traffic accidents and a reduction in the capacity of the road infrastructure. There could also be indirect damage as the failure of the electricity grid causes that of other networks such as the internet and payment transfer systems. Hospitals might also be affected and forced to suspend some services, hopefully on a temporary basis. There could even be problems in upholding public order. In addition to the direct impact, there could also be knock-on effects. During a heavy rainstorm in August 2008, a lightning strike incapacitated the pumps which prevent flooding in the Botlek road tunnel. The tunnel was closed, and traffic on the Rotterdam Ring (the longest and busiest peripheral road in the Netherlands) was brought to a standstill. As a result of this incident, the systems were upgraded and are now much better protected.

3. Adverse impact in agriculture and horticulture

The increased frequency and intensity of weather extremes will result in even greater damage to crops and production resources. Crops will be vulnerable to storms, heavy rain, hailstorms and saturated soil throughout the growing period and harvest season. Storms, hailstones and lightning can also damage glasshouses, farm buildings and essential installations. Extended dry periods will result in a serious water shortage and the salinization of extensive areas of agricultural land. Extreme heat may cause significant deterioration of water quality and provoke heat stress in livestock. It is not unknown for water management authorities to avert major problems in one area by allowing farmland elsewhere to flood. Unless mutually satisfactory prior agreements have been made, the landowner may not receive adequate compensation.

Once again, there can be knock-on effects. Following the hailstorms which caused significant damage in Brabant in mid-2016, farmers experienced problems in transporting what remained of their produce to the processing plants. A shortage of some vegetables, including carrots, was announced because crops throughout Europe had been badly affected by the freak weather. Prices rose accordingly.

4. Shifting climate zones

Natural systems are generally very resilient. Nature has the ability to recover from quite serious setbacks and can adapt to new circumstances. Nevertheless, nature in the Netherlands is already under severe pressure and climate change can only exacerbate the problems. As the climate zones shift, the composition of the country's flora and fauna populations will change. New species are now establishing themselves here while indigenous species have been displaced. Larger mammals and birds are generally more mobile and able to adapt. Other species, including small mammals, reptiles, amphibians and insects, are less mobile. They cannot simply follow the climate zones because the nature areas are not interconnected. The lack of spatial cohesion between the nature areas in the Netherlands and those of our neighbouring countries is a life-threatening problem for these creatures. For the same reason, some species which would thrive in the Netherlands are unable to reach a suitable habitat. Other species can do so, but as pests and invasive exotic species they represent a significant threat to economic activity. Still other new species are carriers of zoonoses and veterinary disease, or are a threat to the established biodiversity. There can be 'mismatches' within the food chain, which will also have a negative impact on biodiversity. The nature of the Netherlands' delta region is of great international importance but is under pressure due to the rising sea level. Some habitats, such as tidal mudflats, are disappearing. Extremes of weather, soil compaction and subsidence, ongoing eutrophication of surface water and the changing hydrology of the coastal areas combine to reinforce effect of the shifting climate zones. Irreversible changes to the ecosystem are the inevitable result. The European Union's aim of maintaining biodiversity will then be far more difficult, perhaps impossible, to achieve.

5. Health burden

Both the Netherlands Environmental Assessment Agency and the National Institute for Public Health and the Environment conclude that various health effects caused by climate change will be seen within the next few years. As average temperatures rise, the hay fever season may become longer in duration and more intense as exotic allergenic plant species such as ragweed (*Ambrosia artemisiifoliae*) establish themselves. At present, over two million people in the Netherlands take medication to relieve the symptoms of hay fever. This figure is expected to double.

Another development is likely to be seen with regard to infectious diseases, both vector-borne and environmental. The increasing popularity of recreation on and in the water means that more people will be exposed to water of poor quality (e.g. containing cyanobacteria, also known as blue-green algae) and the associated health problems. Health care costs will then rise, while there can also be economic consequences due to lost productivity. The influence of climate change on public health must be considered alongside that of demographic developments such as population growth, population ageing, migration and urbanization.

6. Cumulative effects

Almost all reports draw attention to cumulative effects, whereby a systems failure in one sector or at one location will cause problems elsewhere. Many effects of climate change are not limited to specific sectors and any aggregation is likely to have major societal consequences. At present, however, the extent of those consequences remains unclear.

3.2. Measures already in place

Heat stress

The Ministry of Health, Welfare and Sport is mindful of the possible effects of climate change, which it addresses within its regular policy. The particularly hot summer of 2006 prompted the ministry to commission the National Heat Plan. This document, produced in association with the Red Cross, the National Institute for Public Health and the Environment (RIVM) and GGD Nederland (the federation of municipal health departments) was published in 2007 and updated in 2015. Its aim is to minimize the impact of heat stress, especially among the elderly and other vulnerable groups. However, the National Heat Plan is specifically concerned with the residential care sector and the action to be taken when a formal heatwave warning is issued. Current government policy seeks to reduce reliance on residential care, allowing people to live in their own homes for as long as possible. In the event of a heatwave, it is possible that not everyone who needs assistance or advice will actually receive it.

Alongside the direct health care provisions, certain medium-term and long-term climate adaptation measures must be introduced within the urban areas. The physical structure of towns and cities should include more open space and greenery, for example. As part of the *Knowledge for Climate* research programme, a number of provincial and municipal authorities have studied the 'urban heat island' effect. However, measures which entail extensive modifications to the physical structure are difficult to implement, not least because other objectives must also be taken into account.

The Delta Decision on Spatial Adaptation encourages local authorities to devote attention to heat stress as part of a local climate scan. The *Climate Effect Atlas* has been updated accordingly and a website has been set up to disseminate knowledge and best practice examples. However, progress in restricting heat stress by means of spatial measures (or any other measures) would appear to be slow. The most recent monitoring results suggest that the topic has been given little attention by municipalities, provincial authorities or water management authorities.

Vital and vulnerable functions

The definition of 'vital' infrastructure has been expanded to include the energy, IT, telecommunications and water supply systems in addition to the transport infrastructure. Climate change is one component of the 'all-hazard' safety and security approach which seeks to identify and manage all risks to the Netherlands' vital infrastructure. The process also involves examining whether additional capacity is required to safeguard the resilience of that infrastructure.

In 2014, as part of the Vital and Vulnerable project (which is in turn part of the Spatial Adaptation programme), the responsible authorities undertook to identify facilities and infrastructural components which are susceptible to flooding and to develop policy which would minimize the associated risks. Where necessary and appropriate, this policy would then be embedded within legislation.

In a number of pilot projects, government authorities at all levels are working alongside private sector companies and network managers to devise ways in which to climate-proof the vital functions. The extended drought of 2003 prompted energy companies to seek coastal locations at which to abstract process (cooling) water rather than relying on rivers in which water levels and flow may be insufficient in future. Several grid managers have undertaken research to determine the potential impact of flooding on their section of the infrastructure, the objective being to reduce risk. Research has also examined how a large-scale power outage would affect the chain of vital functions. The participation of the grid managers in the pilot projects has provided valuable experience and created a good basis for further cooperation. Given the high degree of network security achieved, service disruptions can be promptly identified and managed, thus precluding any serious or large-scale consequences. The grid managers are also able to incorporate renewable sources, such as wind and solar energy, into their systems although doing so raises certain challenges in terms of network and supply stability.

Climate adaptation in practice



Five Brabant cities sign the 'Health Deal'
PHOTO: HENRI CORMONT/INZICHT-FOTO

A healthy human environment

A human environment which is both healthy and economically vital: that is the aim of the fifteen organizations which signed the 'Brabant Health Deal' partnership agreement in July 2016. In future, all economic and spatial decisions will take the interests of health and welfare into account. The partners will strive to create a healthy human environment, maintain attractiveness and liveability, create a welcoming business climate and maintain a strong competitive position. One of the most significant challenges they face is climate change. Climate adaptation is therefore an integral component of the Brabant Health Deal.

The programme partners include the Province of Noord-Brabant, the five largest cities in the region including Eindhoven and Breda, water management authorities, municipal health departments, the National Institute for Public Health and the Environment, Utrecht University, the University of Tilburg and its Centre for Sustainable Development, Telos. The social issues of today demand a partnership such as this, states Eindhoven alderman Mary-Ann Schreurs. "Only by working together are we strong enough to rise to the many challenges. We must make good use of each other's knowledge and expertise. With such diverse partners – representing every level from private individual to the European Commission – we can make health the key focus of urban and rural development."

As yet, there is no firm climate adaptation policy for the national transport infrastructure (road, rail, waterways and air). This is because there is no clear picture of how climate change is likely to affect the transport system as a whole. It is therefore not possible to identify the measures required or how much they will cost. However, the current climate and weather extremes have been given a place in some projects undertaken by the individual sectors.

The new *Omgevingswet* (Environmental Planning Act) includes a requirement for a 'water assessment' which does take climate change implicitly into consideration. Rijkswaterstaat (the national Department of Public Works and Water Management) is currently examining whether it is necessary to update and amend the guidelines for road design. The procedures for replacing essential water management structures such as locks and dams already take the risks created by climate change into account. Climate is also an important aspect within the new methodology for the renovation of major roads.

ProRail, which manages the national rail infrastructure, has conducted research to identify the risks associated with flooding and extreme weather. Measures have been implemented.

Flood safety in the urban setting

There are some climate effects for which the relevant sectors are well prepared: their adaptation capacity is high and measures have been incorporated into policy and implementation programmes. For this reason, the NAS does not devote special attention to aspects such as water management and flood safety in the urban area.

Flood safety

Flood safety policy shows a high degree of adaptation capacity, as illustrated by the Delta Programme. Responsibilities are clear and well organized; the necessary resources have been reserved. Flood safety policy is based on a multi-level risk management approach. In practice, there are three levels. Prevention (Level 1) is the most important. Prevention is always better – and less expensive – than cure. Disaster response (Level 3) forms the final safety net, regardless of the nature of the crisis: floods, extreme weather, an outbreak of some infectious disease or the failure of vital functions due to heat or drought. It is possible to achieve the necessary level of protection by replacing

certain Level 1 measures by measures at Level 2 (spatial design) or Level 3. A good spatial structure will provide physical protection to the vital and vulnerable functions. This is an important component of the Delta Programme on Spatial Adaptation. Similarly, good crisis management will limit the impact of a flood. This responsibility has been assigned to the Water Crisis and Flood Management Taskforce (*Stuurgroep Management Watercrises en Overstromingen*), which includes representatives of all relevant parties, including ministries, water management authorities and the security regions. The Ministry of Security and Justice and the Security Council are working alongside partners in the water sector on the 'Water and Evacuation' project. The Ministry of Education, Culture and Science has included climate adaptation in its Vision Document on Cultural Heritage, 2017-2018.

Flooding in the urban area

One of the climate effects listed is 'flooding in the urban area'. Localized flooding is already a relatively common occurrence

and is often reported by the media, sometimes with disturbing images. In most cases, the incidents are relatively minor in that they are confined to a small area, although they can cause much inconvenience, distress and expense. Municipal authorities and water management authorities are jointly responsible for reducing the risk of flooding. The Administrative Agreement on Water stipulates that measures must be taken to prevent 'unacceptable' flooding. It is for government authorities to decide precisely how they will address the water challenges of the 21st century, what resources they will deploy, and the timeline they will follow. The water management authorities are working to climate-proof the water system. The Association of Netherlands Municipalities (VNG) is monitoring its members response to increasingly severe and protracted rainfall. Approximately one third of the investments in water management tasks at this level are intended to improve rainwater drainage. Flood prevention is of course a component of the Delta Programme on Spatial Adaptation.

Crop damage

Farmers are accustomed to changing weather conditions and have been able to respond effectively for thousands of years. Nevertheless, the agricultural sector (including glasshouse cultivation) must now prepare for increasingly frequent weather extremes. In principle, it is for the farmers and growers themselves to make the relevant choices and implement the necessary measures. The government acts as facilitator. It supports knowledge development, partly in the context of the 'top sector policy'. One example is research to develop plant strains which are more resistant to dry or saline conditions. The Ministry of Economic Affairs subsidizes premiums for the Broad Weather Insurance scheme under which farmers can recover losses incurred further to crop damage caused by extreme weather. The aim of the Delta Programme on Fresh Water is to ensure that farmers have adequate water for optimal crop production. Where this is not the case, assistance will be provided. The sector itself is working on the Delta Plan for Agricultural Water Management, one aim of which is to ensure that water of adequate quality is readily available.

Nature

The Netherlands' nature management policy takes the effects of climate change into account, and has done so for several decades. At the heart of the policy is the desire to create robust and resilient nature which can 'take a knock' and emerge unscathed. In 1990, the government introduced the National Ecological Network, a concept intended to offset the impact of climate change by allowing natural processes more space. It was hoped that the proposed infrastructure of interconnected nature areas would encourage vulnerable species to migrate: a form of 'managed relocation'. The principle has been retained and forms the basis of the policy document *Natuurlijk verder* (Ministry of Economic Affairs, 2014).

In 2012, many nature management tasks were devolved to provincial level, with the existing budgetary reserves transferred to the Provinces Fund. The provincial authorities are now responsible for the management of existing nature areas as well as the expansion of the ecological network, for which 80,000 hectares is to be acquired. Within the physical domain, central government has limited its own responsibility to the large bodies of water and to certain aspects of agricultural nature management, the latter being undertaken in association with the provinces.

Under its own Delta Plan for Agricultural Water Management, the sector intends to implement measures which will help to achieve the objectives of the European Water Framework Directive, most notably by restricting the discharge of nutrients, fertilizers and crop protection products into surface water or groundwater.

Between 2007 and 2014, a coalition of nature management organizations created a number of 'climate buffers' with financial aid from the Ministry of Infrastructure and the Environment and the National Postcode Lottery. These are areas in which natural processes are allowed free rein. The coalition is still in existence and is overseeing the physical development of the climate buffers to keep pace with climate change. The buffers will do much to maintain and improve spatial quality in the Netherlands.

Health

Monitoring of vectors and vector-borne conditions is undertaken by the National Institute for Public Health and the Environment and the Netherlands Food and Consumer Product Safety Authority, both of which act under the auspices of the Ministry of Health, Welfare and Sport. Government policy seeks to prevent the establishment of exotic (i.e. non-indigenous) mosquito populations in the Netherlands. If monitoring reveals the presence of exotic mosquitoes, they will be exterminated. A policy on indigenous mosquitoes (and other *culcidae*) is currently in preparation. It is possible that in time they too will become vectors of disease, or that the exotic species will gradually extend their habitat into the Netherlands. Developments with regard to infectious diseases will be reported using the existing mechanisms which allow for targeted communication and the amendment of existing guidelines as necessary.

Municipal health departments provide various forms of support in the prevention of climate-related infectious diseases and exposure to allergens. They are responsible for monitoring risks in and around open water used for recreational purposes (in association with the water management authority) and for public information concerning these risks. They are also responsible for pest control and will arrange for the extermination of rats and other vermin (which are potential carriers of leptospirosis) and will respond to outbreaks of the oak processionary moth (*Thaumetopoea processionea*) whose caterpillars provoke an extreme allergic skin reaction. The municipal health departments also provide advice on other allergens, including pollens, spores and mites, to members of the public and to the departments responsible for parks and recreation.

3-3- Aspects demanding special attention

Heat stress, infectious diseases and allergens

Some of the climate effects discussed in the National Climate Adaptation Strategy call for an adequate response to be devised as a matter of urgency. In other cases, a response is already in place but must be improved.

The problem of heat stress has not yet attracted adequate attention. Further knowledge development is required and countermeasures must be improved. This is also true of the response to infectious diseases and allergies, whereby attention must also be devoted to the interrelationship between these health conditions, the urban environment and developments in nature.

Vital and vulnerable functions

Although the vulnerability of certain vital functions has prompted the revision of policy and the implementation of measures, it could be claimed that too little attention has been given to the likely impact of flooding. The urgency of effective measures is partly due to the long life-cycle of the infrastructure that supports vital functions such as energy provision and transport. There is limited flexibility and it will be difficult to adapt the infrastructure to cope with climate change at a later date. The choices and investments made today will do much to determine the form and function of the networks for decades to come. This applies to a far lesser extent to the IT and telecommunications infrastructure which is, for the time being at least, more flexible.

Agriculture

The agricultural sector (including glasshouse cultivation) receives direct support in the form of subsidized insurance cover against losses incurred due to weather extremes, as well as indirect support in the form of an excellent knowledge infrastructure. It is for the sector itself to implement further measures to limit the impact of weather extremes. This calls for collaboration with various partners, including the water management authorities.

Nature

Much is already known about the effects of climate change on nature. However, measures must now be taken as a matter of urgency because the climate effects in combination are likely to bring about irreversible changes to our ecosystems.

Cumulative effects In each area listed above, special attention must be devoted to the cumulative effects.

Coherent policy It will be particularly challenging to introduce the necessary cohesion between the response to climate change within each of the various sectors. The Court of Audit calls for attention to be devoted to this point in its 2012 report 'Adapting to Climate Adaptation: strategy and policy'. It is becoming increasingly clear that climate adaptation is a particularly broad undertaking. It goes beyond flood safety and water provision to touch on many other societal domains, including the physical environment, health and nature. The call for a fully coherent and cohesive policy is therefore being heard ever more clearly from a wide range of actors, including those who are directly involved in the design and upkeep of the physical environment.

4. The approach

Climate-proofing the Netherlands is a joint undertaking for which every member of Dutch society is partially responsible. The government invites local and provincial authorities, private sector companies, water authorities and societal organizations to contribute. The National Climate Adaptation Strategy sets out the course. The government will initiate specific projects and programmes in order to:

1. increase awareness of the necessity of climate adaptation
2. encourage the implementation of climate adaptation measures
3. develop and exploit the knowledge base
4. address urgent climate risks
5. embed climate adaptation within policy and legislation
6. monitor the progress and effectiveness of the adaptation strategy.

4.1.

Raising awareness

Innovative forms of communication

Climate adaptation measures are not the responsibility of government alone: companies and individuals also have a part to play. Good communication and information about developments in policy and research will raise awareness and encourage action. The tempo at which non-governmental actors implement measures should now be increased, not only to prevent further environmental damage but to ensure that the public tasks and services remain affordable. The Delta Programme has spawned a network which has been further strengthened during the preparation of the NAS. This network is to be further expanded in the months and years ahead. The Delta Programme will continue to coordinate activities in water management and spatial adaptation, and will remain responsible for the relevant communications. It is important that the necessity of measures at all levels – local, regional, national and international – is quickly translated into affirmative action. The Ministry of Infrastructure and the Environment will create a ‘digital workspace’ for the NAS and will respond promptly to new developments. Innovative forms of communication will be sought and applied.

4.2.

Climate adaptation in practice

Resources

Implementing the necessary measures demands cooperation between various policy domains, partly because no climate effect is confined to any particular policy domain and partly because certain solutions can address several aims simultaneously. The government intends to promote cooperation by means of financial support to those parties which currently have insufficient capacity. They will be able to use the additional resources to fund the initial problem analyses and the subsequent development of solutions. The assistance of representative bodies such as the IPO, VNG and UvW will be sought. Some resources might also be used to allow the existing coalitions to build upon their achievements to date. In real terms, this will entail the following activities.

a. Broad-based action

Delta Plan for Spatial Adaptation

The National Climate Adaptation Strategy seeks to raise awareness and promote action across the full breadth of all sectors. The practical adaptation tasks which seek to reduce the risks associated with flooding, heat and drought fall within the Delta Decision on Spatial Adaptation. The relevant parties have agreed to approach these tasks with greater urgency and are to produce an action plan – the Delta Plan for Spatial Adaptation – as part of the Delta Programme 2018. However, it is important to formulate the climate adaptation process in a broader context, to include consideration of the consequences of climate change for nature, health, the food supply chain, spatial design, cultural heritage, housing, urban transformation, and so forth. The Ministry of Infrastructure and the Environment has therefore opted to place the emphasis on ‘climate-adaptive action’ and, in consultation with its partners, will undertake the following.

- **Operationalization of the concept of climate-adaptive action**

In order to monitor the progress made by the sectors (and hence the Netherlands as a whole) in climate-adaptive action, a set of objective performance indicators is to be developed in 2017. This process will involve close consultation with the various stakeholders to ensure that the concept of climate-adaptive action is operationalized in a fully measurable way. In the further operationalization of climate-adaptive action, the ministry will align itself with the efforts of the Delta Programme partners in terms of 'climate-proof and robust spatial design', as described in the Delta Decision on Spatial Adaptation. This work will continue throughout 2017 as part of the Incentive Programme on Spatial Adaptation and the Vital and Vulnerable project, and will include the production of the aforementioned Delta Plan for Spatial Adaptation. The 'living lab' pilot projects will provide valuable experience with regard to the incorporation of climate adaptation in regional and local development plans. Where appropriate, activities will be aligned with those of the City Deals programme and ongoing cultural heritage projects, since climate-adaptive action will often be undertaken in areas which represent historic cultural values. The Netherlands Commission for Environmental Assessment is currently preparing guidelines for the inclusion of climate adaptation within environmental impact assessment reports.

- **Encouraging climate-adaptive action**

The Ministry of Infrastructure and the Environment wishes to promote climate adaptation initiatives in all sectors by providing knowledge and resources. Some initiatives will qualify for support under the Delta Programme on Spatial Adaptation.

- **Expansion of the current digital workspace**

If climate-adaptive action is to have access to up-to-date knowledge, it is essential that an effective digital working environment is in place. All parties must be able to contribute and share their knowledge as part of an 'online community'. It is not necessary to set up an entirely new digital environment. There is already a knowledge portal for Spatial Adaptation which will now be expanded and refined. It is a central point of reference for everyone who is involved in climate adaptation in the physical environment, and particularly the urban setting. Its expansion to cover the entire breadth of climate adaptation will call for the addition of knowledge concerning the rural areas and all societal sectors. One of the portal's key features will be the digital versions of the diagrams presented in this NAS. They will be regularly updated and the possibilities for user interaction will be exploited to the full so that everyone has the opportunity to contribute to the overall process.

b. Initiate and facilitate coalitions based on crossovers

At the regional and local levels of scale, it is often necessary to address various problems – in several sectors – simultaneously. It is worthwhile examining whether a single solution can be found which will address multiple issues, particularly if all are evident at the same location. Such solutions are termed 'crossovers'. One example is the inclusion of more open water and greenery in the urban design. This reduces the risk of flooding during heavy rainfall and also improves the quality of the human environment. It is, of course, essential that the water and greenery are properly maintained and remain 'healthy'. Another example is the creation of 'green zones' which will also act as a climate buffer for the urban area. New coalitions have also been formed to address the problem of subsidence. It is important to adopt an active approach to the crossovers which will help to solve various problems. Many potential crossovers were identified during the preparation of the NAS: see Appendix 2. The Ministry of Infrastructure and the Environment sometimes takes the initiative in forming and facilitating new coalitions with a view to exploring the opportunities offered by these crossovers.

Crossovers

Forming coalitions

Climate adaptation in practice



Dordrecht: partner in the
Climate Adaptation City Deal.
PHOTO: TINEKE DIJKSTRA FOTOGRAFIE

Climate Adaptation City Deal

In September 2016, fourteen public sector authorities and twelve (semi-) private organizations formed the Climate Adaptation City Deal partnership, which aims to move climate adaptation in the urban environment onto the next level. Over the coming four years, the partners will share their knowledge and experience as they work to implement the Delta Decision on Spatial Adaptation. Various pilot projects will be undertaken to demonstrate how climate-proof solutions help to create a pleasant and healthy human environment while also reducing management and maintenance costs. The programme hopes to inspire other cities to follow its example.

The partners will develop new governance arrangements, financing structures and innovative solutions, all of which will be subject to a careful assessment of effectiveness and added value. Results will be shared with national and international partners through an open platform.

Climate-proofing government buildings

c. Research examining the climate status of government buildings

The Dutch government owns and maintains many buildings and sites. It is also responsible for much of the country's transport infrastructure. In 2017, a study is to be conducted to determine how climate-proof the government's holdings are. The results will be used to formulate policy objectives. This is another way in which the government is contributing to the shared task of climate adaptation.

A team of brokers

d. Brokers

Climate adaptation is a complex undertaking which demands cooperation between various parties: government authorities, research institutes, private sector companies and individual members of society. Not all have access to the necessary knowledge, expertise or networks. A team of brokers representing various disciplines is to be formed. It will bring together the various parties, helping to match demand for knowledge to supply. In areas which demand cooperation, the team will help to form new coalitions or expand existing coalitions. One of the team's first tasks will be to organize the climate adaptation dialogues (see below).

At the international level, the Netherlands is among the European countries which have joined forces to form a network of experts involved in the production of climate adaptation strategies. The members of the network share their knowledge and inspire each other.

Insurability of climate risks

e. Adaptation dialogues

To explore the issues in greater depth, stakeholders are holding a series climate adaptation dialogues. These discussion meetings offer an opportunity to clarify the challenges and brainstorm possible solutions. The first topic to be discussed will be the possibility of insuring against climate risks. This dialogue will build upon the many discussions that have already taken place, bringing all stakeholders together around the same table. Prospective participants include the four lead ministries (the Ministry of Economic Affairs, the Ministry of Infrastructure and Environment, the Ministry of Security and Justice and the Ministry of Finance), UvW, IPO, VNG, industry federations, the Dutch Association of Insurers and DNB (the central bank of the Netherlands).

4-3-
Using and expanding
existing knowledge

In recent decades, the Netherlands has made significant investments in research examining the effects of climate change and the necessary adaptation measures. The 'Knowledge for Climate' programme is just one example. The knowledge and expertise gained in the past remains valuable and should be put to good use, particularly in terms of its practical implementation. It is also essential to build upon that knowledge, as in the adaptation dialogues described above. The Netherlands' climate knowledge must be at least maintained at the current level. Ideally, it should be raised onto an even higher level. Both the demand and supply side are to be asked to suggest areas in which additional investment in knowledge development is now required. This will enable the knowledge agenda to be updated in the years ahead. Above all, it is essential that the research network which has been developed in recent years is further strengthened in order to formulate new research questions and find appropriate answers.

Updating the knowledge agenda

Mutual reinforcement

Climate adaptation is a particularly knowledge-intensive policy area. The process of knowledge development is directed by public sector bodies at various levels: ministries, regional and local authorities and the water management authorities. Coordination can be improved, and the Ministry of Infrastructure and the Environment is to take the lead in doing so. It should be easier for those who require knowledge to find those who can supply it. All parties involved in formulating research questions, establishing budgets and disseminating the results should support one another. The National Water and Climate Knowledge and Innovation Programme can play an important role in this respect. Better coordination may well lead to new research questions in areas such as governance or

intersectoral integration. There is increasing worldwide demand for the knowledge and skills of Dutch researchers, companies and public sector managers. Given the increased risk of flooding in some countries, Dutch water management expertise represents a valuable export product. In addition to physical interventions, there is a clear demand for visualizations of the results of abstract modelling, methods and instruments with which research results can be more readily communicated.

Integrated approach The Netherlands' international profile is based on an integrated approach. Climate adaptation is one component of our country's expertise, alongside other societal themes such as sustainability, urbanization and food provision. The government wishes to see Dutch knowledge and expertise used to support projects which will help to achieve the United Nations Sustainable Development Goals. To this end, it intends to establish a Global

Centre of Excellence Centre of Excellence on Climate Adaptation.

4.4. Addressing the urgent risks

This document considers climate adaptation in its full breadth, with an emphasis on new developments in research and policy. In Chapter 3, we identified certain risks which must be addressed as a matter of urgency. Failure to do so is likely to result in significant societal costs within the foreseeable future. Central government has therefore initiated research, policy formulation and the development of practical solutions in collaboration with knowledge institutes, other levels of government, societal organizations and the private sector. Attention must be devoted to policy coherence to ensure that the proposed adaptation measures in one sector do not cause undesirable negative effects in another.

Heat stress

It is now clear that extended periods of high temperatures will have very serious effects. The Netherlands can expect to experience summer heatwaves on an increasingly regular basis. To complement the current reactive approach, as set out in the National Heat Plan, municipalities must produce local heat plans which consider the position of vulnerable people in the community. Provincial authorities, municipalities and private stakeholders must also implement (spatial) measures to prevent urban heat islands: areas which have a significantly higher temperature than the surrounding region. Primary responsibility falls to the public sector authorities further to their participation in the Delta Programme on Spatial Adaptation. The National Heat Plan will be reviewed and revised as necessary. A possible effect of climate change is an increased risk of skin cancer. The Ministry of Health, Welfare and Sport will therefore provide public information about the risks of exposure to ultraviolet radiation and will advise on lifestyle choices.

Local heat plans

Spatial measures

Preventing urban heat islands

Vital and vulnerable functions

The Vital and Vulnerable project is part of the programme undertaken further to the Delta Decision on Spatial Adaptation. In 2017, the level of ambition with regard to each function is to be determined with due regard for coherence between the ambition levels for each of the thirteen vital functions identified. This process will support the development of policy and possibly new legislation. The main transport infrastructure – the motorways and trunk routes which are the responsibility of central government – is covered by agreements made in 2014. In September 2016, the government announced its intention of expanding the arrangements to cover other modalities (see the second progress report of the Vital and Vulnerable project and the background report to the Delta Programme (2017)). The 2014 agreements relate to the role of the main transport infrastructure during a precautionary evacuation and during an actual flood, and the rapid repair and reopening of roads following a flood.

Study of weak links in rail system A study to identify ‘weak links’ which make the main roads infrastructure more vulnerable to the effects of flooding has been completed. A similar study examining the rail infrastructure and its chain dependency will now follow. It is important to have full information about the effects of a (temporary) disruption of transport infrastructure as a whole. This information will therefore be gathered by the Ministry of Infrastructure and the Environment. Various scenarios will be examined, based on which a general contingency plan can be developed. The process will consider both flood risks and climate risks to the greatest extent possible. It is clear that a higher level of ambition will entail higher costs. Management measures are usually location-specific and should be coordinated with the measures implemented by the local stakeholders. It should be remembered that the risk of flooding is also location-dependent but the effects of a systems failure will be felt across a far greater area or along an entire ‘corridor’.

Crop damage

Climate-proof regional water management The Broad Weather Insurance subsidy arrangements have been evaluated and a report submitted to government. The Minister for Agriculture is expected to inform the House of Representatives of the government’s response in spring 2017. Insurers have met with representatives of the agricultural sector to discuss ways in which the insurance products can be better tailored to actual requirements. Following the extreme weather experienced in the southeastern Netherlands in June 2016 water management authorities have undertaken to climate-proof the regional water management processes. They will also join the sector organizations in examining the desirability of further research into the effects of climate change and the measures that individual landowners can implement.

Nature

Extending agricultural nature management It is important to create robust and resilient nature areas which form part of an interconnected pan-European network. Nature must also be firmly embedded within the cultural landscape, which entails improving hydrological and environmental conditions, pursuing current policy and programmes in a consistent manner, and implementing ‘best practices’. Natural eco-corridors are part of the desired approach, as is the sympathetic management of waterways, verges and other components of the ‘light green’ national nature network. Adaptive, flexible formulation of the objectives for nature areas and individual species will also promote good nature management. The prevention of peat oxidation will not only benefit nature but will help to slow climate change. It is proposed that agricultural nature management should be extended to include activities which support climate adaptation. The possibility of including climate adaptation measures in the Common Agricultural Policy is to be examined. To counter ‘coastal squeeze’ (the loss of nature habitats such as mudflats and salt marshes) it may be appropriate to raise artificial sandbanks along or behind the foreshore. It is important for nature to be considered as a (partial) solution to problems in other sectors (as in ecosystem services and nature combinations). Cooperation within and between sectors should therefore be encouraged.

Health

Climate risks to be included in RIVM report The 2018 edition of RIVM’s four-yearly Public Health Status and Foresight study will devote specific attention to climate risks. The predicted increase in the incidence of allergic conditions has prompted the Ministry of Health, Welfare and Sport to provide public information about pollen, dust mites, spores and other allergens, and to issue lifestyle advice.

Climate adaptation in practice



Experts from insurance companies and the local authority to visit a city neighbourhood.
PHOTO: HENRI CORMONT/INZICHT-FOTO

Cooperation between local authority and insurance company

The City of Tilburg and the insurance company Interpolis are working together on climate adaptation. The partners share knowledge and information relating to the damage caused by extreme weather. For example, Interpolis reports the number of claims received from certain postcode districts, together with their total monetary value. Further analysis of the data in the claims database will help both parties understand the risks and how they can be addressed. An inspection tour of one affected neighbourhood is planned, during which experts from Interpolis and the local authority will assess the situation and share their experiences. Although the partnership is still in its early days, there is a very real prospect of a 'win-win' situation. The local authority will be able to implement effective measures and plan its maintenance budgets more accurately. Interpolis will receive fewer claims.

<p>Embedding health within policy and legislation</p>	<p>4-5. Because climate adaptation affects practically all aspects of our lives, there are many points of convergence between the various policy domains. It is possible that certain legislative instruments overlap. If climate adaptation is to be taken to the next level, it is important to ensure that policy and legislation are complementary rather than contradictory. However, the overlap also creates opportunities, when policy in flanking areas is being prepared for example. Such opportunities will be more actively pursued by means of the following activities.</p>
<p>Regional adaptation strategies to be included in official documents</p>	<p>Embedding climate adaptation within regional environmental policy documents The National Environmental Vision announced in mid-2015 outlines government policy with regard to the physical environment. It lists and explains the main objectives for the long-term spatial development of our country, including climate adaptation measures. Several regional and municipal authorities have started work on their own environmental policy documents. Central government has requested the provinces to take the lead in producing regional climate adaptation strategies and has asked both provincial and municipal authorities to devote specific attention to climate adaptation in their policy documents.</p>
<p>Climate adaptation in the MIRT</p>	<p>Embedding climate adaptation within government investment programmes In projects with a particularly long lifetime, such as most infrastructural projects, it is important to incorporate climate adaptation measures from the outset. It could be decades before a replacement or major overhaul allows the opportunity to change anything.</p> <p>Central government works alongside provincial and municipal authorities on spatial projects and programmes in all regions. The Multi-Year Programme for Infrastructure, Spatial Planning and Transport (MIRT) provides an investment framework. In November 2016, the Ministry of Infrastructure and the Environment issued revised guidelines for the MIRT. The latest version devotes specific attention to climate change and allows adaptation measures to be form part of the planning and implementation processes for all major spatial investments. In 2017, a handbook is to be produced with a view to the further operationalization of climate adaptation. It will provide guidance for project managers and other stakeholders in MIRT projects.</p>
<p>Climate adaptation handbook</p>	<p>Capacity building in the public sector For provincial and municipal authorities, climate adaptation is a relatively new area of attention. Given the integrated nature of climate adaptation and the various policy domains of which it forms part (water management, spatial development, economic policy, health, safety and environment), it is difficult to assign responsibility to any particular department. It is important that all public sector authorities develop the necessary knowledge and resources: there must be a process of capacity building. A central point of contact is required. Cooperation between the smaller municipalities is likely to be of value.</p>
<p>Capacity building Central point of contact</p>	<p>A number of meetings have been held further to the National Safety and Security Strategy, at which public and private stakeholders were invited to discuss topics such as heat and drought, flooding, extreme weather conditions and (forest) fires. An ongoing study (the National Threats and Capacities Programme) will determine the extent to which the Netherlands is prepared to counter various risks to public safety. The NAS complements this process by recommending measures which will help to climate-proof our country.</p>

Supplementary or new legislation**Preparing post-2020 legislation**

Climate adaptation will become increasingly important in the years ahead, if only due to the extent of the societal and financial interests at stake. It seems likely that supplementary or new legislation will be required. Over the period to 2020, the relevant departments will join the societal partners in examining the requirement in more detail. The degree to which the challenges described in the NAS have been addressed will of course form part of their deliberations.

The Caribbean Netherlands**A separate plan**

Climate-related issues in the Caribbean Netherlands are significantly different to those in Europe and demand a separate plan. During the first half of 2017, the Ministry of Infrastructure and the Environment will hold talks with the ‘special municipalities’ of Bonaire, Sint Eustatius and Saba, and will offer assistance in producing a climate adaptation strategy. Should they so wish, the autonomous islands of Aruba, Curaçao and Sint Maarten can avail themselves of the same opportunity, subject to the approval of Interparliamentary Council of the Kingdom.

4.6.**Monitoring**

It is important to monitor the progress of activities undertaken further to the NAS.

Indicators

Evaluation will reveal whether the activities have indeed reduced the climate risks. A set of performance indicators should therefore be agreed: what results will be deemed satisfactory at given points in the process. Evaluation will also reveal whether any new risks have emerged, or whether the known risks are developing more quickly than had been expected. The main focus will be the ‘impact-based’ risks. It then becomes possible to apply a flexible, adaptive strategy intended to minimize the impact of climate change risks. Prompt identification of increasing risk – an ‘early warning’ system – is important in this regard.

Basic facility

The Ministry of Infrastructure and the Environment, assisted by the knowledge institutes, is to implement a basic monitoring system which allows central government, provincial authorities, local authorities, water management and other stakeholders to monitor climate adaptation progress. The sharing of results will inspire, create a common sense of purpose, avoid ‘reinventing the wheel’ and – not unimportantly – provide a basis for more formal monitoring. The intention is not to create an entirely new monitoring system but to adapt existing methodologies such as the ‘Measure, Know, Act’ approach applied by the

Gaps in knowledge

Delta Programme and the impact-and-risk assessments used by the PBL. Where any gaps in the knowledge are identified, the Ministry of Infrastructure and the Environment will help the stakeholder network to rectify them, perhaps based on the best practices developed by provincial and local authorities. The National Climate Adaptation Strategy 2016 provides the

Baseline measurement

baseline measurement: a starting point against which progress can be compared. Thus far, data on the quantifiable loss or damage due to climate change and extreme weather has not been systematically recorded. Efforts to do so will be intensified as part of the monitoring process. The Ministry of Infrastructure and the Environment will make agreements with the PBL with regard to the regular updating of the risk analyses on which the NAS 2016 is based.

5. From strategy to implementation

This National Climate Adaptation Strategy forms the precursor of a Climate Adaptation Implementation Programme which will build upon the various activities already in progress, such as those of the Delta Programme. The necessary manpower and financial resources must now be put in place. The Delta Programme supports the implementation of the NAS in various ways, including the production of the Delta Plan for Spatial Adaptation. This will set out how the various parties are to pursue the objectives of the Delta Decision on Spatial Adaptation, establishing the instruments and measures required to achieve the intended transition. The Climate Adaptation Implementation Programme will continue to be considered in relationship to the Delta Programme.

Learning by doing

The Ministry of Infrastructure and the Environment as coordinator

Climate change is subject to a number of uncertainties, as of course are societal developments such as the rate of (technological) innovation, population growth and urbanization. Ongoing adjustment of the strategy will therefore be necessary. However, this is nothing new. The original design of the Haringvliet dam was modified to allow salt water intake via the sluices; we have created 'more room for the rivers', and fish will soon be able to swim between the IJsselmeer and the Wadden Sea along a 'migration river' through the Afsluitdijk (dam). The Netherlands is never 'finished'. Learning by doing is the essence of the NAS.

Progress reports

The government has taken up the challenge. The ministries will ensure that all aspects of climate adaptation are included in their implementation and monitoring processes by the end of 2017. The Ministry of Infrastructure and the Environment has taken on the role of coordinator because climate adaptation is a matter for diverse actors in many different sectors and domains. Connections must be created between them. Regular progress reports will be issued; the first is planned for 2019. If necessary, a revised and updated version of this climate adaptation strategy will also be produced. Once again, it will represent a process of co-creation involving all parties who must take action in order to address the most urgent climate risks.

Important choices

The necessity of adapting to our changing climate can only increase in the years ahead. It is already clear that climate change is progressing more quickly and with greater impact than we had anticipated. We must respond accordingly. Fortunately, the Netherlands possesses the required knowledge, experience and innovative ability. As the examples given in this document make clear, there are many opportunities for effective action: in the cities, on the coast, alongside the rivers, at neighbourhood level and at that of the individual building. It is all a question of ambition. Nothing worthwhile is ever easy!

Financial implications

Climate adaptation entails expense. Certain important choices must be made by government departments, businesses and individual households. Modifications to the main transport infrastructure will have substantial financial implications. Adapting to climate change requires everyone to make investment decisions. Putting off those decisions, or making the wrong choices, is likely to prove very much more expensive in the longer term. However, there will also be returns on the investment, not only in the financial sense but in terms of a more attractive and healthier human environment.

Participation Everyone has a part to play in helping to devise policy and in the research needed to prepare the Netherlands for the effects of climate change. The new government will present the Climate Change Implementation Programme during the second half of 2017, following due consultation with the ministries, the Delta Programme, local and provincial authorities, knowledge institutes and societal organizations. Preparations are already well under way. Everyone in the Netherlands is invited to contribute ideas and to take an active part in climate adaptation.

The implementation programme

Appendix 1 Climate effects by impact and urgency

Economic impact per event	Unlikely this century (to 2100)	Likely this century (to 2100)	Likely this decade (2010-2020)
High (> 100 million euros)	<ul style="list-style-type: none"> Flood due to failure of primary water defence Epidemic of a disease new to the Netherlands Crop damage due to pests or disease Flood in eastern Netherlands due to breach of dikes in Germany 	<ul style="list-style-type: none"> Failure of crucial components of the electricity grid due to protracted heat, drought or still air Crop damage due to protracted drought Disruption to shipping due to extreme high or low water Damage to buildings or underground infrastructure due to unusual subsidence 	
Medium (10-100 million euros)		<ul style="list-style-type: none"> Flood due to failure of secondary water defence Failure of crucial IT hubs elsewhere in the world due to extreme weather Local electricity outage due to extreme weather Disruption of rail and/or road traffic due to storm damage or wildfires Crop damage due to extreme weather Food price increases due to protracted drought in Europe 	<ul style="list-style-type: none"> Disruptions to traffic and transport due to high winds and rain Damage to water supply pipelines caused by trees being uprooted during high winds Increase in health care costs and lost productivity due to longer, more intensive pollen season (hay fever, asthma)
Low (< 10 million euros)			<ul style="list-style-type: none"> Local flooding due to extreme rainfall Disruption of rail and/or road traffic due to extreme rainfall Rising electricity prices at European level due to scarcity of cooling water and/or still air Production losses by Dutch companies due to climate effects in other countries Price fluctuations for raw materials Emergency aid to other countries

Risk

Small
 Medium
 High

Source: *Aanpassen aan klimaatverandering. Kwetsbaarheden zien, kansen grijpen* ('Adapting to climate adaptation: recognizing risks, seizing opportunities'), PBL 2015.

Impact on people

	Unlikely this century (to 2100)	Likely this century (to 2100)	Likely this decade (2010-2020)
High (> 100,000 affected and/or > 10 fatalities)	<ul style="list-style-type: none"> Flood due to failure of primary water defences Epidemic of disease which is new to the Netherlands Consequences of political conflicts elsewhere in the world Flood in eastern Netherlands due to failure of water defences in Germany 	<ul style="list-style-type: none"> Failure of crucial components of the electricity grid due to protracted heat/drought/still air Large-scale failure of IT services due to problems affecting crucial hubs or service providers elsewhere in the world Large-scale failure of IT services due to overheating 	<ul style="list-style-type: none"> Heat stress in urban areas
Medium (10,000 – 100,000 affected and/or 1 – 10 fatalities)		<ul style="list-style-type: none"> Flood due to failure of secondary water defence at local/regional level Regional power outage due to weather extremes Disruption of rail or road traffic due to storm damage Fire causing local IT failure or transport disruptions 	<ul style="list-style-type: none"> Extension and intensification of pollen season (hay fever, asthma) Increase in cases of Lyme disease Infectious diseases due to deterioration in water quality Road traffic accidents or other disruption due to extreme winds and rainfall Damage to water supply pipelines caused by trees being uprooted in high winds Dutch victims of extreme weather conditions or (infectious) diseases when travelling abroad
Low (< 10,000 affected and 0 fatalities)			<ul style="list-style-type: none"> Local flooding due to extreme rainfall Disruption of road or rail traffic due to extreme heat Local power outage due to storm or earth movement

Risk

Small
 Medium
 High

Impact on nature and the environment

	Unlikely this century (to 2100)	Likely this century (to 2100)	Likely this decade (2010-2020)
High (national and/or irreversible)	<ul style="list-style-type: none"> Loss of species due to shifting climate zones Loss of marine habitats (mudflats and salt marshes) due to seawater incursion 	<ul style="list-style-type: none"> Loss of species and habitats due to extreme low water in river systems Changing migration patterns of migratory birds 	
Medium (regional and/or difficult to rectify)		<ul style="list-style-type: none"> Temporary disruption of habitats due to recurrent extreme drought Disruption of subsoil and unexcavated archaeological heritage due to increased subsidence Acceleration of environmental impact caused by groundwater depletion and eutrophication 	<ul style="list-style-type: none"> Deterioration of ecological water quality Decline of indigenous species due to shifting climate zones
Low (local and or reversible)			<ul style="list-style-type: none"> Local disruption of habitats due to extreme weather Increased CO₂ emissions due to increased subsidence and peat oxidation

Risk

Small
 Medium
 High

Appendix 2 Crossovers

Water-Nature-Urban Design-Health

- Water quality, prevention of cyanobacteria, lower incidence of infectious diseases.
- An attractive environment which invites outdoor recreational activity has a positive health effect. However, recreation also increases the change of exposure to pathogens and vectors (such as ticks and Lyme disease).
- More greenery helps to decrease heat stress. 'Smart' design is necessary in the interests of air quality.

Water-Spatial Planning-Public Spaces-Housing-Infrastructure

- Urban transformation based on climate-proof design.
- Use new planning and environment legislation to promote cooperation and create cohesion.
- Tackling potential flooding within the spatial structure is cheaper than doing so within the water system.
- Knowledge-sharing between local authorities and suppliers such as tree nurseries with a view to promoting climate adaptation through choice of species to be planted.
- New design requirements for (residential) buildings and roads.
- Subsidence and water table management in relation to spatial functions: there can be conflicts of interest which lead to economic dilemmas and a need for transformation.

Transport-Infrastructure-IT

- Rijkswaterstaat and the Ministry of Infrastructure and the Environment wish to approach the roads infrastructure with due regard for urbanization, sustainability and climate adaptation but experience difficulties due to the current division of responsibilities and budgetary issues.
- Mobility is increasingly dependent on IT, as in the case of autonomous ('driverless') vehicles. Failure of IT systems due to climate effects will therefore have a significant impact on transport and accessibility.

Industry-Energy-IT

- Disruption of industrial production due to failure of IT or electricity supply caused by heat or other extreme weather conditions.

Spatial design-Disaster management

- Ongoing consideration must be given to the maintenance of essential functions in a disaster management situation. The results of the National Vital and Vulnerable Functions project will provide valuable input in this regard.

Agriculture-Nature-Water-Infrastructure

- Agriculture, nature and water have long been associated with each other. Good land management has resulted in the creation of climate buffers, while attention has also been devoted to soil quality, fertility and biodiversity. Moreover, well-maintained soil retains water, helps to maintain the quality of both groundwater and surface water, and makes a lower contribution to CO₂ emissions.
- Maintaining the stability of logistic processes is the result of examining whether the infrastructure is reliable enough to support the transport of feed, livestock and other agricultural products. Disruptions to transport will lead to economic losses and can create animal welfare issues (overcrowding, deterioration of unsold produce).

Agriculture-Health

- New animal species may be introduced to the Netherlands, bringing a potential threat to human health (zoonoses).
- Heat stress in animal sheds.

Agriculture-International Food Systems

- High temperatures will lead to increased waste throughout the supply chain which will have both financial and health implications.

Climate response -Business climate

- It is essential that the Netherlands is seen to manage climate risks effectively so that the country remains attractive as an international business location.

Colophon

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