PBL Netherlands Environmental
Assessment Agency

WORLDWIDE CLIMATE EFFECTS

RISKS AND OPPORTUNITIES FOR THE NETHERLANDS

POLICY STUDY

Worldwide climate effects
Risks and opportunities for the Netherlands

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MAIN FINDINGS

Summary

Climate change abroad is having an increasing impact in the Netherlands

The climate is changing in the Netherlands and abroad. Climate change abroad has consequences for the Netherlands, in terms of how the country functions. This is because the Netherlands is connected with the rest of the world in many different ways, through economic and production chains, for example, as well as the power grid, ICT and transport networks. Many Dutch businesses also have branches outside the Netherlands and many Dutch citizens travel abroad for their work or holidays. The Netherlands and the Dutch are therefore at risk due to climate change effects elsewhere.

The main risks to the Netherlands of climate change abroad arise from weather extremes, such as cyclones, extreme precipitation events, heatwaves and drought. It is expected that the probability and intensity of weather extremes worldwide will increase due to climate change. The more gradual changes in the global climate will also affect the Netherlands in the longer term. These changes could include the melting of the polar ice, the shifting of climate zones thus affecting the growing conditions for crops, as well as the warming of the oceans leading to the migration of fish stocks.

Most important climate risks in the European context: vital networks

In Europe, the climate risks with the greatest impact are related to (1) the international power grid and ICT networks, (2) water levels in the rivers, and (3) health.

The Netherlands is already preparing to deal with two of these risks: the risk of flooding has been addressed in the Delta Programme and there is already a monitoring and screening system in place for infectious diseases. The biggest challenge for the National Adaptation Strategy throughout Europe therefore lies in the power supply and ICT services. The probability that the Netherlands will be faced with a failure of the power grid or a collapse of ICT networks due to weather extremes is small at the moment, but should it occur, the impact would be huge.

Apart from the already established natural gas network, the power grid is also becoming increasingly international. Grids and networks are becoming increasingly closely connected with one another internationally. At the same time, over the next few decades, there will be a shift in the sources for power generation with an increasing share generated by solar, wind and hydropower. These developments will make the Netherlands more vulnerable to extreme weather conditions abroad, such as heavy rainfall, extreme drought and heatwaves. The interdependence of the power grid and ICT networks means that a disruption in just one of these networks could trigger cascade effects.

Climate adaptation efforts on the part of the Netherlands to make the power supply more robust will be most fruitful if they are undertaken in close cooperation with the other countries in north-western Europe. Various governments could, for example, on the basis of collective stress tests, make binding agreements with the

operators concerned to lessen the vulnerability of these networks. This strategy could include an agreed rationing plan between countries should problems occur, such as a situation of reduced power generation further to a long-lasting period of windless weather conditions or heatwaves with low river discharges.

Global climate risks: disruption of economic chains, possible political tensions

The most probable risks to the Dutch economy of climate change abroad are mainly related to price, if weather extremes in Europe or elsewhere in the world lead to temporary shortages and disruptions to the supply of raw materials, products and services. Dutch businesses and citizens in a disaster area could also fall victim to weather extremes. For the Dutch economy as a whole, the impact of these disruptions would perhaps be small per event, but does not preclude the fact that it could be serious for individual companies or private citizens. The consequences for the local population in the affected areas may also be very serious.

Climate change could also affect international stability. Simmering conflicts, such as those surrounding the availability of agricultural land and water, could flare up as a result of climate change and lead to political instability. Higher food prices due to harvest failures following drought, for example, could also lead to increased tensions. The possible increase in conflicts and natural disasters will lead to a greater demand for relief in other regions and a need for more humanitarian aid. In the Arctic region, tensions could mount surrounding the rights to natural resources which would become extractable due to the melting polar ice. Although it is unlikely that this will lead to a conflict, the impact could be major, should it occur.

Climate adaptation in a global context – also relevant to the Netherlands

The Netherlands is well organised and sets high safety standards. This is not always the case in other countries, as is shown by the disasters caused by weather extremes around the world, including in Europe. Climate change means that these disasters will escalate if no adaptation measures are taken. This could constitute a major risk to the Netherlands, given its numerous and extensive foreign relationships. Climate adaptation on a global scale is therefore also relevant to the Netherlands. The World Economic Forum recognises that climate change constitutes a threat to the functioning of the world economy and sees a worldwide failure in climate adaptation as one of the major risks facing the world.

This underlines the importance of Dutch and international policy initiatives already in progress that are intended to introduce effective adaptation measures in the developing regions by strengthening institutional capacity and making financial resources available under the climate treaty that is to be concluded in Paris in 2015.

Dutch expertise and experience as an important export product

Giving adaptation to climate change a more prominent place in foreign policy will create international opportunities for the Netherlands; for example, in the fields of international stability, agriculture and urban planning and development. The Netherlands is world-renowned for its experience and expertise in the field of water management; the Delta Works being the prime example. The Dutch method based on a designed strategy that takes an integrated approach such that multiple public interests can be served, is also widely recognised and appreciated. From New York to Vietnam, Dutch companies, academics and public officials are asked for advice. The growing demand for knowledge and experience on the subject of climate adaptation provides opportunities for Dutch expertise as an export product.

This report shows that it is important that the National Adaptation Strategy addresses the risks and opportunities of global climate change. If government authorities, the private sector and research institutes, today would start to specifically take climate risks and opportunities into account in policy and strategic investment decisions, this will bring benefits to the Netherlands. This will make it possible to limit the risks, seize opportunities and combine goals, thereby increasing policy effectiveness.

Worldwide climate effects
Risks and opportunities for the Netherlands

The climate is changing and climate risks are growing around the world

Natural disasters due to weather extremes occur frequently, both in Europe and in the rest of the world. In the first decade of the 21st century, for example, 3000 natural disasters were reported worldwide due to flooding, heatwaves, droughts, storms and cyclones. Almost 400,000 people died as a result of these events. The total damage in the same period amounted to more than USD 800 billion. In Europe, in this period, there were more than 500 weather-related natural disasters.

Climate change means that disasters such as these could occur more often. Both temperature and sea levels are rising, cyclones are increasing in strength, patterns of precipitation and river discharge are changing, and weather extremes such as heat waves and periods of drought are expected to increase in frequency and intensity.

But it is not just the climate that is changing, society is too. Social, technological and geo-political developments worldwide will also affect how vulnerable the Netherlands is to the effects of global climate change. Power grids and networks, for example, are becoming increasingly interconnected with one another internationally. This brings greater vulnerability to extreme weather conditions, such as heavy rainfall and heatwaves. Climate risks worldwide are growing due to climate change combined with global developments in society, such as population growth, urbanisation and economic development.

The Dutch Government intends to publish its National Adaptation Strategy in the first half of 2016. This strategy will consider all the sectors that could be affected by climate change, as well as the international aspects. The European Commission has asked for such a broad approach to be taken and has given each Member State until 2017 to prepare an adaptation strategy.

PBL was asked to survey the risks and opportunities in relation to these global climate effects for the Netherlands and its citizens. This report therefore serves as one of the building blocks for that National Adaptation Strategy.

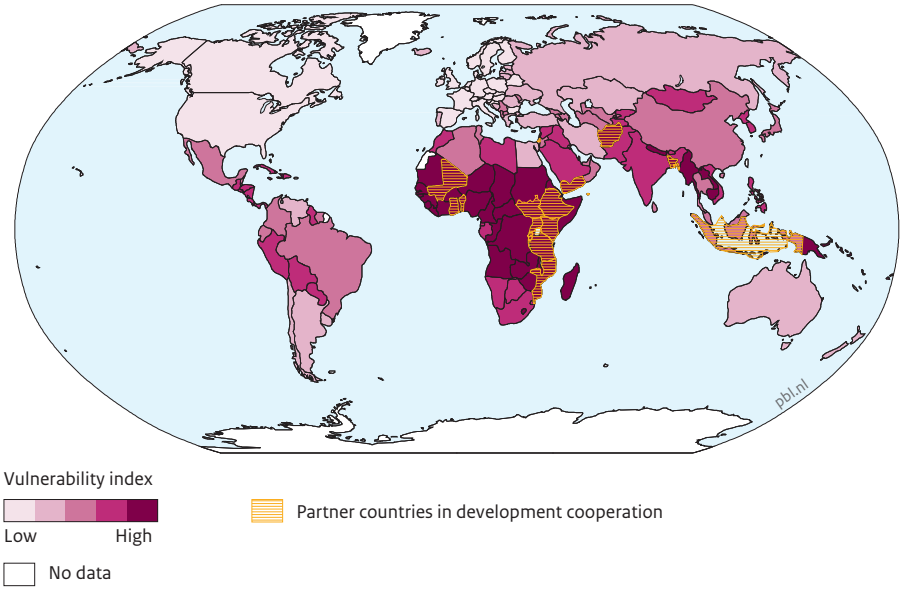
The Netherlands is vulnerable to climate change beyond its national borders

The Netherlands is a trading nation and maintains relationships with many countries in Europe and the world through economic and production chains, the power grid, and ICT and transport networks. Many Dutch businesses also have branches outside the Netherlands, and many Dutch citizens travel abroad for their work or holidays. The Netherlands and its citizens are therefore at risk of climate change that occurs elsewhere in the world.

Some of the countries with which the Netherlands has trade and other types of relationships are more vulnerable to climate change than others. This applies particularly to countries in regions such as Africa, Asia and parts of South America (Figure 1).The expected effects of climate change and the limited adaptive

Figure 1

Climate change vulnerability, 2012



Source: ND-GAIN

Every country in the world is vulnerable to climate change (and its consequences). A country's vulnerability to climate change comprises a) exposure, b) sensitivity, and c) its capacity to adapt to climate change (and its consequences). The countries most vulnerable to climate change lie in Africa, along with some in Asia and South America.

capacity in these areas makes these countries even more vulnerable. Without additional efforts, climate risks will increase in the future, also for Dutch businesses and expatriates.

Climate risks can be broken down into a wide range of effects, from incidents with a huge impact and a small probability, to events with minor consequences that occur relatively frequently (Figure 2).

Most important climate risks in the European context: vital networks

The Netherlands is closely linked – physically, socially, economically, administratively, organisationally and geo-politically – with other European countries. More than 80% of Dutch trade flows, migration and travel takes place in Europe. The energy, ICT and logistical networks are strongly interconnected. This interconnectedness will only increase over the coming decades, as will the interwovennes with other sectors.

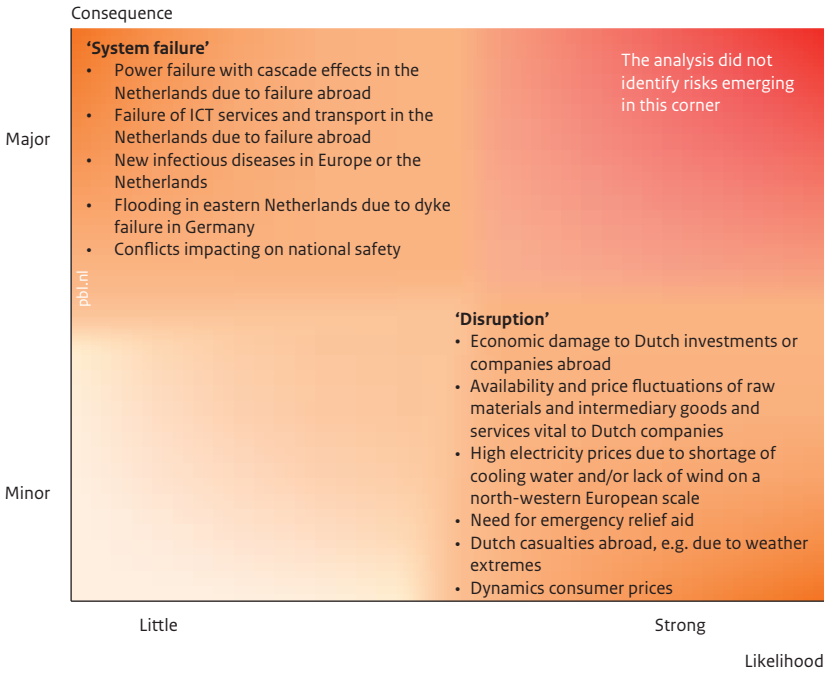
This study shows that the climate risks with the greatest impact in Europe are related to (1) the international power grid and ICT networks, (2) water levels in the rivers and (3) health. The probability of the Netherlands being affected. by extremely high or low river discharges or flooding caused by dyke failures across the border or by major power grid or ICT network failures due to extreme weather abroad is small at the moment, but should they occur, the effects would be major (Figure 2). This also applies to the possibility of new diseases establishing themselves and spreading; for example, infectious diseases in humans and pest organisms affecting livestock and crops.

The water-related risks to the Netherlands, including the cross-border risks, have already been taken into account in the Delta Programme. The EU Floods Directive provides a framework for European coordination in this context. On the matter of infectious diseases too, there is already an adequate monitoring and screening system in place. Given that the healthcare system generally functions well, no major additional measures in this area appear to be necessary. The risks identified do underline, however, the importance of maintaining and continually updating these systems.

The greatest challenge therefore lies in the power supply and the power grid. The power grid is becoming increasingly international. Over the next few decades,

Figure 2

Main risks to the Netherlands due to climate effects elsewhere



Source: PBL

The Netherlands may become affected by risks of system failure; the probability of such failures occurring is only small, but they would have a very serious impact on the population, economy and society as a whole. There are also significant risks related to disruption. These events will occur more often but have less impact on the population, economy and society each time.

there will be a major shift in the energy mix, with solar, wind and hydropower constituting an ever larger share of power generation. The greatest concern relates to periods of cloudy, windless days in winter in which the demand for power is at its greatest while there is limited additional natural gas available to generate power from, because of the high demand for gas for heating.

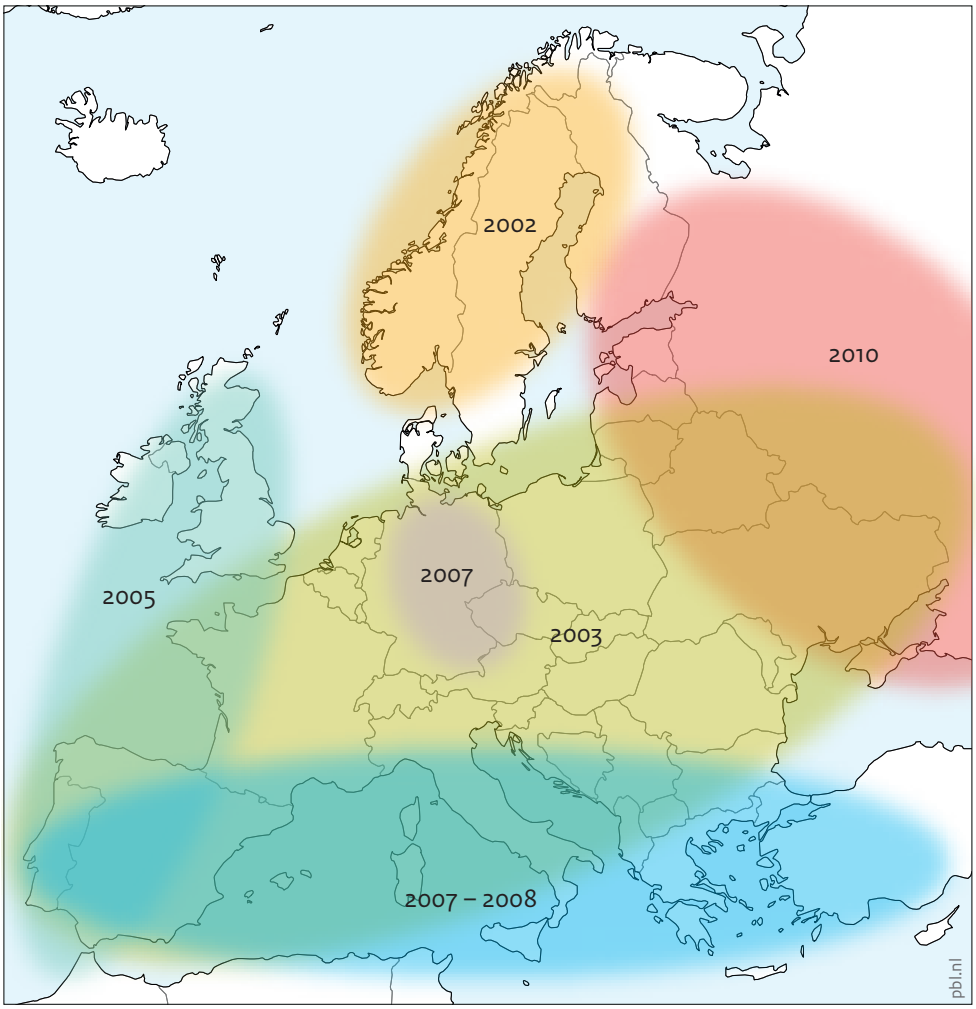
The mutual dependence of the power and ICT networks means that a disruption in one of these networks could trigger cascade effects; for example, due to the more frequent occurrence of extreme drought, peak precipitation, heatwaves, lightning strikes and gusting winds. Given the importance to society of reliably operating power supply and ICT networks, devoting specific attention to this possible vulnerability in relation to climate change would be in order.

Most important climate risks in a global context: disruption of economic chains

We have been able to identify a number of risks that, per event, carry greater probability but relatively minor consequences to the Netherlands that are linked to weather extremes occurring elsewhere in Europe and the rest of the world. The risks to the Dutch economy lie mainly in temporary shortages or interruptions in the supply of products and services used in production processes in the Netherlands. These temporary shortages or supply interruptions would be caused mainly by the incidence of weather extremes (and their consequences), such as cyclones, flooding, extreme precipitation or drought. These are already occurring and will only increase due to climate change. An interruption in the supply chain can often be compensated for by production and supply from other regions or the use of alternative products, although price rises could ensue. Droughts generally cover wide areas and could easily lead to a major reduction in agricultural yields and thus to price rises. Consumers are more likely to be faced with price fluctuations due to weather extremes.

Figure 3

Most severe cases of drought in Europe, 2000 – 2010



Source: SOER 2010; Barriopedro et al. 2011

Europe was affected by several long periods of drought in the first decade of the 21st century. The chance of wide-scale drought will increase in the future due to climate change.

1 Periods of drought in Europe

In the first decade of the 21st century, Europe was affected by several long periods of drought. The heatwave and attendant drought that affected a large part of Europe in 2003 was exceptional. How often such events will occur depends on location and certain aspects, such as extreme temperature, as well as the duration or extent of the drought. Unless significant measures are implemented in this century to reduce greenhouse gas emissions, climate change could mean that hot summers such as that of 2003 will occur every other year. In the context of risk assessments for agricultural products and the energy supply, it is important to understand that prolonged heat and drought are linked to one another. This weather type is characterised by a persistent and powerful high pressure area in which the formation of precipitation is suppressed. The high temperatures together with the smaller volumes of precipitation lead to drought and lower river levels. The scale of such persistent high pressure systems may be such that this blocking phenomenon covers a wide area of Europe. These often hot and dry periods can have a major impact on crop yields, the power supply, nature and inland shipping in Europe.

Flooding, extreme precipitation and cyclones can also result in direct damage to Dutch investments abroad and personal misfortune (Figure 2). Climate change may also make it more likely that Dutch citizens travelling abroad are exposed to infectious and other diseases as the probability of water becoming contaminated or food perishing, for example, could increase with higher temperatures. In the context of the Netherlands, the consequences will be minor but this does not preclude the fact that the impact could be serious for businesses and private parties.

To limit the risks to the economic and production chains, it is necessary to have an understanding of the origins and climate sensitivity of all the products in the production chain. Subsequently can be established, for the regions that are important for Dutch trade, how the knock-on effects of climate change could impact the supply security of raw materials, products and services, their transport and product markets. Businesses and individuals can limit the risks to themselves by making sure they are adequately informed about the possible risks in a particular region and the avenues for action in the event of a disaster, as well as the opportunities for limiting the damage.

Climate change could heighten political tensions

Climate change in various ways could become a significant factor in the area of international security. Drought, for example, leading to harvest failures and famine in areas that are already vulnerable and possibly further igniting already simmering conflicts. This could lead to greater migration within countries and across national borders and greater regional instability. The drought and food crises between 2005 and 2008, for example, could be seen as the touch paper that lit the powder keg that was already waiting to explode in northern Africa and the Middle East. So far there have been no indications that climate change will lead to more migration to the Netherlands. It is more likely that climate-related migration will lead to a greater demand for relief in other regions and that the possible increase in conflicts and natural disasters will lead to more demand for humanitarian aid.

Another area where tensions could potentially heighten is the Arctic region. The ice in the Arctic region is melting and, as a result, the Arctic Sea is ice-free for part of the year more often. This will bring benefits, such as a new and shorter navigation route for shipping and access to new areas where natural resources can be extracted. But it will also bring risks because several countries, including NATO partners, will lay claim to the reserves. The probability of this leading to a conflict is at the moment estimated to be very small, but the impact could be immense should it occur.

Climate adaptation requires a joint north-western European approach

Dutch climate adaptation efforts related to river levels and discharges, the power grid and ICT networks and health will be most fruitful if they are undertaken in close cooperation with neighbouring countries and other partners in north-western Europe. The scale at which this cooperation could best take place will depend on the topic. Where the threat of river flooding is concerned, coordination with the immediate neighbouring countries will be sufficient. There is already international agreement on managing river discharge levels. Cooperation across north-western Europe will be the minimum requirement to make the energy supply more robust.

Making the national and international power grid, ICT and transport infrastructures climate-resilient is a national government responsibility. This requires cooperation in a European context and with the private sector businesses operating these vital networks and hubs. To make this vital infrastructure more climate-resilient requires greater awareness and understanding of the potential climate effects. The government could play an instigating and coordinating role here. For example, it could undertake or have regular stress testing carried out throughout north-western Europe in cooperation with the power supply, ICT and transport operators. Certainly in a European context, and for north-western Europe in particular, this could provide a useful instrument for the power grid and possibly for the ICT and transport networks, too. On the basis of collective stress tests, the government could, for example, enter into binding agreements with the operators and public authorities concerned, with a view to reducing the vulnerability of these networks. Part of this strategy could include an agreed rationing plan between countries should problems occur, such as in a situation of limited power generation resulting from a long-lasting period of windless weather conditions or heatwaves with low river discharges.

Strengthening global climate adaptation is a major challenge

Water and food are key areas in the current foreign policy on development cooperation. This is the right decision from the point of view of climate adaptation; water and food supply are also sectors that could be vulnerable to climate change, particularly in the regions of Africa and Asia that are already vulnerable. If climate adaptation were to be more specifically addressed in foreign policy on trade and security, this would also increase this policy's effectiveness. Through international organisations, the Netherlands is advocating that, besides mitigation, more attention should also be devoted to climate adaptation; for example, by urging

that more long-term funding for climate adaptation in developing countries be provided under the new climate treaty (Paris 2015).

The leveraging points available to the Dutch Government and private sector are limited when it comes to reducing the risks of global climate change; security levels, infrastructure quality, disaster preparedness and aid are largely in the hands of foreign governments. In its recent risk assessment, the World Economic Forum considers worldwide failure of climate adaptation as a serious economic risk. In terms of impact, it ranks this in 7th place and in terms of probability in 5th place in the top 10 global risks in 2015. This underlines the importance of all the policy initiatives already in progress that are intended to introduce effective adaptation measures in the developing regions by strengthening institutional capacity and making financial resources available under the climate treaty that is to be concluded in Paris in 2015. The key areas of food and water in Dutch development cooperation policy, making economic chains more sustainable and the additional impetus given to disaster preparedness, are all in line with these urgent challenges. Increasing the resilience of other countries also reduces the vulnerability of Dutch businesses that depend on products from these countries for their production processes, as well as those that have important sales markets in these developing countries.

Benefitting from global opportunities

From a global perspective, climate change not only poses risks but also offers opportunities for the Netherlands. The government could contribute, with regard to the latter, by making climate adaptation a specific topic in foreign policy and in networks with multinationals, civic organisations and other countries. These opportunities lie mainly in the export of Dutch expertise and practical experience in relation to climate adaptation. The activities of Dutch companies and academic institutions are held in high regard worldwide. Specifically in relation to projects concerned with food and water, developing climate-resilient cities (particularly in delta regions) and taking an integrated approach to flood safety and water management, spatial planning and development, sustainable development and sustainable economic chains. Added value will be created by incorporating climate adaptation as a specific element in such projects.

International climate adaptation cannot be put off indefinitely

Not all aspects of climate change are equally urgent. This however does not mean that adaptation can be postponed indefinitely or put on hold for the long-term agenda. The degree of urgency is dictated not only by climate change itself, but also by the schedule for investment and policy decisions, which often have a long cycle time. In Europe, this also applies to the power and ICT sectors, as well as to flood defences strategy. Globally, this mainly concerns urban development, as well as protecting the water supply and infrastructure against flooding.

To identify climate risks and include them in strategy development in time, existing global and European consultative fora need to ensure that the climate resilience of policy and investment decisions is included in their agendas. It will be worthwhile to ensure that the possible effects of climate change are taken into account in every long-term investment made over the coming decades. This will only be to the benefit of the Dutch commercial sector, research institutes and Government. The uncertainties surrounding the nature and rate of climate change, as well as socio-economic and political developments and technological advances, would also indicate that there should be regular reassessment of the risks and opportunities for the Netherlands. It is recommended that this should be a joint process carried out by government and private sector parties.

FULL RESULTS

Introduction

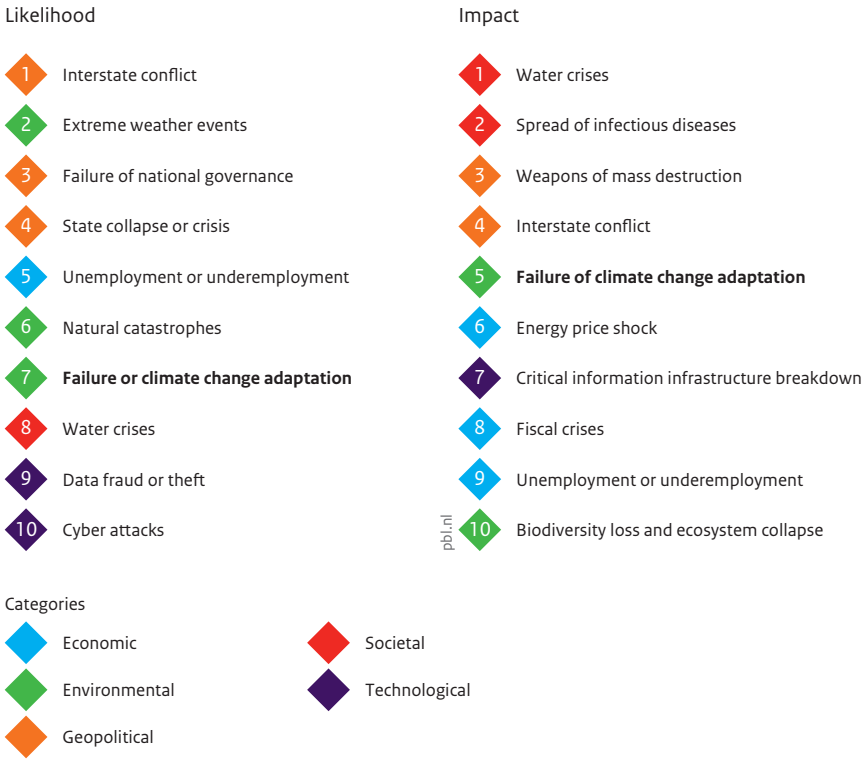
The effects of worldwide climate change that are relevant to the Dutch National Adaptation Strategy

People, cultures, countries and businesses, worldwide, are becoming increasingly interconnected. This globalisation is shown by the growth in the international exchange of goods and services, as well as the flow of capital, information and people. The Netherlands[1] too is connected with Europe and the rest of the world in many ways; through economic chains, flows of goods and raw materials, power grids, financial and data flows, as well as the movement of people through immigration, emigration and tourism. The Netherlands has one of the most open economies in the world (PBL and CPB, 2013). Of all EU countries, the Netherlands, in 2012, was the fourth largest foreign investor with more than 4% of all investments worldwide (CBS, 2013a). Every year, millions of Dutch citizens travel abroad. Owing to its geographical position, the Netherlands is a transport hub for the entire European continent. And Dutch power grids and natural gas networks are connected with those of its neighbouring countries and Scandinavia. Compared with other countries, the Netherlands has frequent and extensive socio-economic and trade relations abroad (Ghemawat, 2011). This also makes the Netherlands particularly vulnerable to foreign developments, especially in Europe. Developments abroad can therefore have an impact on Dutch society and the economy. The changing global climate is just such an example.

The effects of global climate change are already visible; it is getting warmer, there are more heatwaves, glaciers are retreating (affecting water supplies) and the ice in the Arctic is melting. Due to the warming of sea water, tropical cyclones are expected to become increasingly severe. In many already arid parts of the world, such as in parts of the tropics and southern Europe, even less rainfall is expected, while the countries in the wet tropics and northern Europe will have more precipitation to deal with. Plant and animal species are shifting to higher latitudes and higher zones in the mountains. Due to climate change, crop yields in various parts of the world are likely to change this century, with expected increases in the higher latitudes (such as northern Europe) and decreases closer to the Equator. If countries fail to adapt their coastal defences in time, the rising sea level will lead to greater flood risks, particularly in deltas; precisely where major cities are often located (IPCC, 2014). Economic institutions, such as the World Bank, the International Monetary Fund, the International Energy Agency, Standard & Poor's (S&P, 2014) and the Organisation for Economic Cooperation and Development (OECD), acknowledge that climate change could have a disruptive effect on society and the economy. Weather-related natural disasters, climate adaptation failure and water crises are also included as important factors in the risk assessment by the World Economic Forum (WEF, 2015) (Figure 1.1).

[1] The 3 Dutch municipalities and the 3 countries of the Netherlands Antilles will not be specifically discussed here.

Figure 1.1
Top ten global risks in terms of likelihood and impact



Source: World Economic Forum 2015

Weather-related natural disasters, climate adaptation failure and water crises are also important factors in the risk analysis by the World Economic Forum (WEF, 2015). Climate change may also play a part in many other risks, such as the spread of infectious diseases, international conflicts, extreme fluctuations in energy prices and the collapse of vital ICT infrastructure.

International building blocks for the Dutch National Adaptation Strategy (NAS)

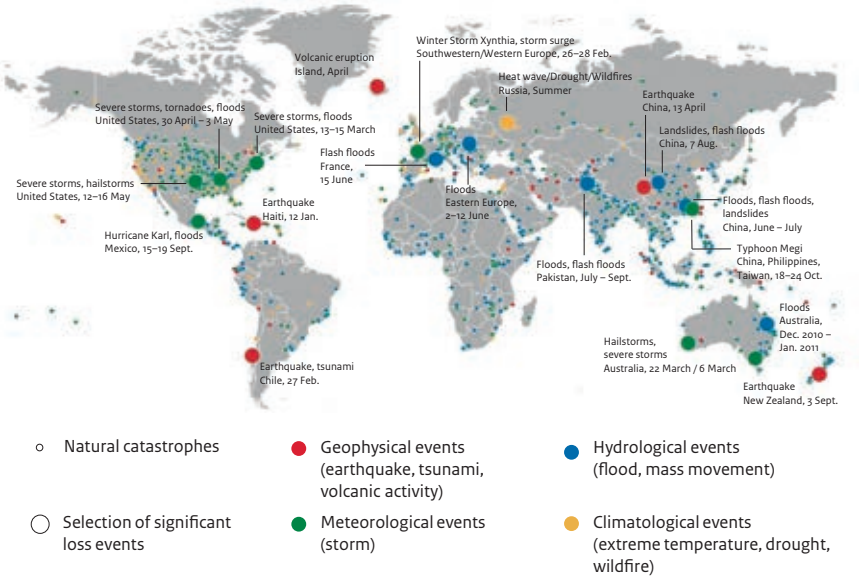
Further to Dutch research carried out for the Delta Programme[2] and the research programme Knowledge for Climate[3], there already is a large amount of information available on the potential effects of climate change in the Netherlands. However, not a great deal is known about the possible consequences to the Netherlands of climate change elsewhere in the world. Studies in the United Kingdom (PWC, 2013) and Switzerland (INFRAS, 2007) show that some of these international risks of effects of climate change may be greater outside national borders than within them. According to a recent EU study, the effects on the Netherlands of climate change outside the European Union would be less than on other EU Member States (Ciscar et al., 2014).

This is the English summary of the full Dutch PBL report (‘*Van wereldwijde klimaateffecten naar een Nederlandse adaptatiestrategie*’). The study was conducted at the request of the Dutch Ministry of Infrastructure and the Environment (IenM) to describe the possible consequences for the Netherlands of climate change elsewhere in the world. It is not only about climate-related risks but also about opportunities (possible positive impacts). It provides an initial overview of the adaptation options to reduce these risks or take advantage of the opportunities.

This summary outlines the results; from international climate effects to adaptation. The purpose of the study was to show how climate change elsewhere could affect the Netherlands. In this context, we also looked at the options for climate adaptation; those which reduce risks on the one hand, and widen the avenues for opportunities on the other. This report also serves as *one* of the building blocks for another PBL study on climate change adaptation, related risks and opportunities (‘*Aanpassen aan klimaatverandering- kwetsbaarheden zien,*

[2] http://www.deltacommissaris.nl/english/delta-programme/delta-decisions/index.aspx
[3] www.knowledgeforclimate.nl

Figure 1.2
Natural catastrophes, 2010



Source: NatCat database, Munich Re 2011

There are a large number of natural disasters in the world. In 2010 alone, 960 disasters were reported; a large share consists of flooding disasters and storms.

kansen grijpen' (PBL, 2015a) [English summary: Adaptation to climate change in the Netherlands - Understanding the risks, seizing the opportunities] and for the National Adaptation Strategy which is to be finalised in 2016 (Ministry of Infrastructure and the Environment). This strategy will consider all the sectors that could be affected by climate change, as well as the international aspects. The European Commission has asked for such a broad approach to be taken and has given each Member State until 2017 to prepare an adaptation strategy (EC, 2013b).

PBL has collaborated with the Royal Netherlands Meteorological Institute (KNMI) on climate projections. Findings on foreign policy were largely based on a contributing study carried out by Clingendael, the Netherlands Institute of International Relations (Schaik et al., 2015).

Reader

The analysis in this report was conducted according to a number of steps. First, we needed to establish the various ways in which the Netherlands is connected to other countries, and then list the climatic effects that may occur in these countries. We not only considered such events themselves, but also for example the related governance and socio-economic situation and society's capability to cope with such problems (Chapter 2). Chapter 3 gives an outline of the types of risks and opportunities, as well as the main risks, ordered according to likelihood and consequence (Figure 3.1). Subsequently, the themes that apply to the Netherlands – health, food supply, energy, ICT, water, biodiversity, economy and trade, and foreign policy – are discussed in relation to the risks and to the opportunities and options for adaptation to the possible impact that global climate change may have on the Netherlands. The final chapter discusses a number of subjects in relation to the National Adaptation Strategy (Chapter 4). The analysis was based on information derived from other publications and data sets.

This report provides the findings from PBL research; the digital version contains an elaboration of the full results, background and context. It can be downloaded (in Dutch) from www.pbl.nl.

TWO

International relationships and climate impacts

The impacts of climate change in other countries also could have an impact on the Netherlands. It is therefore important to first take a look at the international relationships; with which countries does the Netherlands have ties and how are they connected? Subsequently, the climate impacts in these regions are discussed.

What international relationships does the Netherlands have and how strong are the ties?

The impact of climate change elsewhere in the world affects the Netherlands in various ways: through cross boundary personal contacts, through vital sectors, through physical cross-border flows of water and nature, through economic relationships such as in trade and investment, and relationships regarding international security and foreign policy (Figure 2.1). These international relationships can be divided into the following themes:

- People: *health, family ties and mobility*
- Vital sectors in the Netherlands: *food, energy, ICT*
- Physical flows: *water and nature*
- The Dutch economy: *trade, transport, investment and services*
- Foreign policy: *international security, aid, trade relations, development cooperation*

Strong ties with European countries

At the moment, the social, physical, economic, political and administrative ties that the Netherlands has with its neighbours and the other European countries and, to a lesser extent, with the United States (Figure 2.2) are stronger than ever. For example, 90% of the Dutch population holidaying abroad stays within Europe, 70% of Dutch exports and imports are within Europe, the Dutch power grid is connected with that of neighbouring countries, and 70% of its data traffic is within Europe. Climate change in Europe therefore receives special attention in this report.

For the Netherlands, about 30% of foreign investments and international outsourcing of services lies outside Europe. Countries in Asia (China, India and Malaysia) and the Americas (United States and Brazil) are important trade partners for the Netherlands. The partner countries in the area of development cooperation lie mainly in Africa.

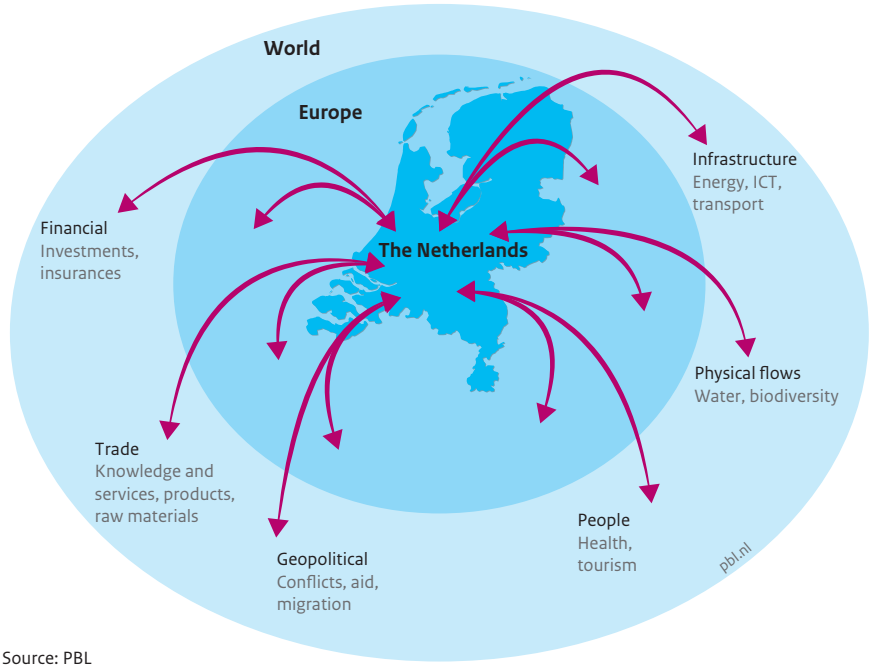
Climate change impacts in the countries and regions with which the Netherlands has ties

The global climate is changing, as can be seen from the changes in temperature observed over the past century. Over the last 130 years, the global average annual temperature has increased by 0.9 °C, with increases in certain regions of 1.5 to 2.5 °C (IPCC, 2013). IPCC studies show that these changes are likely to continue in the coming centuries.

This study looks at the impact of climate change in all the countries and regions with which the Netherlands has close ties, also drawing on regional knowledge wherever available.

For the future, 2050 is the main focus year of the analysis, sometimes expanded to 2100. Often, the uncertainty about the rate and scale of the changes between now and

Figure 2.1
International relations of the Netherlands



Source: PBL

The Netherlands can be affected by global climate change (and its effects) in various ways: due to disruption of trade chains and the supply of raw materials; financially, due to damage to Dutch investments abroad; due to damage to vital services such as energy or ICT infrastructure; through people travelling to countries where health risks are increased; or even through the geo-political route due to conflicts or migration.

2050 is very large; in such cases the risk is described, based on what is currently known about the direction of change, such as a large chance in heatwaves. Information on climate was derived from various IPCC reports (IPCC, 2012; IPCC, 2013) as well as KNMI expertise (see Chapter 2).The climate effects are also based on IPCC information (IPCC, 2014; KNMI and PBL, 2015; see also Chapter 3). Global climate change (and its impact) can be divided into three types:

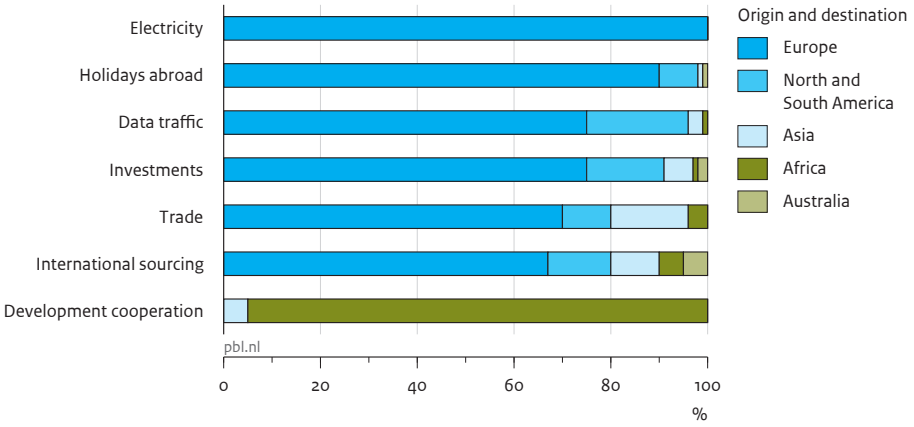
- systemic changes (theoretically possible reversal of the Gulf Stream);
- gradual changes (rise in sea level, disappearance of sea ice and glaciers, changes in precipitation patterns);
- changes in weather extremes (storms and cyclones, extreme precipitation, heat, drought and flooding).

Scientists are largely in agreement about the direction in which the climate is changing, but the scale and speed of the changes and how these will manifest regionally is still highly uncertain. This depends on the extent to which the causes of global climate change are tackled with mitigating measures taken around the world. IPCC and KNMI have therefore run scenarios for both a strong reduction in the emission of greenhouse gases (with global warming limited to 2 °C) as well as a scenario with high emission pathways ('business as usual' scenario with a 4 °C global increase). The focus of this report is not on mitigating climate change but on adapting to it. However, global mitigation measures will largely determine the extent and therefore the consequences of climate change and thus also the risks for the Netherlands. The risks, in any event, will be more manageable under the 2 °C scenario than under 4 °C global warming (World Bank, 2013).
For this study, we focused on the risks and opportunities related to the last two types of changes and their impact; the gradual changes and the changes in weather extremes. This risk and opportunity assessment does not include the risks of a global temperature rise of more than 4 °C or of systemic changes in climate, such as a shutdown of the Gulf Stream. The risks and opportunities of such changes cannot be estimated on the basis of current knowledge and understanding.

Worldwide climate effects

The consequences of climate change are already visible, worldwide: it is getting warmer, there are more heatwaves, glaciers are retreating and the Arctic ice is shrinking (Figure 2.3).The warmer seawater is increasing the severity of cyclones. In many areas where it is already

Figure 2.2
International relationships of the Netherlands



Source: Statistics Netherlands; UN Comtrade; OECD; Teleography; Dutch Ministry of Foreign Affairs

The Netherlands has its strongest ties with European countries and, to a lesser extent, with North America and Asia. The partner countries for development cooperation are mostly in Africa

arid, such as in parts of the tropics and southern Europe, even less rainfall is expected, while the countries in the wet tropics and in northern Europe, for example, are having to deal with increased levels of precipitation. Crop yields in various parts of the world will probably change over the course of this century, due to climate change, with expected increases at higher latitudes (such as in northern Europe) and reduced yields closer to the equator. If countries fail to adapt their coastal defences in time, rising sea levels will lead to greater flood risks, particularly in deltas – which is precisely where many of the large cities are located.

Weather-related natural disasters in countries that have ties with the Netherlands

In the first decade of the 21st century, 3,500 weather-related natural disasters occurred. Almost 400,000 people died as a result, mostly due to storms and cyclones in Asia and due to heat in Europe and Russia. The total damage in that period amounted to more than USD 800 billion, particularly due to cyclones in the United States and disasters due to various causes in China and Europe. This also occurred in regions where the Netherlands has strong ties in the areas of trade, infrastructure or aid (Figure 2.4).

The numbers of natural disasters vary from year to year (e.g. see Visser et al. 2012). In 2010, for example, 960 large natural disasters were reported worldwide, with many of them water- and weather-related caused by heavy rains, hail storms, hurricanes, heatwaves and drought) (Figure 1.2). Dutch companies abroad and expatriates, therefore, have a greater chance of being affected by a large disaster and its aftermath than companies and people in the Netherlands. This is also true for Europe, where around 480 water- and weather-related disasters were recorded between 2001 and 2010. During that decade, Europe also saw many periods of drought and heatwaves (Text box 1).

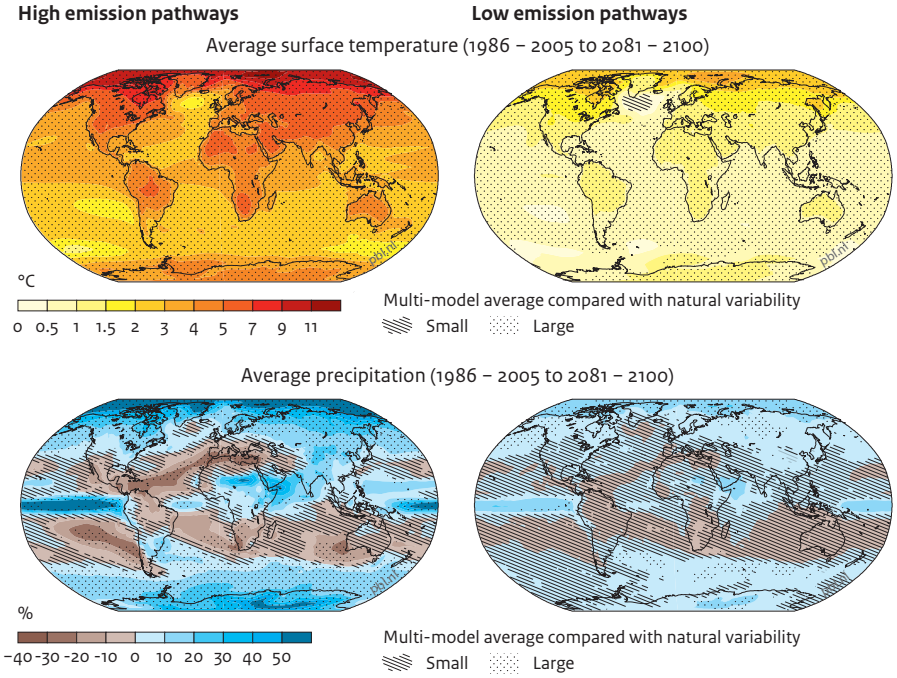
What impact all these disasters have had on the Netherlands is difficult to estimate quantitatively. Examples of effects are that drought in Europe and Russia caused grain prices to rise in the same period, and following Hurricane Katrina (2005) there was demand from the United States for Dutch water management knowledge, skills and enterprise. There have been examples in recent years, too; owing to Hurricane Sandy the Wall Street financial centre was closed for several days and following Typhoon Haiyan in Asia the Netherlands offered aid, public and private financial support and there was a temporary shortage of palm oil.

Impact of developments in society and its resilience in relation to risks and opportunities

The vulnerability of a country depends not only on the climate effects but also on socio-economic, technological, governance and geo-political developments, and the ability of that society to cope with setbacks and to implement adaptation measures. Many of these aspects play a more fundamental role than climate change itself. Often, a combination of developments will drive changes in susceptibility.

Figure 2.3

Change in climate system under two scenarios

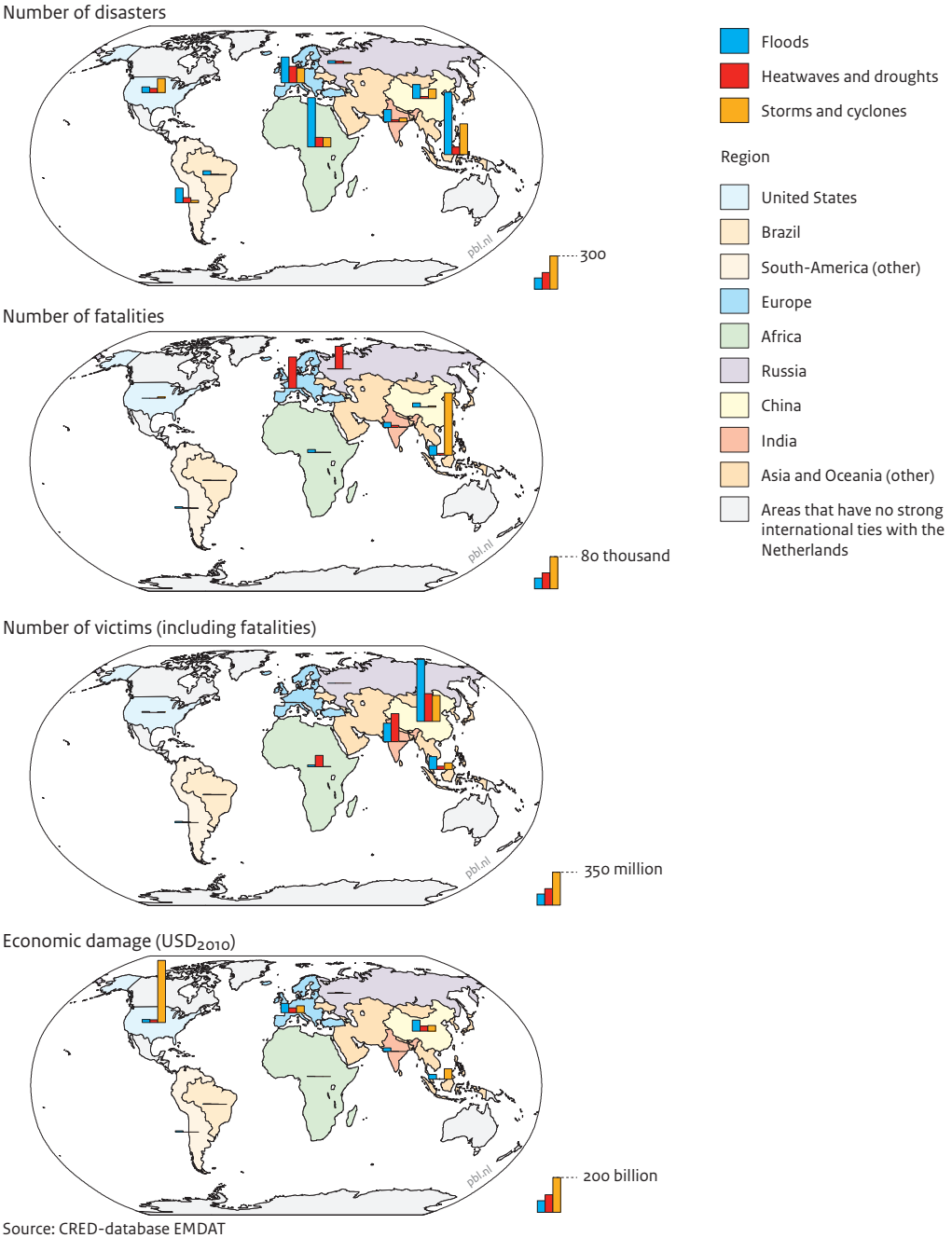


Source: IPCC WGI 2013

At the end of the 21st century, global temperatures will have risen and precipitation patterns will have changed. Under the scenario with high emission levels, temperature increases are projected of 3.2 to 5.4 °C for the end of the century, compared to those of the late 19th century. Under the scenario with the lowest emission levels, this is 0.9 to 3.3 °C. The amount of precipitation will increase, but there will also be more contrast between wet and arid regions and between wet and dry seasons. At the end of the 21st century, sea levels may have risen by 26 to 82 centimetres, compared to the 1986–2005 period.

Figure 2.4

Weather-related natural disasters in areas with strong international relationships, 2001 – 2010



Source: CRED-database EMDAT

The most casualties of weather-related natural disasters in the 2001–2010 period were in Asia. The most casualties due to flooding and heatwaves were in China and in Europe, although to a lesser extent due to heat. There were few fatalities in North America and not a great many people affected, although considerable damage was caused by cyclones and drought. Some of the casualties in Africa were due to flooding, but most were affected by drought and heat.

2 The ND-GAIN index; Vulnerability to climate change

ND-GAIN is a project of the University of Notre Dame (ND) in the US State of Indiana. The project publishes an annual Global Adaptation INdex (GAIN) for each country. The ND-GAIN index provides an overview of a country's vulnerability to climate change and the avenues for coping with it. Such vulnerability comprises exposure, sensitivity and the adaptive capacity to cope with climate change and its consequences. Indicators are used for scoring various sectors on the basis of these factors: food, water, health, ecosystems, social environment and infrastructure. A complete list of the indicators can be found at: http://index.nd-gain.org:8080/documents/methodology_2014.pdf
http://www3.nd.edu/~nchawla/methodology.pdf

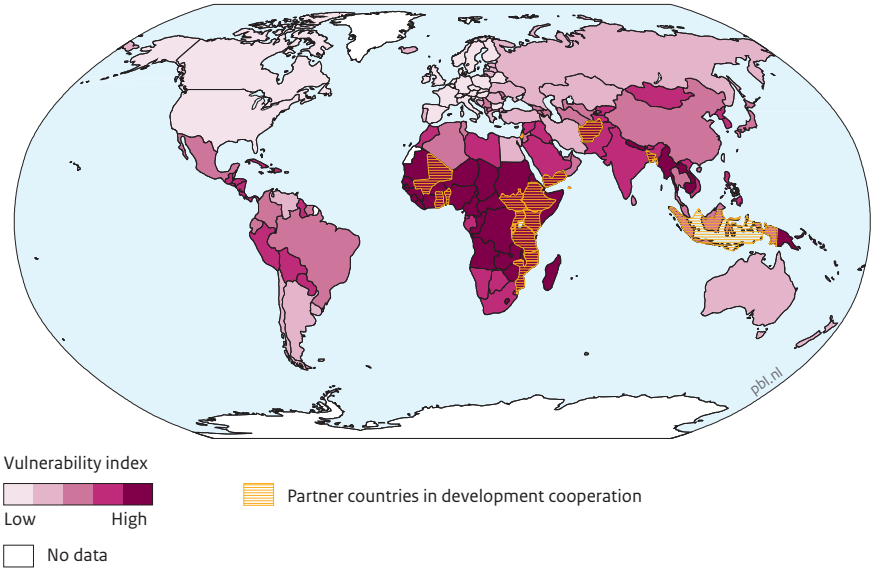
The existing risks could change due to changes in climate; more long-term drought abroad could result in more frequent interruptions in product supply for Dutch businesses and lead to price rises for consumers.
Socio-economic changes, such as the internationalisation of the power market (generation and infrastructure) could mean that the climate abroad has more impact on the risks to the Netherlands, such as power failures; for example, due to long periods of drought in large parts of north-western Europe.
Because socio-economic and technological developments affect the exposure and vulnerability of a country or sector, insofar as this is known, these have been included in the risk assessment for 2050. The related uncertainties are, of course, large. How will the circular economy affect the Dutch import and export flows? Will the trend towards international outsourcing continue? How will the technological advances in the area of large-scale energy storage affect the risks to the energy mix in 2050? We used the ND-GAIN index (see Text box 2) to estimate the vulnerability of countries in the world.
To be able to estimate the impact of climate change on a country, besides vulnerability, its resilience in terms of its economy, governance and social readiness is also important. This is about a country's ability to take investments and use them for climate adaptation measures. Important indicators in this area include the levels of political stability, integrity, education standards, and social equality of the population. Ecological resilience is an important factor for biodiversity.

Countries that have ties with the Netherlands differ in vulnerability

Climate change in countries that are trading partners of the Netherlands could have an impact on the Dutch population, Dutch businesses, the Dutch economy and, in relation to development cooperation countries, to achieving Dutch policy objectives.

Within large countries such as China and the United States, the levels of vulnerability and resilience vary widely.
Compared with other parts of the world, Europe and North America have a low to medium vulnerability (Figure 2.5) to climate change and its consequences, and these parts have considerable resilience to deal with it in the long term. The Netherlands will also be impacted by the effects of climate change that occur in more vulnerable countries which, currently, are less resilient, such as China, India and Brazil. These are countries with which the Netherlands conducts increasing amounts of trade and also has other relationships. Compared with these trading partners, the partner countries in development cooperation are highly vulnerable to climate change and hardly prepared to deal with its consequences. These are mainly located in Africa.

Figure 2.5
Climate change vulnerability, 2012



Source: ND-GAIN

The countries most vulnerable to climate change are located in Africa, along with some in Asia and South America. The partner countries of the Netherlands in development cooperation are highly vulnerable.

THREE

Risks and opportunities

3.1 Introduction

Risks to the Netherlands

Climate effects may be associated with certain risks. Important here is to know how likely it is that an event will occur; how great the impact will be; and to what extent it is possible to recover from these impact. We made a distinction between 'system failures' (events with a small probability and very large impact) and 'disruptions' (events that are more probable but whose impact will be small each time).
Flooding and heatwaves are examples of events that occur relatively frequently around the world. Their impact is very disruptive on a local level, but will not lead to system failures or disruption of Dutch society and its macro-economy. For businesses and individuals, however, the effects may well be severe. Events that occur often but are not disruptive to the Netherlands by themselves could, when combined, cause as much damage to the Netherlands on an annual basis as one truly disruptive event that occurs only occasionally. This is where impact criteria are important: the number of casualties, economic damage and any environmental damage. In view of the major uncertainties, it has not been possible to make a quantitative estimate of impact and probability. This is why a classification system was used.

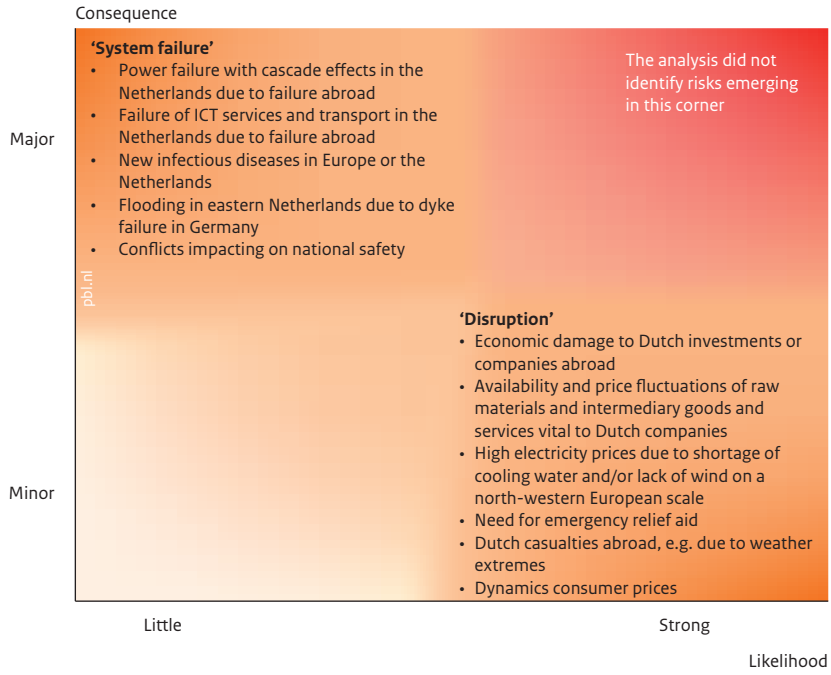
Risks of events with a large impact *and* a high probability were not identified during the course of our study. But some risks with either a large impact (disruptions) or high probability (systemic effects) were identified (Figure 3.1). The following sections elaborate on these risks per sector, and sometimes also include risks that have a low probability and small impact. In addition, a number of adaptation options for the Netherlands have been listed.

Our inventory shows that particularly the occurrence of weather extremes elsewhere in the world involves risks for the Netherlands, both today and in the future. Gradual changes, such as the shifting of climate zones and the related production circumstances for important crops and the migration of fish stocks due to ocean warming, will also have certain consequences for the Netherlands in the long term. As those changes are taking place gradually, they can be anticipated in time. At this moment, there is little likelihood of these changes leading to large effects on the Netherlands, over the coming decades.

Opportunities for the Netherlands

Although climate effects are often referred to in the same breath as risks and threats, adverse effects abroad may also offer opportunities for the Netherlands.
In considering the opportunities for the Netherlands due to climate change elsewhere in the world, a wide range of opportunities were noted:

Figure 3.1
Main risks to the Netherlands due to climate effects elsewhere



Source: PBL

The Netherlands has a small chance of being exposed to risks related to system failure,, but with major consequences for people, the economy and society. There are also significant risks related to disruption. These events occur relatively often (once every 1 to 10 years), but with minor consequences for people, the economy and society as a whole.

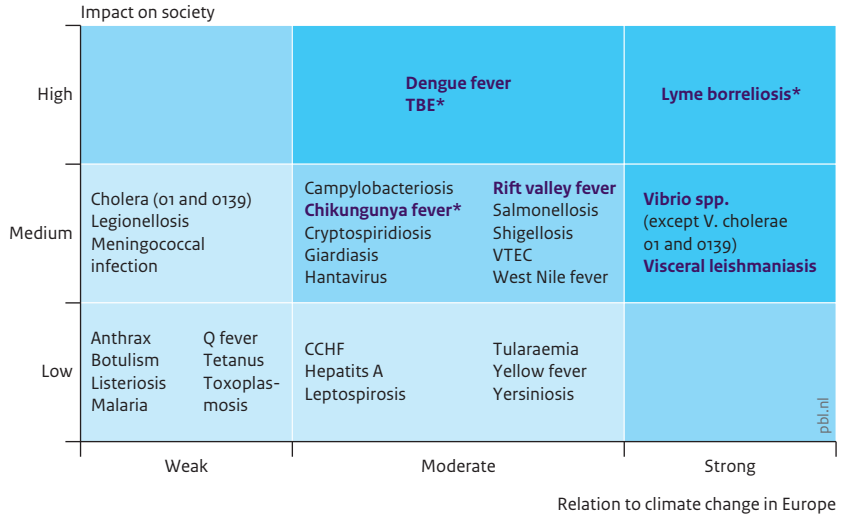
- direct opportunities: for example, opportunities for the private sector in the Netherlands to sell pumps, insurance, or expertise in the field of water management.
- relative benefits: for example, the potential benefits for the Dutch ports because of transport routes in the Arctic region becoming accessible, or the relatively mild climate and climate change creating an attractive business climate.
- opportunities for the Dutch Government and society to speed up the realisation of certain goals in the area of development cooperation or to link adaptation to other goals such as sustainable development and integrated solutions for water management and water safety issues.

Realisation of these potential opportunities is highly uncertain. It is therefore also not possible to estimate their scale and level of probability.

3.2 Health

The transmission areas of some infectious diseases and their vectors, such as mosquitos and ticks, could shift due to global climate change. In Europe, it may be expected that the risk of tick-borne meningitis, TB and Lyme's disease, and the Chikungunya and Dengue viruses transmitted by mosquitos, will increase in those parts of Europe where these diseases already occur and will manifest themselves in areas where they are 'new' (Figure 3.2).
It is not impossible for a new disease to establish itself in the Netherlands, but the probability is very small, not in the least thanks to the monitoring and good healthcare that already exists. The chance of new diseases establishing themselves in southern Europe is greater, although that risk is also very uncertain. The often-mentioned risk of malaria in the Netherlands or the EU due to climate change is very small. The mosquitos that transmit malaria may well occur in Europe, but the pathogenic organism responsible for the disease (parasite) is not expected to thrive in Europe even under conditions of further climate change (RIVM 2014a).
The likelihood of new diseases emerging in the Netherlands is particularly related to the heavy international traffic of people, animals, plants and goods.

Figure 3.2
Impact of climate change on infectious diseases in Europe



In purple : New diseases to be monitored
* : Diseases which are currently subject to a notification requirement in some EU Member States

Source: Lindgren et al. 2012

Climate change will have a health impact in Europe. Warmer longer summers, warmer winters and more rainfall will change the epidemiology of ticks which can transmit Lyme's disease and TB, and mosquitos which can transmit Chikungunya and Dengue fever, along with sand fleas through which people can become infected with visceral leishmaniasis, to include areas where these diseases did not previously occur. Higher temperatures will lead to an increase in food transferrable diseases, such as Salmonella, and water transferrable diseases, such as Cryptosporidiosis in drinking water and Vibrio bacteria in bathing water.

There will be a greater chance in the number of Dutch tourists and emigrants who contract infectious and other diseases abroad due to contaminated water or tainted food (ECDC, 2010) or who are affected by weather extremes such as heatwaves and flooding related to climate change. This applies worldwide, but certainly also to Europe; for example, in southern Europe where there are many Dutch people visiting the area or who have emigrated there.

Holidaymakers and expatriates more often will be faced with extreme weather conditions, such as heatwaves, drought, extreme precipitation events and their consequences, such as forest fires, flooding and landslides. Because most of the foreign trips made by Dutch citizens are to areas that are not particularly vulnerable, such as Europe or the United States, the health risks to individuals will be small, but nonetheless present. According to model calculations, a heatwave such as that of 2003 could occur in western Europe once every 10 years between 2020 and 2049 (Barriopedro et al., 2011). Chikungunya infections have already been noted in the Dutch Antilles (RIVM, 2014b). Current socio-economic trends indicate that Dutch citizens, at an advanced age, travel further away, also outside Europe. Because of this trend health risks related to climate change, such as heat stress and food poisoning, increases; especially for the elderly.

Adaptation options

- Continue – and where necessary increase – European and global monitoring, education, vaccination and surveillance, based on estimations of climate risks related to vectors and pathogens. For the Netherlands, this is important on both a national and global scale, particularly in the neighbouring countries and those where many Dutch citizens are staying (in Europe, the United States and the Dutch Antilles). The chances of a new vector disease emerging in the Netherlands are small, but the impact could be great.
- In light of climate change and the increasing traffic of both goods and people, regular stress testing of the healthcare system would be prudent. This would provide insight into the degree to which the Netherlands could manage sudden disease outbreaks.

3.3 Food

A third of what people in the Netherlands eat comes from abroad. For part of their diet, the Dutch depend on agricultural production and fisheries elsewhere in the world, and thus also on the weather conditions there. Although food security in the Netherlands is in no danger because the Netherlands produces a large amount of food itself and in the event of shortages in the world

there are many alternative products or production areas available.

Pests and diseases can be imported together with the import of raw materials. Agricultural pests and diseases could increase elsewhere in the world due to climate change. The ports and airports are important gateways in preventing pests and diseases from entering the country. Other risks include internal incidents and large-scale epidemics of infectious animal diseases or prolonged periods of drought in the European Union that result in a large-scale reduction in agricultural production. This would mainly affect livestock management. Food safety monitoring by the Netherlands and the EU continues to be important. Climate change will increase these risks, given that a widespread drought in Europe, similar to that of 2003, under the scenario with low emission pathways in 2050, could occur every other year.
The growing variability in the climate, with extreme drought or indeed very wet periods, means that crop yields abroad will also fluctuate more from year to year, which will affect the price of products for people in the Netherlands. Protectionism in the producing countries could further drive up prices. An example is the loss of 30% of the grain harvest in Russia in 2010 due to the extremely hot, dry summer following which the Russian Government decided to halt the export of grain. Russia is the fourth largest grain producing country in the world. Such disruptions could occur more often in the future, with minor consequences each time and only for a small part of the Dutch economy and society as a whole.
A particular weak spot for Europe and the Netherlands would be if soy imports were to cease due to harvest failure overseas or for geo-political reasons. Owing to its relatively large share of the soy imported in the EU, the Netherlands is most vulnerable. Because soy is mainly used in animal feed, this could affect the meat sector, in particular.
For the continuity of the food supply in the Netherlands, it is important to safeguard global grain production. Holding strategic stocks in the world is just one of the measures which could help to achieve this. This interest extends further than that of the Netherlands: safeguarding the global grain production is important in combatting hunger in developing countries and maintaining political stability in regions that are already becoming more volatile.

If the import of soy as a raw material for animal feed should be severely affected as a result of drought, for example, Europe will respond by exporting less grain and importing more instead. This will drive up the price of grain on the world market. Poor population groups in food-importing developing countries will suffer most as a result (PLIS, 2011).But even within the European Union (e.g. in Romania) it is possible that due to harvest failures, the food price would become too high for that part of the population living on the edge of poverty.

Adaptation options

- Regular stress testing could be undertaken throughout Europe to identify the weaknesses in the European agricultural and food system. For this purpose, it will be useful to carry out a regularly updated risk assessment covering developments in these sectors, and in food consumption and climate change.
- It is important to maintain the knowledge resource infrastructure. This is also an important export product, such as the knowledge on risk management in agriculture (with regard to weather and climate risks), including insurance.
- A proper monitoring of pests and diseases and the water efficiency of crops is also important.

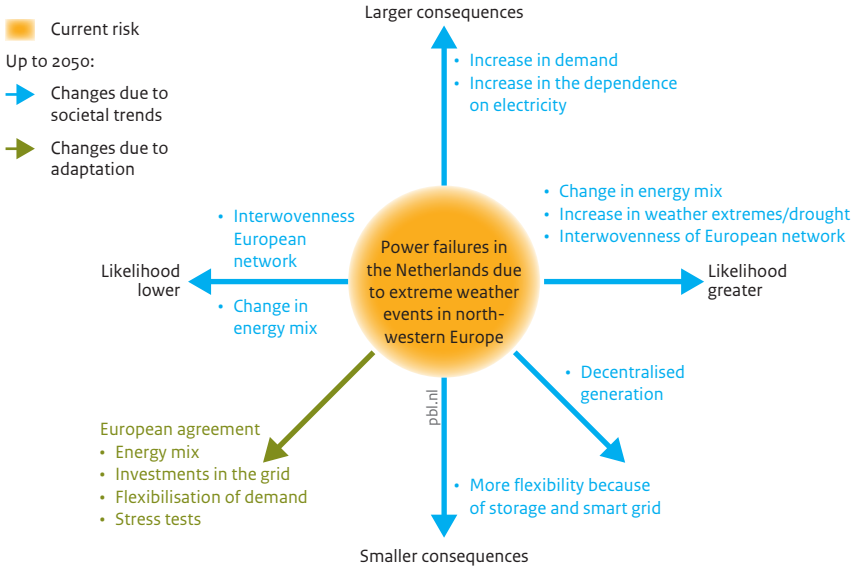
3.4 Energy

The energy sector is highly internationally oriented. The Netherlands imports oil and coal from far afield, such as from Russia and Colombia. It is connected via its power grid with neighbouring countries and, to some extent, with the rest of Europe. Power generation and the market are also on a European scale.
Climate change elsewhere in the world has no great impact on the import of raw materials used in the energy supply for the Netherlands. Although, in the future, Dutch natural gas extraction will decline and the Netherlands will depend more on foreign supplies, in cases of calamities in those foreign regions, there are still many alternative resource areas. In addition, the Netherlands has a buffer in the form of stocks. Furthermore, the demand for natural gas will decrease in all of north-western Europe, as a result of higher temperatures in winter reducing the demand for natural gas used for heating. The energy supply is part of the vital infrastructure; outages can lead to disruption in society and cascade effects in other vital infrastructure elements such as ICT and transport.

Probability of failure of power supply small, but with major consequences

The present power generation infrastructure in the Netherlands and Europe is vulnerable to climate change and the attendant changes in the frequency and intensity of weather extremes, such as storms, heatwaves, periods of drought and flooding. A prolonged period of drought and low river discharges could lead to a lack of cooling water for power plants.

Figure 3.3
Forcefield of risk of and adaptation to power failures between now and 2050



Source: PBL

Future changes in energy supply will have different impacts with respect to possible power failures in north-western Europe due to weather extremes. Climate chance further increases the likelihood of such failures. In addition, power grids in European countries are becoming more and more interconnected and connected to other networks. Although this causes more redundancy and flexibility, a foreign power grid failure therefore may also have an impact on the Netherlands. Furthermore, social developments, such as an increasing dependence on power, only enlarge the impact of power failures. Technological developments, for example in storage and decentralised power generation could reduce the impact. Adaptation options such as that of European collaborations would reduce both the likelihood and the impact of power failures.

Large-scale power failure is one of the major risks for the Netherlands, both with respect to the potential economic damage and the disruptions to everyday life with possible casualties as a result. The chances of this happening are slim, but cannot be ruled out, entirely (Vogel et al., 2014); particularly in the case of heatwaves with a high demand for electricity to run air conditioning systems, in combination with low river water levels. Such a situation may force a shutdown of power plants that extract their cooling water from the rivers. During the heatwaves of 2003, 2006 and 2009, several power plants had to reduce their generation levels due to a shortage of cooling water (Forster and Lilliestam, 2011). The 2006 heatwave affected all of north-western Europe. The Netherlands, therefore, was able import less power than usual. To prevent total system failure when a few plants were shut down, the Dutch Ministry of Transport, Public Works and Water Management awarded dispensation for the intake of cooling water, although the water was too warm. The continued discharge of water after having been used for cooling, in these cases, leads to a further rise in water temperatures which, in turn, poses a threat to water quality, public health and nature.

A reduction in power generation due to the failure or shutdown of power plants in north-western Europe will cause a rise in electricity prices on the spot market (a financial market where electricity is traded for immediate delivery). This particularly will have an economic impact on the industry, but will also slow down demand and thus help achieve a new equilibrium between supply and demand. Large peaks and declines in north-western European power generation through wind and/or solar energy may also unbalance the power grid with the risk of failure as a result.

The north-western European power grid is fairly stable. It is therefore unlikely to fail; however, the impact of this happening would be very large (Figure 3.1). The energy supply system is a vital infrastructure. A large-scale failure carries the risk of social disruption (Vogel et al., 2014). This would affect households and important users, such as hospitals. The seriousness of such a failure would depend largely on its duration, the time of day and scale of the failure, as well as on the availability and effectiveness of emergency systems. The consequences of a scenario of national power grid failure has been estimated in the Dutch so-called National Risk

Assessment (NRB). The scenario does not state a particular cause of failure, but the NRB considers a power grid failure in the Netherlands that is due to failure abroad, a real risk (BZK, 2009). Such a national failure may lead to cascade failures in ICT and transport infrastructures and in financial transfer systems (Vogel et al., 2014). Even if such cascade effects only occur abroad – for example ICT failure in the railway system of a neighbouring country – this may also have an impact on the Netherlands.

Power supply more vulnerable because of climate change and social developments

The risk of future disruptions in power supply is increasing. This increase is caused by a combination of an increase in the frequency and intensity of weather extremes and certain social developments (Figure 3.3). These factors are elaborated below.

Increase in weather extremes / drought

Although the amount of solar radiation and wind will hardly change due to climate change, the risks of power supply disruptions will nevertheless become larger in the future. Dry periods with low river discharges will occur more often, and periods of drought or no wind due to areas of high pressure occur on a scale of a few thousand square kilometres (e.g. in regions the size of north-western Europe). This causes peaks and declines in renewable power generation and in electricity demand to enhance each other in neighbouring countries.

Interwovenness of the European network

The internationalisation of the power grid infrastructure, generation and market is an important development that affects the vulnerability of the power supply. The international interwovenness has the advantage of increasing the redundancy within the network (see Text box 3) and of reducing the risk of failure. A disadvantage would be that failure of the power grid in one of the connected countries may also cause problems in one or more of the other countries (Figure 3.3).

The international linking has the benefit that it increases the redundancy in the network (see textbox: international alliances). A drawback however is that a grid failure in one country could also cause problems in another. The likelihood that the power supply in north-western Europe or Europe as a whole will fail is very small, but cannot be ruled out. The grid managers already experienced this in 2006 ((ENTSOE 2014b). An overhead power line was taken out of commission just when there was a peak in (wind) power generation in Germany. The power overload and the complexity of the management of the European grid (by 42 different operators), led to a partial blackout of the European power grid.
More than 15 million people were without power for more than two hours. During this incident there was great concern that this could lead to a complete failure of the European grid. This would have involved a complex operation to restart the grid, something that may take several weeks.
In the evaluation, the TSOs pointed to the fact that the system is increasingly operating at maximum capacity owing to the ever growing international trade in power. Over the past 50 years, the system has been developed as a back-up in the event of a blackout in one country – which could then be compensated for by the power generated in other countries. Today, however, there is no longer a back-up system. There is an intensively used infrastructure, in which price fluctuations cause energy to be traded and transported between countries within the hour. This was never envisaged at the time the original system was designed.

The strong growth in the power exchange between countries means that it is necessary to see the issue of supply security in the context of north-western Europe as a whole. The governments of the North Sea countries have therefore asked the allied national transmission system operators to undertake a joint analysis and present their proposals. The initial results of this project were published at the end of 2014. Roughly 19 connections could result in an annual saving of 1 to 4.1 billion euros in addition to an investment of 17 to 22 billion (ENTSO-E 2014a).

Figure 3.4
International connections of the Dutch power grid, 2015

Source: Structuurvisie Infrastructuur en Ruimte (SVIR); TenneT

The Dutch power grid is closely connected with other north-western European countries. The 220,000 km long European grid (380/400 kV) connects 23 European countries or 450 million European citizens with one another. The 42 European Transmission System Operators (TSOs) involved work together through the European Network of Transmission System Operators for Electricity (ENTSO-E)[4].

3 Increase in international power grid alliances

In recent years, internationally operating transmission system operators (TSOs), such as TenneT, have entered into alliances with other national grids. The Netherlands has a 400 MW connection with Norway and a 1000 MW cable with the United Kingdom. In periods of energy surplus in one country and shortages in another, power can be transferred via the cables. This has a positive effect on electricity prices and leads to further integration of the European power market.

A particular goal of the connection with Norway is the optimum exchange of sustainable energy between the Netherlands (wind energy) and Norway (hydropower). If a surplus of sustainable power has been generation in the Netherlands, it can be transported to Norway. The water reservoirs in Norway can be used as 'natural storage', for generating electricity, for example to be used by the Netherland in times of no or too little wind.

[4] The ENTSO-E network was established and given legal mandates by the EU's Third Legislative Package for the Internal Energy Market in 2009, which aims to further liberalise the natural gas and power markets in the EU.

Change in energy mix

Another important development is the change in energy mix in Europe. The impact of weather and climate on energy supply will become greater in the future, due to a larger share of solar and wind energy, hydropower and biomass in the north-western European power supply (Figure 3.5). Disruptions in power supply, thus, become more likely (Figure 3.3).

One of the characteristics of wind and solar power generation is that the energy is generated in all available installations at the same time. Once the wind picks up, it often blows in most parts of the country, and often there is also a strong correlation with wind in neighbouring countries. This also applies to solar power generation, albeit to a lesser degree. The sun and wind are intermittent resources that, in contrast to power plants, cannot be 'turned on' in times of large demand (Verzijlbergh et al., 2014). In other words, the generated amount of wind energy varies, making its supply not fully reliable. In 2011, Dutch-German operator TenneT had to intervene and switch to power generation by other sources on a thousand occasions, compared to only twice in 2003. Market parties do have a responsibility, but reliability is a public matter.

In addition, weather extremes such as heatwaves and periods of no wind due to the atmospheric blocking may happen on a north-western European scale and can last a long time. Therefore, the fact that the Netherlands and its neighbouring countries are only able to *simultaneously* generate much or perhaps very little power from wind, needs to be taken into account. Whether the buffer capacity of hydropower and the connections with Scandinavian countries are sufficient to bridge prolonged periods of no wind, remains to be seen. The greatest concern is having a period of cloudy winter days with no wind, with limited power supply and a large demand, due to the large demand for natural gas for heating.

Increase in demand and the dependence on electricity
The demand for services and products that require large amounts of electricity is increasing; for example, in electric driving and the ICT sector. The cooling of buildings in summer also will require increasing amounts of electricity, particularly during heatwaves. Furthermore, electricity will increasingly replace other energy sources; for example, because cooking on gas is replaced by electric cooking. As the demand for and the dependence on electricity becomes larger, the impact of power scarcity and failure increase. (Figure 3.3). At the same time, there is also a reduction in demand due to the development of energy-efficient appliances. These things combined create a moderate increase in electricity demand (Hekkenberg and Verdonk, 2014). The impact of power failures on society is due to become larger, because of the lack of alternative energy sources in times of calamities (e.g. in houses that have no natural gas stoves).

Flexibility through storage and the development of a smart grid
The likelihood of scarcity or failure will decrease due to power storage options. In addition to such options, which cause an increase in power grid costs, there is also the possibility of reducing the demand for electricity in times of low power generation (Figure 3.3). Efficient and smart use of energy may be stimulated further by the introduction of the smart energy meter in combination with offering variable hour tariffs for small-scale energy users. A *smart* grid regulates the supply and demand to keep it balanced, in order to prevent both overloading and shortages. These grids reduce the likelihood of disruptions in power supply. The risk of cascade effects during disruptions to the ICT supply, however, is increasing. Various pilot projects have been set up within the European Union to test this concept, which is expected to be further developed over the coming years (Lund, 2014).

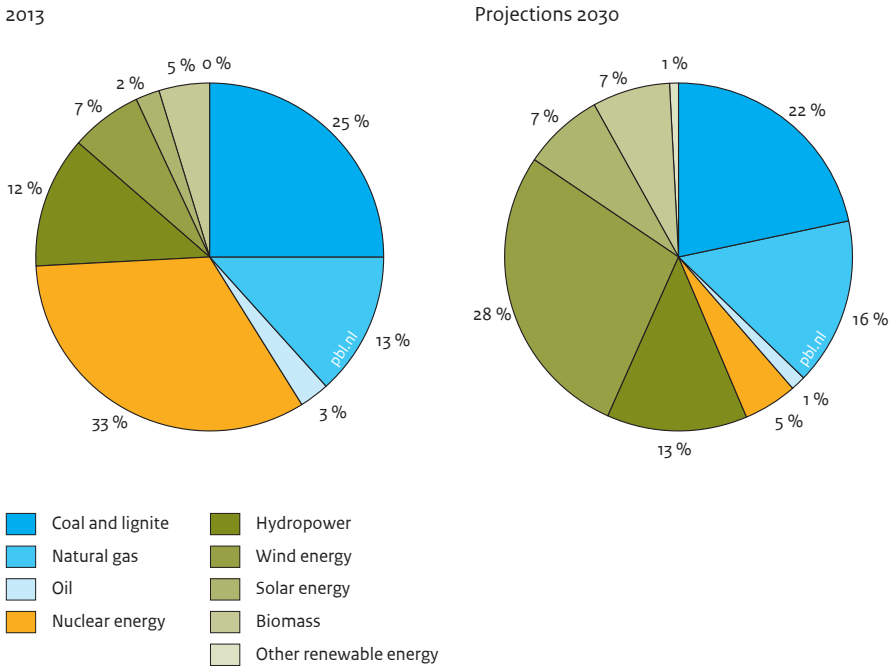
Decentralised generation

Heat and electricity are no longer generated only in large energy plants, but also on a smaller scale and distributed over a large area. As smaller shares of the production are affected, this reduces the risk of total failure but increases the risk of local failure due to weather extremes. However, the risk also increases because balancing the power grid is more difficult to manage and recovery times may be longer if failure does occur.

Adaptation options

Adaptation of the power supply to the consequences of climate change is a matter of some urgency. Not so much because of climate change itself, but because there are developments now taking place which can be exploited. The sector is working on an energy transition that, in the short term, will require major investments in the network and production units. Decisions in this context are now being taken and investments made. At such moments, measures can be introduced to anticipate changes in the climate. This energy transition with many investment moments could make the system generally more climate robust throughout Europe. It is important to keep abreast of developments in order to achieve this, taking into account the European climate risks and opportunities, as well as the dependence on international services and networks.
Options for the Dutch Government and energy sector include:

Figure 3.5
Sources of power generation in north-western Europe



Source: ECN/Eurelectric

The share of power generation sources that are vulnerable to weather extremes (e.g. biomass, hydropower, solar and wind energy) in north-western Europe will increase from a quarter in 2013 to more than half by 2030. The power generated from wind, in particular, will increase from 7% to 28%. North-western Europe refers to the Netherlands, the United Kingdom, Germany, Denmark, Norway, Belgium and France.

- Coordination of the strategy for energy with other north-western European countries; the government can then steer this towards maintaining a varied, resilient and climate-proof power generation system with sufficient buffer capacity.
- Technological advances could be promoted, such as ways to store electricity or introduce more flexibility into the system, so that supply and demand can be better matched. For example, by introducing smart meters, in combination with the possibility of variable hour tariffs for small-scale users.
- For investments, incentives may be included to test whether the robustness and diversity of the energy system would benefit from the investment, such as preconditions for storage and back-up capacity.
- For investments, minimum criteria could be drawn up on a European level, in order to minimise the possible effects of climate change; for instance, through normalisation or by adjusting the regulations for supervisors. This could be achieved by setting standards for the choice of location or the use of cooling water, and by limiting the risk of flooding in the construction of a power plant.
- Stress tests could be developed and conducted for climate-sensitivity of the north-western European energy mix, in order to spread the risks. Consider the risks of climate change and the dependence of international services and grids, specifically on the basis of pan-European risk assessments, and for north-western Europe in particular. An important stress test which could be regularly conducted together with north-western European partners is to examine various worst-case scenarios of long periods of no wind and a lack of cooling water occurring in combination with a huge demand for electricity across a large part of the north-western European region.
- A set of harmonised European standards could be developed, together with ways of providing exemptions for the use of cooling water, managing the risks of power plants flooding, and sparing ecologically vulnerable areas. Pan-European coordination could be strengthened, which could also help to enhance the climate resilience of the energy sector. In this way, the impact of incidents involving the power grid on people and the environment can be kept to a minimum.

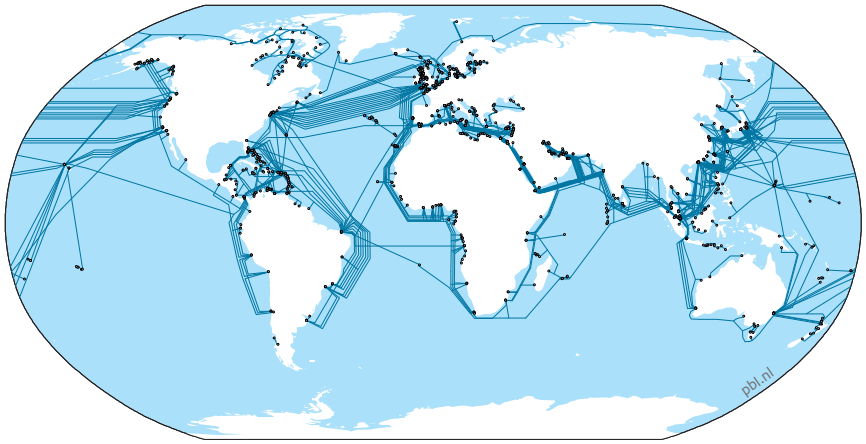
3.5 ICT

ICT, similar to energy, is a vital sector; the interruption of ICT services could lead to a disruption of society. The fact that energy, ICT and transport are interdependent means that there is a risk of cascade effects, such as failure in other vital infrastructures, including financial transactions and healthcare.
The ICT sector is highly internationally oriented. The ICT infrastructure is part of a hyper-connected global ICT infrastructure (Figure 3.6).The ICT facilities in the Netherlands are part of a global network and worldwide services; a patchwork of international infrastructure and globally operating private enterprises. The international data and telecommunications traffic is carried over international internet backbones made up of transatlantic submarine cables, satellite connections and high-speed fibre-optic cables on land that provide the data transport services. About 99% of the international telecommunications traffic takes place via these submarine cables. Internet exchanges (networks of many data centres) are connected to these international internet backbone networks, where data are stored and from where application services, Cloud and other internet-related services are offered internationally. Problems in exchanges, data centres and operators can affect businesses worldwide. But the underlying services provided by third parties that are often overlooked – which provide the 'lubrication' for the visible ICT infrastructure system – are also often provided by parties outside the Netherlands. This, for example, may concern the management of addressing and domain names. Similarly, an error in the international routing tables or at the worldwide operating Internet Service Providers can lead to an interruption of the service (Luijff and Oort, 2014).

This international character of the sector causes the ICT infrastructure and thus the ICT services in the Netherlands to be vulnerable to climate change (and its consequences), worldwide, including weather extremes, such as storms, heatwaves and flooding (Carter et al., 2009). This sector has solid connections to other European countries (Figure 2.2), but a proper functioning of many ICT services also requires many connections with parts of the world that are more vulnerable to the impact of climate change or that have less adaptive capacity. The impact of a disrupted ICT supply in the Netherlands would be large; the likelihood of this occurring due to events abroad that are caused by climate change is very small, but cannot be ruled out (Figure 3.1).

A study on 18 European countries showed that, in 2011, 12% of ICT failures that lasted longer than 24 hours (up to even a few weeks) were due to natural causes, such as storms, flooding and heavy snowfall (ENISA, 2012). In addition to direct failure of ICT due to weather-related disasters, an even greater share was the result of power failures, which in turn were also partly caused by weather-related disasters (ENISA, 2012). The failure of an international submarine cable due to a storm can lead to disruption of communications affecting large areas, such as the Far East, Australia or several countries in Africa at the same time. Repair can sometimes take weeks and in many cases there is insufficient back-up capacity via other cables and satellites. Data centres and other infrastructure can also fail due to extreme weather, such as floods, storms, lightning strikes and any ensuing fires. Data centres generate a large amount of heat and in many regions they have to be cooled. In heatwaves, data centres can fail due to overheating if the cooling is interrupted because the demand for power is too high (see Text box 4). Data centres use cooling water in some regions where in periods of drought there may be a water shortage. In the event of an outage of part of the network or hubs (e.g. data centres), the data traffic can be diverted or supported with back-up services. Diversion often results in congestion which, in some cases, can lead to a serious reduction in the quality of the service. In some cases, data may be lost if the back-up is at the same location.

Figure 3.6
International submarine communications cables, 2015



Source: TeleGeography (www.submarinecablemap.com, 2 februari 2015)

Many submarine cables connect the Netherlands internationally. Submarine cables are vulnerable to climate change; for example, to landslides caused by heavy storms.

4 From the media

The internet down due to extreme heat

'Australia is suffering a heatwave that has affected the internet. An internet service provider in Perth had to completely shut down its servers', the BBC reported [in January 2015] on their website. This concerned iiNet, Australia's second largest ISP. With outside temperatures of over 44 °C the servers cooling system was at risk, the provider reported. Shutting them down was a 'precautionary measure'. The data centre's shutdown resulted in black screens. Large numbers of users in and around Perth had no internet connection for over 6 hours. Normally, iiNet is able to continue under extreme outside temperatures, but in this case the provider faced a double failure. 'The main air conditioning unit stopped working and its back-up system had some defects. In such a case, it is better to be safe and shut down the system', said iiNet's chief technology officer Mark Dioguardi.'

See http://www.automatiseringgids.nl/nieuws/2015/02/internet-plat-door-extreme-hitte

The international character of the ICT sector means that the Dutch dependence on ICT could be affected by climate change anywhere in the world. The sector has connections in parts of the world that are more vulnerable to the effects of climate change or that have less adaptive capacity to be able to cope with such situations than we are accustomed to in the Netherlands. Disruption of the ICT system would have a major impact on the Dutch population, economy and society (system failure), and although it is very unlikely that this will occur due to climate change (or its consequences) abroad, it is not impossible. Floods in India, the United States or the United Kingdom could have an impact on ICT services in the Netherlands. A third of Dutch businesses use international outsourcing (e.g. to India) for services such as financial accounting and ICT. Dutch interests abroad could also be damaged by the failure of ICT elsewhere when this disrupts, for example, the production or transport of goods and raw materials.

These risks are reinforced by the greater probability of weather extremes worldwide together with trends in both the ICT sector and society, such as a growing dependence on vital infrastructures and ICT and the explosive growth in data traffic in relation to network capacity. Another trend that increases the vulnerability of the Netherlands to climate change elsewhere is one where increasing numbers of offshore services are being used and data are being stored 'in the cloud'. Data and applications that are crucial for the Netherlands are increasingly located outside the country.

The ICT business environment is an opportunity for the Netherlands

The Netherlands has a relatively attractive business climate for ICT and other businesses, even when the climate effects worldwide become more evident. The climate is and will remain relatively mild and water safety is relatively good due to the Dutch investments in coastal and flood defences. Therefore, in addition to being in a central location in Europe and having a dense ICT network, the Netherlands also has considerable ICT security with little cooling necessary in data centres. The power supply is also very secure in comparison with some other countries; owing to its coastal location there is sufficient cooling water and most of the grid network has been laid underground and is therefore less susceptible to extreme weather conditions.
Besides the Port of Rotterdam and Schiphol Airport, there is a third mainport of major economic importance, namely the Dutch internet exchanges, hosting companies and data centres, referred to as 'the digital port'. In 2013, the data traffic passing through the Amsterdam Internet Exchange (AMS-IX) grew by 30%. By comparison, transhipment activities in the Port of Rotterdam grew by 1% and growth in passenger numbers at Schiphol was 4.6%.
This staggering growth in data traffic means that, during peak periods, 3.2 terabytes of data per second are being exchanged on the Amsterdam 'internet hub', equalling more than 3000 gigabytes (Deloitte, 2014).

Adaptation options

The ICT sector is seeing explosive growth, which sometimes requires major investments. Just as with the energy sector, the need to take measures is therefore urgent; not so much because of climate change, but rather because investments for the long term will be required in the short term – particularly in the network and in data centres. Long-term investments in the international network and in data centres can be used to anticipate the consequences of climate change.

This sector is highly adaptive due to its considerable dynamics. However, there is little awareness of the risks of climate change. Regulation to ensure ICT services will be maintained does not yet apply to data centres (Runhaar et al., 2014). National government is responsible for the functioning of vital infrastructure. This does not mean that it is also responsible for the actual implementation of adaptation measures. On the contrary, there are other parties far better equipped to do so.
Climate adaptation in the ICT sector will require an international approach (risks and opportunities) by both government and the commercial sector. The main starting points are:

- to identify the risks of climate change for the entire international chain of ICT services and facilities for Dutch users (public and private sectors and the general public).
- to provide insight into the role of ICT in vital sectors, in view of the interrelatedness of energy, ICT and transport, and the financial, food and health sectors. Such insight can be used to estimate the likelihood of cascade effect in case of failure. It would be important to carry out regular international stress testing; specifically consider the risks of climate change based on EU risk assessments. What would be the effect for the Netherlands of, for example, flooding of the data centres in the catchment area of the Rhine river; or what would be the impact of a large-scale European heat-wave on the electricity demand of data centres, businesses and households? This can be done within the existing European structures for the ICT sector that, for example, are already looking at cybercrime risks.
- to enter into international agreements on the allocation of responsibility along the entire chain, at least within the EU. National government sets standards and

preconditions by way of legislation and regulation. From the ICT sector's perspective, this will function well, provided the continuity plans are also effective in practice and ICT regulation also includes data (Runhaar et al., 2014).

3.6 Water safety and security of supply

Water arrives from outside the Netherlands entering the Dutch delta from the Rhine, Meuse, Ems and Scheldt. What happens to the water in Germany and Belgium has an impact on the water flowing in these rivers. The water management in Germany and Belgium therefore is important to the Netherlands. This applies to both water safety and the freshwater supply.

Without measures, the likelihood of the rivers flooding increases due to climate change. The risk of floods not just in the Netherlands but also in neighbouring countries, therefore, needs to be monitored. A dyke failure in Germany or Belgium, for example, could cause flooding in the Netherlands. If a dyke in Germany close to the Dutch border in the Rhine basin were to break, the east of the Netherlands as far as Zwolle could end up under water (Ten Brinke et al., 2010). This could result in many deaths and damage amounting to tens of billions of euros.

The parties concerned in the Netherlands and Germany have recognised the risk, and adaptation options are being discussed. The European Flood Directive requires that countries in river basin areas work together and make coordinated agreements about managing extremely high river discharges.

Because of climate trends, changing patterns of precipitation and higher temperatures, there is also an increased chance of reduced river discharges. This could pose a threat to the freshwater supply and, at extremely low water levels, inland shipping could also experience problems. International coordination of water use and the minimum discharge rate of the river Rhine is therefore all the more important. The Dutch and Belgian Governments have made agreements on the water discharge of the river Meuse in drier years. No hard and fast agreements have been made with neighbouring countries along the Rhine (and the Waal). Target values have been set for a minimum depth, but in 2003, for example, Germany and the Netherlands were unable to meet this standard.

Increased air temperatures also lead to higher water temperatures. A great deal of research has been done on this within the framework of the International Commission for the Protection of the Rhine (ICPR)(ICBR, 2015). Simulations for the near future show that the number of days with water temperatures above 25 °C will increase, relative to the baseline situation; with low river discharges this could even double. Conversely, years in which the water temperature does not exceed 25 °C will become a rarity in the distant future. In addition to the maximum temperature, the duration of the hot period will also impact on the survival of water organisms. In the summer of 2003, the temperature in the main stream of the Rhine, for example, was higher than 25 °C for a period of 41 days, as a result of which shellfish and algae perished in large numbers. In 2006, the heat lasted only 31 days and then there was no massive mortality (ICBR, 2015).

Adaptation options

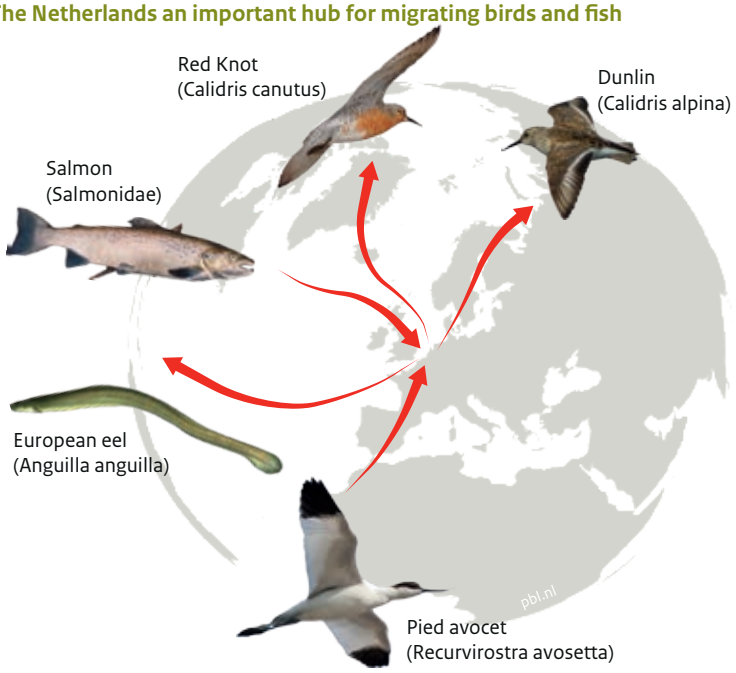
- Cross-border risks must be taken into account in the monitoring, implementation and evaluation of water safety measures and risk assessments in the context of the European Flood Directive, as included in the Delta Programme (Dutch Government programme on flood protection and freshwater supply).
- International agreements on water usage and the minimum discharge rate of the Rhine river will be necessary for the water supplies drawn from the Rhine.

3.7 Biodiversity

The effects of climate change elsewhere can affect nature and nature policy in the Netherlands. Climate zones are shifting and in Europe, too, there has been a clearly noticeable shift in plant and animal species; species preferring the cold are shifting northwards, while new species from the south are spreading. The distribution patterns of various species in the sea are changing, including species that are fished. When western Africa becomes warmer and drier, the conditions change along the route of 'Dutch' migrating birds, for example. Conditions along the route of migrating fish can also change, for example, due to a much higher water temperature and, as a result, they may well change their migration patterns. The composition of flora and fauna communities will very likely change in the second half of this century as a result. Warming and acidification of the seawater is continuing, adding to the pressure on corals and organisms with calcium carbonate exoskeletons (IPCC, 2014).

The worldwide climate change affects global diversity and thus the targets and measures to which the Netherlands has subscribed for its protection; these are laid down in the Convention on Biological Diversity (CBD) and elsewhere (CBD, 2010). Over the next few decades, climate change will play an increasingly important part in the loss of nature. Combatting climate change is therefore necessary also to achieve the long-term goals agreed upon in the CBD and prevent loss of biodiversity (Kok et al., 2014).

Figure 3.7
The Netherlands an important hub for migrating birds and fish



Source: PBL; Imares

With the Wadden Sea, Ems delta and south-west (Rhine) delta, the Netherlands is an important hub on the migration routes of many aquatic birds and fish. More than 10% of the European dunes, tidal waters and vegetated mud flat habitats are situated in the Netherlands.

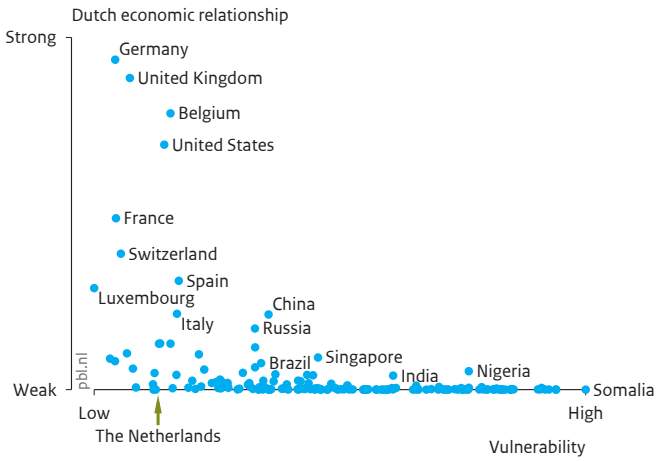
Adaption options:

- Change moments could be taken advantage of; particularly with neighbouring countries and the rest of the European Union, such as drought measures and flood defences in the rivers regions. Such measures can also help to strengthen or restore nature in and around rivers. This would need to happen in the next few years, because decisions in these programmes can lead to irreversible long-term developments.
- It would be good to use the links between nature, the environment and other sectors, also worldwide. There is huge potential in other sectors for 'nature-based solutions'. Mangrove forests, for example, could provide coastal protection, and planted greenery in cities could help to alleviate heat stress.
- The climate resilience of Europe's nature could be enhanced by developing European climate corridors, thus incorporating a coherent Natura 2000 network. An important element in this is how the concept of 'green infrastructure' will be developed, also in relation to connecting fragmented areas of nature.
- Climate effects could be included as an integral part of global nature policy on the protection of biodiversity, including the effects of climate change in all areas along the migration routes of birds and fish.

3.8 Economic ties

The Netherlands has an open, export-oriented economy as well as trade relations with many countries. It is the world's seventh largest importer and fifth exporter (BZ, 2013). On a global scale, the Netherlands is the second largest exporter of agricultural and food products. The Netherlands is favourably situated as a hub and transit country for trade flows. Much of this trade flows via the Port of Rotterdam and Amsterdam Schiphol Airport. More than in other EU countries, the Dutch economy is dependent on the export and transit of goods. Of all EU countries, in 2012 the Netherlands was the fourth largest foreign investor with more than 4% of all investments, worldwide (CBS, 2013c).
The Dutch economy, therefore, may run certain risks, due to a combination of climate change and socio-economic and political developments elsewhere in the world. These risks could affect Dutch investments and cause production losses to Dutch companies abroad; for instance, following a flooding incident. But there are also risks to businesses and consumers in the Netherlands, caused by disruptions of the supply chains for raw materials, semi-finished products, goods and services; for example, due to production stoppages or harvest failures abroad.

Figure 3.8
Vulnerability and economic relations, 2012



Source: UN Comtrade; OECD; ND-GAIN

The Netherlands has its strongest import ties with its neighbouring countries, other EU countries and the United States. These countries' vulnerability to climate change is relatively small. In the future, the share of the EU in the Netherlands' trade relations will decline, mostly in favour of the BRIC countries, as well as the rest of the world.

There are also risks related to the disruption of services outsourced abroad, such as ICT, due to a power failure elsewhere. A flood in Thailand in 2011, for example, led to a number of factory stoppages that interrupted the supply of products to businesses and consumers, also in the Netherlands. Transport may also be effected, such as by flooded harbours or railway tracks.
Economic damage may also be incurred due to ports elsewhere in the world being more affected by storms and the damage that these cause. The rise in sea level may mean that harbours are less accessible (Becker et al., 2013). In the event of prolonged disruption of the transport facilities to and from these ports, shortages or even a build up of large stockpiles could occur in the Dutch ports.
The goods arriving via the Port of Rotterdam and Amsterdam Airport Schiphol find their way to the hinterland, including Germany. A large part is transported by inland shipping. Low water levels in Germany could mean that inland shipping customers could suffer damage because less freight can be carried per trip. The reduced water level would be mainly due to insufficient precipitation in the upper Rhine regions. There is also a greater chance of collisions occurring when water levels are low. Delays to inland shipping caused by collisions could soon lead to difficulties for those ordering the shipped products. The damage would be passed on to consumers (Maas et al., 2014).

The impact of flooding or other climatic effects can be far-reaching, because manufacturing processes in recent decades have become more decentralised. Semi-finished products make up an ever increasing share of world trade. The various parts of end products are made in various places in the world, often in countries where labour is cheap. The raw materials and semi-finished products are transported all over the world. The raw materials for food, in particular, are imported from many different countries before being processed to become the products we put on our table.

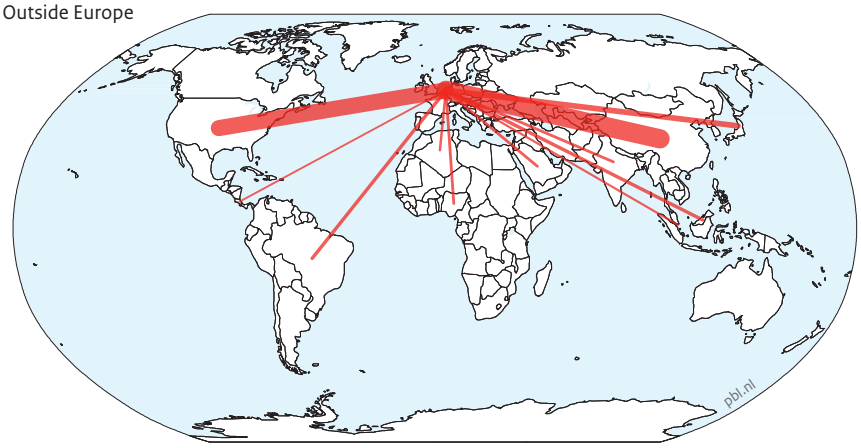
Weather extremes and the natural disasters they cause are already occurring frequently (Figures 1.2 and 2.3). An increase in the occurrence of weather extremes and rising sea levels will increase the economic risks for the Netherlands.

For example, in the future, the availability of water may become a problem more often, due to more and prolonged drought At the same time, because of socio-economic developments, the demand for water, particularly in the developing countries, is rapidly increasing. The population is growing and becoming more prosperous. More and more water is needed for food, energy and industry. The growing scale of water shortages due to an increased demand and declining availability will lead to higher prices for water. As a result of such disasters, other countries also could move towards protectionism, leading to price hikes or an interruption in the supply to the Netherlands.

Figure 3.9
Largest import flows to the Netherlands, 2012

Within Europe

Outside Europe



Import flow (in billion USD)

1
10
25
50

Source: UN Comtrade

The Netherlands has many import trade relations. Expressed in monetary terms, in 2012 the Netherlands imported most from Germany, Belgium, China, the United States and the United Kingdom.

Vulnerability of imports due to climate effects abroad is low

Most of Dutch trade, investments and outsourcing takes place within Europe – in countries that are not heavily affected by climate change (Figure 3.8). A large part of the Netherlands' imports comes from just a few countries (Figure 3.9). The countries from which the Netherlands imports the most, in monetary terms, are situated in the least vulnerable areas. These are mainly European countries, and Germany in particular. China, Russia and Japan are among the more vulnerable countries from which the Netherlands also imports large amounts. In the future, the Netherlands' share of trade with other European countries is expected to be reduced in favour of trade with the so-called BRIC countries (Brazil, Russia, India and China). Climate effects occurring in other European countries are unlikely to pose a major risk to the Netherlands. Although flooding or drought may cause a temporary interruption in the availability of raw materials and products, the risks are spread rather widely and Dutch companies are generally able to compensate for these shortages (see also Text box 5). On a European scale, the production efficiency in those cases will be low. The risks related to Dutch trade relations with countries

outside Europe mostly concern the supply of raw materials, products and services used in the production process, and some consumer goods produced only in a few locations. Such interruptions particularly lead to price increases, but may also cause inefficiencies within the production processes.

Disruption of transport to and from the Netherlands
The Port of Rotterdam and Amsterdam Airport Schiphol are important international transport hubs for freight. Goods and raw materials are brought in here from all four corners of the world. The transport to the ports could be disrupted by the increasing incidence of extreme weather conditions *en route* (e.g. storms) as a result of which diversions will be necessary more often, involving additional costs and delays.

Agri-food strongly internationally oriented

On a global scale, the Netherlands is the second largest exporter of agri-food products, and obtains its raw materials for this from South America and western Africa among other places.
It is important that continuity in the supply and price level of raw materials, such as grain, soya, cacao, coffee and palm oil, is maintained. These agricultural raw materials are climate sensitive. The more frequent extreme weather conditions in other parts of the world will cause the price of agricultural products to fluctuate more widely. The availability of these raw materials will also be more often subject to temporary shortages. This will impact on food prices and therefore also affect consumers. Fluctuating yields will more often be reflected in higher prices on the shelves of Dutch supermarkets, and if the shortages lead to protectionism in the producing countries, this could further drive up prices.
The agri-food sector invests a great deal in innovation and expertise. A great many of the globally operating food and drink companies have R&D branches in the Netherlands. The research institutes for the agri-food sector are showing considerable interest in technology; for example, for the collection and analysis of satellite data and the development of early warning systems. In addition, the Netherlands is a frontrunner in the area of agriculture risk management in which analyses of past risks (including weather-related risks) are extrapolated to the future. This expertise and technology could also be supplied abroad.

Risks because of investments abroad and outsourcing

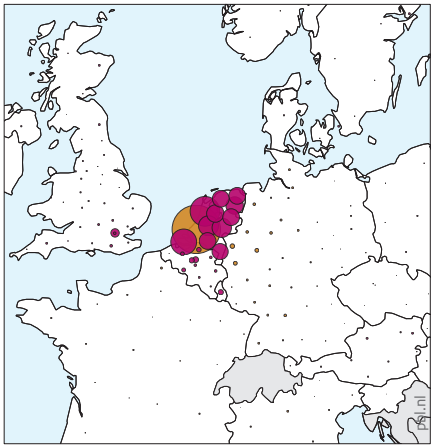
Of all the EU countries, in 2012 the Netherlands was the fourth largest foreign investor, with more than 4% of all investments worldwide (CBS, 2013c). Dutch investors, investing abroad could be exposed to greater risks as the frequency and intensity of weather extremes increases. Production may be halted due to flooding, for example, but also because energy supply or ICT services fail due to drought and a lack of cooling water. These could affect investments by large multinational businesses, such as Rabobank, Unilever or Heineken, as well as more public investments, such as by the Dutch pension funds.
Depending on the vulnerability to climate change and the options countries have to reduce that vulnerability, the increased exposure to weather extremes and other more gradual climate changes could impact on Dutch investments abroad. It is believed that climate change represents a risk increase of 10% in a typical investment portfolio (Mercer, 2011). The degree to which the risk will increase will depend on the risk diversification of the investors concerned. Most investors are familiar with risk assessments and will therefore also include and cover these climate risks in their analyses. Most is invested in countries with a low level of vulnerability.

Climate change and particularly the uncertainties surrounding its extent, have been recognised as a major source of risk to investors over the next 20 years (Mercer, 2011; Munich RE, 2013; S&P, 2014). It has been estimated that roughly two-thirds of current total losses in the United States were caused by weather extremes. This share is likely to increase due to climate change (Munich RE, 2013). According to the credit rating agency Standard & Poor's (S&P), climate change represents one of the greatest threats to the economy and creditworthiness of vulnerable countries over the next few years.
Businesses and consumers are at risk, not only due to climate change (and its effects) elsewhere because products and raw materials come from abroad, but also because some operational activities have been relocated abroad (international outsourcing).
Between 2009 and 2011, almost 10% of companies with a workforce of more than 100 people used international outsourcing. Developments in telecommunications and information technology meant that it was no longer necessary for service providers to be in the immediate vicinity of their customers. This has led to growth in the international trade in services. This applies, for example, to IT help desks and call centres in eastern Europe and India, which provide services to companies in high-income countries, such as the Netherlands. After the core activities, it was the ICT and financial accounting roles (both amounting to 30% of relocated activities) that were most often outsourced abroad (CBS, 2013d).
Nevertheless, vicinity still plays an important role in the choice of location. Those Dutch companies that relocated business activities abroad mainly chose European locations (67%) rather than far-away destinations such as China and India.

Figure 3.10

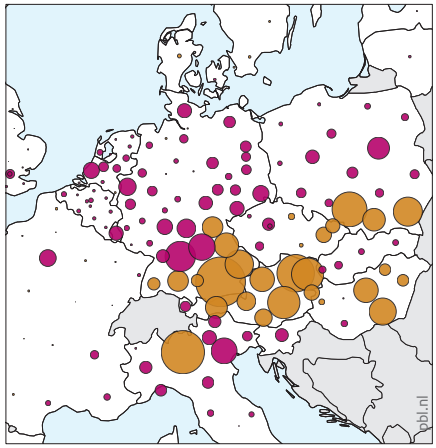
Change in production level as a result of flooding (model simulations)

Area outside the dykes around the Port of Rotterdam



Net impact on production (*) in million euros per region

The Danube



Net impact on production (*) in million euros per region

Source: E.E. Koks & M. Thissen 2014

(*) Direct damage and restoration costs are not included in this figure

Model simulations show that flooding would also have an impact on companies in unaffected regions. This figure only shows the changes in production levels. The actual economic impact would also include direct damage, restoration costs and efficiency losses. The total economic impact from flooding is always negative. (See also http://themasites.pbl.nl/eu-trade/ for trade relations between regions.)

5 Flooding impacts on production exceed regional borders

Flooding events in one European region may have substantial consequences for businesses elsewhere in Europe. This is shown in model simulations of production following flooding events, used by PBL together with the VU University Amsterdam to study the pattern of the consequences that exceed the affected region (Koks and Thissen, 2014). In simulations of flooding, the companies in the affected areas suffer losses due to disruptions in production. Customers that normally buy these products from them (within the region or elsewhere) may also experience a loss in their production, if they are unable to buy these products elsewhere on time or only at higher costs. Disruptions to production in the flooded areas can be compensated for, in part, by other companies in non-flooded areas or in other regions. Production in those places may increase, as companies step up their output to meet the rise in demand for restoration work, such as in the construction sector. In order to determine the actual economic impact within a region, also the direct damage, restoration costs and the incurred efficiency losses must be taken into account. The total economic impact from flooding is always negative.

Continued on page 46

To demonstrate regional interdependence, various flooding events were simulated, including flooding of the area outside the dykes at the Port of Rotterdam and a more large-scale flooding of various regions along the Danube (Figure 3.10). In the Rotterdam flooding, production losses experienced in the region of South Holland had a negative result. Companies in neighbouring, unaffected regions would be able to compensate for part of the production loss and they may also contribute to restoration work. Taking on compensation production always involves inefficiency (costs). Moreover, the additional production for restoration work must be funded by society. In the simulation of a large-scale flooding along the Danube, the impact was very comparable. As multiple areas are affected simultaneously, the loss in production capacity can only be partly taken over by neighbouring regions – a much larger share ends up in regions further away.

These model results illustrate how a flooding event in one region may have consequences for companies in other, unaffected regions. This emphasises the importance of collaborations between regions and countries in developing effective adaptation strategies.

Most economic ties not very vulnerable to the effects of climate change

The economic risks for Dutch investments abroad, disruptions to supply chains and price fluctuations of goods and services for companies and private consumers may have very serious effects locally, but will not lead to system failures or to disruptions of society or the macro-economy of the Netherlands. For businesses and individuals, however, the effects may well be severe. Because these events can occur often, when added together they could cause a great deal of damage to the Netherlands on an annual basis, and thus, constitute a major risk (Figure 3.1).
Most of the Dutch trade, investments and outsourcing takes place within Europe; thus involving countries whose vulnerability to the effects of climate change is relatively limited (Figure 2.6).

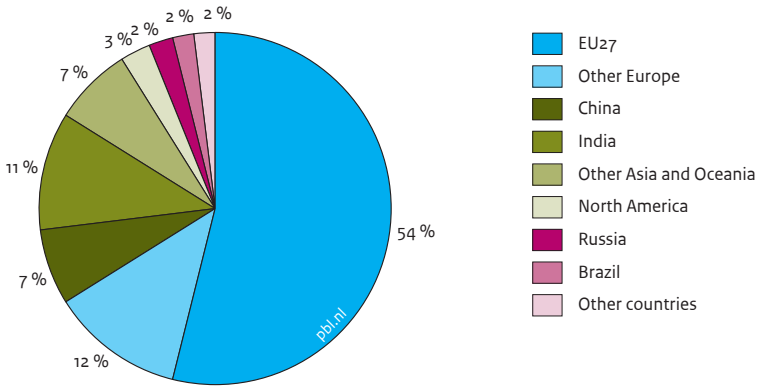
Economic opportunities for Dutch trade and industry

Climate change is not just a risk to economic development. There are also opportunities for the Netherlands and Dutch businesses. Global warming and the melting of the Arctic ice means that shipping routes via the Arctic will become navigable. This could create an opportunity for Dutch ports, as navigation routes to the Far East via the Arctic would be considerably shorter. It is as yet unknown what this would mean in terms of competitiveness relative to other ports. Other opportunities include offering consulting engineering and other expertise to help protect low-lying urbanised deltas against flooding, and to improve the yields, harvest security and weather resilience of crops in drought-prone regions. Increasing the resilience of other countries in the area of water safety, water supply, agriculture and infrastructure would not only earn money for the Netherlands but would also reduce the vulnerability of Dutch businesses that are dependent on these countries for their raw materials or sales markets.
In the future, the Netherlands will still offer a relatively attractive business climate for foreign companies, such as in the ICT sector. The climate in this country is relatively mild, it is centrally located and the water safety in the Netherlands is good due to the Dutch investments in coastal protection and flood defences, and there is a relatively high degree of energy and ICT security (cool data centres, redundancy in the network).
The top sectors policy that is being pursued provides a vital framework for the development of new technology and expertise in the areas of water management, integrated urban planning and development, and agriculture, thereby creating opportunities for the Dutch commercial sector as a result of climate change.

Adaptation options

- Companies would do well to take a close look at their entire supply chain, pinpointing where it is vulnerable to climate change (and its consequences). On the basis of this an estimate can be made of the risks associated with the supply security of raw materials, the sales markets for products, as well as the dependence on outsourcing and investments in general. In this way, the risk management can be strengthened and where necessary diversity in sourcing countries can be widened.
- It would be important to specifically pinpoint the risks and opportunities of climate change elsewhere to the economic security of the Netherlands. In order to spot unfavourable developments or indeed opportunities in time, it will be necessary to carry out regular reassessments of the climate risks. A concerted effort, with the public and private sectors working together, will be vital in order to arrive at a common view and decide on how both parties can best operate in this context. This could

Figure 3.11
Location of international outsourcing, 2009 – 2011



Source: CBS, 2013

Most of the outsourced services for Dutch companies are conducted within Europe. Some are outsourced to more vulnerable countries, such as ICT services to India.

include regularly putting the risks and opportunities of climate change on the agenda of the economic security consultative group of seven ministries (Economic Affairs, Security and Justice, General Affairs, Foreign Affairs, Finance, Defence, Infrastructure and the Environment), the security services and the Confederation of Netherlands Industry and Employers (VNO/NCW).

- Take advantage of opportunities, as the Dutch agricultural sector is doing; for example, with the 'salt potato' crops which are currently successfully grown on the island of Texel. Salinisation of low-lying, subsiding and urbanising deltas is also an interesting subject, offering additional opportunities for the Dutch agriculture and food sectors.
- Keep the knowledge infrastructure up to date. Knowledge is also a premium export product, such as that on risk management in agriculture (in relation to weather and climate risks), including insurance against harvest losses.

3.9 Foreign policy

The effects of climate change on international stability

Simmering conflicts, such as those surrounding the availability of agricultural land and water, could flare up as a result of climate change. The ice is melting in the Arctic region, which means the Arctic Sea more often is ice free for part of the year. This will not only provide a new navigation route for shipping and thus an opportunity for the Port of Rotterdam and other types of opportunities because natural resources can be extracted more easily, but it will also bring risks because several countries, including NATO partners, will lay claim to these raw material reserves. The chance of a conflict about the Arctic is estimated to be very small, although its impact would be enormous should it occur.

Harvest failures as a result of drought, for example, could lead to increased tensions and high food prices worldwide (see Text box 6: Drought, PLIS 2011). Poor population groups in developing countries that import food will suffer the most, as a result. This may also lead to international safety risks.

Although tensions around the world could escalate and the economic vitality of regions could be affected by climate change, it is unclear whether climate change will lead to increased migration to the Netherlands. There have been no indications of such, so far. It is more likely that climate-related migration will lead to a growing demand for relief in other regions and that the possible increase in conflicts and natural disasters will lead to an increased demand for humanitarian aid. It is also expected that the development cooperation partner countries and trade partners will be affected by more regional migration. Although many international organisations make a link between climate change and the likelihood of conflicts and future security risks for countries, many scientists consider this link to be still insufficiently demonstrated. Owing to the expected increase in the number of natural disasters, emergency aid will more often be provided by both the Dutch Government and the Dutch society in the form of donations, goods and expertise.

Focus development cooperation on areas relevant for climate adaptation

Development cooperation and climate change are closely interrelated. The partner countries of the Netherlands are vulnerable to climate change and not well-prepared to deal with its consequences (Figure 2.6). In 2012, the Netherlands spent USD 5.5 billion in total on Official Development Assistance (ODA) (OECD DAC, 2013).This funding will be less effective in alleviating poverty and supporting development when the recipient countries are particularly vulnerable to climate change. The growing demand for emergency aid will place a greater burden on lean development budgets, and if this situation remains unchanged, there will be less left over for sustained long-term development.

Climate change is already one of the themes on the policy agenda for development cooperation. Although climate change is not specifically referred to as a key area, it is clearly part of the Dutch policy. This particularly applies in relation to the key areas of 'water' and 'food'; for example, through its 'climate smart agriculture' action plan.

The Dutch development cooperation policy devotes a reasonable amount of attention to the need to integrate adaptation policy into activities that will increase resilience to be able to cope with the effects of climate change in its partner countries (Schaik et al., 2015). But there is still more that could to be done; the goals of development policy and climate change need to be coherent and consistent (AIV, 2013).

Strong demand for Dutch expertise in adaptation challenges

In view of the expected increase in weather extremes, the deltas, river regions and areas susceptible to drought, worldwide, will become all the more vulnerable. Deltas and river catchment areas may become flooded more often and dry areas could be affected by even longer periods of drought. This could threaten the supply of raw materials, goods, and trade flows, leading to price fluctuations, with flooding posing a threat to the local population (Figure 3.13).

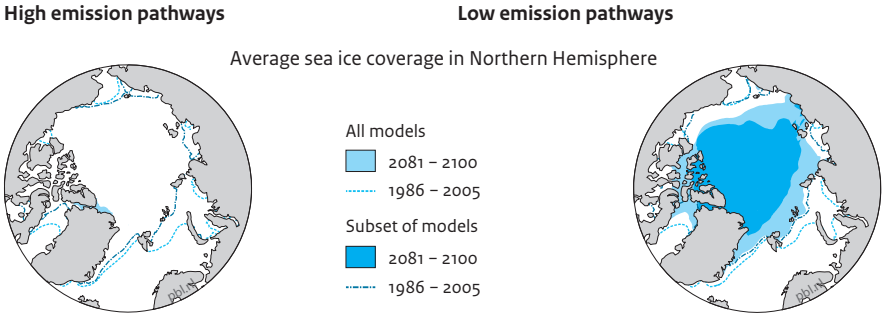
By 2050, according to the latest calculations, there will be 1.3 billion people living in flood-prone areas around the world. This is about 15% of the global population. The impact of flooding by rivers or the sea will increase even further, due to the growth in urban areas. This applies particularly to Asia; hundreds of billions of US dollars in infrastructure, industry, commercial and private properties and millions of people will be at risk of possible flooding. The changing climate will lead to an increase in the global demand for knowledge, expertise, products and innovations in the area of climate adaptation, such as water management, food supply and urban planning and development. These are among the strengths of Dutch research institutes and the private sector, and also represented in the top sector policy of the Dutch Government. Dutch companies are already often approached to bring their expertise to adaptation challenges in various parts of the world; in the future, the number of projects that they are awarded could well increase.

This offers opportunities for the Dutch Government to link adaptation to other objectives, such as integral solutions for urban development and water issues. The Dutch strategic programme 'Room for the River' is well-known and praised, internationally. Another similar icon is the *Benthemplein,* the large-scale 'water square' in Rotterdam. Such integration of flood risks into the design of urban areas will reduce the risk of flooding, while also enhancing the quality of the human environment. The costs of effective flood-protection measures need not be high. An interesting concept that enables such integration is that of 'smart cities', or in this case 'smart water'. Smart water includes both a technical and a spatial approach and also takes social issues into account, such as equal opportunities and risks for everyone. The various current urban networks, such as 'connecting delta cities', are important platforms for gaining insight into the societal challenges, and for sharing knowledge and economic, spatial and social innovations (PBL, 2014a).

The large Dutch engineering firms and urban developers are attracting international attention. The Delta Programme 2015 explicitly mentions connecting water and spatial planning. Certain iconic projects related to the Delta Programme may serve as a catalyst, to enhance innovation in the Netherlands and contribute to improving our international competitive position. Dutch companies are already asked to use their expertise in adaptation issues around the world; in the future, these types of assignments may increase further.

The contribution made by companies and research institutes to integral solutions for water safety issues and spatial development can help to reduce the risks to the Netherlands and, thus, coincide with the priorities of the Dutch Government. In view of the expected increase in the frequency or intensity of weather extremes, an international approach to adaptation and reducing the vulnerability of deltas, river regions and drought areas could help to reduce the risks to the Netherlands (interruption in the supply of raw materials, goods and trade flows; limiting price fluctuations and personal losses due to flooding). With an approach in the context of the coming climate treaty and the UNISDR (appointing a disaster reduction team, contributing to knowledge acquisition for global adaptation strategies, bilateral support for delta planning projects) and by taking part in

Figure 3.12
Changes in climate system under two scenarios



Source: IPCC WGI 2013

In the future, the Arctic Sea more often will be ice free during part of the year. This creates new shipping routes and access to natural resources.

6 Drought, a causal factor in high food prices and tensions

Food shortages and high food prices can be the cause of political and social tensions. One of the possible causes is climate change. Severe drought in both the United States and Australia, the two largest producers of grain, led to poor harvests. Prices were pushed up, not only by these bad harvests, but also by a larger demand for food (particularly in Asia), strategic food stocks that were smaller than before, a higher oil price, a greater demand for biofuel, speculation on the futures market, and agricultural land speculation by speculators. The grain price nearly doubled between 2005 and 2008 (OECD, 2008). This strong increase led to a food crisis.

This price rise led to higher food prices and helped to drive up inflation in the developed countries. Because households in developed countries do not spend a very large share of their income on food, a price rise in these countries can be easily absorbed. The consequences of high grain prices and rising food prices affected mainly the world's poorest – mostly those living in cities in developing countries. These people were forced to spend a larger share of their already meagre income on food (OECD, 2008). The high price of food led to political unrest in a number of countries – unrest that had already been simmering in the background. In this way, the drought and ensuing food crisis for many people was the touch paper that lit the powder keg that was already waiting to explode in northern Africa and the Middle East.

specialist networks, such as the Delta Alliance and Connecting Delta Cities, the Netherlands can contribute to raising awareness and increasing understanding of flood vulnerability, so this vulnerability can be reduced. Dutch businesses are already often asked to provide their expertise in adaptation projects in various parts of the world. Known examples can be found in water management, the agri-food sector and urban planning and development. These areas have been included in the top sector policy for good reasons.

Opportunity to make production chains more sustainable

For the Dutch Government and the European Union, the creation of inclusive green growth worldwide constitutes an important goal. Part of this includes sustainable production processes that consume less energy and water, together with recycling and reducing biomass flows. The need to use water and energy more carefully is reinforced by the changes in precipitation patterns and the increase in the likelihood and duration of periods of drought.

Climate change means that companies will be affected not only by the nuisance of the change in water availability, but are themselves also contributing to the problem by using water in production processes elsewhere in the world. At the same time, they could improve the efficiency of these processes by introducing innovations. Because the Dutch commercial sector has a great deal of knowledge and expertise in the water and food sectors most relevant for climate adaptation, there are opportunities for the private sector, certainly with an

approach geared to sustainability and integral solutions. The focus on climate adaptation can be combined with the Dutch goals in relation to sustainable economic chains. Policy in this area could be strengthened by specifically linking the goal of making economic chains more sustainable (in the context of sustainable production), with climate change adaptation and mitigation.

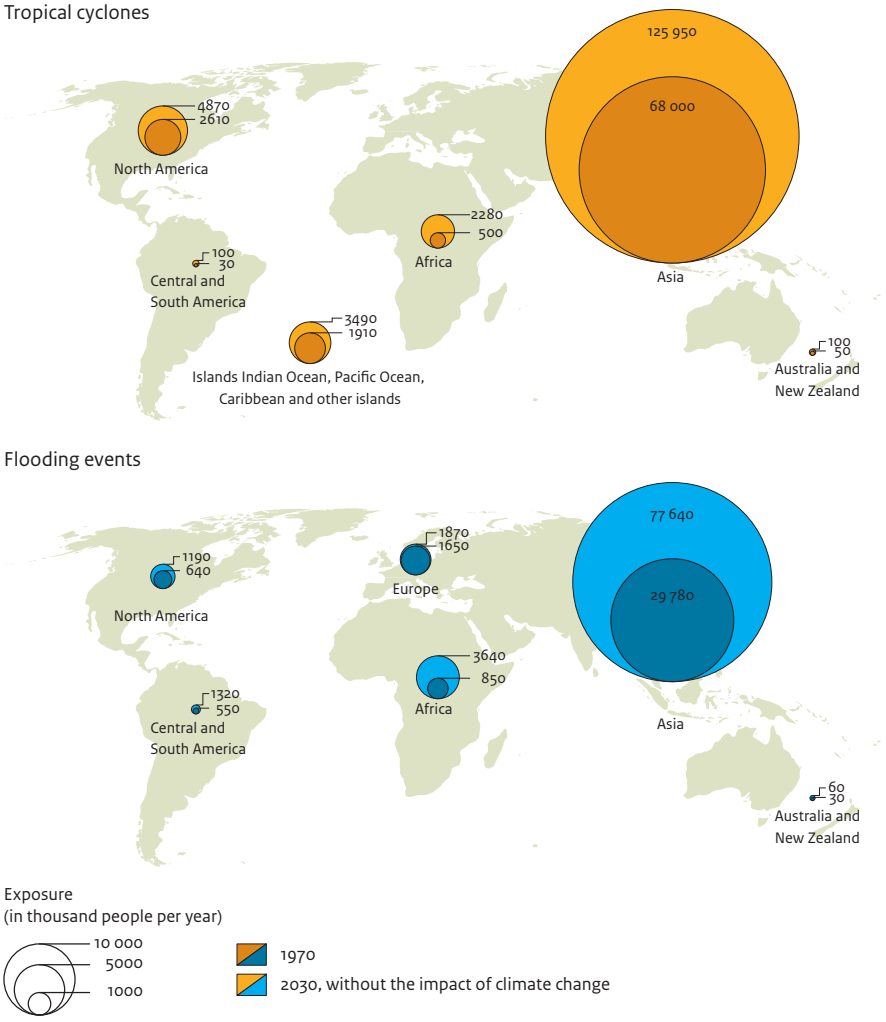
Adaptation options

The adaptation measures are not new, but climate change is making them all the more necessary and urgent.

For example, with the finance and expertise of development cooperation and through the private sector, the Netherlands can make an important contribution to the future resilience of its partner countries and others. This can be done by increasing the resilience of society and especially by reducing vulnerability to climate change (and its consequences). The focus could remain on water and food as the focal points in international cooperation. The objectives of development policy could be connected to those of climate adaptation, more often than they are today, as these could complement and strengthen each other. Via bilateral and multilateral relationships in partner countries, the institutional capacity and resilience could be enhanced in the areas of water, agriculture, energy and health. Through international organisations, NGOs and development banks, for example, the Netherlands may help to reduce climate risks related to flooding and drought.

- Climate change and climate adaptation could be given a more prominent position in foreign policy as joint, transboundary issues. Although Governments as well as business communities are becoming increasingly aware of the relationship between the international effects of climate change and their countries' foreign policies, they do not (yet) consider anticipation on the consequences of climate change to be a global public goods challenge. Policy on development cooperation, however, already combines climate and development objectives. This shows that in the Netherlands and the European Union the international dimension of adaptation is looked at, particularly, as a matter for development cooperation rather than one that has an impact on the safety or economic interests on a much wider level. The joint challenge concerns especially the strengthening of institutional capacity and increasing the adaptive capacity of developed countries, in the areas of water, food, agriculture, energy, urban development, health and disaster and risk management through multilateral and bilateral relationships.
- The knowledge that is available in European countries on climate adaptation could be integrated further into policy; particularly in European safety, development cooperation and trade policies. For example, this could concern the integration of climate-related insights into policy on humanitarian aid, specific development cooperation funds for climate adaptation, and taking climate impacts into account in risk analyses related to safety. The consequences of climate change for product supply chains to Europe could receive greater emphasis.
- Through international organisations, the Netherlands could advocate that, in addition to mitigation, more attention is devoted to climate adaptation; for example, by urging that more funding for climate adaptation in developing countries be provided for in the new climate treaty (Paris 2015). It should also be noted however that the Netherlands, to date, has still made relatively little funding available for the recently established Green Climate Fund and that focusing on mitigation (reducing greenhouse gas emissions) will, of course, make an important contribution to reducing the scale and effects of climate change.
- Through sustainable trade, the application of climate resilient agricultural methods and sustainable management of production systems could be promoted, enabling more carbon capture and storage, at the same time (i.e. combining mitigation for the longer term with adaptation in the shorter term).
- The private and public sectors could join forces to take advantage of opportunities in the areas of urban planning and development for Dutch architects and planners, consulting engineers and research centres, to realise the opportunities offered by 'smart water' solutions. Furthermore, resilience in the areas of water safety, water supply and infrastructure could be increased in collaborating countries.

Figure 3.13
Population exposed to tropical cyclones and flooding



Source: IPCC 2012

The numbers of people who are exposed to tropical storms and flooding around the world are expected to increase substantially towards 2030, particularly in Asia. This increase is mostly the result of population growth.

FOUR

Starting points for the National Adaptation Strategy

In this study on the global effects of climate change we focused mainly on the question of WHAT: what are the risks and opportunities for the Netherlands arising from global climate change and what options are available for the Netherlands to adapt to this?

The National Adaptation Strategy (NAS) is to provide answers to the questions of Who, How, Where and When. Where and when should what steps be taken? Who will do so and how?
To what degree are adaptation options already taken into account in policy or by organisations? On which scale are measures implemented (local, national or international)? Who are the 'agents of change' (governments, businesses, NGOs) and what are the 'moments of change'? Which areas require additional effort in order to reduce risk or seize opportunities? For this outlook study, we have attempted to answer these questions. In the next phase, the National Adaptation Strategy could address these issues in more detail. In closing, this chapter presents the starting points for elaborating on the WHO and HOW questions; the international aspect, the role of the business community, and the changing international networks.

Specific attention for the international aspect of climate adaptation in debate and policy

In many areas, the Netherlands already has the knowledge and experience of dealing with the risks and taking advantage of the opportunities of climate change, worldwide. There is, for example, already legislation concerning the continuity of the energy supply and ICT services, both the public and private sector have their emergency response plans, and Dutch development cooperation already focuses on food and water, two key areas in climate adaptation in developing countries. The National Risk Assessment (NRB) led by the Ministry of Security and Justice also carefully considers risks by running climate change scenarios; although widening this to include the impact of climate change (and its effects) elsewhere in the world on sectors in the Netherlands has, so far, only been considered to a limited extent. The role of climate change in international security policy and the economic security of the Netherlands has only recently been acknowledged.
In many cases, it will therefore be a matter of specific attention for international climate adaptation in policy, consultation and risk assessments.

WHO and HOW: international cooperation also involving the private sector

The effects of climate change beyond Dutch borders will increase the known risks to the Netherlands, but also offer opportunities. This underlines the need for coordination and cooperation on an international scale in order to develop a large and effective adaptive capacity for all. This could involve strengthening the adaptive capacity of the Dutch private sector and other internationally operating Dutch organisations, but also helping to strengthen the adaptive and institutional capacity of other countries where possible.

The Netherlands has its strongest economic, infrastructural, social, political and administrative ties with other European countries. The consequences of climate change in western European countries could affect and reinforce the impact of climate change on the Netherlands, because these countries have essentially the same climate and will face the same changes. What this means is that the Netherlands will have to work closely with its neighbouring countries and other EU countries to strengthen its adaptive capacity.
A wide range of actors play an important part in numerous adaptive measures. This is why the National Adaptation Strategy is more than a government strategy. In the worlds of trade, transport, ICT and the energy supply it is mainly multinationals that call the tune. This means that these parties must not be left out of the national and international climate adaptation process.

In relation to the risks in the category of 'system failure', the government has a coordinating, steering and content management role to play. For 'disruption' risks, the adaptation options are more a matter of custom solutions agreed between governments, businesses, NGOs and other parties. The role of government here will be one of facilitation.

WHO and HOW: smart governance in changing international networks

Based on the understanding that the need for climate adaptation extends further than national borders, there is also the question of what would be suitable steering mechanisms in light of current governance trends. In a globalising world in which the significance of national borders and national sovereignty are losing ground (WRR, 2010a) and international networks are becoming more important, these networks will play an important part in both increasing awareness of climate impacts on Dutch territory (e.g. food security through international trade relations, and migration through international social networks), as well as steering adaptation measures. In this respect, climate change could be considered a global threat and climate adaption a benefit (or global public good). With the blurring of national borders and an overshadowing of sovereign rule, this means that climate adaptation has become less of a 'national' governance issue, which essentially means that the aim of realising this global public good has only increased (Dijstelbloem et al., 2010; WRR, 2010b).

Furthermore, in the western world in particular, we see a trend towards decentralisation and privatisation of government tasks with a growing claim being placed on the energy and organisational ability of society itself (Hajer, 2011; Council for Health and Society, 2013). From an international perspective, both these developments will require 'global' governance. Because of the absence of an international sovereign power and due to the growing role of non-governmental actors (e.g. companies, social organisations, media and knowledge networks) active participation in these international, non-governmental networks by national governments is becoming increasingly important for tackling the collective action problem presented by climate change (Biermann et al., 2009; WRR, 2010a). The idea that cross-border climate impacts can be anticipated from a sovereign cockpit, therefore, is not realistic. Governments that – implicitly or explicitly – give the impression that this can be controlled, at some point, will be faced with public disappointment and loss of confidence (Noordegraaf-Eelens et al., 2012).

The solution for successful management in this changing governance environment lies in a recognition by all concerned that government is not the only party holding the key to climate adaptation. Government will also have to allow itself to be represented by several ministries and operate tactically in various international networks (WRR, 2010a).

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