Routeplanner 3:

What we do and don't know about climate change in the Netherlands

THE GREEN HEART, NATURE, THE CITY AND FLOOD SAFETY

Routeplanner

2050

Contents

1 Adapting Spatial Planning to Climate Change programme

There is no doubt about it: the climate is changing. The effects are already tangible and predictable. Scientific research has shown that even if we significantly reduce greenhouse gas emissions (mitigation), climate change cannot be prevented. But if we do nothing, society will be exposed to serious risks. And that is why we have to adapt to make the unavoidable effects of climate change acceptable: the Netherlands must be made climate-proof.

To galvanise this process of climate-proofing, four ministries and the three BSIK[1] research programmes Climate changes Spatial Planning, Living with Water and Habiforum have established the National Programme on Adapting Spatial Planning to Climate Change (Adaptie Ruimte en Klimaat, ARK; see Box 1). The core research questions being examined by ARK are:

- What is the nature and scale of the already observable and expected impacts of climate change on various themes and economic sectors?
- What spatial issues do they throw up?
- How can we tackle these spatial issues?
- What dilemmas (technical, administrative, economic, social) will we face when trying to resolve these spatial issues?

The Routeplanner is the scientific arm of ARK. The three research programmes, supported by other research institutes, 'feed' ARK with scientific information and insights on climate-proofing the spatial development of the Netherlands.
The Routeplanner 2 project resulted in four reports and the brochure 'Towards a Climate-Proof Netherlands' (Naar een klimaatbestendig Nederland). Routeplanner 3 takes this further and indicates the problems and potential solutions for each region and theme. Linkage documents have been drawn up for the Green Heart region and the Nature, City and Flood Safety themes. They address the following topics:

- Which research questions have already been answered
- What these answers are
- Which research questions are now being studied in the BSIK Climate changes Spatial Planning, Living with Water and Habiforum research programmes
- Which research questions are being examined outside the BSIK funding programme
- Which knowledge gaps still remain

The aim is to use the identified knowledge gaps when formulating projects in the BSIK programmes, the new Knowledge for Climate (Kennis voor Klimaat) programme and other research programmes. This brochure summarises the main conclusions of the four linkage documents.

[1] BSIK is the Dutch abbreviation for the Decree on subsidies for investments in the knowledge infrastructure (Besluit subsidies investeringen kennisinfrastructuur)

2 The climate is changing

In 2006 the Royal Netherlands Meteorological Institute (KNMI) drew up four future climate scenarios for the Netherlands. The main conclusions from this exercise are given below (the figures are for 2050, compared with 1990):

- Global warming will continue, with mild winters and hot summers becoming more frequent
- The four scenarios show an increase in temperature, varying from 0.9 to 2.3 degrees in the winter and from 0.9 to 2.8 degrees in the summer
- Winters will on average become wetter, varying from between 4 and 14 per cent, and extreme precipitation amounts will increase
- The severity of extreme rainfall in summer will rise, but the number of summer days with rain will decline. On average, summer rainfall will increase by 3 to 6 per cent if atmospheric circulation patterns remain the same, but will decline by 10 to 19 per cent if easterly winds become more frequent
- The calculated changes in the wind climate are small in comparison with natural fluctuations
- The sea level will continue to rise, varying from 15 to 35 cm in 2050

By about 2050 the average summer will probably resemble the hot summer we experienced in 2003. For example, in De Bilt the average number of summer days (>25°C) will increase from 24 in 1990 to 30 to 47 in 2050, depending on the scenario. In 2050 the Dutch climate will resemble the current climate in Bordeaux (in the spring, summer and autumn) and the Po valley (in the winter).

The greatest uncertainties lie in the amount of precipitation we can expect in summer and the changes in the direction and – to a lesser degree – the force of the wind.

3 The Green Heart region

IMPACTS

The fen meadow landscape has not changed significantly during the last 800 years and is characterised by grazing cattle, black-tailed godwits flying overhead, broad ditches and wide open views. Many generations of farmers have created and managed this landscape. Over the centuries the towns and cities around this open fen meadow area have largely coalesced to form an urban ring called the Randstad. This development pattern has been dictated by the natural conditions in the region: the lowland peat area of Holland was hard to reclaim and even more difficult to build on. It was only in the 1950s that the qualities of this spatial configuration were discovered and the central open area was given the name 'the Green Heart'. Three qualities were identified:

- The amenity value of a large area of countryside as a counterpole to the rapidly expanding cities around it
- The functional value (utility) of the green environment for agriculture, nature and recreation
- The future value of the area as a land reserve for functions that require a central location

Parts of the Green Heart are threatened by rapid land subsidence caused by shrinking of the peat through drying and oxidation (up to two metres per century), waterlogging and the risk of flooding, an encroaching urban 'shadow' and increasing international competition in the agricultural sector. Reversing these threats to create prospects for sustainable land use in the area, while respecting the unique qualities of this cultural landscape, is a highly complicated business.

Climate change increases the need to store water in the area and prevent more rapid land subsidence. It also heightens the demand for recreational space by city dwellers and alters the agricultural conditions of production and the prospects for nature. Due to oxidation of the peat, current land use in the Green Heart accounts for about 0.5% of Dutch greenhouse gas emissions. If present land uses continue, the rate of oxidation of the peat will increase because the temperature is rising as the climate changes.

ADAPTATION STRATEGIES

To make the Green Heart climate-proof the layout and management of the characteristic water system, open space and cultural landscape will have to change. As a result of climate change the area can expect more frequent wet and dry periods than in the past. To cope with a more changeable regime of wet and dry periods the water system must be made more robust. Making the landscape and development pattern dependent on the water level ('function follows water level'), instead of current practice in which water levels are controlled to suit the desired land uses ('water level follows function'), would make the Green Heart more climate-proof and would also reduce greenhouse gas emissions.

Within the constraints of a robust water management system, more space should be made available for adapted urban and recreational facilities and the creation of new natural habitats. Agriculture will have to respond to the implications of a more robust water system and to new social needs.

The overall direction of these changes is becoming clearer, and is already being translated into policy. We are at a turning point in our thinking about the sustainable development of the Green Heart, but it is not yet clear how and at what rate the complex and wide-ranging processes of change can be brought to fruition in a socially acceptable manner.

The BSIK research programmes Climate changes Spatial Planning, Living with Water and Habiforum are delivering important information for the social decision-making process for a climate-proof landscape structure and land management for the Green Heart. These programmes are producing building blocks for development perspectives to be built on:

- → Adapting land uses, especially agriculture, to more robust water systems
- → New functions and economic drivers
- → A new vision for existing and new natural habitats
- → Risk management as a factor in planning and construction
- → Social embedding of adaptation strategies

4

KNOWLEDGE GAPS

Many research projects focus on just one of these issues. The major challenge for the years to come is to integrate these development issues to create a coherent vision for a sustainable, climate-proof spatial structure and use of the Green Heart. The prime objectives of research efforts are to reveal the effects, the effectiveness and the social, economic and ecological feasibility of regional transitions in the physical planning and management of land and water. Various types of research and actions are needed to achieve the necessary integration of knowledge:

1. Linking together models on different fields of knowledge, such as hydrology, land subsidence, greenhouse gas emissions, ecology and economics, to enable the production of integrated maps of specific areas showing the effects and effectiveness of transitions in the region
2. Deriving visual materials and tools from these integrated models that support participatory planning and policy development, and using them in area-based planning processes
3. Conducting trials to test the effectiveness and the social and economic feasibility of innovative water management regimes and land uses, such as floating homes, floating greenhouses and floating roads in lakes with a fluctuating water level

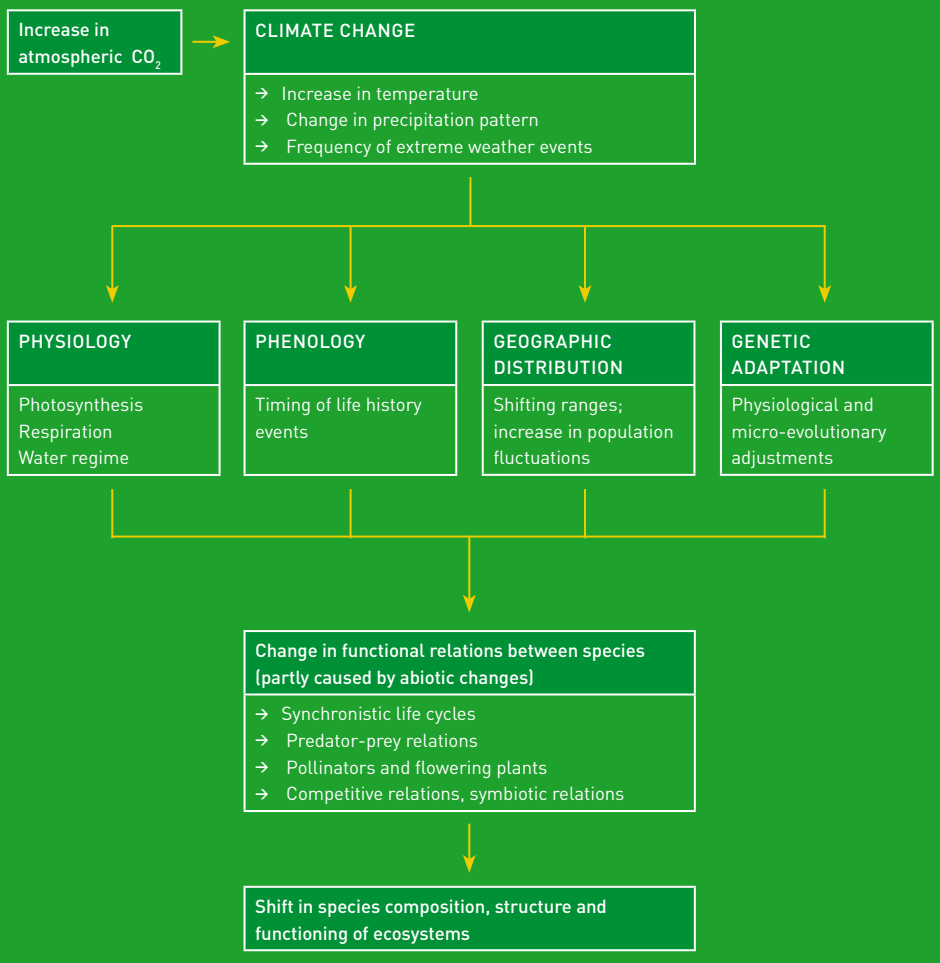
It is essential that these research efforts are conducted in close cooperation with actors from the worlds of policy, land management and civil society. These integrated research products will only be used for policy-making if they are made accessible to non-experts.

4 Nature

IMPACTS

The responses by plant and animal species to climate change will lead to changes in the structure and species composition of ecosystems, as shown in Figure 1. The impacts at the ecosystem level are not only determined by climate change itself (exposure), but also by the sensitivity of the ecosystems concerned (partly determined by other pressure factors, such as fragmentation, urbanisation, eutrophication and water-table drawdown) and their adaptive capacity (resilience).

FIGURE 1 →
Climate change as a pressure factor threatening biodiversity



Ecosystem functioning can be damaged by many factors. For example, some species are unable to reach Dutch nature reserves and protected areas where the climate will be suitable for them because the habitats within their range are fragmented. Target species of nature policy which have a preference for cold temperatures are coming under pressure because the climatological conditions are worsening for them. The survival of some species in the Netherlands is coming under further pressure because of increasingly frequent population fluctuations owing to extreme weather conditions.

ADAPTATION STRATEGIES

The most important adaptation strategy is geared to increasing the resilience of ecosystems and the recovery capacity of species. To pursue this aim the current, rather static policy strategy, which is geared primarily to conservation and recovery, will have to be transformed into a more dynamic strategy with the following elements:

- → Creating spatial structures that enable ecosystem resilience
- → Adapting the National Ecological Network (NEN) and surrounding areas
- → Changing the criteria underlying conservation objectives, from rarity and uniqueness to indicators for the functionality of nature
- → Stronger integration of the functional role of nature into spatial planning and area development

The elements of such a strategy will include:

- → Increasing the spatial connectivity within the NEN and Natura 2000 areas, for example by creating 'robust ecological corridors', linking the NEN into international protected areas, increasing the size of the conservation areas, connecting and amalgamating smaller areas, and removing physical barriers
- → Increasing the ecological resilience of ecosystems through land use planning measures at the local level, such as increasing internal heterogeneity (gradients) within nature conservation areas
- → Adjusting abiotic conditions within nature conservation areas, for example by altering the landscape layout and land management to capitalise on changes in the nutrient and water regimes

These measures must preferably be accompanied by measures in the zones surrounding the NEN areas, such as the creation of interlocking networks of terrestrial and aquatic habitats in the landscape. Nature must also become a more important consideration in spatial and land use plans for making the Netherlands more climate-proof. For example, nature conservation areas can help to buffer more extreme fluctuations in water level and contribute to carbon sequestration.

Spatial adaptation for nature conservation is about changing physical structures to promote the sustainable functioning of ecosystems and landscapes. However, because ecological processes often work at sub-regional and regional scales, adapting spatial structures requires that local decision-makers can integrate information on land use conditions at the different scales required for the desired functioning of natural systems.

Unfortunately, the effects of climate change are not predictable enough to be sure about the best spatial solutions. Adaptation measures must therefore be properly analysed.

The impacts of climate change demand an interpretation of goals that is based more on the role of biodiversity and ecosystem resilience and less on the local presence of endangered and rare species. A second adjustment is that the size of the units on which policy goals are measured is scaled up: from the actual areas of conserved habitats to the functional networks of ecosystems. These developments demand a shift in thinking across broad sections of society about nature and nature conservation values, the spatial scales of decision-making, the translation of policy into practical measures, and the delegation of policy responsibilities.

KNOWLEDGE GAPS

In the Netherlands about 60 different projects are currently being implemented in the field of adaptation and nature conservation, 17 of which are financed by one of the BSIK programmes. Much research examines effects and processes, but research into how these can be translated into spatial configurations is scarce. The research currently being conducted in this area and the gaps in our knowledge are summarised below.

Enhancing the spatial interconnectivity of the NEN and Natura 2000 protected areas

Current research includes studies of species with a preference for either warm or cold temperatures and the shifts in species' ranges. Less is known about the impacts of weather extremes on fluctuations in population numbers and the spatial requirements for the optimum genetic adaptation of species. Various studies are currently in progress on developing spatial guidelines for adapting the NEN and Natura 2000 areas. No measures have yet been implemented.

Ecological resilience of ecosystems

Many projects are still in the knowledge development phase and are not yet at a stage where adaptation strategies can be formulated. As yet, hardly any research is being done on the spatial conditions that facilitate resilient ecosystems.

Measures within nature conservation areas to improve abiotic conditions

Various studies are currently investigating the impacts of climate change on nutrient and water regimes. Much less research is being conducted to identify landscaping and management measures in nature conservation areas that can effectively offset any undesirable impacts on the abiotic conditions.

Embedding NEN and Natura 2000 areas within a multifunctional 'climate zone'

Hardly any research is being conducted into possibilities for establishing multifunctional 'climate zones' (zones with different forms of integrated land uses) around nature conservation areas to support adaptation. The Climate changes Spatial Planning A2 project is examining the potential contribution that can be made by multifunctional agriculture around nature conservation areas.

Nature as an integral part of multifunctional spatial adaptation

A fair amount of research is looking at multifunctional adaptation in which (new) natural habitats contribute to the adaptation of other functions, for example by acting as a water buffer to prevent flooding near rivers. Areas of natural habitat are already being used for buffering peak discharges under the Space for the River (Ruimte voor de Rivier) programme. The Climate changes Spatial Planning project 'Climate Buffers' (COM20) concentrates on this topic, both for the buffering of excess water along rivers and in polders as well as in coastal defences.

Increasing learning capacity; dealing with uncertainty

No studies have been found that focus specifically on the increasing uncertainty, due to climate change, surrounding decision-making on nature conservation in area-based policy and management and in spatial development. There is no specific monitoring programme that can determine the effectiveness of spatial adaptation, and many ecosystem functions cannot yet be quantified in spatial terms. The ecological knowledge about natural systems that has been obtained for the NEN is still only scantily used in policy plans, and little scientific knowledge and few knowledge tools are available that can shed light on the complicated interaction between the size of administrative areas and spatial scales of natural systems.

A new vision for nature in spatial planning

Nothing is yet known about the impacts of climate change on the functional role of biodiversity in ecosystems. Our ability to apply concepts such as resilience, landscape memory and recovery capacity to landscape planning is still very much in its infancy. Some attention is being given to institutional transition processes under increasing uncertainty in the Climate changes Spatial Planning project IC12.

5 The City

IMPACTS

For the first time in human history more people live in cities than in rural areas. It is therefore important that we investigate the influences of climate change on urban areas and identify possible adaptation measures. More frequent flooding and water damage, water shortages and high temperatures in cities are the main impacts of climate change in urban areas.

The temperature in cities is several degrees higher than in the surrounding area, a phenomenon known as the 'urban heat island'. The urban heat island is caused by:

- → Greater absorption of sunlight in cities through the use of darker materials
- → A lower rate of cooling through the emission of longwave radiation
- → Anthropogenic heat sources, such as heating in buildings, motor vehicles, air conditioning, factories, etc.
- → Lower evapotranspiration, because there are fewer plants
- → Less heat loss, due to lower wind speeds

Under normal conditions cities are warmer than the surrounding area, but during heatwaves the difference is even greater and can cause problems, as evidenced by the increased mortality during the heatwaves in Belgium in 1994 and in the whole of Europe in 2003. Old people, small children and the sick are hit hardest by heatwaves. Very high temperatures lead to lower labour productivity and push up sickness absentee rates and general levels of aggression. Electricity demand can also exceed the amount that can be supplied: demand rises considerably during heatwaves because people use cooling appliances, while supply may drop if the temperature of the cooling water discharged from power stations becomes too high.

City life will probably move increasingly outdoors. Parks and public open spaces will be used more intensively, for example for concerts, festivals and sporting activities. The positive effects of this are that people will be more physically active and breathe more outside air instead of unhealthy indoor air, more social interaction will take place and there will be more leisure opportunities. Walking and cycling will become more attractive, thus reducing the need for motorised transport. A negative effect of a more outdoor lifestyle is that people will experience more nuisance, such as noise annoyance.

Besides high temperatures, cities will be affected by more frequent extreme precipitation events. The effects will be exacerbated because the urban area consists largely of hard surfaces, which means that the rainwater has to be discharged because it cannot all infiltrate into the soil.

During long periods of drought the water table may fall, as in the summer of 2003. In the cities in the lower-lying areas of the Netherlands parts of the wooden piles that support many of the older buildings may dry out, making them susceptible to rot. Trees and other plants in the city will suffer from parching.

ADAPTATION STRATEGIES

Climate-proof development must be addressed at four scales: the building, the neighbourhood or district, the city and the region. At the building level, government can set standards for how much heat buildings may accumulate. Some of the ways for making new and existing homes and offices more heat-proof are the use of smart ventilation through windows and with electric fans, roof insulation, white roofs and walls and vegetation on roofs and walls. Roof gardens increase water storage capacity and increase evaporation in cities, and also remove particulates from the air.

Heat and cold storage systems can be used to cool buildings in summer with water pumped from deep underground or deep lakes. The warmed up water is then pumped back into the ground. In the winter the warm water is pumped up again from the underground storage.

In hot weather the level of comfort people experience on the street and in their homes is influenced by the layout of the neighbourhood. The location and orientation of streets, ditches, canals and rivers determines whether the wind has a cooling effect or not, and the height and shape of buildings influences the heat profile of a neighbourhood through the shadows they cast. Trees release moisture into the air through evapotranspiration and provide shade. The heat island effect can also be ameliorated by road-surface cooling measures, for example by avoiding black asphalt and using grass concrete surfacing for parking places. Water storage capacity is required in or near the city to contain excess water during periods of peak precipitation.

The Dutch government sees adaptation policy as being complementary to mitigation policy. Adaptation and mitigation are often closely related, especially in urban areas, an example being the use of air conditioning. Lowering the temperature in a building uses a lot of energy, which contributes to climate change. The air conditioning system discharges the heat to the outside environment, thus contributing to the heat island effect. Sometimes mitigation and adaptation measures can stand in each other's way. For example, solar panels are a mitigation measure, but the spaces on roofs taken up by the solar collectors could also be used for roof gardens or painted white to help reduce the urban heat island effect.

KNOWLEDGE GAPS

The research into integrated adaptation options tends not to focus specifically on urban areas, but many individual options are applicable to urban areas. Most of these options are for reducing the heat island effect (green spaces in the city, urban layouts) and storing water.

Potential adaptation measures should be taken in areas where there is considerable pressure on the use of space. These will involve numerous sectors, government authorities and other stakeholders, and many of the integrated measures will be extremely complicated to implement. This is an important obstacle.

Table 1 lists the gaps in our knowledge about the urban climate. The first seven knowledge gaps are about impacts. Interestingly enough, little is known about the size of the heat island effect in the water-rich Dutch cities (1). The Climate changes Spatial Planning programme will investigate this knowledge gap in one of its new projects.

Other interesting questions about the impacts that require further study concern people's attitudes, the vulnerability of housing configurations to climate change, consumption behaviour and lifestyles (4, 5, 6, 7). Much work has been done on this topic in Germany (Klimes project) and England (Impacts of Climate Change on London study).

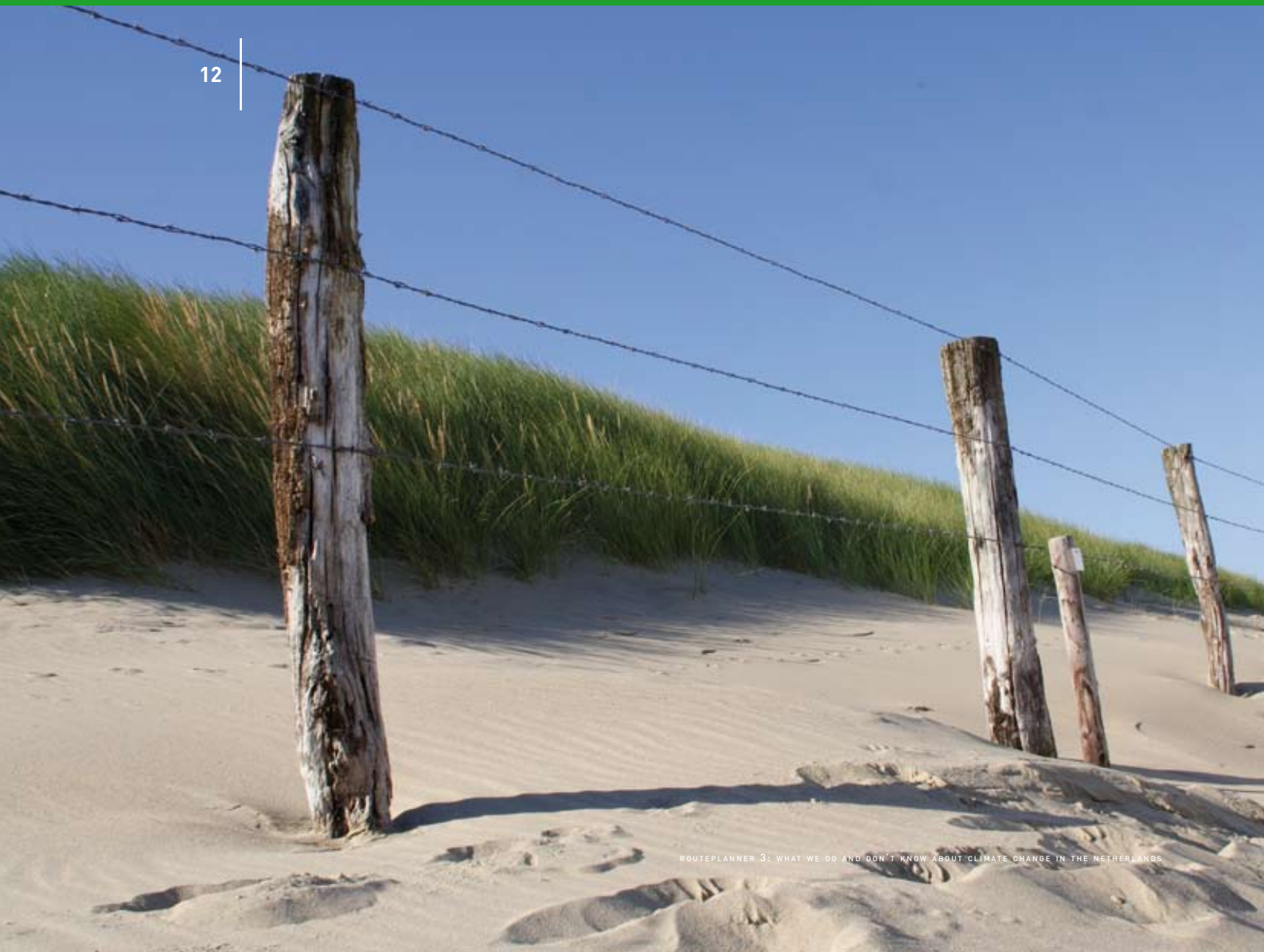
Knowledge gaps 8, 9 and 11 are being investigated by Wageningen University in the Climate changes Spatial Planning project IC5.

Knowledge gaps 14, 15, 16 and 17 have much in common. Much research is being conducted in this area, including studies in the Living with Water research programme (e.g. P1009 and P4086) and so these gaps may well be filled. On the other hand, the underlying problems (administrative) are highly complex and it remains to be seen to what extent the projects can deliver ready-made solutions.

TABLE 1 →
Identified research questions on climate change in urban areas

IMPACTS	
1	How big is the heat island effect in Dutch cities? What are the effects of options for adapting buildings on the living environment in the neighbourhood, and vice versa?
2	How many people are at risk from flooding in Dutch urban areas?
3	To what extent is the attitude of the Dutch population to flooding changing?
4	What are the direct and indirect impacts of climate change on air quality, water quality and public health in Dutch cities?
5	How vulnerable are different types of existing housing and neighbourhood configurations to climate change?
6	How sensitive is the pattern of water and energy consumption in urban areas to climate change?
7	To what degree are the Dutch able and willing to adapt their lifestyle?
MEASURES	
8	Which adaptation options are available for urban areas? How can they be evaluated in an integrated way?
9	What are the costs and benefits of the adaptation measures for climate-proofing the Netherlands, and how are the costs and benefits shared out?
10	How can we prepare for extreme conditions?
11	What are the consequences of measures taken to ameliorate the heat island effect?
12	How can the design of civil engineering works be adapted to a changing climate?
13	What is the potential for innovation in technological adaptations to climate change?
IMPLEMENTATION	
14	What forms of governance will be needed to make the transition to a climate-proof city?
15	Which legislation frustrates the implementation of climate measures?
16	How can citizens and other stakeholders participate effectively in decision-making on urban development?
17	What practical information is needed by managers and policy-makers responsible for introducing adaptation measures?
18	What are the synergies with mitigation measures?

YEAR	SEA LEVEL	PLE SCENARIO	COSTS	ENGINEERING	SPATIAL DEVELOPMENT	ADMINISTRATIVE
2020	+5cm	16–17 million people GDP Per capita growth 1–2.2%	900 million €/year	System in order: → Barrier Dam → Weak Links → Space for the River → Flood defences	All spatial investments Climate-proof → Different construction methods in deep polders → Different construction methods in risk areas Risk map for the low-lying Netherlands	Standard adjusted Central coordination of flood safety & spatial planning Flood safety a determining factor in spatial planning Flood insurance Clear appraisal framework
2050	+30cm	15-20 million €/year	500-800 million €/year	River widening Adapt dike-ring areas → New flood defences → Compartments → Buffers	Risk differentiation for site selection	Robust financing for flood safety → Via water boards → Public-private partnerships Risk coverage for housing and commercial development



6 Flood Safety

← TABLE 2
Decision points for flood safety policy, divided into engineering, spatial development and administrative tasks. PLE stands for the Prosperity and Living Environment (Welvaart en Leefomgeving) scenario study.

IMPACTS

The KNMI climate scenarios show that in addition to rising sea levels, the storm regime and associated storm tides may change in character. Moreover, peak river discharges and localised extreme rainfall will become more frequent, particularly in winter.
Flood safety will be affected by other developments besides climate change, including administrative changes, such as the influence of the EU, and economic trends in certain areas. Scenarios indicate that with an annual economic growth of 2%, potential damage will increase by a factor of seven over a period of a hundred years.

ADAPTATION STRATEGIES

How are we going to deal with the consequences of climate change and other long-term trends in future? To answer this question we need to take a broad view of flood safety. It is therefore desirable that we take an integrated approach to the way we think and act, that we learn to cope better with uncertainties and base our policies on all the links in the safety chain. Furthermore, spatial planning is a crucial factor in research and policy because potential flood prevention options are closely linked to spatial development (the location and layout of development, and construction methods). Examples include strategies ranging from floating housing estates and raising whole neighbourhoods to creating new coastal areas and developing alternative evacuation routes. Building higher and wider dikes in urban areas can also have a major effect on new developments.

The levels of investment in limiting the risk of flooding are already high. Important programmes include the High Water Protection Programme (HoogWater BeschermingsProgramma), Space for the River (Ruimte voor de Rivier) and Weak Links on the coast (Zwakke Schakels aan de kust). But more still needs to be done if the Netherlands is to remain climate-proof in future. Given that at least an additional 500,000 to 1.5 million homes will be built between now and 2040, the key question is how we can adapt the water management regime to the trends in spatial development. Which investments do we make in flood safety now, and which ones can we put off until later? Three strategic options are conceivable, which can be summarised as Space for Water, Protection and Partial Withdrawal. It is advisable that we assemble a flood safety policy and package of measures for the period to 2050 that do not foreclose any of these three options, or combinations of these options, beyond 2050 (Table 2).

KNOWLEDGE GAPS

Some flood safety research is being conducted by the BSIK Climate changes Spatial Planning, Living with Water and Delft Cluster programmes. In addition, much flood safety research is being conducted by various research organisations, including specialised divisions of Rijkswaterstaat (the government department for public works and water management), Deltares, the Royal Netherlands Meteorological Institute, universities and research and consulting firms.

To keep options open for future flood safety strategies we need expertise on implementing adaptation strategies, as described above. Existing knowledge and knowledge gaps are described below.

A better insight into flood risks

To take the risk of flooding properly into account requires insight into the nature and magnitude of the risks; in other words, the probability of floods and their consequences (economic damage, numbers of casualties and how people will react to a catastrophic flood). The Safety Map of the Netherlands project (Veilig Nederland in Kaart) is a major step forward in this respect. It is still unclear how the risk of flooding in dike rings will change as a result of economic development and climate change.

Robust flood barriers

Better protection can be provided by higher and stronger flood barriers, but also by more 'robust' flood defences: dikes and barriers that do not fail suddenly when the normative water level is exceeded, but still provide a certain amount of protection. Overflow dikes are one example of this type of flood defence. Research into robust flood defences is at an early stage. Other knowledge gaps are the effects of developing wide coastal zones and natural buffer zones, and compartmentalising dike rings.

Efficient management and solid financing

Significant sections of the flood defences do not meet the current standards and technical specifications. It is important to work on administrative arrangements that improve management efficiency. The Vellinga Commission has made proposals on modifying the financing structure which could form a basis for developing a more solid financing structure. The corresponding knowledge gaps concern methods for informing the public about risks and the measures to be taken, cooperation between stakeholders, such as public-private partnerships, and possible insurance arrangements.

Prospects for multiple and 'adapted' land uses

If an adaptation strategy is chosen that makes more use of natural processes (space for water), risk zones will have to be designated within dike rings and an appropriate mix of land use planning and administrative measures adopted for each zone. To do this we will need to have more insight into the types of land uses that are compatible with specific flood risks. Some research is already underway into the possibilities for floating homes and greenhouses, but none on any larger-scale applications. Other knowledge gaps concern multifunctional land use, such as floating homes and building houses on 'terps' (artificial mounds).

7 Conclusions

As a result of climate change the Green Heart region can expect more frequent wet and dry periods than we have been used to in the past. A landscape and development pattern that is dependent on the water level ('function follows water level'), instead of current practice in which water levels are controlled to suit the desired land uses ('water level follows function'), would make the Green Heart more climate-proof and also reduce greenhouse gas emissions.

The responses by plant and animal species to climate change will lead to changes in the structure and species composition of ecosystems. Improving the connectivity between the National Ecological Network and Natura 2000, as well as area-based measures, will allow species to migrate to areas where the climatic conditions are more favourable (generally to the north and east) and also help to maintain biodiversity.

The consequences of higher temperatures are more serious in the city than in rural areas because of the urban heat island effect. Very high temperatures lead to higher levels of aggression and mortality and to lower labour productivity. The heat island effect can be mitigated by introducing more green space in cities, such as wall vegetation and trees, the use of light coloured materials and heat-mitigating urban design. To prevent flooding rainwater must be stored in or near cities.

Climate change increases the risk of flooding and economic growth means that the damage caused by flooding will be greater. It is questionable whether it will still be possible to maintain existing flood risk standards. A risk approach will make it possible to pursue a more effective and efficient flood safety policy. Elements of such a policy include more robust flood defences, such as overflow dikes and adapted land uses in areas with a high risk of flooding. The challenge now is to adopt a flood safety policy and package of measures for the period to 2050 that will leave the three options of Partial Withdrawal, Space for Water and Protection, or combinations of these options, open after 2050.

The adaptation measures mentioned above should be taken in areas where there are high pressures on the use of space. These will involve numerous sectors, government authorities and other stakeholders, and many of the integrated measures will be extremely complicated to implement. In fact, Nature, the Green Heart and Flood Safety will require transitions in governance. In other words, the principles and aims of public administration and governance must change if the country is to become climate-proof. These are significant obstacles.

The important identified knowledge gaps are listed in Table 3. Various projects in the BSIK Living with Water, Habiforum and Climate changes Spatial Planning programmes are attempting to provide answers to these questions.

TABLE 3 →

The most important research questions per theme. Some of these knowledge gaps are being examined in current projects; see the relevant reports for details.

NATURE	→ What are the spatial requirements for increasing the resilience of ecosystems? → How can ecological knowledge be applied in spatial policies and land use management?
THE CITY	→ How effective are measures to ameliorate the heat island effect in the Netherlands? → What influence does the behaviour of urban dwellers have on the living environment?
GREEN HEART	→ How can models that describe the water regime, land subsidence, emissions, ecosystems and the economy be combined?
FLOOD SAFETY	→ How do economic development and climate change affect the risk of flooding? → What are the possibilities for robust flood defences, innovative forms of housing (terps, floating homes) and insurance arrangements?
ALL THEMES	→ What is the expected severity of the impacts of future climate change, such as precipitation amounts in the summer and extreme weather (storms, rainfall, drought, heatwaves)? → Which measures will contribute to both mitigation and adaptation? → How can the social costs and benefits of adaptation options be evaluated in an integrated way? → How can they be planned and implemented, in terms of governance? → How can stakeholders participate effectively in decision-making?

ROUTEPLANNER 3 LINKAGE DOCUMENTS

All Routeplanner reports are available from www.programmaark.nl

Michiel van Drunen en Ralph Lasage (2007).
Klimaatverandering in Stedelijke Gebieden - Een inventarisatie van bestaande kennis en openstaande kennisvragen over effecten en adaptiemogelijkheden.

Jeroen Aerts, Bas Kolen, Herman van de Most, Matthijs Kok, Susan van 't Klooster, Bert Satijn en Aalt Leusink (2007).
Waterveiligheid en klimaatbestendigheid in breder perspectief.

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Cees Kwakernaak and Peter Dauvellier (2007).
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klimaat voor ruimte

leven met water

Habiforum

landbouw, natuur en voedselkwaliteit

Ministerie van Economische Zaken

Ministerie van Verkeer en Waterstaat
Rijkswaterstaat

VROM

klimaat voor ruimte

leven met water

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2010