

# Towards a climate-proof Netherlands

## Summary routeplanner

Routeplanner



2050



# Foreword to the Summary Routeplanner for climate adaptation

We know the climate is changing. We will experience higher temperatures, rising sea levels and heavier rainfall. It is already clear that much effort will be needed to adapt to these changes. The question is, how are we going to do it?

We are currently in the stage of exploring this 'uncontrollable challenge', for which there are no ready-made answers. At this stage, contributions from scientists are more than welcome. Over the past year a group of scientists under the 'Routeplanner' banner has been supplying government with knowledge about the effects of climate change and possible ways of dealing with them.

This report summarises the results from this period. It clearly shows that the consequences of climate change are much more complex than is often thought. Besides a greater chance of flooding as sea levels rise and river discharges increase, they include the potentially major impacts of drought and the effects of rising temperatures on agriculture and nature.

A Riviera on the North Sea coast may sound attractive, but 'heat islands' in the city are certainly not. In 2003 we saw in Paris, and to a lesser extent in the Netherlands too, how catastrophic the consequences can be. Many old people died that summer because of the heat. Climate change will encourage new diseases. Its consequences will be felt throughout society and reverberate in the economy – transport, energy and possibly the construction sector will all feel the effects. Under these changing conditions, shouldn't we be building houses differently? Smaller windows on the south, and more thought given to cooling than to heating, for example?

The Routeplanner has taken an important first step in obtaining the knowledge we need to make the Netherlands 'climate-proof'. We still have a lot to learn about this subject and much new research will be needed. But that does not prevent us from taking action right away. With the effects almost upon us we simply cannot afford to wait. Central government is working with regional and local authorities on a National Strategy on Adapting Spatial Planning to Climate Change (ARK), laying down the ground rules for making the spatial development of the Netherlands climate-proof. Input from the scientific community, the corporate sector and civil society is also essential. The Routeplanner research studies provide a solid platform for further work in future.

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# A climate-proof Netherlands?

There's no doubt about it: the climate is changing and the effects are now tangible and predictable. Scientific research has shown that even if we make significant reductions in greenhouse gas emissions (mitigation), climate change cannot be prevented. Which is why we have to adapt to make the effects of the changing climate acceptable: the Netherlands must be made climate-proof.

To stimulate climate-proofing, four ministries and the Climate changes Spatial Planning (CcSP), Living with Water (LmW) and Habiforum research programmes have established a National Programme on Adapting Spatial Planning to Climate Change (ARK, see Box 1). The core research questions examined by ARK are:

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

The Routeplanner is the scientific arm of ARK: the three research programmes, assisted by other research institutes, supply ARK with scientific information and insights on climate-proofing the spatial development of the Netherlands. This brochure summarises the outcome of phase 2 of Routeplanner, which took place in 2006. It consisted of a Climate-proofing Baseline Assessment, a review (Quickscan) of knowledge gaps, formulation of adaptation strategies, a qualitative assessment of adaptation options, a quantitative assessment of adaptation options and identification of case studies.

This brochure answers the following questions, as far as current scientific understanding permits:

- How will climate change affect the Netherlands?
- What are the consequences of climate change for the Netherlands?
- What must be done?
- When must we act?
- What examples are there of climate-proof strategies?
- What next?

The main conclusion of the Routeplanner is that climate change can cause considerable damage in the Netherlands. If we do nothing it will cause widespread disruption to society. It is imperative that we make the Netherlands more climate-proof. And we must start gaining experience with integrated approaches tomorrow, because many forms of adaptation are highly complex to administer. We also need to know more about the costs, and especially the benefits, of adaptation options.

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While recognising that climate change has a highly detrimental effect on developing countries, **ARK** focuses on making the Netherlands climate-proof. Some civil society organisations have problems with adaptation policies because they fear the government will then neglect mitigation. The corporate sector, on the other hand, wonders whether money spent on reducing emissions is money well spent. Adaptation and mitigation work on very different spatial and temporal scales. Adaptation delivers results within the short term and in specific places, even if other countries do little or nothing in response to climate change. Mitigation only has an effect in the long term and if other countries also cooperate. It aims at reducing the impacts of climate change across the whole world. If mitigation policy fails, no affordable adaptation options will be left open in the long run (after 2100). For that reason alone, a solid international mitigation policy is absolutely essential.

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In a 2005 report the **European Environment Agency (EEA)** describes **Europe's** vulnerabilities to climate change and rising sea levels. Ecosystems, water resources, flood protection, forestry, agriculture and fisheries, public health, energy supply and tourism are all particularly vulnerable to climate change. The most vulnerable regions are the regions around the Mediterranean Sea and Central Europe (drought), the subarctic areas (ecosystems), the mountains (ecosystems, tourism) and the low-lying coastal areas (flood protection). Various countries have drawn up adaptation policies for specific sectors. **Norway** and **Finland** have policies for forestry, infrastructure and buildings, **Switzerland** and **Austria** for tourism and hydroelectric power, and the **Netherlands** and the **United Kingdom** for flood protection. Adaptation policies are being produced at a rapid rate.

In the **United Kingdom** climate change is considered to be an external risk on top of existing risks. An Adaptation Policy Framework for adaptation measures in response to climate change was drawn up in 2003. It contains directions for policymakers on the initial description of risks, assistance with defining the problem and specifying the objectives of the adaptation measures before a decision is made, and help with a review of the actions taken to monitor their effects. (See also Box 3.)

In 2004 **Denmark** concluded that it would experience limited direct impacts from climate change and is in a position to adapt to them. Little systematic attention has been given to the secondary effects of climate change, such as changes in recreational patterns, migration of refugees from threatened areas, changes in the prices of agricultural goods, etc. Most adaptation strategies are in the research stage and concrete policies have only been formulated for forestry.

**Finland** published its national adaptation strategy in 2005. Its overall goal is the same as for the Netherlands: to make the country more resilient to the possible consequences of climate change. It identifies the following priority areas: incorporating the consequences of climate change and adaptation into mainstream sectoral policy, bringing climate change into decisions on long-term investments, and coping with extreme weather events. Priority areas are agriculture and food production, forestry, fisheries, reindeer farming, water, biodiversity, industry, transport and communications, land use, communities, buildings and structures, public health, tourism and insurance.

The **United States** has not yet produced any policies specifically on adaptation, but the most vulnerable areas, sectors and issues have been identified. The **Australian** government has recently produced a decision framework for public authorities and companies to use for determining the need for policies on adapting to climate change. Their approach to climate adaptation is based on a risk analysis.



# How will climate change affect the Netherlands?

## ← BOX 1

National Programme on Adapting Spatial Planning to Climate Change (ARK), mitigation and the role of developing countries.

## ← BOX 2

What is happening in other countries?

In 2006 the Royal Netherlands Meteorological Institute (KNMI) published climate scenarios for the Netherlands for 2050 and 2100. For the first time in their analyses of the future climate they used a whole range of advanced global and regional climate models combined with information from time series of measured data, which allowed them to incorporate changes in air flow patterns in their models. Given the uncertainties about whether and how these flows are affected by the enhanced greenhouse effect, the KNMI decided to use two sets of climate scenarios: one set in which the flow patterns remain unchanged (current situation) and second set in which the flow patterns do change. The latter are indicated by a '+' in Table 1.

The calculations for the climate scenarios with altered circulation patterns provide strong evidence for more frequent dry summers similar to those experienced in 1976 and 2003. Both sets consist of two scenarios. In the first scenario the average global temperature in 2050 is 1 degree higher than in 1990, and in the second scenario it is 2 degrees higher than in 1990. Extreme changes – such as those that would be caused by a reversal of ocean currents and which would cause widespread disruption to society – have not been included because the chances of such events occurring are low. According to current understanding, there is an 80% chance that the trends in the Dutch climate will be within the range covered by the four scenarios. This means that in 2050 there is an 80% chance that the average winter temperature will rise by between 0.9 and 2.3°C and that the sea level will be 15 to 35 cm higher than in 1990 (see Table 2).

Observations in recent years indicate that the average temperature in the Netherlands is rising faster than the global average, and that extreme high temperatures are occurring more frequently. The warmer scenarios appear to describe the current situation best. The KNMI does not yet know whether these phenomena are a product of natural variability or a speeding up of climate change in the Netherlands. If the latter, the impacts will be more severe and the costs will be higher than those described below.

Table 2 lists the percentage changes from the climate in the baseline year 1990. To give an impression of what the change in climate could mean for the Netherlands, we compare the expected future Dutch climate with places in Europe which have a similar climate. The average changes in the seasons indicate that Dutch summers will in future be similar to those now found on the west coast of France around Bordeaux. Winter in Bordeaux is at present somewhat warmer than the expected Dutch winter climate, which will in future be more like that now found in the Po valley in northern Italy (Milan–Venice).

CODE	NAME	DESCRIPTION
G	Moderate	1°C temperature rise on earth in 2050 compared with 1990 no change in air flow patterns in Western Europe
G+	Moderate+	1°C temperature rise on earth in 2050 compared with 1990 + milder and wetter winters due to more westerly winds + warmer and drier summers due to more easterly
W	Warm	2°C temperature rise on earth in 2050 compared with 1990 no change in air flow patterns in Western Europe
W+	Warm +	2°C temperature rise on earth in 2050 compared with 1990 + milder and wetter winters due to more westerly winds + warmer and drier summers due to more easterly winds

2050		G	G+	W	W+
Worldwide rise in temperature		+1°C	+1°C	+2°C	+2°C
Changes in air flow patterns in Western Europe		no	yes	no	yes
Winter	average temperature	+0,9°C	+1,1°C	+1,8°C	+2,3°C
	coldest winter day per year	+1,0°C	+1,5°C	+2,1°C	+2,9°C
	average precipitation	+4%	+7%	+7%	+14%
	10 day total rainfall exceeded once in 10 years	+4%	+6%	+8%	+12%
	highest average daily wind speed per year	0%	+2%	-1%	+4%
Summer	average temperature	+0,9°C	+1,4°C	+1,7°C	+2,8°C
	warmest summer day per year	+1,0°C	+1,9°C	+2,1°C	+3,8°C
	average precipitation	+3%	-10%	+6%	-19%
	10 day total rainfall exceeded once in 10 years	+13%	+5%	+27%	+10%
	potential evaporation	+3%	+8%	+7%	+15%
Sea level	absolute rise	15-25 cm	15-25 cm	20-35 cm	20-35 cm

← TABLE 1

Description of the four KNMI climate scenarios.

Source: KNMI

In the KNMI scenarios the trends in Table 2 continue beyond 2050. For 2100 they show an increase in average temperature of between 1.7 and 5.6°C and a rise in sea level to between 35 and 85 cm above the 1990 level. Table 3 links the relevant climate factors to each theme and their main consequences, which are described in more detail in the next section. We use the following categories to describe the degree of uncertainty involved:

- Very likely (more than 90% probability)
- Likely (66-90% probability)
- Medium likelihood (33-66% probability)
- Unlikely (10-33% probability)
- Very unlikely (less than 10% probability)

These categories are also used by the Intergovernmental Panel on Climate Change (IPCC). The percentages are based on expert judgements, taking account of the most recent results from research into changes in the climate and their effects. The target year is 2050.

← TABLE 2

Climate scenarios for 2050 for the Netherlands compared with 1990.

Source: KNMI

	Increase in average temperature (vI)	Increase in number of heat waves, summer droughts (vI)	Increase in intensity of summer precipitation (I)	Increase in winter precipitation (I)	Increase in wind velocity during storm events (md)	Sea level rise (vI)
<b>Water</b>			More frequent flooding of urban areas (I)	Increase in peak discharges from rivers thus raising chance of flooding (vI) Increase in flooding of rural areas (vI)	Worsening of coastal erosion and flooding by the sea (vI)	Intensification of coastal erosion and flooding by the sea (vI) A rise in water levels in low lying Netherlands and an increase in chance of flooding (vI)
<b>Nature, Agriculture</b>	Extension of the growing season (vI)	Decrease in surface and groundwater levels, salination (vI)		Increase in surface water levels (vI)		
<b>Energy</b>	Decline in natural gas consumption (vI) Increase in electricity consumption (vI)	Increase in frequency of cooling water constraints (vI)			Increase in damages to high voltage lines due to extreme storms (md)	
<b>Transport</b>	Fewer problems due to extreme winter conditions (vI) Lower chance of constraints on water transport capacity due to ice cover (I)	Reduced transport capacity of river vessels due to low water levels (vI)	Increase hindrance of heavy rainfall (vI)	Reduced transport capacity of river vessels due to high water levels (vI)	Increase in damages to vehicles due to extreme storms (md)	
<b>Housing and Infrastructure</b>	Fewer occasions when roads need to be gritted or salted (vI)	Increase occurrence of melting road surfaces due to heat (vI)	Increase damages to infrastructure and buildings due to flooding (vI)	Increase in flooding (vI) Increase in river discharge (vI) Increase damages to buildings due to flooding (vI)	Increase in damages to oil rigs, roads, bridges, buildings and vehicles due to extreme storms (vI)	
<b>Public health</b>	Increase in Lyme disease, allergies (md)	Drop in air quality (vI)				
<b>Recreation</b>	Rise in recreation (I) Limitations water recreation (I)	Decline in bathing water quality (vI)			Worsening of dune and beach erosion (vI)	Worsening of dune and beach erosion (vI)

# What are the consequences of climate change for the Netherlands?

## ← TABLE 3

Effects of climate change on different systems (vl = very likely, l = likely, md = medium likelihood).

Source: 1

### CLIMATE-PROOFING, RESISTANCE AND RESILIENCE

The concept of climate-proofing is still in its infancy. From an engineering perspective, climate-proofing is the capacity of a system to continue to function well as the climate changes. It is a measure of the range within which the system, such as an ecosystem, a socio-economic system or a technological system, continues to function 'normally'. Climate-proofing can be considered to be the result of two other, more specific system characteristics: resistance and resilience. Here, resistance refers to the capacity to withstand an external pressure without reacting, and resilience is the capacity to absorb the pressure and recover quickly once it has gone.

The Dutch coastal defences, for example, have a high resistance and a low resilience to climate change: they can hold back a limited rise in sea level and more powerful storms, but once breached they would take a long time to recover to their previous state. The cooling systems in power stations, on the other hand, have a low resistance and high resilience: they will consistently fail when the temperature of the river water rises, but as soon as the temperature falls they function normally again.

### RISKS AND OPPORTUNITIES

The above examples already show that it will not be easy to determine whether the Netherlands as a whole is climate-proof: it depends on which 'system' you look at and how you define resistance and resilience in these systems. For example, the resistance of the coastal defences can be expressed as the probability of flooding. This is the traditional approach, which underlies the Delta plan. But to compare how climate-proof the coastal defences are against other systems we need to know the risk of flooding. A commonly used method to calculate this is the probability of failure times the severity of damage, but this rational approach is often not very satisfactory because the public and experts can hold different opinions about the seriousness and scale of risks (and experts can also disagree among themselves). Participatory methods can be used to bring social values, norms and convictions into the process of establishing the risks.

Besides the engineering approach to climate-proofing, the Routeplanner introduces the concept of 'climate-proof land use'. This is a state in which climate-related risks are reduced to a socially and economically acceptable level by a series of combined technological and social adaptation measures and low-emission land use. Climate change and the knowledge gained in the process can then generate socio-economic opportunities in the form of advanced social, technological and institutional innovations.

## SOCIO-ECONOMIC SCENARIOS

Determining what is climate-proof is also complicated by the fact that the effects of climate change will (mainly) be felt in the future. As Dutch society is continuously changing there is little sense in projecting future climate effects onto the current socio-economic situation. The Routeplanner gets around this problem by using socio-economic scenarios in the analysis. These scenarios were developed in The Future of the Dutch Natural and Built Environment (Welvaart en Leefomgeving, WLO) by the Netherlands Bureau for Economic Policy Analysis (CPB), the Netherlands Environmental Assessment Agency (MNP) and the Netherlands Institute for Spatial Research (RPB). They envisage that while climate change will affect Dutch agriculture, its impacts will be marginal compared with the consequences of future European agricultural policy. These WLO scenarios also respond differently to the opportunities and threats of climate change, for example in relation to flood risks. Both the KNMI and WLO scenarios assume stable policy trends in which there is no place for significant emission reductions and new adaptation policy.

## WATER

The main effects of climate change on the water system are:

- A rise in sea level, thus raising the likelihood of coastal erosion and flooding (very likely)
- An increase in peak discharges from the rivers in the winter, thus raising the likelihood of flooding (very likely)
- An increase in water levels in the IJsselmeer area and the main inland waterways of Zuid-Holland and Zeeland, thus raising the likelihood of flooding (very likely)
- An increase in flooding during winter in rural areas (very likely)
- More frequent flooding in urban areas (likely)
- An increase in household consumption of drinking water in summer (very likely)
- Greater penetration of saline water into surface water bodies (very likely)
- Salination of groundwater resources (unknown)
- Lowered ground water tables (unknown)

Over the past 100 years the sea level has risen by about 20 cm. The rising sea level leads to erosion of sand from the coast and reduces the safety levels of sites directly on the coast. The climate scenarios also predict higher wind speeds, although the increase is small and lies within the current variability in wind speed from year to year.

The expected higher precipitation in winter will feed into higher discharges through the flood basin of the Rhine and Meuse. In the Rhine this effect will be reinforced by the rise in temperature, which will cause more rain and less snow to fall in the Alps during the winter. The combined effect of these two trends almost certainly means higher winter discharges in the Rhine. The likelihood of flooding from the river will rise accordingly, with the greatest likelihood in the lower reaches of the rivers in the province of Zuid-Holland, downstream from around Zaltbommel or Vianen. Here the river levels are a product of the discharge through the river and the – higher – water levels at sea.

The higher winter discharges of the Rhine will be accompanied by greater volumes of water flowing through the river IJssel to the IJsselmeer, the lake created by the enclosure of the former Zuider Zee. Drainage from the IJsselmeer will become more difficult because water levels in the Wadden Sea will also rise. A rise in winter precipitation in the polders will lead to more frequent flooding in winter; land will

be under water more frequently or for longer periods. As the sewage systems were designed to cope with less violent downpours, heavier summer storms will mean more flooding in urban areas.

It is very likely that average demand for drinking water will rise by a few per cent as the temperature rises. More frequent heat waves will cause more frequent peaks in the demand for water. Some surface water abstractions (for example at Ridderkerk) will experience more frequent periods when the water is too saline for treatment and the intake has to be temporarily shut down. This usually happens in summer when the demand for drinking water is highest. Preparing drinking water from poorer quality or even brackish water is technically possible, but very expensive.

A higher risk of flooding is not just a reflection of the likelihood of it happening; as a first approximation at least, risk is the probability multiplied by the damage. The WLO scenarios assume the potential for damage is growing faster than the threat from climate change because the capital investments in areas susceptible to flooding, in relative terms, rising faster.

### NATURE

The main effects of climate change on the natural system are:

- An increase in surface water levels in winter (very likely)
- A decrease in surface water and groundwater levels in summer (very likely)
- Wetter winters (very likely)
- Drier summers (very likely)

Climate change will allow some plant and animal species from warmer, more southerly regions to become established in the Netherlands. Examples include the oak processionary caterpillar and several lichens. Species with limited means of dispersal will be restricted in their range by the fragmentation of ecosystems and habitats.

Plant growing and flowering periods and bird breeding times have shifted in response to climate change and food chains are being disrupted in the process. Hydrological changes in groundwater and surface water and temperature changes are putting ecosystems such as forests, grasslands, coasts and fenland under increasing pressure. Our aquatic and wet terrestrial ecosystems, such as stream and river systems, wetlands, wet heath and raised bog, are particularly sensitive to extremes in the weather. Rising sea levels affect the coastal ecosystems by eroding the coastal dunes and flooding salt meadows.

Climate is the overriding parameter for natural systems, and climate change aggravates the effects of habitat fragmentation and water table drawdown. Although the WLO scenarios presume an improvement in water quality and a more robust National Ecological Network, these cannot compensate for the negative consequences of climate change.

## AGRICULTURE

The main effects of climate change on agriculture are:

- Greater disruption in winter from high water levels and flooding in the rural areas of the lower-lying North and West of the Netherlands (very likely)
- Extension of the growing season (very likely)
- More frequent and longer lasting soil water deficits during the summer (very likely)
- An increase in the likelihood of brackish groundwater seepage (very likely)

Changes in the climate will generally improve the average climatic conditions for farming in the Netherlands. Higher temperatures mean longer growing seasons and thus higher potential crop yields. Energy costs for heating greenhouses will fall because of higher winter temperatures. The four WLO scenarios paint a set of very different prospects for agriculture: the sector is sensitive to the main variables in the scenarios – international cooperation and market liberalisation – and possibilities for expansion in the agricultural sector are limited by environmental policy and animal welfare policies. Markets are also becoming saturated and the cultivated area in the Netherlands is shrinking. Market liberalisation (in two of the four scenarios) accounts for an expansion in dairy farming, but a contraction of arable farming and intensive livestock farming. Dutch agriculture is largely independent of the climate and can react flexibly to changing climatic conditions; smaller yields in dry years will often be compensated by higher prices. Extreme weather will have only a limited effect on the economic success of the sector.

## ENERGY

The consequences of climate change for the energy sector are:

- A decline in natural gas consumption in winter (very likely)
- An increase in electricity consumption in summer (very likely)
- An increase in the frequency of cooling water constraints (very likely)

It is very likely that natural gas consumption in winter will decline because less will be needed for space heating in homes, offices and greenhouses. However, the reduction in CO<sub>2</sub> emissions will be largely cancelled out by an increase in electricity consumption for air conditioning in the summer.

Power stations extract surface water for cooling and so higher surface water temperatures are a major problem for them. If the intake water is warmer than 23°C the discharge water is so hot that it causes oxygen deficiencies downstream, which is disastrous for river ecosystems. Cooling water is already in short supply during dry years, sometimes preventing the power stations at Bergum, Diemen, along the Amsterdam-Rhine Canal and along the North Sea Canal from operating at full capacity. Further warming of the water will make cooling water constraints more frequent and electricity production will fall.

The degree to which the electricity supply system can continue to operate under extreme conditions is determined partly by existing overcapacity. In recent years overcapacity in the privatised energy sector has declined as efficiency has gained in importance. Some overcapacity guarantees greater security of supply but is expensive to maintain, which is reason enough to abandon it on commercial grounds. Energy demand varies considerably in the four scenarios, but fossil fuels remain important in all of them. All the scenarios assume an increase in electricity demand, but here too the differences are wide: the lowest is +16% and the highest is +123% compared with 2002.



## TRANSPORT

The consequences of climate change for the transport sector are:

- Increasing problems of heavy rainfall (very likely)
- More corrosion of vehicles (likely)
- More damage to vehicles from extreme storms (medium likelihood)
- Increased constraints on transport from air pollution (unknown)
- Fewer problems due to extreme winter conditions (very likely)
- Fewer accidents due to fewer days with frost (unknown)
- Fewer delays to journeys because of snow (very likely)
- Reduced transport capacity and loading capacity of river vessels due to periods when water levels are too high or too low (very likely)
- Lower chance of constraints on water transport capacity from ice cover (likely)

Driving conditions will be affected by extreme downpours in the summer and more rain in the winter. On the other hand, there will be fewer disruptions because of extreme winter weather (snow and icy conditions). An increase in the number of extreme rainstorms may cause temporary hold-ups to air traffic. Metal corrosion will become more of a problem owing to the higher temperatures and will probably force a shorter write-off period for vehicles.

By attracting many people to the coast, heat waves will be accompanied by traffic congestion. As people suffering from heat stress are less alert, the likelihood of accidents will consequently increase. Heat waves are also often accompanied by a sharp rise in air pollution, but it is still unclear how far traffic will be affected by measures taken to curb air pollution.

It is very likely that periods with low river levels will become more common in summer and periods of high river levels will be more frequent in winter. Both will limit the number of vessels and/or prevent loading capacity being used to the maximum. Ice will probably be less of a problem. Extreme weather conditions will have incidental impacts on the transport sector. Assuming that weather conditions in the Netherlands will become like those in south-west France, no major impacts on road or rail traffic are to be expected. The relatively short depreciation periods for investments in the road haulage sector allow it to react flexibly to climate change. Investments in transport by rail and waterway, however, require more time and the replacement periods of materials are much longer, making them more vulnerable. The effects of low river discharges could become an important factor in water transport.

Other developments are much more important for the performance of the transport sector, such as economic growth, energy prices and the available infrastructure. The WLO scenarios show increasing congestion on the Dutch roads to 2020; in three of the scenarios congestion eases thereafter and in the other one it doubles by 2040.



## HOUSING AND INFRASTRUCTURE

The consequences of climate change for housing and flood protection infrastructure are:

- Increase in corrosion due to higher precipitation and higher temperatures (likely)
- Increase in damage to oil rigs, high voltage transmission lines, roads, bridges and buildings from extreme storms (medium likelihood)
- Greater occurrence of melting road surfaces in hot temperatures (very likely)
- Fewer occasions when roads need to be gritted or salted (very likely)
- Reduction in damage to rail tracks and roads by frost and salt/grit, and fewer inspections required (very likely)
- Reduction in ice accretion on wind turbines (very likely)
- Increased damage to buildings from flooding (very likely)
- Reduction in navigability of river arms during the summer (very likely)
- More frequent obstructions to shipping during high water in winter (very likely)

Extreme storms can damage buildings and infrastructure directly, or cause damage indirectly through falling trees and the like. High voltage transmission lines and other overhead lines are particularly vulnerable, and some bridges and dikes will have to be closed during powerful storms. The Stern Review Report (Box 3) states that the economic costs of storms and floods could be very high.

### BOX 3 →

Main conclusions of the Stern Report.

Source: Stern Review Report

**The Stern Review Report** to the British Government reviews the impacts of climate change, adaptation options and the economic costs of transforming society into one that is much less dependent on fossil fuels. The report was published just after the Routeplanner studies had been completed, but contains some identical conclusions:

- There is still time to prevent the worst effects of climate change, if we act now.
- Climate change can have serious consequences for economic growth and development; for example, without adaptation measures the costs of flooding in the UK will rise from 0.1 to 0.2–0.4% of GDP if it becomes 3 to 4 degrees warmer in summer. The additional costs of climate-proof infrastructure and buildings in OECD countries are £11–110 billion per year (0.05–0.5% of GDP).
- The costs of stabilising the climate are considerable, but not insurmountable: the annual cost of stabilising greenhouse gas concentrations at 500–550 ppm CO<sub>2</sub> equivalents is about 1% of GDP in 2050. Further delay in taking action is risky and will entail higher costs in the end.
- All countries must take climate measures, but these should not frustrate the growth aspirations of both poor and rich nations.
- Many measures can be taken to reduce emissions, but targeted policies are needed to get them off the ground.
- The response to climate changes must be international and based on agreement about the long-term objectives and the principles underlying the measures to be taken.

More precipitation combined with higher temperatures will accelerate corrosion of viaducts, bridges and other infrastructure, and inspections and maintenance work will be needed more often. More frequent heat waves will damage roads because of melting asphalt. Salt and grit spreading in winter will be needed on fewer occasions, resulting in less damage from frost and salt. Ice accretion on wind turbines will occur less frequently.

A decline in the discharges of the main rivers during the summer will lead to lower water levels, reducing navigability of the river channels and limiting load draughts during dry periods. An increase in the winter discharges will cause frequent obstruction to shipping because of restricted headways under bridges.

Damage to buildings may increase as a result of extreme storms and flooding and urban areas could become 'heat islands' in summer. Heat stress will feed demand for 'intelligent' buildings built to stay cooler in summer. Existing buildings have a depreciation period of 40 to 50 years, and retrofitting these buildings is an expensive option. But given the rate of climate change, the changing functional demands being made on buildings (such as more comfort) are of greater influence than the demands made on the building by the changing climate.

Investments in infrastructure are large and can have long depreciation periods. Once it is built, infrastructure is highly persistent. Weather conditions are an important factor in the usability of road and rail and the regularity of maintenance work. Compared with the change in the levels of use (increased traffic, heavier vehicles), climate change makes little contribution to wear and tear, proceeding as it does at a slow pace compared with the frequency of regular maintenance work of dry infrastructure.

## PUBLIC HEALTH

### The direct consequences of climate change for public health are:

- An increase in mortality during summer (very likely)
- A reduction in mortality during winter (medium likelihood)
- An increase in mortality from flooding and high water levels (unlikely)
- An increase in stress caused by more frequent flooding and high water levels (very likely)
- Higher mortality from storms (medium likelihood)

### Indirect consequences are:

- Vector-transmitted diseases
  - increase in malaria (unlikely)
  - increase in Lyme disease (medium likelihood)
- Diseases linked to air quality
  - increase in summer smog (ozone and particulates) (likely)
  - reduction in winter smog (particulates) (medium likelihood)
- Allergies
  - increase in hay fever (likely)
  - increase in house mite allergy (unknown)
- Increase in water-related diseases (medium likelihood)
- Increase in food-related diseases (unlikely)
- Increased exposure to UV-related disorders (medium likelihood)

The direct consequences of climate change are an increase in the chances of mortality from heat stress and a decrease in the chances of mortality from extreme cold. Flooding and high water also cause stress. During heat waves the incidence of heat stress temporarily raises the mortality rate about 15% above the rate during a comparable period without a heat wave. These extra fatalities include older people who die a few weeks sooner because of the heat, and some who probably die as a result of the poorer air quality that usually accompanies a heat wave. Mortality rates also rise during periods of extreme cold, but the number of cold periods is expected to decrease (medium likelihood). The air pollution (particulates) frequently found during extremely cold periods will also be reduced.

Many of the indirect effects are related to changes in behaviour: people are expected to go outside more often and for longer because it will become warmer on average and they will spend more time on outdoor leisure and recreation activities. Exposure to UV radiation, air pollution and pollen, waterborne diseases (cyanobacteria, amoebae) and Lyme disease will increase as a result. Climate change in the Netherlands will increase the chances of contracting Lyme disease (medium likelihood) and lead to more cyanobacteria in surface waters (medium likelihood). House mite allergy may become more common because winters will probably be wetter and so the indoor climate will be moister as well. The ozone layer above the Netherlands will probably recover more quickly because of climate change, reducing exposure to UV radiation. Although food goes off quicker at higher temperatures, this is not considered to be a risk because of the high food safety standards in the Netherlands.

In all four WLO scenarios, the health care sector makes up a much greater proportion of the economy than at present. The reasons for this include the ageing population, advances in medical technology and social and cultural factors such as the expectations of – relatively rich – patients. Although climate change has an influence on diseases, and thus on human health, other factors have a much greater impact. Examples include frequent travel, which makes it much easier for diseases to spread, as well as infectious diseases, quality of the indoor environment, lifestyle and eating patterns (obesity and cardiovascular disease).

### RECREATION

The consequences of climate change for the recreation sector are:

- Worsening of dune and beach erosion (very likely)
- Restrictions on water-based recreation, such as reduced navigability and more delays at bridges and locks (likely)
- Decline in bathing water quality (medium likelihood)
- Increase in numbers of day trips (unknown)
- Rise in number of foreign tourists (unknown)

Rising sea levels and more severe storms will increase erosion of beaches and dunes. Beach nourishment or recharging with imported sand will be needed on a large scale to maintain beach width, which will make coastal tourism dependent on successful beach recharging schemes.

The water sports sector will probably face a reduction in water quality, poorer fish stocks and more delays at bridges and locks because of lower river discharges in summer. Bathing water quality has the greatest impact on recreation, but the positive effect of good weather will be much bigger than the negative effects of lower bathing water quality. Depending on the climate scenario, net spending in the recreation sector will rise by between 1 and 6%. However, no account has been taken of any changes in leisure and recreation behaviour.

European studies show that in the months of June, July and August the temperature in the traditional holiday regions in the Mediterranean will be too high for many tourists. In the more temperate climates, on the other hand, conditions will become more favourable. The numbers of foreign tourists coming to the Netherlands may rise, and more people may stay in the Netherlands for their holiday.

The previous chapter has shown that a range of systems in the Netherlands are sensitive to climate change. The Routeplanner describes no less than 96 adaptation options to reduce these vulnerabilities. The options were evaluated against five criteria: importance, urgency, no regret (also favourable without climate change), side effects and mitigation effects (reduced amounts of greenhouse gases). The criteria were scored on a scale from 1 to 5, five being the highest score. Table 4 shows the 44 options with the highest weighted total, plus two options which received a 5 for urgency or importance. The weight for each criterion is given between brackets. Radical options, such as building artificial reefs in the sea and abandoning the lower-lying areas of the Netherlands, are not included in the table because they received low marks for all the criteria, at 85 and 95 on the list.

The table also shows the complexity of the issues measured as the weighted sum of the technical, social and institutional complexity: the higher the score, the lower the feasibility of the option. Social complexity depends on the number of stakeholders, the diversity of the values they hold and the level of resistance to the proposed measure. Institutional complexity consists of the conflicts between administrative regulations, the consequences for institutions, the degree of cooperation required and the changes to current administrative arrangements. The colours in the table indicate the themes: blue for water, green for nature, grey for housing and infrastructure, red-brown for energy, dark yellow for agriculture and orange for public health.

A conspicuous feature of the table is the large number of options for the water theme (37%) and the low number for public health (2%). The other themes each make up about 15% of the total. This is more or less in line with the analysis of climate resilience per theme in the previous chapter.

The high scores for complexity obtained by many of the options in Table 4 show that the barriers to implementation are high. Many of these barriers are institutional in nature and the Routeplanner recommends finding new, temporary and flexible institutional arrangements that permit an integrated and coordinated approach. In many cases, the social complexity is high because the options involve a high number of stakeholders. Realising such options will require a higher sense of urgency among many of these stakeholders. Significant input from stakeholders (farmers, fishers, residents) in the decision-making process creates public support and makes it easier to implement the measures. In technical terms, the measures are generally not very complex.

A correlation can be drawn between ranking and complexity: many of the important and urgent options are hard to implement. Examples include more room for water, spatial planning informed by risks and new institutional alliances for water management. Nevertheless, some important and urgent options are relatively easy to implement, such as nature education and many of the more technical measures.

ADAPTATION OPTIONS	Weighted sum	Importance (40%)	Urgency (20%)	No-regret (15%)	Ancillary benefits (15%)	Mitigation effect (10%)	Complexity
More space for water	4.9	5	5	5	5	4	4.4
Risk based allocation policy	4.9	5	5	5	5	4	4.4
Risk management as basic strategy	4.9	5	5	5	5	4	3.2
New institutional alliances	4.9	5	5	5	4	5	4.0
Integrated nature and water management	4.9	5	5	5	5	4	4.2
Integrated coastal zone management	4.9	5	5	5	5	4	4.2
Make existing and new cities robust - avoid 'heat islands', provide for sufficient cooling capacity	4.8	5	5	4	5	4	3.0
Construct buildings differently in such a way that there is less need for air-conditioning/heating	4.7	5	4	5	4	5	2.6
Change modes of transport and develop more intelligent infrastructure	4.7	5	5	4	4	5	4.0
Evacuation plans	4.5	5	5	5	3	3	4.0
Design and implementation of ecological networks (The National Ecological Network - NEN)	4.5	4	5	5	5	4	3.6
Design spatial planning - construct new housing and infrastructure	4.5	5	5	4	3	4	4.0
Design houses with good climate conditions (control) - 'low energy'	4.5	5	4	5	3	5	2.4
Development of more 'intelligent' infrastructure that can serve as early warning indicator	4.5	5	4	4	4	5	2.6
Increasing genetic and species diversity in forests	4.4	4	5	5	4	4	2.8
Fresh water storage to flush brackish water out during dry periods	4.3	5	3	5	4	3	4.0
Maintain higher water table to prevent salt water intrusion	4.3	5	3	5	4	3	3.8
Afforestation and mix of tree species	4.3	4	4	5	4	5	2.3
Educational programs	4.3	4	4	4	5	5	3.0
Widening the coastal defence area (in combination with urbanisation and nature)	4.2	5	4	3	4	3	2.3
Re-enforcement of dikes and dams, including 'weak spots'	4.2	5	5	3	3	3	2.3
Creating public awareness	4.2	4	5	4	3	5	2.7
Revision of sewer system	4.2	5	4	4	3	3	2.7
New design of large infrastructure	4.2	5	4	4	3	3	3.7
Introduction of ecosystem management in fishery	4.2	4	4	5	5	3	2.7
Monitoring nature, interpreting changes and informing	4.1	4	5	5	3	3	3.0
Spatial planning of locations for powerplants (nuclear in particular)	4.0	5	4	3	3	3	3.3
Relocation of fresh water intake points	4.0	5	4	3	3	3	3.3
Adapted forms of building and construction	4.0	4	4	3	5	4	3.3
Adaptation of highways, secondary dikes to create compartments	4.0	5	4	5	1	3	3.7
Stimulate economic activity in other parts (eastern and northern) of the Netherlands	4.0	5	5	3	3	1	2.7
Options for water storage and retention in or near city areas	4.0	4	4	4	4	4	2.7
Lowering the discount factor for project appraisal	4.0	4	5	3	3	5	4.0
Development of cooling towers	4.0	5	3	3	4	3	4.0
Increase standards for buildings as to make them more robust to increased wind speeds	3.9	5	4	4	1	3	4.0
Introduction of southern provenances of tree species and drought resistant species	3.9	4	3	5	4	3	3.7
Acceptation of changes in species composition in forests	3.9	4	3	5	4	3	2.7
Changes in farming systems	3.8	4	3	4	4	4	2.0
Adjustment of forest management	3.7	4	3	5	3	3	4.0
Emergency systems revision for tunnels and subways	3.7	5	3	4	1	3	4.3
Constructing more stable overhead electricity transmission poles	3.7	5	3	4	1	3	4.3
Improvement of vessels	3.7	4	4	3	4	2	4.7
Water storage on farmland	3.7	3	4	5	4	3	4.3
Higher water level IJsselmeer	3.6	5	2	3	3	3	4.3
Increase sand suppletions along coast	3.5	5	3	3	1	3	3.7
Improvement of health care for climate related diseases	3.4	4	5	3	1	2	2.0



#### ← TABLE 4

Ranking of adaptation options in the Routeplanner scored for the five criteria. The complexity of their introduction, which was not included in the weighting, is also shown.

Source: [3]

When calculating the benefits of the adaptation options it is important to choose a good reference point. Table 5 sets out the possibilities, from which we can determine the costs and benefits as follows:

- The cost of climate change is the difference between the wealth of society at present and the unadapted society:  $W(A0, T1) - W(A0, T0)$
- The net benefit of adaptation is the difference between the wealth of the adapted society and the unadapted society:  $W(A1, T1) - W(A0, T1)$
- The cost of climate change after adaptation is the difference between the wealth of the adapted society and present-day society:  $W(A1, T1) - W(A0, T0)$

Relatively little is known about the costs and especially the benefits of the adaptation options investigated. As can be seen from Table 6, data are available for only 17 of the 46 options and the benefits are monetarised for just 7 options. Uncertainty levels are very high where the costs and benefits have been monetarised. The costs cannot be added up because a choice for option X could mean that option Y would become unnecessary, or partly redundant. Although the Routeplanner provides an overview of costs and benefits for the first time, much more research is still needed. The exact costs and benefits of many of the adaptation options can only be determined once the locations of the measures to be taken are known.

The costs of the options differ widely: the most expensive options are for water retention measures to 2050, costing more than €19 billion. For some options, for example forestry and preventing heat islands, the benefits are higher than the costs, which makes them attractive from an economic point of view. Most of the options with the highest costs are connected with flood protection, but here it is not very clear what proportion of the costs are due to climate change and how much is due, for example, to changing safety standards. Other expensive adaptation options are construction of climate-proof buildings and upgrading sewer systems.

The costs and benefits are expressed as net cash value at 2006. A discount rate of 4% has been applied to reflect the fact that costs are more attractive the further in the future they will actually be incurred. Benefits, on the other hand, are preferred immediately. When determining benefits realised in future higher net values are assigned when the discount rate is lower. Lowering the discount rate, therefore, stimulates investment in benefits to be obtained in the (distant) future. This is often the case in climate adaptation options, which is why lowering the discount rate is also included as an adaptation option.

Adaptation type	Climate does not change (T0)	Climate changes (T1)
Adaptation to current climate (A0)	Current society (A0, T0)	Society did not adapt to the changed climate (A0, T1)
Adaptation to changed climate (A1)	Society is 'adapted' but climate did not change (A1, T0)	Society is adapted to changed climate (A1, T1)

ADAPTATION OPTIONS	Net present value cost (million €)	Net present value benefits (million €)
Regional water system - Regional water system - Improving river capacity	19000 >7000	Unknown Unknown
Risk based allocation policy	0-10	Unknown
Make existing and new cities robust - avoid 'heat islands', provide for sufficient cooling capacity	65-65€/m <sup>2</sup>	>2200€/m <sup>2</sup>
Construct buildings differently in such a way that there is less need for air-conditioning/heating	23000	Unknown
Design and implementation of ecological networks (The National Ecological Network - NEN)	7000	>7000
Increasing genetic and species diversity in forests	0.43/ha	>0.43/ha
Widening the coastal defence area (in combination with urbanisation and nature)	1000	Unknown
Re-enforcement of dikes and dams, including 'weak spots'	>5000	Unknown
Revision of sewer system	3000-5000	Unknown
Monitoring nature, interpreting changes and informing	340	>340
Relocation of fresh water intake points	50-100	Unknown
Options for water storage and retention in or near city areas	3300	Unknown
Lowering the discount factor for project appraisal	0	Unknown
Development of cooling towers	275-500	6.6-11
Water storage on farmland	15-50	Unknown
Higher water level IJsselmeer	>500	Unknown
Increase sand suppletions along coast	750-1500	Unknown

> means minimal

	Autonomous	Policy
<b>Short term</b>	Short term adjustments, like planting date crops; sharing of risks, through for instance insurances	Development of further knowledge on climate risks, improve emergency response
<b>Long term</b>	Invest in climate resilience as future effects are clear and benefits large, for instance local irrigation	Invest in infrastructure; avoid the effects, for instance through spatial planning policy

## ← TABLE 5

Costs and benefits of adaptation.  
Source: adapted from the Stern review Report

## ← TABLE 6

Indicative costs and benefits of the adaptation options, as far as is known, in millions of euros at 2006.  
Source: [3]

Climate change could cause considerable damage in the Netherlands. The Stern Review Report (Box 3) confirms that the effects of climate change could cause widespread disruption to society and that action must be taken soon. Stern recommends planning adaptation options for areas where high risks are expected and where costs are low. Adaptation will be an autonomous process, but policies will have to be put in place for many options, as indicated in Table 7. Good adaptation policy requires planning in advance and a choice of robust measures that are practicable in various climate scenarios and which could be adjusted at a later stage if required. Because many of the options are expensive, financing will require very careful planning. Table 4 shows that the water management options in particular are urgent and important, as well as the construction of climate-proof buildings and preventing heat islands in urban areas.

Deciding on adaptation measures with a spatial dimension is a complex process. Adaptation to climate change throws up complex challenges on four fronts:

- Various sectors will have to work on efficient and effective solutions, with greater emphasis on development and change than on maintaining existing land uses
- The solutions, in different places and at various scales, must provide an effective answer on the scale at which climate change is operating
- Costs, benefits and risks must be fairly distributed between present and future generations and between countries
- Costs, benefits and risks must be fairly distributed between government, public and private organisations and citizens

In a time of administrative decentralisation and internationalisation, new strategies will have to be developed that can catalyse more decisive management. Integrated area development is one of them. Central government considers it one of its tasks to promote the uptake of adaptation in all area development projects and the development of appealing, wide-ranging development visions and policy tools. Improving the design and problem solving capacities of the actors is also important. Obstructive regulations should be dispensed with and replaced by regulations that encourage collaboration between different sectors and areas.

Because both institutional and social complexity is high, implementation of many adaptation options should involve participation by stakeholders, such as farmers and other citizens. The sense of urgency among many stakeholders will have to improve, though, if the participatory process is going to be successful. This underlines the importance of educational and awareness-raising programmes, which can also be considered to be adaptation options.

Case studies that take an integrated view of an area can give us a better feeling for the interaction between the measures taken in that area and the administrative processes required to manage the often radical interventions. We need to make a quick start. Not only is the climate already changing, but we still have little experience with such integrated approaches. The lessons from the case studies will form a necessary step towards the successful implementation of administratively more complex adaptation options. Some examples of the case studies are described in the next chapter.

## ← TABLE 7

Examples of adaptation options.  
Source: Stern review Report



## What examples are there of climate-proof strategies?

### INTRODUCTION

After holding several workshops and interviews, the research programmes Climate changes Spatial Planning (CcSP), Living with Water (LmW) and Habiforum drew up a list of 39 potential demonstration projects for the Routeplanner. The demonstration projects were then ranked according to criteria for the following facets:

- **Policy:** opportunities and constraints in the field of climate change and various themes
- **Support:** supported by several administrative tiers
- **Communication:** appealing to a wide public; effects of climate change are clarified
- **Action perspective:** without climate change the project would have been interpreted differently

In addition to the criteria mentioned above, the final list of prioritised demonstration projects has to reflect a balanced geographical distribution and thematic coverage. Three of the top five projects are described below. They are not intended to be representative, but provide a good indication of the opportunities and threats resulting from climate change in three very different areas.

### BIESBOSCH

The Biesbosch is located between the southern edge of the Randstad and the Brabant city ring. This freshwater tidal zone performs important functions for a broad hinterland: power generation, recreation, shipping, water retention and drinking water supply. It has proved very difficult to achieve a sustainable water management regime because the region is one of the main nodes in the national water management system.

In the short run, the Rhine and Meuse, which run through the area, will have to be given room to expand. The need for this was amply demonstrated during the high water levels of 1995. The dikes along two river channels in the lower reaches of the Rhine and Meuse, the Beneden-Merwede and Beneden-Waal, just held because the sea was quiet at the time and water could be discharged continuously. The polders around the Haringvliet inlet were also badly hit during the extreme rainfalls in 1998, when they proved to have far too little temporary water retention capacity. Problems have not just been caused by the presence of too much water, but by too little as well: in the dry summer of 2003 the combination of low river levels and penetration of salt water far inland caused a serious water shortage.

The goal of the Biesbosch case study is to reveal the longer term effects of climate change on the Biesbosch and surrounding area, and how the effects of climate change can be offset by changes in the landscape structure and innovative land management. By looking at the region as a whole, the project can demonstrate how spatial aspects relating to water throughout the whole region can be used to address the shortage of space for recreation, housing, agriculture and nature conservation – issues on which climate change is casting a new light. Specific questions include:

- How can 'depoldering' and 'polder conversion' create more room for water in the low-lying parts of the Netherlands? By giving water more space in the thinly populated parts of the 'Low Netherlands', we can not only alleviate the problems of other more densely populated areas, but also make use of the energy potential in the water (natural land reclamation and peat growth).
- How and to what degree is it possible to generate the energy needs of the Biesbosch-Haringvliet region from biomass? A robust natural system in the green/blue axis offers opportunities and potential for producing biomass such as willow and reed, and for extensive livestock farming.

The Biesbosch case study will produce a strategy and scenarios for a climate-proof green/blue axis from Biesbosch to Haringvliet. Concrete projects that put the strategy into practice will be drawn up for several strategic points and implemented by various coalitions of stakeholders, such as water companies, the city of Dordrecht, energy companies, nature conservation organisations and Rijkswaterstaat (the government department for public works and water management).

#### KAMPEN - IJSSEDELTA

The Kampen/IJsseldelta study broadly covers an area to the south-west of Kampen. The proposal is to build several thousand new houses on the south-western edge of the town. In addition, the planned Hanzelijn railway connection is due to be built and operational in 2012, and the capacity of the N50 trunk road will be increased. In the future, higher discharges are expected in the river IJssel, which at Kampen becomes a bottleneck that prevents the full discharge of the water in the river. Over the short term (to 2015), deepening the summer bed will be sufficient to cope with the rising discharges. But soon after that (at a discharge of about 16,600 m<sup>3</sup>/s at Lobith, where the Rhine enters the Netherlands, a bypass will be necessary. It is known that a bypass is the most sustainable option for tackling the problem of high river levels, with a major water-lowering effect (about 60 cm) extending far upstream.

Overijssel Provincial Council have prepared a masterplan with the cooperation of all the stakeholders in the region and the central government partners. The plan replaces the deepening of the summer bed with the construction of a new river arm (bypass) combined with several other partly autonomous developments in the area, including house building, the construction of the Hanzelijn railway line, natural habitat restoration and recreational facilities. This alternative is more expensive than dredging the channel in the summer bed of the river, but delivers better spatial quality. Moreover, it lays a foundation for development in the longer term (from 2015), when even higher discharges are expected. The aim of the Kampen/IJssel project (integrated area development) is to bring forward the construction of a new river arm.

Climate change effects are mainly felt through the higher river discharges in the IJssel. In the long term this will be joined by a further factor as rising sea levels force up water levels in the IJsselmeer. Under prevailing westerly winds (and storms) the water in the IJsselmeer can be forced up through Ketelmeer into the IJssel. In the longer term, the existing sea defences along the lower reaches of the delta may not be high enough to withstand the water. The case study is an integrated assessment of the summer bed deepening, bypass and masterplan alternatives for Kampen/IJsseldelta.

### TILBURG

Tilburg lies on a more elevated part of the Netherlands (sandy soils) and has a population of more than 200,000. The city lies in the fine network of streams and tributaries of the river Dommel, which flows into the country from the higher sandy areas to the south. The surrounding natural habitats consist largely of forest and bog pools. The region is known for its many tourist and leisure attractions, such as the Efteling theme park and the Beekse Bergen safari and fun park. Table 8 summarises the climate change issues affecting Tilburg.

**TABLE 8 →**  
Climate change issues  
affecting Tilburg.

Primary effect	Secondary effect	Financial consequences	Relevance to Tilburg region
More and/or more intensive precipitation	Sewer overload	Considerable damage	'Old' districts in lower-lying areas in particular
More precipitation, greater water inflow	Watercourses overloaded	Damage to agricultural land and natural habitat	Will affect stream systems south of Tilburg
Temporary hot weather	Health problems among vulnerable groups Appropriate measures at major events Comfort or 'H&S effect'	Specific attention to high risk groups 'Heat breaks', 'tropical working hours', cooling costs	Hot weather plan for: → events → social map → community health services Need for energy, water greenspace and shade: climate-proof buildings
Average temperature rise	Longer agricultural growing season Longer tourist/recreation season	Boost for new crops Economic stimulus to recreation sector	Promotion of Tilburg region Economic vitality Employment

The first phase of the case study, to be carried out under the Climate changes Spatial Planning programme, focuses on the following questions:

- What is going to change in and for our region? (content)
- How are we going to deal with these changes? And who with? (process)

In the second phase the ideas and concepts arising in the first phase will be put into practice:

- Creating a vision on the spatial development of the region to 2050; adaptation and mitigation are both important and will be looked at together
- Developing a climate and opportunity plan
- Designing new climate-proof housing areas (city centre and extension)
- Restructuring old districts

The alliance of municipal councils, housing corporations, developers, water boards and residents groups is at the heart of the last two topics. Important aspects are water management, sewerage, heat-resistant buildings and the ratio between built-up areas and the open countryside. The idea of a climate alliance will also be central to the study.





In the second phase of ARK, which will run for a year, agreements will be made with various parties on implementing the national adaptation agenda. Preparations will also be made for the third phase, which will run for a further six years. Under the ARK strategy, national government does not work alone, but works with local authorities, market players and other stakeholders. The aim is to put climate change into the mainstream of policy and investment decision-making, public behaviour and research programmes during the course of the third phase, making it as much a part of decision-making as a financial analysis. Box 4 reviews the principles for the implementation of an adaptation agenda. The implementation agenda itself is of course specific to each location.

Examples of activities to be taken over the short term:

- Central government will take the effects of climate change into account when drawing up strategic national plans and implementing existing plans.
- Central government will review the economic and social opportunities and constraints associated with shifting the weight of investment from lower lying areas to higher sites.
- Central government will draw up a list of criteria for preparing new building and infrastructure plans which appraise the effects of temperature rises, high water and flooding, wind direction and aspect.
- The Ministry of the Interior will be responsible for preparing disaster emergency plans that factor in weather conditions and will calculate what they contribute to reducing the scale of damage and saving lives.
- The Association of Provincial Authorities (IPO) will draw up a list of case studies to serve as demonstration projects for locations where climate change has to be taken into account.
- IPO will prepare a resource guide for provincial councils to help them draw up spatial visions that incorporate the effects of climate change.
- The provinces will take the effects of climate change into account when revising a regional plan (streekplan) or an integrated spatial and environmental plan (omgevingsplan).

It will be up to the new Government and the new Provincial Council (Provinciale Staten) to make progress with the integration of the effects of climate change into spatial policies, and with putting them into practice. Implementation must be targeted on innovation and climate-proofing. The role of the National Programme on Adapting Spatial Planning to Climate Change is to stimulate, advise and monitor.

**BOX 4 →**Principles for adaptation  
measures

- Deal with the inevitable negative consequences
- Short-term local benefits
- Prevent damage
- Exploit opportunities
- Make systems more robust and/or flexible
- Start no-regret measures in good time
- Deal with uncertainties: risk management
- Government steering versus autonomous adaptation
- Increase climate awareness and climate communication
- Review options

**ROUTEPLANNER REPORTS ON SUBPROJECTS**

All Routeplanner reports are available from [www.programmaark.nl](http://www.programmaark.nl)

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# Colophon

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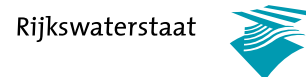
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klimaat 2008 ruimte

leven met water



2010

