Foresight study on climate adaptation in Limburg

Final report

Province of Limburg

October 2008
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CONTENTS PAGE

SUMMARY

The climate is changing. Global warming will continue, even if we are successful in our efforts to reduce CO2 emissions. The rise in temperature will also change precipitation patterns. Winters will be wetter, and dry summers more likely. The consequences of this for nature conservation, agriculture, urban areas and infrastructure will become noticeable in many different ways.

The Province of Limburg has asked DHV to advise it on the challenges of climate adaptation. In this document, *Foresight study on climate adaptation in Limburg*, the Province is continuing the process of developing a climate-proof policy for Limburg. The key question addressed in this report is "What issues should the Province of Limburg address when developing its climate-proof policy?"

Policy in Limburg already takes climate change into account to some extent. The Draft Water Management Plan, part of the Provincial Environment Plan (POL), is based on the KNMI'06 climate scenarios with respect to excess water and flooding. That is not, however, the case for desiccation policy and in the Agriculture and Urban Planning policy domains. The Province's water policy has been partially aligned with the climate scenarios published in 2000 (part of the national "WB21" water management policy). The Draft Water Management Plan takes the KNMI'06 climate scenarios into account with respect to excess water/flooding. Those scenarios and, more recently, the recommendations of the Delta Commission have increased our understanding of climate change.

The Royal Netherlands Meteorological Institute (KNMI) published a series of four climate scenarios in 2006. All four are equally likely. The biggest differences between the four are the scale of the global temperature increase and whether or not there will be changes in major air current patterns. The climate scenarios dating from 2000 emphasise excess water, but two of the KNMI'06 scenarios (W+ and G+) also assume longer dry periods in summer. Specifically, the W+ scenario forecasts heat waves, heavy showers and wet winters. If this scenario is correct, hot summers such as experienced in 2003 will occur every other year by 2050, and the summers will be even drier. As a result, the Meuse will fall dramatically, leading to fresh water shortages for nature conservation, agriculture and drinking water; the navigability of the river will also deteriorate and poor water quality and heat stress in urban areas will lead to public health problems. This problem has not been taken fully into account in current policy.

In terms of safety (risk of Meuse flooding), the authorities are working hard to maintain the current desirable level of safety in the years ahead. Spatial policy is already anticipating an increase in extreme water discharge in this century, as are new projects such as Sand Meuse II. The recent Delta Commission report confirms this discharge level and indicates that additional measures will be required before 2050.

Climate change also means gradual changes in biodiversity, water quality, water shortages and excess water. The Province's large-scale area-specific spatial development plans offer considerable leeway for adaptation measures in projects and property development programmes: nature conservation can be enhanced, water retained, and provision made for excess water caused by intensive precipitation. In order to implement such measures, we must constantly be on the lookout for adaptation opportunities. As the coordinating body for such developments, the Province can put climate adaptation on the agenda and keep it there.

We advise the Province to initiate a process whereby the KNMI'06 scenarios are used as a basis for policy making and integrated into the Provincial Environment Plan, so that Limburg's policy can be climate-

proofed before 2050. An adaptation project team, staffed by representatives from the Province's various programmes and departments, should keep up with the latest information and developments in this area, ensure that climate adaptation is placed on the agenda of the various provincial departments and programmes, and see to it that the necessary policy changes are made. In the short term, it is important that the team helps to highlight the importance of climate adaptation in area-specific spatial planning.

1 INTRODUCTION

The Province of Limburg has asked DHV to advise it on climate adaptation. This foresight study constitutes the Province's first step towards climate proofing its policy.

The key question posed in the project – "What issues should the Province of Limburg address when developing its climate-proof policy?" – has been tackled along two lines of enquiry (see Figure 1.1). The first line of enquiry, which addresses the actual issues at hand, has demanded the most attention. What effects will climate change have? What effects have already been addressed – sufficiently – in policy? What "blank spots" remain, i.e. climate change issues that have yet to be addressed by policy? And what subjects should be tackled in the near future? The second line of enquiry, which addresses processes, considers potential objectives, the role of the Province in climate adaptation, and how climate adaptation can be aligned with the Province's policy.

These lines of enquiry have resulted in recommendations as to how the Province can climate proof its policy in terms of both actual issues and processes. The Province will, however, need to develop both lines of enquiry in more detail in order to make the necessary climate-proof adjustments to its policy. Those details are needed in order to develop a properly substantiated, targeted policy that also considers how best to generate political and public support for implementation.

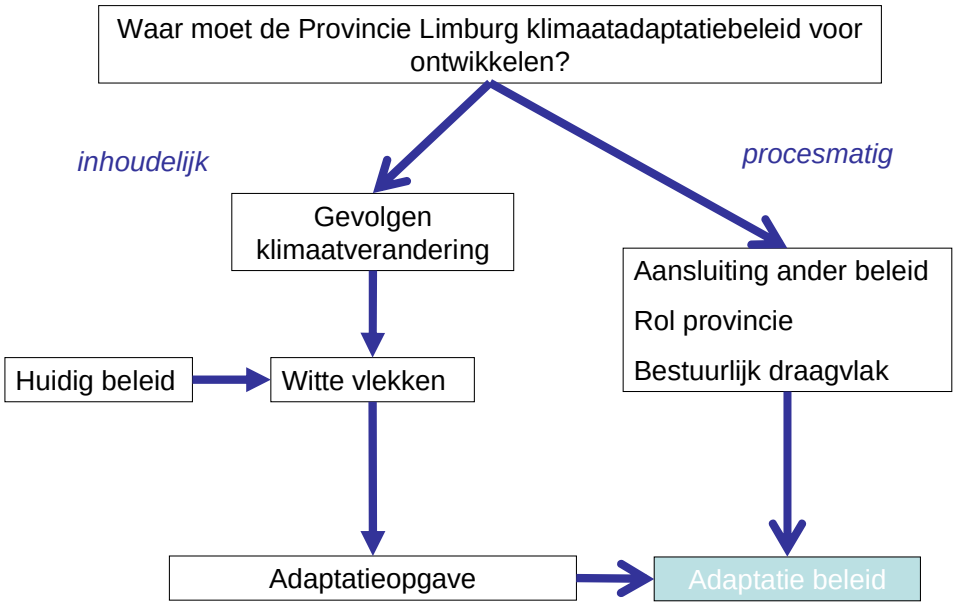


Figure 1.1: Structure of Foresight Study on Climate Adaptation in Limburg.

Guide to this document

Section 2 discusses the KNMI's climate scenarios, produced in 2006. The KNMI is the Royal Netherlands Meteorological Institute. Wherever possible, we estimate the consequences for Limburg.

Section 3 describes the Province of Limburg's current policy and the degree to which it takes those consequences into account, either explicitly or implicitly. The section ends by reviewing the policy "blank

spots": the potential effects of climate change that current policy has not addressed, or only to an inadequate extent.

Government need not develop policy covering every consequence of climate change. Nor do all of the consequences of climate change require specific short-term measures. There are also different ways of dealing with the consequences of climate change. But how can the Province determine, right now, what blank spots it needs to address? And in what way should it then deal with the consequences of climate change? These are the questions we look at in Section 4. That section ends with initial recommendations for tackling the adaptation challenge in Limburg.

The Province will have to adjust its policy, and Section 5 begins by summarising how other provinces have attempted to climate proof their policy. The section continues by describing the process and organisation that will be needed in the Province of Limburg to arrive at such a policy. This section also looks at the question of prioritisation.

2 CLIMATE SCENARIOS FOR 2050

2.1 Introduction

The Royal Netherlands Meteorological Institute (KNMI) published a series of climate scenarios in 2006. In these scenarios, they distinguish between primary climate effects (impact on temperature and precipitation, etc.) and secondary climate effects (impact of temperature and precipitation changes on the natural environment, water management, agriculture, etc.).

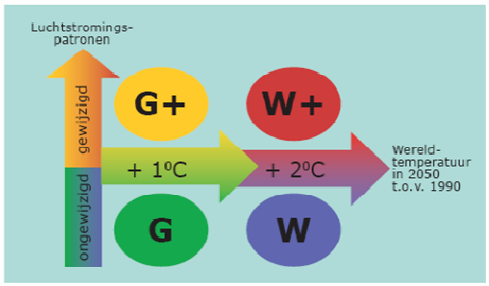
> Draft Water Management Plan for Limburg: *The climate is changing and the effects are visible around the world. We will unavoidably be forced to adapt to these changes. One of the most significant factors is the rising temperature, which will have major consequences for water systems. Rainfall in the Netherlands will increase and become more extreme (more rain in shorter periods of time), with excess water and more risk of floods. In addition, periods of drought will become more frequent in the summer season. Other anticipated effects include the quality of our water and the functioning of the ecology. If we do not alter our policy, the impact on the water system will have implications for public safety (floods), agriculture (drought), public health (heat stress and non-compliances) and wetland habitats (desiccation, loss of biodiversity).*

The KNMI has produced a series of climate scenarios mapping the primary effects on the Netherlands. Within the framework of its Climate Effects Sketchbooks project (www.klimaatvoorruimte.nl, project number COM21), it refined two of the national scenarios to the provincial level in order to explore the impact on seven of the twelve Dutch provinces. A provincial-level scenario is not yet available for Limburg.

Experts from the participating provinces and from the research institute Alterra, the KNMI and DHV have also described and, where possible, mapped out the secondary effects within the same project. This section makes use of the insights gained in drawing up the climate effects sketchbooks. The sketchbooks project revealed many gaps in our knowledge, in particular with respect to area-specific climate effects. This section is also based on a policy document produced by the Province of Limburg entitled “The consequences of climate change for water-related policy” [*Gevolgen van klimaatverandering voor het beleidsveld Water*]. Where possible, this section discusses the situation in Limburg.

2.2 KNMI climate scenarios dating from 2006

The KNMI presented four new climate scenarios in 2006, referred to as the KNMI’06 scenarios (source: *Climate Change in the 21st Century: Four Scenarios for the Netherlands*, KNMI 2006, and www.knmi.nl). How the climate in the Netherlands will change depends largely on the increase in temperature worldwide and on changes in air current patterns. The KNMI’06 scenarios are based on these two factors: see the figure below.



G	Gematigd	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
G+	Gematigd +	1°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind
W	Warm	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 geen verandering in luchtstromingspatronen in West Europa
W+	Warm +	2°C temperatuurstijging op aarde in 2050 ten opzichte van 1990 + winters zachter en natter door meer westenwind + zomers warmer en droger door meer oostenwind

Figure 2.1: Climate scenarios for KNMI'06

The G scenario is moderate (in Dutch: *gematigd*). There is also a warm scenario (W) and two dry scenarios (G+ and W+). The main difference is that, in addition to excess water, there will also be periods of drought with effects that go beyond water management:

- higher temperature;
- drier summers in two of the four scenarios;
- wetter winters and more heavy showers in summer.

Appendix 1 reviews how the four scenarios expect the climate to have changed by 2050 compared to the average climate in the Netherlands around 1990 (baseline year).

Climate scenarios as basis

Considerations of climate change consist not only of uncertainties: they also provide a basis for our thinking about the future and in fact make it possible to avoid useless investment. It should be noted that we can no longer base ourselves on a single scenario, as has been the case since 2000, but rather on the bandwidth of the four new scenarios. Specifically, the KNMI has indicated that the scenarios are all equally probable. We must hence assume that we will be facing both excess water *and* drought, high *and* low water levels in rivers. The scenarios cover approximately 80% of the global climate models. In addition, there is a 20% chance that climate change will be more extreme or less extreme than the scenarios assume.

There are various things we do not know about the climate system, the level of greenhouse gas emissions, how they will affect the climate, and how accurately we can estimate the consequences for the specific situation in Limburg. These uncertainties are shown in the figure below. Appendix 3 discusses methods for dealing with uncertainties.

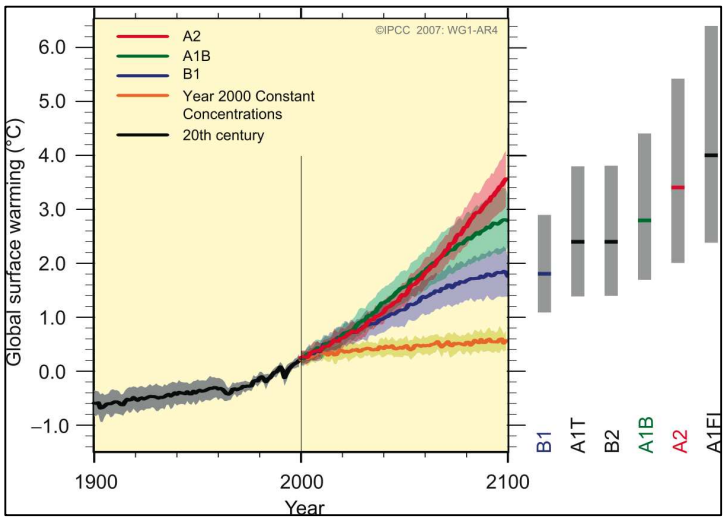


Figure 2.2: Uncertainties in climate change (source: www.IPCC.ch).

Primary climate effects

Temperature

The temperature rises in each of the scenarios. It rises most in the W+ scenario and least in the G scenario. The increase in temperature extremes is larger than the increase in average temperatures. This means that the number of warm (maximum temperature >20 ˚C), summery (maximum temperature > 25 ˚C) and tropical (maximum temperature > 30 ˚C) days will increase, and the number of ice (maximum temperature < 0 ˚C) and frost days (minimum temperature < 0 ˚C) decrease. The difference is largest in the G+ and W+ scenario.

In our present climate, it tends to be warmer in the summer in Limburg than in the rest of the Netherlands. In winter, it tends to be colder than along the coast, but warmer than in the north of the country. These spatial patterns will remain in future (KNMI scenario assumption).

Precipitation

Summer brings the heaviest showers, which can result in excess water. The showers increase in each of the scenarios by approximately 10%, and in the W scenario by as much as 27%. Precipitation also increases in the winter in every scenario, most notably in the W+ scenario. This could give rise to excess water in densely populated areas such as Maastricht and the clayey soil along the Meuse; it could also lead to erosion and water management problems on the steeper hills of South Limburg. There will be fewer water-related problems in urban regions with plenty of green areas and water courses (Parkstad) and on the sandy soil of North-west Limburg.

A recent study by the KNMI shows that there will be an even sharper increase in short intense showers than forecast in the KNMI'06 scenarios. A recent publication[1] predicts that the maximum hourly intensity during extreme showers will increase by 14% per degree Celsius average temperature rise.

[1] Lenderink G. and E. van Meijgaard, 2008: Increase in hourly precipitation extremes beyond expectations from temperature changes. Nature Geoscience 1, 511-514. Doi: 10.1038/ngeo262.

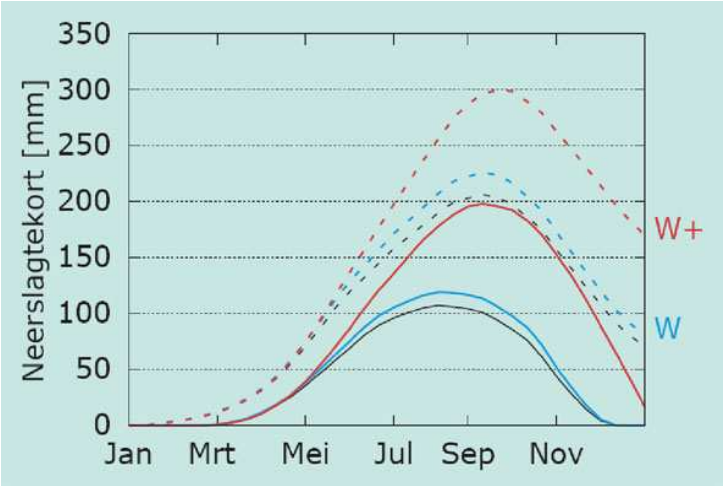


Figure 2.3 Cumulative precipitation deficit in the Netherlands.[2]

Precipitation deficit

Temperature rises will increase evaporation and reduce the amount of precipitation in dry periods. This can lead to a sharp increase in the precipitation deficit (precipitation minus evaporation). The precipitation deficit in the summer will increase most in the "+ scenarios". The average precipitation deficit (from 1 April on) between 1906 and 2000 was 144 mm.

But a "precipitation deficit" can also arise in the wetter scenarios if the precipitation occurs in the form of heavier showers. Heavier showers will cause more water to drain away on the surface, certainly in hilly areas. That means that less of the water will be absorbed by the soil and that there will therefore be less available for crop and plant growth.

Sea level

The scenarios forecast an absolute rise in sea level along the coast of the Netherlands of between 15 and 35 cm in 2050. By 2100, the rise will vary between 35 and 85 cm, and continue after this date. By 2300, it will have reached between 1 and 2.5 m.

This means that sea water will encroach farther inland in the rivers, with peak levels in the Meuse being discharged more slowly. This will have no impact on Limburg, however.

2.3 Climate effects by theme

The table below offers a qualitative estimate of the climate effects of the various scenarios compared to our present climate (1990). Appendix 1 briefly summarises the KNMI'06 scenarios. It shows climate change in 2050 compared to the baseline year 1990 in percentages for the various themes.

[2] Explanation of figure: Cumulative precipitation deficit (= difference between precipitation and potential evaporation) in the Netherlands (average of 13 stations) for the historical climate (1906-2000; black), and two climate scenarios for 2050 (W and W+). The cumulative precipitation deficit is represented in two ways:
- solid line: the maximum cumulative precipitation deficit that is exceeded in 50% of the years;
- dashed line: the maximum cumulative precipitation deficit that is exceeded in 10% of the years.
Source: KNMI, 2006, *Climate change in the 21st century: four scenarios for the Netherlands*.

This section continues with a brief explanation of the estimate on a theme-by-theme basis. We wish to emphasise that this qualitative estimate is highly uncertain in nature. Using scenarios is one way of managing such uncertainties. Appendix 3 provides a more detailed account of how one deals with uncertainties.

Theme	Effect	G	W	G+	W+
Safety	flood risk	-	-	-	- -
Water shortage	fresh water shortage	+/-	+/-	-	- -
Water quality	blue-green algae/botulism (swimming water)	-	-	-	- -
	storm overflows (miscellaneous water)	-	- -	-	-
	ecological standards (WFD)	-	-	- -	- -
	chemical standards (WFD)	-	- -	-	- -
Urban areas	excess water in urban areas	-	- -	-	-
	health	-	-	-	- -
Agriculture	water damage/erosion	-	- -	-	- -
	drought damage	+/-	+/-	-	- -
	diseases/pests	-	- -	-	- -
	opportunities in agriculture	+	+	+	+
Nature conservation	biodiversity/ability to adapt	-	-	-	- -
	desiccation	+/-	+/-	-	- -
	inability to achieve nature conservation targets or need to modify such targets	-	-	-	- -
Recreation	opportunities for recreation	+	+	+	+
Infrastructure	wet infrastructure	+/-	+/-	-	- -
	dry infrastructure	+/-	-	-	- -

Table 2.1: Qualitative estimate of climate effects rising from 2006 scenarios compared to present climate (1990)

Legend

+	Change for the better
+/-	Uncertainty about effect
-	Change for the worse
- -	Considerable change for the worse

2.3.1 Safety

Effect	G	W	G+	W+
flood risk	-	-	-	- -

If climate change leads to an increase in 10-day precipitation sums, peak discharge in the Meuse will also increase. The Border Meuse and Sand Meuse projects have been dimensioned in such a way that the Meuse embankments will protect Limburg against a peak discharge occurring once every 250 years (flood risk is 1:250 per year). Currently, peak discharge is approx. 3300 m^3/s. If the peak discharge increases, the “protection level” will fall below 1:250 per year unless additional measures are implemented. The Sand Meuse II project has such measures, ensuring that the protection level will remain at 1:250 per year, despite the increase in peak discharge.

2.3.2 Water shortage

Effect	G	W	G+	W+
fresh water shortage	+/-	+/-	-	- -

Low river discharge

In summer dry spells, the Meuse is fed almost entirely by groundwater. The average discharge falls to around 100 m^3/s in the summer months, and frequently even lower in dry periods. In its Water Distribution Covenant with Belgium, the Netherlands has agreed that the supply of water to the Border Meuse must not fall below 10m^3/s, a level sufficient for the Border Meuse ecology. There is no difficulty achieving this level at the moment, but there might be if extreme drought becomes more frequent. There will then be more occasions in which it becomes impossible to meet the needs of various water consumers. It is therefore important to safeguard groundwater supplies in Belgium. The river Roer supplies a considerable quantity of water during dry spells from retention basins have been constructed in its catchment area. These are of vital importance when it comes to maintaining the water level of the Meuse downstream from Roermond. For navigability, see “wet infrastructure”.

Dry sandy soil

The rising precipitation deficit leads to a sharp increase in drought in the six-month summer period in two of the four scenarios (G+ and W+). This means that desiccation will increase during the six-month summer period, but there will also be periods of extreme dryness with acute water shortages impacting on wildlife and agriculture. The most extreme drought and water shortages will occur on sandy soil. Water from the Meuse is supplied to farms and nature areas in Central Limburg via canals.

There is some discussion as to whether it is still necessary to supply water to the Groote Peel Nature Reserve, and whether it can be replaced by local measures, as this would allow local water to be conserved. Although it may be true that nature areas currently have less need of a water supply in dry periods, in the long term, as these periods increase in frequency and become more extreme, the natural environment and agriculture will probably benefit from any such supply.

Drinking water

Limburg is aiming to guarantee a sustainable supply of drinking water. Drinking water is made of surface water and groundwater. The policy of the Province emphasises protecting groundwater supplies. Climate change can impact the amount of groundwater available for extraction in two ways: directly, owing to changes in groundwater replenishment (precipitation minus evaporation) and indirectly, owing to changes in groundwater policy necessitated by desiccation, with the risk of one type of policy measure (combating desiccation) conflicting with the other (sustainable water supply). There is a significant gap in our knowledge of groundwater replenishment. What we do not know is whether climate change will result in more replenishment or less. This question is particularly pertinent for South Limburg’s limestone plateau. Water extraction in sandy areas appears to be less sensitive to this. Climate change can also affect the quality of the surface water. The extraction facilities in Panheel combined with other groundwater extraction can keep the supply of water going for six months in the event that uptake at Panheel ceases. This seems to be sufficient to anticipate the impact of climate change. We may conclude that there are various “blank spots” in our understanding of the effects of climate change on our drinking water supply.

Cooling water

Water taken from the Meuse is used as cooling water for the power stations at Maasbracht and Buggenum. In present circumstances, the only bottleneck is at Buggenum. In warm periods when the river discharge drops, the cooling water may be too warm to discharge into the Meuse, resulting in a fall in

production capacity. The power station in Maasbracht is equipped with cooling towers, so no problems are anticipated in the event of drought. If climate change leads to a rise in the demand for energy as well as an increase in water temperatures, existing problems may become more serious.[3]

2.3.3 Water quality

Effect	G	W	G+	W+
blue-green algae/botulism (swimming water)	-	-	-	- -
Storm overflows (miscellaneous water)	-	- -	-	-
ecological standards (WFD)	-	-	- -	- -
chemical standards (WFD)	-	- -	-	- -

Blue-green algae/botulism
When the ambient temperature rises, the water temperature rises as well. This may mean a possible increase in the occurrence of algae/blue-green algae and botulism. Blue-green algae can take over nutrient-rich stagnant water such as found in the Meuse Lakes, harbours and urban waters and lead to problems (loss of biodiversity, fish mortality, athlete's foot, gastro-intestinal complaints, liver disorders, stench). Increasing drought in the G+ and W+ scenarios means more slow-flowing and stagnant water, increasing the risk of blue-green algae infestations. Heavy showers can wash away the blue-green algae, but also cause run-off that supplies the nutrients on which such algae thrive. Botulism is caused by a bacterium (*Clostridium botulinum*) carried by birds that thrives in stagnant water and at the bottom of rivers and ponds under warm and oxygen-poor conditions. Botulism kills off fish and water fowl and can cause food poisoning in human beings, often quite serious. Blue-green algae dominance and botulism will cause swimming areas to be closed more often, disrupt biological equilibrium (loss of biodiversity) and lead to stench in urban waters and marinas.

Storm overflows
During heavy showers, a large quantity of water enters the drains/sewers in a short period of time. An increase in such showers will mean more occasions when the drains/sewers are unable to cope with the heavy rainfall. Storm overflows discharge the excess water into ditches, streams or ponds. In mixed drainage/sewer systems, this water is combined with waste water. This means more frequent occurrences of the E.coli bacterium, for example, leading to a deterioration in water quality and a greater risk to public health.

At the moment, many of the storm overflows can handle a basic frequency of six overflows a year. To cope with a higher frequency of extreme showers and achieve a satisfactory water quality/ecological condition (within the context of the WFD), many municipalities in Limburg are decoupling rainwater drainage from the mixed sewer/drainage system. This will reduce the number of occasions when mixed sewers overflow into the surface water, and allow rainwater to infiltrate into the soil. In addition, various municipalities are constructing natural discharge reservoirs to prevent drainage/sewer water from ending up in the surface water.

WFD objectives
The European Water Framework Directive (WFD) stipulates various ecological and chemical standards for bodies of water, the primary aim being to prevent any further deterioration in their chemical and ecological

[3] Royal Haskoning, 2004, *Droogtestudie Maasstroomgebied*.

status and to improve the ecological status of surface waters, wetland habitats and the chemical quality of water. The 2010-2015 Provincial Water Management Plan includes measures pertaining to the restoration of streams, efficiency improvements at sewage treatment plants, and more far-reaching measures to control storm overflows that discharge into vulnerable and very vulnerable water courses, the aim being for the water systems to meet a “good” ecological and chemical status by 2015, but certainly by no later than 2027.

Climate change may make it difficult or more difficult to achieve that good ecological and chemical status even in the short term, i.e. by 2027, the date indicated in the WFD.

Climate change can affect the chemical quality of water, making it more difficult to meet standards set for oxygen, nitrogen, phosphate and priority substances. A higher ambient temperature results in a higher water temperature, lowering the oxygen content in the water. In hot, dry summers, when water discharge levels drop, concentrations of effluents (including priority substances) will increase, potentially leading to non-compliance with standards. Heavy rainfall can cause concentrations of nitrogen and phosphate to increase even more because it flushes out fertilisers from agricultural areas and washes them along the surface.

Climate change can also have an impact on the ecology of water systems. For example, a higher water temperature will lead to a decline in biodiversity in aquatic communities. In particular, the disappearance of oxygen-dependent cold-water species (including salmonids) will reduce aquatic biodiversity in streams in the Downs (*Heuvelland*) and terraced hills of Limburg. Such communities will come under further pressure from alien pest organisms (exotics), which thrive in higher water temperatures. There are already examples of this: ditches and streams that have been invaded by the alien water pennywort (*Hydrocotyle ranunculoides*) and other invasive pond plants (water primrose, water hyacinth, water cabbage, cabomba, parrot feather, *Crassula helmsii*) that cover the surface of the water, leading to oxygen deprivation and aquatic animal mortality.

Longer periods of drought will lead to lower discharge levels in rivers and streams and higher temperatures in water courses. More frequent periods of extreme precipitation can cause organisms to be washed away. Such changes in discharge patterns may reduce biodiversity in aquatic communities, making it more difficult to meet the ecological objectives of the WFD.

2.3.4 Urban areas

Effect	G	W	G+	W+
excess water in urban areas	-	- -	-	-
health	-	-	-	- -

Excess water in urban areas

In urban areas with a lot of paved surfaces, short heavy showers in the summer are indicative of drainage problems. All the climate scenarios predict more intense heavy showers, with those forecast in the W+ scenario being the most extreme (27% increase by 2050 compared to 1990). Excess water is already a problem in various towns, for example in Sittard, Roermond and Maastricht, as a result of extreme precipitation. Tunnels beneath the railway line have flooded repeatedly there. But problems can also occur in other places. Weert and Voerendaal are particularly troubled by excess groundwater. In South Limburg, heavy showers flush large quantities of water down the slopes into built-up areas in the valleys, regularly leading to excess water. Such problems also occur along the smaller streams and rivers. The situation may be aggravated by an increase in paved surfaces.

Another problem is erosion on the hills of South Limburg’s Downs. Erosion causes fertile soil to be washed out of the fields and leads to mud accumulating on roads and in residential areas. With climate change increasing the number of extreme showers, the rate at which erosion takes place may increase

considerably. It is possible to tackle excess water caused by the Meuse and streams and by erosion outside urban areas, however, by retaining and storing water upstream from the affected areas.

Health

Rising temperatures and more frequent extremes can lead to hyperthermia or *heat stress*. The average temperature in a city is higher than in the surrounding countryside, sometimes by as much as 5˚C. Cities develop “heat islands”. The extent to which this effect occurs depends largely on the size of the city. The heat-island effect is particularly important at night. The surrounding countryside cools down more quickly at night and stores less heat during the day than the city. Limburg is particularly built up in the south. Areas of concern include Maastricht (which lies in a valley, where heat is more easily held captive), Sittard-Geleen, and Parkstad (Heerlen, Landgraaf, Kerkrade), although the latter area has a lot of greenspace. The heat-island effect can be moderated by broad streets, parks and other green areas, and water.

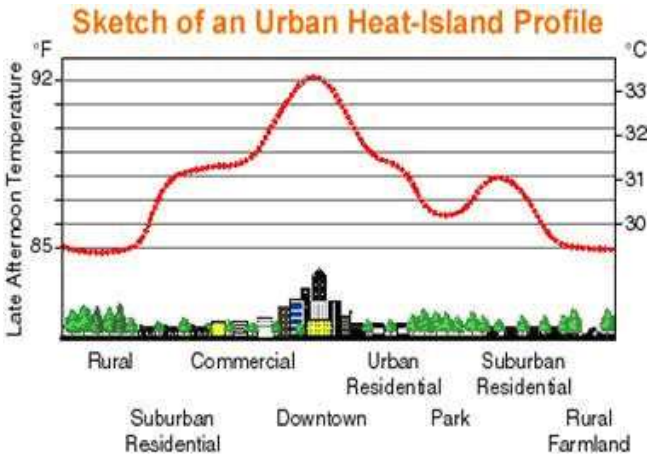


Figure 2.4 Urban heat-island effect (source: *Klimaateffectschetsboek Zuid-Holland*).

Air quality depends largely on weather conditions, such as wind direction and sunshine, which influence the supply of pollutants. For example, a summer smog (high concentrations of ozone) often coincides with a heat wave (bright sunshine). If the number of tropical days increases in the Netherlands (maximum temperature ≥ 30 ˚C) and emission levels remain the same, the chance of summer smog will increase, especially in the W+ scenario. The chance of winter smog is reduced in the G+ and W+ scenario because of an increased supply of relatively clean air from the west.[4]

The city of Maastricht lies in a valley. In the present climate, the city sometimes has poor air quality in the summer, as well as smog. Such occasions may increase in future, especially in the W+ scenario.

Illness resulting from climate change was the topic of an article in a supplement to the Dutch national newspaper *NRC* (18 September 2008). In the next few decades, global climate change will lead to several hundred more deaths and a few thousand more cases of illness in Netherlands in summertime, according to a report on the impact of global environmental change by Erasmus MC, Maastricht University, the National Institute for Public Health and Environment (RIVM) and the Living Environment Planning Office.

[4] KNMI, 2006, climate scenario brochures.

Because the summers will be warmer, more people will die during this period, there will be more allergies and more cases of Lyme's Disease from tick bites, food poisoning, and infections picked up in swimming water. Increased exposure to ultraviolet rays – the effect of the thinning of the ozone layer – will also result in more cases of skin cancer and cataracts. On the other hand, fewer people will die as a result of winter cold. Whether this decline will balance out the rising mortality rate in summer is unknown.

2.3.5 Agriculture

Effect	G	W	G+	W+
water damage/erosion	-	- -	-	- -
drought damage	+/-	+/-	-	- -
diseases/pests	-	- -	-	- -
opportunities in agriculture	+	+	+	+

Water damage/erosion

Average precipitation increases in all the scenarios. Land will be flooded more frequently. Incidental damage may increase owing to peaks in precipitation. In the W scenario, there is a greater risk of harvests failing due to excessively wet conditions. The W+ scenario also entails possible wet damage in the winter/spring, making it difficult to sow (winter grain in autumn or other crops in spring). Outside the growing season, poor water quality or structural deterioration of the soil may also lead to problems.

The South Limburg Downs suffer from erosion. Heavy showers flush fertile soil from farmland and clogs roads and residential areas with mud. Unless preventive measures are introduced, peak precipitation will increase such problems.

The wet winters forecast in all the scenarios may be favourable for the high moorlands, the Mariapeel and Groote Peel moorlands, which are facing the slow draw-down of the groundwater table. It is also possible, however, that the groundwater table will fluctuate dramatically (summer/winter), which would be unfavourable for these areas.

Wetter soil and rising temperatures have an important impact on the increase of diseases and pests. Known diseases and even those new to the Netherlands will be able to survive the milder winters more easily. The level of damage depends on the stage of plant growth, the ambient temperature, opportunities for the disease to spread, etc. Incidents and extremes are a particular threat to agriculture.

Drought damage

In the G+ and W+ scenarios, the precipitation deficit increases considerably in the summertime, a situation that could lead to drought damage. This depends on the type of soil and its function, however. Some crops can cope better with drought than others. Calculations performed within the context of the National Drought Study (RIZA, 2006) show that drought damage in 2050 could increase to up to EUR 50 to 100 per hectare, and to more than EUR 100 per hectare in some areas in the W+ scenario.[5]

The dry summers in the + scenarios may endanger high moorland areas, the Mariapeel and the Groote Peel moorlands. This area is rather sensitive to increases in evaporation and the resulting fall in the groundwater table and water levels. The differences that may arise between dry and wet periods are also adverse for the area. The chance of a ban on spray irrigation using surface water owing to summer drought in North and Central Limburg increases in the + scenarios. If farmers are prevented from irrigating

[5] Calculations by Alterra (2008) for the climate effects sketchbooks for various provinces.

their crops with surface water, they switch to groundwater (insofar as there are wells available; the amount of water extracted for agricultural purposes may not exceed present figures, as stipulated in the Provincial Ordinance on Water Management). This will put more pressure on the groundwater. Irrigation also costs money, possibly leading to a loss in revenues. In South Limburg, heavy showers lead to considerable run-off, and the water is not absorbed into the soil. This leads to additional problems in the W scenarios in particular.

At the same time, climate change may offer agriculture new opportunities. Higher temperatures will extend the growing season and may make it possible to grow new types of crop.

2.3.6 Nature conservation

Effect	G	W	G+	W+
Biodiversity/ability to adapt	-	-	-	- -
Desiccation	+/-	+/-	-	- -
Inability to achieve nature conservation targets or need to modify such targets	-	-	-	- -

In an intensively managed geographical area like the Netherlands and Limburg, climate change is only one of the factors impacting the natural environment. The effects of climate change and adaptation measures should therefore always be assessed in relation to land management and fragmentation, urbanisation, overfertilisation, desiccation and other pressures.

In general, we can divide the negative effects of climate change on biodiversity into four main categories: physiology (photo synthesis, respiration, water system), phenology (timing, life cycle events), geographic distribution (shifts in acreage, increase in number of fluctuations), and genetic adaptation (physiological and micro-evolutionary adaptation). Ultimately, these effects can lead to a change in the functional relationships between species and, as a result, to changes in the species composition, structure and functioning of ecosystems. In the end, the cumulative impact and mutual reinforcement of the above undermines the resilience and recuperative powers of ecosystems, leading to a decline in biodiversity. The foregoing negative effects will generally lead to the following problems:[6]

Shift in climate zones, more frequent weather extremes and current fragmentation of habitats

- Ecosystems will be affected by phenological and physiological species adaptation, changing complex relationships between species. This may lead to local species dying out entirely, particularly in areas where habitat fragmentation and/or other pressures have already led to a decline in numbers.
- Target species in nature policy with a preference for cooler climates will be under pressure as climate conditions worsen. That means we must determine whether these species have a long-term future in the Netherlands (or parts of it). Policy measures undertaken within the current nature conservation policy and the static nature conservation targets do not take into account the increasingly dynamic nature of ecosystems as a result of climate change. This may mean that we

[6] Much of this section is based on and borrowed from the study *Klimaatverandering en ruimtelijke adaptatie natuur: wat we (niet) weten*. [Climate change and spatial adaptation in nature: what we (don't) know], part of NWO's Climate Changes Spatial Planning (CcSP) programme.

will be working to achieve unattainable objectives for far too long, while at the same time failing to make good use of the opportunities offered by climate change.

— Wildlife species will be unable to reach nature conservation areas in Limburg that offer them an appropriate climate because their habitats are too fragmented and the landscape throws up too many obstacles to migration. It is therefore becoming increasingly important to create more and larger robust nature conservation units and to connect up cross-border nature conservation areas. For Limburg, the biggest opportunities lie in reinforcing the robust Schinveld-Mook corridor, the Border Meuse/Meuse Lakes and Sand Meuse, the east-west corridors between these areas via stream valleys, the Peel peat fens (although this poses risks to nature conservation targets), the Weerterbergen and Budelerbergen/Wijffelterbroek nature conservation area, the Stramproyerbroek/Tungelroysche streams, the Geul valley/Gulp valley/Vijlen woods and the corridors to the Ardennes.

— The ecological corridors between these areas constitute the most serious problems owing to the pressure of urban expansion and infrastructure. See Figure 2.5.

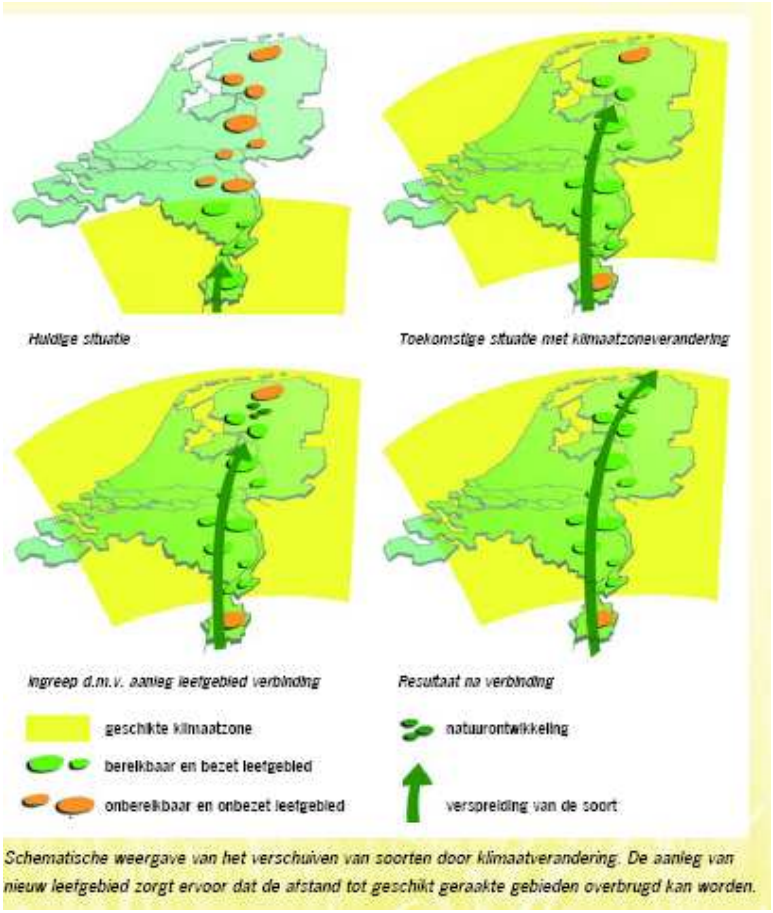


Figure 2.5. Shifts in species distribution owing to climate change.

Source: *Natuur en klimaatverandering, wat kan het natuurbeleid doen?*, Alterra 2006

The inability of species to make the necessary local genetic adaptations quickly enough aggravates the foregoing effects.

- Local and regional species are put under greater pressure as population numbers fluctuate more owing to weather extremes. Recovery after several rounds of fluctuations is slower in fragmented habitats.
- Climate change will also cause an increase in the populations of species introduced by humans outside their natural area of distribution, at the expense of native species.
- Zones with certain abiotic conditions, for example seepage zones, will shift, causing nature conservation areas to shrink or making it difficult to demarcate them properly.

Changes in environmental quality of nature conservation areas and habitats.

- An increase in biomass production leads to shifts in competition between plant and tree varieties and to grassland and woodland ecosystems being overgrown with rough vegetation.
- An increase in evapotranspiration and reduction in summer precipitation will lead to the desiccation of wetland ecosystems: climate change will increase desiccation. Desiccation has a negative impact on wetland habitats that depend on groundwater. Wildlife in Limburg that is already suffering from desiccation will suffer even more in the G+ and W+ scenarios. Natural features like stream systems, woodland on nutrient-poor soil, marshes, wet moorland and peat moors are very vulnerable in this respect. The Province of Limburg has a list of 48 regions that already feel the effects of drought.
- Extreme precipitation leads to flooding and inundation, circumstances that may be unfavourable for certain ecosystems, for example owing to an undesirable supply of nutrients. There are, for example, areas along the Border Meuse with very interesting vegetation (dry stream valley grasses). If these areas are inundated frequently and nutrient-rich sediment is deposited farther down, then new and more general varieties of grasses may arise there.

2.3.7 Recreation

Effect	G	W	G+	W+
opportunities for recreation	+	+	+	+

Climate change may have implications for the demand for recreation. Outdoor recreational areas are popular in the Netherlands in hot summers. When the temperature rises above 30◦ C, however, amusement parks do not attract as many visitors as swimming locations. Section 2.3.3 on water quality already referred to the possible impact of climate change on the quality of swimming water.

In our present climate, hot summers and extreme heat in Southern Europe are good for the tourist industry in the Netherlands. Such summers are expected to occur more frequently owing to climate change, opening up new opportunities for the recreation and tourism sector in Limburg. Current Limburg-based projects such as the “Lazy River” project and the Floriade World Horticulture Exhibition would do well to take advantage of this.

2.3.8 Infrastructure

Effect	G	W	G+	W+

wet infrastructure	+/-	+/-	-	- -
dry infrastructure	+/-	-	-	- -

Extreme precipitation, drought and heat can also affect dry and wet infrastructure. The dry scenarios (G+, W+), with their lengthy dry periods, may be particularly problematic for the navigability of the Meuse.

In the case of flooding, roads play a role in evacuations. Extreme precipitation can lead to drainage problems, especially in tunnels and sunken roads, causing traffic problems. Lengthy periods of tropical temperatures may lead to more extreme road rutting and a bigger risk of verge fires. One advantage is that there will be less need to salt the roads in winter and fewer problems with frost impeding roadworks.

3 CLIMATE PROOFING EXISTING POLICY

3.1 Introduction

This section considers the Province of Limburg's existing policy by reviewing various policy documents. The purpose is to evaluate that policy in the light of climate adaptation. The key question is the extent to which the Province's current policy will be climate proof in 2050. To answer that question, we have considered the extent to which current policy takes the KNMI'06 scenarios for 2050 into account.

The table below shows our conclusions concerning the current policy's climate-proof status in 2050. We then go on to explain the extent to which policy in each theme meets KNMI'06 scenario criteria.

Climate theme		**Climate proof in 2050**	**Policy phase**
Safety	Flood risk		implementation
Water shortage	Fresh water shortage		requires further development
Water quality	Blue-green algae/botulism (swimming water)		no policy as yet
	Storm overflows (miscellaneous water)		implementation
	Ecological standards (WFD)		requires further development
	Chemical standards (WFD)		requires further development
Urban areas	Excess water in urban areas		implementation
	Health		no policy as yet
Agriculture	Water damage/erosion		implementation
	Drought damage		more attention needed
	Diseases and pests		no policy as yet
	Opportunities in agriculture		not incorporated into policy
Nature conservation	Biodiversity/ability to adapt		partial development and implementation
	Desiccation		further development
	Inability to achieve nature conservation targets or need to modify such targets		no policy as yet
Recreation	Opportunities for recreation		better integration of climate change
Infrastructure	Wet infrastructure		implementation (Meuse route), requires further development
	Dry infrastructure		no policy as yet

Table 3.1: Climate-proof status of current policy

Legend:

	policy inadequate, not incorporated into policy, blank spot
	some aspects of policy have been climate proofed, some blank spots still exist
	policy takes climate change adequately into account. Implementation and monitoring merit attention

Draft Water Management Plan for Limburg: *The current water system does not have enough scope or resilience to cope with extreme conditions, something that will become increasingly problematical owing to the future changes outlined. We must therefore give the water system more scope and restore natural processes. …Our intention is to maintain and restore ecologically healthy and resilient water systems that also function as natural climate buffers: ecologically healthy and properly functioning water systems capable of coping naturally with the many different sources and qualities of water.*

Current policy generally focuses on improving the water system by 2015, in accordance with the National Administrative Agreement on Water (NBW), Water Management Policy for the 21st Century (WB21) and the Water Framework Directive (WFD). In 2018, the National Ecological Network (NEN) should be complete. All the improvements being made to the water system and the NEN contribute to climate adaptation, but in many cases they will not be sufficient to achieve a climate-proof system by 2050 in accordance with the KNMI'06 scenarios (see the previous section).

The Provincial Environment Plan for Limburg (version of 22 September 2006, POL 2006) and the execution of this plan as expressed in the Province's Long-range Programme and Progress Reports are based in part on the WB21 climate scenarios, and not the KNMI'06 scenarios (with respect to excess water/flood risk). The key objective of the policy is to improve the current situation before 2015, with respect to the water system (NBW), water quality (WFD) and the natural environment (NEN). The Draft Water Management Plan for Limburg 2010–2015 (partial Revision of the Provincial Environment Plan 2006) does take the KNMI'06 scenarios into account. That means that more effort must be made above and beyond what is currently being done in order to make Limburg's present policy climate proof.

3.2 Safety

The Province's safety policy is described in the Provincial Environment Plan and the Draft Water Management Plan. It includes the Meuse Works (*Maaswerken*, which includes the Border Meuse and Sand Meuse projects), the Overall Survey of the Meuse, and the Long-range Sand Meuse II Plan.

Meuse Works

The Border Meuse and Sand Meuse projects are dimensioned to cope with a peak discharge of 3800 m^3/s at Borgharen and a flood risk of 1:1250/year; they will guarantee safety up to 3300 m^3/s at Borgharen with a flood risk of 1:250/year. The work that is now being carried out does not take recent information on increased discharge into account.

Overall Survey of the Meuse (IVM)

In addition to the Meuse Works, there has been an Overall Survey of the Meuse ("IVM Study") in recent years based on the idea of a rise in the peak discharge of 20% by as early as 2050 (up to 4000m^3/s with a flood risk of 1:250/year and up to 4600 m^3/s with a flood risk of 1:1250/year). The Delta Commission's advice indicates that this representative discharge level will not become reality until the end of the century, and not in 2050.

The IVM Study indicates that it would be too expensive (compared to the damage that would be avoided) to cope with the higher discharge levels only by creating more room for the river, and that land-use measures, retaining water in the capillaries of the water system, and flowing storage basins will be inadequate by themselves. It would not be desirable to raise the level of the embankments, especially because this would increase the risk of collapse and injuries or deaths. That is why measures are required in all these areas that will be cost-effective owing to linkages and side-effects at local and regional level, and that together can cope with higher discharge levels. In other words, the full spectrum of measures is

required: land-use measures, retention of water in capillaries, flowing water storage and renaturation of the central reaches, water storage along the water courses, measures giving the river more room (widening the channel) and, finally, protective measures, for example raising dikes and embankments (slightly).

The Provincial Environment Plan indicates that it is important with respect to spatial planning to take long-term changes into account. The Province must therefore reserve the necessary space to implement the measures proposed in the IVM Study. The national “Room for the River” policy plan applies to the entire (i.e. summer and winter) river bed, prohibiting any further residential or commercial development there. The IVM Study does make it possible to set aside space specifically in places where realistic measures have been provided for. At the same time, it should be possible to select areas in the Meuse Valley where measures are not needed (for example within the embankments), and where more development can be permitted than is now the case.

In tackling the problem of high water levels in the Meuse, the aim is to arrive at closer cooperation and coordination of policy and measures within entire catchment areas, both at national and international level.

Long-range Sand Meuse II Plan 2007-2015

The purpose of the Long-range Sand Meuse II Plan is to develop the Meuse Valley in a way that will climate proof specific areas. The Sand Meuse II project has supplementary measures that ensure a protection level of 1:250 per year, despite the increase in peak discharge. As such, it provides a concrete supplement to the IVM Study. It covers the stretch of river from Roermond to Afferden and is based on broad, area-specific spatial planning intended to meet objectives related to flood safety, nature development, agriculture and horticulture, recreation, housing and raw materials extraction. Where possible, the plan assumes that such measures will be based on or associated with private initiatives. The Delta Commission advocates creating links between projects within the context of flood safety and area-specific spatial planning, such as proposed in the Long-range Sand Meuse II Plan. If this plan is executed, it will already provide for a considerable share of the necessary river enlargement measures needed to cope with the expected 4600 m^3/s discharge. That is a further step in the direction of the IVM Study’s long-term objective, but at a much lower cost to government than calculated in the latter study. A proactive, programme-driven approach can save a great deal of money in this way, and by focusing on other socially relevant objectives it can also count on more support.

Delta Commission

In a recent advisory report, the Delta Commission devotes a section to the Meuse Works:

> *The Meuse Works programme must be implemented without further delays. Subject to cost-effectiveness, measures must be taken already now to accommodate discharges of 4600 m3/sec for the Meuse. In this context negotiations with neighbouring countries have to be conducted under the European Directive on the assessment and management of flood risks in order to harmonise measures. Furthermore, room must be reserved and, if necessary, land purchased so that measures can be taken in the future to safely discharge the 4600 m3/s of Meuse water. Room must be reserved and, if necessary, strategic land positions acquired to allow the river system to safely discharge 4600 m3/s of Meuse water. The possibility of establishing a permanent preference right must be investigated. In anticipation of climate change in a manner comparable to the approach taken to the Rhine, implementation of the Overall Survey of the Meuse II should be prepared in cooperation with the region.*

Safety	Flood risk	

Conclusion

The Meuse Works are being executed in order to achieve the necessary level of safety by 2015. By implementing the measures proposed in the IVM Study, it will be possible to maintain the target safety level even in the event of a peak discharge level rising to 4600 m^3/s (anticipated in 2100). The Sand Meuse II project is already undertaking a number of the measures proposed in the IVM Study, in anticipation of climate change. In this way, Limburg is following the Delta Commission's recommendations.

3.3 Water shortage

The Province's water shortage and drought policy is not yet climate proof for 2050. The Draft Water Management Plan shows that the Province intends to tackle this subject, however.

Drought impacts the discharge level of the Meuse, the distribution of Meuse water in dry periods, water shortages in agriculture and the natural environment, and the uptake of water to produce drinking water and cooling water. The Draft Water Management Plan indicates that measures must be introduced covering all these issues, and that present policy does not adequately address the effects of long-term drought.

Low water discharge in the Meuse

Water from the Meuse is supplied to farms and nature areas via canals. The Provincial government has established a series of "restriction measures" to cope with dry periods when water is not in plentiful supply. Based on these measures and an international convention governing the distribution of Meuse water, agreements have been reached concerning how much Meuse water is available in Limburg in periods of drought. It was decided in 1994 to expand the water supply, and this system remains satisfactory in the present situation.

There is some discussion as to whether it is still necessary to supply water to the Groote Peel Nature Reserve, and whether it can be replaced by local measures, making it possible to conserve local water. Although it may be true that nature conservation areas currently have less need of a water supply in dry periods, in the long term, as dry periods occur more frequently and become more extreme, the natural environment and agriculture will probably benefit from any such supply. Research should demonstrate whether it makes sense to construct reservoirs.

Phase one of the water supply expansion project is currently being evaluated, as stipulated in the water management agreement governing the canals in Central Limburg and Noord-Brabant. Based on the outcome, a decision will be reached on the need to expand the water supply further (phase 2). If expansion is given the go-ahead, the project will naturally have to take recent climate scenarios into account.

Absorption capacity

It would be very expensive – and therefore probably unfeasible – to increase the Province's water supply options. One important way of combating desiccation (and other effects, such as excess water) is to improve the absorption capacity of the soil. The Provincial Environment Plan indicates that by 2015, the absorption capacity of the soil should have improved considerably thanks to the Desirable Groundwater and Surface Water Regime (GGOR). The water boards will take relevant steps for Natura 2000 wetlands, the other priority desiccated areas, and many of the desiccated areas most likely to recover. An increase in the soil's absorption capacity will make more groundwater available in dry periods and reduce dependence on water extraction during drought. Additional measures will be needed to prepare for 2050.

Drinking water

The Province's drinking water policy does not yet take climate change scenarios explicitly into account. The Draft Water Management Plan does indicate that a sustainable water supply is needed, however. It seems it will be necessary to introduce further policy and measures that take climate change more specifically into account. The prognoses of Limburg's water supply company, WML, do do this.

Water shortage	Fresh water shortage	

Conclusion
A policy on combating water shortages has been established (improving absorption capacity of soil, evaluating water management agreement). The policy was not, however, designed to take explicit account of climate change. It would be advisable for it to do so. Additional policy is needed in order to prepare for the climate scenarios in 2050 (specifically, the G+ and W+ scenarios).

3.4 Water quality

The Provincial Water Management Plan envisages improving water quality (i.e. achieving a good chemical and ecological status) by tackling or continuing to tackle storm overflows (that empty into vulnerable water courses), improving the effluent of sewage treatment plants, and restoring streams. The chemical quality of the water will improve considerably by tackling the overflows and sewage treatment plants. Restoring streams will improve the natural character, water transport capacity and self-cleansing ability of streams. When restoring streams, attention must go to natural woodland (shade) along upper reaches in order to reduce temperature rises. The self-cleansing ability of the Meuse (and especially the Border Meuse) has been improved somewhat owing to new riverine wildlife. All these measures improve the chemical and ecological quality of the water and reduce the risk of non-compliance with standards. With respect to stagnant waters, the risk remains that climate change will lead to more frequent occurrences of blue-green algae and botulism owing to higher summer temperatures. With respect to streams, there is still the risk that climate change will make it difficult to achieve the WFD objectives on time.

After 2015, then, extra measures will be needed to maintain the improvements achieved in water quality and to continue such improvements under conditions of climate change. One possibility is to take a more general and far-reaching approach to tackling the manure problem at national level and to continue at regional level to improve the efficiency of sewage plants and the storm overflows that discharge into vulnerable water courses.

Water quality	blue-green algae/botulism (swimming water)	
	storm overflows (miscellaneous water)	
	ecological standards (WFD)	
	chemical standards (WFD)	

Conclusion
Current policy is designed to improve water quality as much as possible in the period preceding 2015, but by 2027 at the latest. As there is a risk that climate change will make it impossible to achieve the WFD objectives on time, extra measures will very likely become necessary after 2015.

3.5 Urban areas

Excess water

The Water Management Plan (POL) is based on the updated National Administrative Agreement on Water (NBW) and the KNMI'06 scenarios. With respect to excess water, the plan states:

> *In urban areas with a lot of paved surfaces, short heavy showers in the summer are indicative of excess water drainage problems. In accordance with the updated NBW (2008), when packages of measures are being developed for urban areas, multiple climate scenarios (ranging from a 5% to a 27% increase in peak precipitation) should be used alongside one another. From the perspective of sustainability and cost-effectiveness, we ask the municipal authorities in urban areas to take a peak precipitation of 20% as a basis when developing policy measures.*

Health

The Provincial Environment Plan has no separate policy concerning heat stress. The quality of life in the city is an important theme in the "Investing in towns and villages" programme. The presence of water and greenspace is regarded as important for the quality of the built environment, as both reduce heat stress. There is a policy on air quality, but it must be developed and implemented further.

Research at Erasmus Medical Centre, Maastricht University, the National Institute for Public Health and Environment (RIVM) and the Living Environment Planning Office on the impact of global environmental changes indicates what can be done to moderate the effects of heat waves: build cooler homes, have more greenspace in cities, provide more public information and encourage changes in behaviour. There is no policy in Limburg focusing specifically on these factors.

Urban areas	Excess water in urban areas	
	Health: Heat stress/air quality/sickness	

Conclusion

Extreme showers increase in all of the scenarios. The W scenario forecasts the biggest increase (27% compared to 1990), and recent research has shown that this figure may be even higher. It is vitally important that the policy set out in the Draft Water Management Plan (POL) is pursued, and that the Province is pro-active about keeping track of new information on possible increases in intensive showers.

There is very little policy concerning the health aspects related to climate change. This applies to all the climate scenarios, the warmest and driest (W+) being most important.

3.6 Agriculture

Water damage

The Provincial Environment Policy aims to restore the natural water-storage capacity of the water system and in doing so, improve the absorption capacity of the soil, so that peak discharges can be moderated. The policy is based on heavy summer showers similar to those forecast in the G, G+ and W+ scenarios (10% more precipitation). The W scenario forecasts the most extreme showers (27% increase in heavy showers compared to 1990). Cost considerations led to a deliberate decision to exclude this extreme scenario when considering the water-storage capacity of the water system.

For a discussion of absorption capacity, see the section on drought. In addition to tackling short-term problems, the Draft Water Management Plan also aims to limit excess water and water shortages in the regional water system by making more room for water available (where possible), in anticipation of climate change.

Erosion

A range of different measures is being taken in the South Limburg Downs to combat erosion. Erosion causes fertile soil to be washed out of the fields and leads to mud accumulating on roads and in residential areas.

The Draft Water Management Plan indicates that the erosion and mud problem must be tackled. At the moment, the Province is working on a new erosion regulation that obliges farmers to take effective measures against erosion in order to improve the infiltration of water and prevent run-off (water and mud). The new regulation will be the product of the Limburg Agriculture and Horticulture Federation (LLTB), the water board and the Province. The water board and the municipal authorities will ensure that the water and loess that does run off is captured in rainwater buffers and/or can be drained away effectively. Current policy does not make sufficient provision for the W scenario, however.

Drought damage

The strategy set out in the Provincial Environment Plan is to maintain the groundwater supply as much as possible. This means that the agriculture sector must not extract more water than it does at present (the "stand still" principle). By 2015, the Province must have put the Desirable Groundwater and Surface Water Regime (GGOR) into place. Within this context, policy focuses on water conservation by artificially raising water levels and increasing water-level-controlled drainage; this will generally allow farmers to continue their operations while cutting back on spray irrigation and having more water available in drier periods. Coping with climate change after 2015 will require additional measures, with farmers having to adapt to more extreme artificially raised water levels and to adjust their cultivation practices to drier, hotter circumstances with heavier showers. The Province's long-range rural development programme targets sustainable agriculture, in particular the sustainable use of water leading to less water consumption, so that farms can manage better in periods of drought.

Diseases and pests

There is no separate policy on preventing diseases and pests that may arise owing to climate change.

Opportunities

There is no separate policy concerning new opportunities for agriculture.

Agriculture	Water damage/erosion	
	Drought damage	
	Diseases and pests	
	Opportunities in agriculture	

Conclusion

The policy concerning excess water takes climate change but not drought explicitly into account. The policy concerning erosion is being developed. The Provincial Environment Plan has sustainable agriculture as one of its aims, but there is no policy on a possible increase in diseases and pests, for example. There is also no policy on keying into opportunities for agriculture arising from climate change.

3.7 Nature conservation

Biodiversity/ability to adapt

The Provincial Environment Plan has identified the creation of a National Ecological Network (NEN, P1) before 2018 as a means to maintaining biodiversity. To maintain biodiversity, it is vital to have robust nature conservation areas. The NEN consists of existing woodland and nature conservation areas, new

nature conservation and managed areas, and waters (Meuse Lakes) and streams that have a specific ecological function ("SEF" streams). The Province's NEN policy focuses on protecting and creating a harmonious, robust structure of larger nature conservation and woodland areas and corridors between them, including the Schinveld-Mook corridor. One of the objectives of the Meuse Works is the expansion of the NEN. A supplement to the Provincial Environment Plan also covers the robust corridor between Schinveld and Mook. This corridor makes a major contribution to climate proofing the natural environment in Limburg.

Climate change will make it even more important to have larger uninterrupted tracts of nature conservation land and to ensure that such areas join up across borders. Redefinition of the boundaries of the NEN on ecological grounds – a process that has already been undertaken in the revision of the Province's Nature, Woods and Landscape Incentive Plan – should also be considered with respect to the consequences of climate change. For Limburg, the biggest opportunities lie in improving existing robust and uninterrupted tracts of nature conservation land (see Section 4, nature conservation adaptation measures). The ecological corridors between these areas constitute the most serious problems, as they are under tremendous pressure from urban development and infrastructure (see also Section 4, nature conservation adaptation measures). Some of these zones lie outside the NEN or across the national border. Existing policy focuses to some extent on creating such areas (implementation of the Province's Long-range Rural Development Programme, area-specific spatial planning coalition programme, cross-border consultation, creation of a Green Provincial Development Zone).

In addition to the NEN, the Provincial Environment Plan also covers the Green Provincial Development Zone (POG), which combines with the NEN to form the ecological network in Limburg. The importance of having multifunctional green zones like the POG is that they can increase the climate-proof buffer zone around the NEN. Specifically, linking the NEN and the POG to the water-related objectives in the Provincial Environment Plan (Perspective 3, Room for Resilient Water Systems) generates more opportunities to create a multifunctional climate-proof buffer zone (see also Section 4).

Desiccation

The Provincial Environment Plan states that, based on the Desirable Groundwater and Surface Water Regime Framework Act (2006), the water boards will produce a Desirable Groundwater and Surface Water Regime (GGOR) for Natura 2000 wetlands (including those dependent on groundwater), other priority desiccated areas, and large stretches of desiccated areas most likely to recover. The water boards are presently working on this regime. The Province's Water Management Plan aims to restore aquatic wildlife by making improvements to the system by 2015.

Inability to achieve nature target types or need to modify such targets

In a changing climate, one relevant question for existing or new nature conservation areas is whether the nature target types are still feasible in Limburg. No policy has been developed in this regard as yet. There are opportunities in this respect, for example within the Natura 2000 area management plans. In addition, much can be done to improve internal heterogeneity (gradients) within existing nature conservation areas. For example, woodland comprises approximately 80% of nature conservation areas in Limburg, making it highly dominant, and the quality of the woodland vegetation in North and Central Limburg is poor. Multifunctional nature conservation targets and legislation sometimes impede the remodelling of natural features and more process-driven management of nature conservation areas. Improving gradients will increase natural resilience and the ability of nature to cope with climate change.

Nature conservation	Biodiversity/ability to adapt	

	Desiccation	
	Inability to achieve nature conservation targets or need to modify such targets	

Conclusion

The impact of climate change is only a very minor consideration in current nature conservation policy. Fragmentation, the creation of the NEN with the robust Schinveld-Mook corridor, and protection of species go a long way towards overcoming current barriers. Additional policy is likely to be necessary in order to preserve biodiversity in the new climate of 2050. Such policy should focus on creating more and larger uninterrupted tracts of nature conservation land (prioritisation), main corridors between these areas, and the embedding of the NEN in a multifunctional climate-proof buffer zone of P2 and P3 areas (see Section 4). Desiccation is a problem in both the G+ and W+ scenario, requiring additional policy. Some nature target types will not be compatible with the changing climate. Adjusting such targets in order to improve gradients will increase natural resilience and robustness, making it easier to cope with the consequences of climate change.

3.8 Recreation

Provincial Long-range Rural Development Programme

The Province's Long-Range Rural Development Programme keys into this theme by proposing improvements to the tourist and leisure sector. Climate change is not considered here, even though higher temperatures could lead to a greater demand for recreational areas in the countryside. Improving the leisure sector, especially along the Meuse, can therefore be regarded as a form of climate adaptation.

Long-range Sand Meuse II Plan 2007-2015

The growing level of prosperity and the ageing of the population will increase the importance of the leisure sector. The Meuse offers enormous potential in this respect. Climate adaptation projects can be combined with efforts to improve recreational opportunities. One important factor in improving the leisure sector is to ensure a good quality of water (see section 3.4).

Recreation	Opportunities for recreation	

Conclusion

The policy on recreation has not been tailored to the opportunities and challenges of 2050. It does, however, involve making improvements to the leisure sector.

3.9 Infrastructure

The Provincial Environment Plan does consider climate proofing the road infrastructure. Once it has been selected, it is very difficult to alter the route of a road or of other infrastructure, owing to the huge investment and long procedures involved. Flood risks or changes in groundwater levels may lead to problems along existing routes. The dimensioning of existing structural works and road designs may be inadequate if the drainage capacity is insufficient to cope with more intensive rain showers. The road surface may be insufficiently robust. There will be more frequent periods of tropical temperatures, with ruts forming in roads more quickly (unless adjustments are made).

In the dry scenarios (specifically W+), the navigability of the Meuse will become problematic, a threat that has not yet been addressed in current policy. The Delta Commission has also emphasised the problem that drought will cause for shipping:

> *Shipping will be confronted more often with low river discharge levels in the extreme climate scenarios, which involve longer periods of drought. Dry summers, like that of 2003, may become standard and lead to many problems. The navigable depth can be improved by constructing longitudinal dams along the groynes to narrow the channel. The Commission also believes that the shipping and other transport sectors would do well to anticipate longer periods of drought by building vessels suitable for lower water levels and by making other technical adjustments. The Commission also recommends making more use of multimodal transport. Such transport combinations should be taken into account in plans to construct new transport hubs and transhipment centres and, where possible, they should be linked to flood safety measures*.

Infrastructure	Wet infrastructure	
	Dry infrastructure	

Conclusion

Climate change will have effects on infrastructure (e.g. drainage and rutting of roads; navigability of the Meuse) that have not been sufficiently acknowledged in policy making.

4 ADAPTATION CHALLENGES FACING THE PROVINCE OF LIMBURG

4.1 Introduction

This chapter presents an initial picture of the adaptation challenges facing the Province and the measures needed to meet those challenges. It will begin by reviewing the outcomes of Sections 2 and 3 in the table below. It will only be possible to summarise the adaptation challenges for policy makers at provincial level, however, after identifying the Province's task in this regard. That is done in Section 4.2. The challenges are then described in Section 4.3. Section 4.4 offers an initial attempt at describing the necessary measures.

Theme	**Effect**	**KNMI'06**			
		G	**W**	**G+**	**W+**
Safety*	Flood risk	-	-	-	- -
Water shortage	Fresh water shortage	+/-	+/-	-	- -
Water quality	Blue-green algae/botulism (swimming water)	-	-	-	- -
	Storm overflows (miscellaneous water)	-	- -	-	-
	Ecological standards (WFD)	-	-	- -	- -
	Chemical standards (WFD)	-	- -	-	- -
Urban areas	Excess water in urban areas	-	- -	-	-
	Health	-	-	-	- -
Agriculture	Water damage/erosion	-	- -	-	- -
	Drought damage	+/-	+/-	-	- -
	Diseases and pests	-	- -	-	- -
	Opportunities in agriculture	+	+	+	+
Nature conservation	Biodiversity and ability to adapt	-	-	-	- -
	Desiccation	+/-	+/-	-	- -
	Inability to achieve nature conservation targets or need to modify such targets	-	-	-	- -
Recreation	Opportunities for recreation	+	+	+	+
Infrastructure	Wet infrastructure	+/-	+/-	-	- -
	Dry infrastructure	+/-	-	-	- -

Table 4.1: Climate effects and existing policy.

Legend:

	policy inadequate, not incorporated into policy, blank spot
	some aspects of policy have been climate proofed, some blank spots still exist
	policy takes climate change adequately into account. Implementation and monitoring merit attention

The foregoing table contrasts the climate effects described in Section 2 with the existing policy described in Section 3. This gives us an initial impression of the climate effects not covered by policy, or to an inadequate extent. The main conclusions are:

- Safety has been guaranteed to 2015 by the Meuse Works. There is policy covering climate proofing after that date. It would be advisable to begin introducing measures now, for example as is being done in the Sand Meuse II project.
- The policy concerning drought and water shortages takes little explicit notice of climate change. In particular, the G+ and W+ scenarios increase the risk of drought-induced summer water shortages combined with heavy showers. This could give rise to a shortage of fresh water with drought causing (irreversible) damage to agriculture and wildlife and problems with drinking water (collection) and cooling water (use), navigability, infrastructure (rutting of roads) and water and air quality.
- Excess water in urban areas is reasonably well covered in current policy, although it is inadequate for the W scenario.
- Health problems arising from heat stress, poor air quality and the possible spread of new diseases are most likely in the warmest and driest scenario (W+) and are not addressed in current policy.
- The Province is already investing heavily in the NEN and thus in nature conservation, which requires a climate-proof approach. To some extent, this will involve making the most of the robust nature conservation areas that fall under the NEN (possible prioritisation with respect to the remaining NEN areas); for the rest, it involves improving the resilience of nature conservation areas by surrounding the NEN by a climate-proof buffer zone of P2 and P3 areas developed to support nature conservation. The nature conservation targets may not be climate proof. Additional knowledge is required.
- Additional policy is also needed for agriculture, nature conservation, recreation and infrastructure, specifically:
    - Agriculture: policy on possible opportunities generated by climate change.
    - Recreation: swimming water quality and opportunities arising from climate change.
    - Wet infrastructure: navigability in dry scenarios.
    - Dry infrastructure: insufficient robustness of existing structural works and inadequate road design (e.g. stability of subsoil, inadequate drainage capacity, increase in road rutting).

4.2 The role of the Province in climate adaptation

The right-hand column of the table below provides an initial estimate (by DHV) of the role the Province can play with respect to the various themes. It is important to consider that role in-depth for each of the themes when drafting climate adaptation policy.

Theme	Effect	KNMI'06				Province's task
		G	W	G+	W+	
Safety*	Flood risk	-	-	-	- -	P
Water shortage	Fresh water shortage	+/-	+/-	-	- -	P
Water quality	Blue-green algae/botulism (swimming water)	-	-	-	- -	M
	Storm overflows (miscellaneous water)	-	- -	-	-	M
	Ecological standards (WFD)	-	-	- -	- -	M
	Chemical standards (WFD)	-	- -	-	- -	M
Urban areas	Excess water in urban areas	-	- -	-	-	M
	Health	-	-	-	- -	M
Agriculture	Water damage/erosion	-	- -	-	- -	P
	Drought damage	+/-	+/-	-	- -	M
	Diseases and pests	-	- -	-	- -	M
	Opportunities in agriculture	+	+	+	+	M
Nature conservation	Biodiversity and ability to adapt	-	-	-	- -	P
	Desiccation	+/-	+/-	-	- -	P
	Inability to achieve nature conservation targets or need to modify such targets	-	-	-	- -	P
Recreation	Opportunities for recreation	+	+	+	+	M
Infrastructure	Wet infrastructure	+/-	+/-	-	- -	P
	Dry infrastructure	+/-	-	-	- -	P

P = Primarily the province's task, M = Minor or shared task for the Province

Table 4.2. The role of the Province in climate adaptation

Legend:

	policy inadequate, not incorporated into policy, blank spot
	some aspects of policy have been climate proofed, some blank spots still exist
	policy takes climate change adequately into account. Implementation and monitoring merit attention

What does the Province not do?

Management of the Meuse is the task of the Department of Public Works and Water Management [*Rijkswaterstaat*]. The Meuse embankments are the responsibility of the water boards. The Province is closely involved in safety because it plays a key role in area-specific spatial planning along the Meuse, supervises the water boards, and coordinates crisis management in floods.

What is primarily the Province's task?

The climate adaptation themes for which the Province bears primary responsibility are:

1. for safety: area-specific spatial planning along the Meuse;
2. investing in nature conservation;
3. constructing and managing infrastructure (provincial roads);
4. formulating policy for the water board with respect to water shortages and excess water .

The Province also plays a role in greenports and in leisure area development.

In addition: climate proofing provincial policy, making general knowledge of climate adaptation available to lower tiers of government, and taking the initiative to fill in gaps in knowledge. Prioritisation between the various themes is primarily something that should take place within the Province, in coordination with other provincial policy and objectives.

4.3 Climate adaptation challenges

Based on the blank spots identified (Section 4.1) and the task of the Province (Section 4.2), we can provide an initial list of the climate challenges that the Province of Limburg should address in its policy.

- Safety is a priority theme. Safety is guaranteed until 2015. Additional measures have been developed for the period thereafter, but more effort must be made towards implementing them. A recent report by the Delta Commission indicates the need to make an extra effort to ensure the level of safety along the Meuse; any spatial development plans should already take this into account.
- Adjustments related to drought and fresh water shortage: the adjustments needed to cope with the dry scenarios (W+ and G+) require policy adjustments with respect to agriculture and nature conservation, drinking water (collection), cooling water (use), navigability, infrastructure (road rutting), water quality and air quality.
- Climate-proof investment in nature conservation: The Province is already investing heavily in the NEN and nature conservation, which requires a climate-proof approach. To some extent, this will involve making the most of the robust nature conservation areas that fall under the NEN (possible prioritisation with respect to the remaining NEN areas); for the rest, it involves improving the resilience of nature conservation areas by surrounding the NEN by a climate-proof buffer zone of P2 and P3 areas developed to support nature conservation. Nature conservation targets may not be climate proof. Additional knowledge is required.
- Climate-proof area-specific spatial planning: The Province's large-scale area-specific spatial plans offer considerable leeway for adaptation measures in projects and property development programmes: nature conservation can be enhanced, water retained, provision made for excess water caused by intensive precipitation, and measures introduced to alleviate heat stress. It is possible to "link" climate adaptation to existing development programmes. In order to implement such measures, we must constantly be on the lookout for adaptation opportunities in existing area-specific spatial development projects (and beyond). As the coordinating body for such developments, the Province can put climate adaptation on the agenda and keep it there.
- Health problems resulting from heat stress and a possible deterioration in urban air quality can arise in each of the scenarios. The W+ scenario is expected to cause the biggest problems. The Province may be able to address this issue as part of the "Investing in towns and villages" programme.

One step that has yet to be taken is to describe the challenges ahead in as much detail as possible: what steps should be taken in each theme? We advise on this matter in Section 5. The section below gives an initial impression of the various adaptation measures that must be introduced.

4.4 First impression of adaptation measures

This section addresses the uncertainties, knowledge gaps and robustness of the system and possible adaptation measures. It can be fleshed out after the climate issues have been specified in more detail. Appendix 3 looks more closely at how to deal with uncertainties and the robustness of the system.

General points

Improving the absorption capacity of the soil is a “no regrets” adaptation measure that will help alleviate a number of climate change effects (drought, water shortage, excess water, wet damage, erosion and nature conservation):

- The strategic policy on absorption capacity set out in the Provincial Environment Plan should be vigorously pursued. Significant methods include developing stream valleys, combining policy with measures to combat desiccation/develop nature and landscape conservation areas, using space for multiple purposes, and executing area-specific spatial development projects.
- The stream valleys and low-lying areas should be kept clear of building where possible and used to catch and retain water. Only activities that are suited to a natural water system and do not limit room reserved for water should be permitted in stream valleys.

Flood risk

Uncertainties

With respect to high water discharge levels, the most important uncertainties are structural ones related to the scale and speed of climate change. With respect to low river discharge levels, trends in the demand for water in Belgium and downstream add to the uncertainty when determining the seriousness of a possible low-level discharge.

Robustness of the system

The Meuse is not climate proof at the moment, but the aim of current policy is to make it so. The flood prevention system is itself somewhat inflexible. It is difficult to build or reinforce embankments with any speed, and hard to convert built-up areas into overflow areas for high water levels. The policy on high water levels is reasonably climate proof, with a reasonable balance between the policy timescale and the period of time in which adjustments can be made.

That is otherwise for low water situations. It is much less clear whether the Meuse system can be easily adjusted to extreme drought conditions.

Adaptation measures for Meuse discharge levels

1. Monitor climate change (and expertise about such change) and the implications for river discharge levels.
2. Always consider spatial planning measures in the Meuse Valley in the light of the adaptation challenges and the Room for the River policy (see, for example, the area-specific spatial plans for Ooijen-Wanssum).
3. Implement current policy (including efforts to tackle problems in the Meuse catchment area at Ooijen-Wanssum, and the bridge at Buggenum) and simultaneously try to extend the climate adaptation strategies. The most important strategy at this point is to prevent flood damage, but other strategies may offer more opportunities. The Province will have to review this together with the Department of Public Works and the municipal authorities.

Water shortage

Uncertainties
One important gap in our knowledge about climate change in Limburg concerns the impact of drought and the increase in heavy showers on the replenishment of groundwater on the limestone plateau. It is important for us to know this because the availability of drinking water depends on having sufficient groundwater.

Robustness of the system
Functions that depend on the water and nature system have not yet been adapted to a fresh water shortage. The system is not only not robust, it is also not flexible.

Adaptation measures

1. The calculations of the GGOR measures needed to combat drought should also take the impact of climate change into account, preferably for the G+ scenario.
2. The GGOR measures should be implemented with extra robustness based on these calculations.
3. The hydrological implications of climate change for existing and new nature conservation areas must be estimated, leading to a clear idea of potential effects for nature target types in these areas. Any large-scale spatial consequences and measures should be determined, at least in part, on the basis of the W+ scenario.
4. Research should be performed into the potential consequences of dry periods and possible precipitation shortages for groundwater replenishment on the limestone plateau.
5. Research should also be conducted into possible trends in the demand for water and the extent to which supplies must be drawn from the Meuse to meet that demand. Further research should explore the options available to eliminate any unbalance in water supply and demand during drought. This could perhaps take place within the context of the new national drought study announced in the National Water Management Plan.

Water quality
Uncertainties
In addition to the structural uncertainties, there are two important gaps in our knowledge of water quality. We do know something about the relationship between climate change and water quality when it comes to various aspects of the water system. However, changes in precipitation patterns and temperature will ultimately combine to influence water quality. Heavier rainfall will force us to use overflows more intensively, for example; combined with higher temperatures, this will affect water quality. We know even less about the relationship between these two factors and their combined effect.

The second gap in our knowledge concerns the impact of the changing quality of water resulting from climate change and the problems that will cause. It is clear that blue-green algae and botulism will cause problems, but we know far less about other factors, for example the extent to which the combination of higher temperatures and stagnant water will attract new and problematic insects to the Netherlands.

Robustness of the system
We can generally say very little about the climate-proof status of Limburg's water quality. The extent to which water quality will continue to comply with the Water Framework Directive standards under changing climate conditions depends largely on location-specific circumstances.

Climate adaptation measures for water quality

6. The measures set out in the Water Framework Directive play an important role in climate proofing. Additional measures are needed to prevent overflowing sewers by decoupling drains from sewers and increasing their capacity, restoring streams and improving the flow of urban

waters. These various options can be worked up in detail within the area-specific spatial development plans for Central Limburg, Parkstad Limburg and the South Limburg Downs (*Heuvelland*).

Urban areas

Uncertainties

The biggest sources of uncertainty are the structural uncertainties about the scale and speed of climate change and social and economic trends influencing the size of the urban area. One gap in our knowledge concerns the relationship between climate change and air quality, especially in the Meuse Valley.

Robustness of the system

Urban systems are not very flexible. It is difficult to alter spatial planning, buildings and functions in built-up areas.

Adaptation measures for urban areas.

1. Adopt “no-regret” measures (to achieve a broad range of adaptation strategies) in urban spatial planning programmes (as is the case in Parkstad Limburg) and urban redevelopment projects that make it possible to cope with heat stress, excess water arising from heavy showers, and water quality problems (for inspiration, see www.hotspottilburg.nl). Examples of no-regret measures are: more greenspace in the city to combat heat stress (see insert on “cool building") and corridors between ecological networks to give flora and fauna more opportunity to adapt to changing circumstances.
2. Consider the risks in the event of very long-term investment (e.g. sewers and infrastructure).
3. Explore the relationship between climate change and air quality in the Meuse Valley.

Building for coolness

There are examples around the world of urban planning projects and individual buildings that are designed to avoid heat or to offer coolness in hot weather (without using energy-intensive solutions like air-conditioning):

- green roofs (www.greenroofs.worldpress.com)
- heat-resistant roofs (USA)
- building with greenspace and water (Tokyo)
- shade created by tall buildings and narrow streets (Mediterranean cities)
- better passage of air through cities (Tokyo)
- “coolness parks” (eight sites in Achterhoek region of the Netherlands)

Figure 4.1 Green roof in Tokyo (www.greenroofs.worldpress.com).

Agriculture

Uncertainties

One current gap in our knowledge concerns the opportunities that the new climate conditions will generate for new agricultural activities and crops in Limburg. Another concerns the influence of climate change on diseases and pests that pose a risk to agriculture in Limburg. The third uncertainty is how the demand for water in agriculture will evolve in areas that now depend on spray irrigation.

It should be noted that the potential impact of climate change on agriculture is relatively small (specifically, changes in crops and growing seasons) compared with the impact that general economic trends and trends in EU agricultural policy will have; in particular market forces and demographic trends have a major effect on agriculture in the Netherlands.

Robustness of agriculture

The agricultural sector is not currently climate proof. In theory, the sector has considerable ability to adapt to new circumstances. Although it will not be possible to switch to new crops overnight, the transition can be achieved in a few years' time. Agriculture's ability to make physical adaptations is often limited by economic factors, however.

Adaptation measures for agriculture

1. In the short term, the most obvious path is to continue introducing no-regret measures focusing on water efficiency in agriculture.
2. In addition, the Greenport Venlo development offers a good opportunity to explore new agricultural activities and crops, following the example set by the Climate and Agriculture Hotspot in the north of the Netherlands.

Climate and Agriculture in the northern Netherlands
The Climate and Agriculture project group for the northern Netherlands was set up in 2007. The purpose of the group is to survey development opportunities for agriculture in the northern Netherlands within the context of climate change. The most important questions that the group is addressing are:

- What consequences will climate change have for production conditions and emergencies?
- Is the agriculture sector in the northern Netherlands resilient enough to cope with climate change?
- What are the implications for spatial planning and the necessary changes in agricultural practices? What are the implications for other functions?

For more information: www.klimaatvoorruimte.nl project A21.

Nature conservation

Uncertainties
Much work is being done to increase our knowledge of the consequences of climate change for the natural world. Nevertheless, the development of a climate-proof natural conservation policy in Limburg is impeded by various gaps in our knowledge. For example, we do not entirely understand the consequences of climate change for specific target species in Limburg, and we also know too little about the robustness of some ecosystems in the province, for example moorland.

Robustness of nature
The adaptability of the natural world to new climate conditions is impeded mainly by the fragmentation of nature conservation areas, the limited scale of some of the existing nature conservation areas, and the fact that much of land bordering such areas is unsuitable for nature conservation purposes. This makes the climate-proof status and robustness of nature an important point of concern. That applies to nature conservation policy as well, some of which focuses on preserving current species.

Adaptation measures for nature conservation

1. *Improve the robustness of nature conservation areas.* Improving the corridors and reducing the fragmentation of the NEN to promote nature conservation is a no-regret measure that will boost the climate-proof status and robustness of Limburg's natural environment. The "Robust Schinveld-Mook corridor" is now known throughout the Netherlands as an example of climate-proof nature conservation. It is important that this supplement to the Provincial Environment Plan succeeds, with the creation of the German sections of the corridor across the border being essential to its success.
2. Climate change will make it even more important to have larger uninterrupted tracts of nature conservation land and to ensure that such areas join up across borders. Redefinition of the boundaries of the NEN on ecological grounds – a process that has already been undertaken in the revision of the Province's Nature, Woods and Landscape Incentive Plan – should also be considered with a view to the consequences of climate change. For Limburg, the biggest opportunities lie in the robust Schinveld-Mook corridor and in reinforcing the Border Meuse/Meuse Lakes and Sand Meuse, the east-west corridor between these areas via stream valleys, the Peel peat fens (although this poses risks to nature conservation targets), the

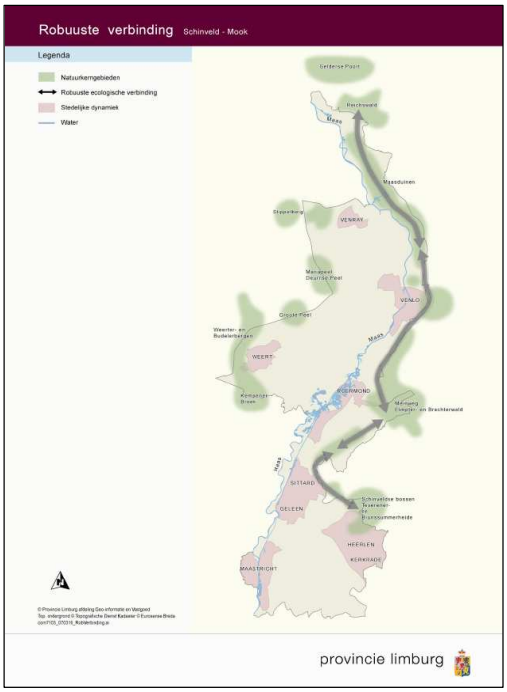


Figure 4.2: Robust corridor Schinveld-Mook, Source: Province of Limburg.

Weerterbergen and Budelerbergen / Wijffelterbroek nature conservation area, the Stramproyerbroek / Tungelroysche streams, the Geul valley/Gulp valley/Vijlen woods and the corridor to the Ardennes. The ecological corridors between these areas constitute the most serious problems, because of the pressure of urban expansion and infrastructure. These are the Meuse Dunes-Reichswald, the Venlo-East passage, the isolation of the Peel peat fens, the Border Meuse-Kempisch plateau, and the lack of east-west corridors through the A2 motorway zone between Roermond and Liège (Solvay, De Doort, Geleenbeek, Graetheide noord, Beek zuid, Geuldelta, area around Rijckholt, Voer). Some of these zones lie outside the NEN or across the border. Existing policy focuses to some extent on creating such corridors (implementation of the Province's Long-Range Rural Development Programme, area-specific spatial development coalition programme, cross-border consultation, creating a Green Provincial Development Zone). All area-specific spatial plans offer opportunities to help climate proof the natural environment and create a multifunctional climate-proof buffer zone (see above under 2).

3. *Surrounding the NEN by a multifunctional climate-proof buffer zone.* The natural environment would become more resilient if the NEN were to be surrounded by a multifunctional land-use zone focusing on nature and wildlife, agriculture, water management and recreation. A climate-proof buffer zone will also create space for dealing with any unforeseen risks of climate change in future. Four Green Provincial Development Zones (POGs) are already performing this task to some extent. Specifically, linking the NEN and the POG to the water-related objectives in the Provincial Environment Plan (Perspective 3, Room for Resilient Water Systems) generates more opportunities to create a "multifunctional climate-proof buffer zone". See the accompanying figure.[7]

[7] Source: *Natuur en klimaatverandering, wat kan het natuurbeleid doen?*, Alterra 2006

Figure 4.3: Example of multifunctional climate-proof buffer zone.

4. *Nature target types.* Policy measures undertaken within the current nature conservation policy and the static nature conservation targets do not take into account the increasingly dynamic nature of ecosystems as a result of climate change. This may mean that we will be working to achieve unattainable targets for far too long, while at the same time failing to make good use of the opportunities offered by climate change. That is why we must investigate the climate-proof status of nature target types. In addition, much can be done to improve the internal heterogeneity (gradients) of existing nature conservation areas. Multifunctional nature conservation targets and legislation sometimes impede the remodelling of nature conservation areas and a more process-driven management of such areas. Improving gradients will increase natural resilience and the ability of nature to cope with climate change. One example is the “climate buffer” which is being developed in the Weert woods.

Recreation

Uncertainties

Uncertainties concerning recreation mainly consist of structural uncertainties about the demand for recreational facilities and trends in tourism as a result of climate change.

Robustness of the system

The climate-proof status of the leisure and tourist sector in Limburg is closely related to the climate-proof status of the natural environment, water, agriculture and urban areas.

Adaptation measures for recreation

Climate change may offer the leisure and tourist sector new opportunities. The anticipated rise in temperature will generate a demand for more outdoor recreation and swimming locations. If tackled in a

way that combines nature conservation, creating room for the river, the development of recreational facilities, urban development and changes in agriculture, adaptation will offer the leisure and tourist sector new opportunities. Research is necessary into future swimming water quality before major work is undertaken to create more recreational facilities, for example in the Meuse Lakes.

Infrastructure

Uncertainties

In terms of Limburg's dry infrastructure, we do not yet have a clear picture of how climate change will affect specific roads. We know much more about the impact on wet infrastructure (Meuse), where the uncertainties can be traced to structural uncertainties (see Meuse discharge levels).

Robustness of the system

A distinction should be made between the robustness of the route (e.g. risk of flooding, possible subsidence owing to changes in groundwater level) and the robustness of the road itself (including vulnerability to rutting, dimensioning for drainage purposes).

Adaptation measures for infrastructure

- New routes. It is important to consider various risks and the possible effects of climate change when selecting a route and a design for an infrastructure project. Infrastructure is being developed in various area-specific spatial planning programmes. The climate-proof status of that infrastructure and its effect on the climate-proof status of the natural environment will be important adaptation challenges.
- Existing routes. Problems may arise along existing routes because of the risk of flooding or changes in groundwater levels. This requires further research.
- Dimensioning of existing structural works. The increasing intensity of peak drainage may lead to problems for existing structural works. This requires further research.
- Road surface: Roads may become rutted quicker owing to more frequent tropical temperatures. Changing the type of asphalt used during maintenance/major maintenance can help avoid this problem.

5 A CLIMATE-PROOF POLICY FOR LIMBURG: CONTINUED

5.1 How do other provinces tackle it?

Climate adaptation has developed into a prominent new issue in the past few years, alongside such existing policy themes as spatial planning, water management and nature conservation. Climate adaptation is not separate from these other themes, however - indeed, it is an integral part of existing issues. It will have to be regarded as a criterion when developing policy plans within the various areas of concern.

The various Dutch provinces differ from one another in the way they approach such integration. Some provinces have a climate change programme that covers both mitigation (reduction of greenhouse gas emissions) and adaptation. One good example is the climate change programme in Gelderland, entitled "Gelderland Climate Change Programme 2008-2011: Tackling and Adjusting" (draft version, Provincial Executive 27 May). The programme provides a general framework for adaptation that is then refined on a theme-by-theme basis, with an emphasis on nature conservation and water management. The overall aim is to arrive at a "climate-proof organisation by 2050", with the subsidiary objectives being "climate-proof nature conservation", "climate-proof water system", "climate-proof urban area" and "climate-proof roads and infrastructure" and the process-related objective "Adaptation must be an integral part of government policy and of the agenda of relevant social factors by 2015".

The Province of Utrecht also has an organisation-wide programme, "Climate in order", that aims to make climate change a more important topic of concern in various departments.

The Provinces of Groningen and Zuid-Holland have tackled climate adaptation mainly as a guiding principle in spatial planning. The Province of Groningen has made adaptation and the spatial impact of climate change an important consideration in the various phases of developing a new environment plan.[8] The Province of Zuid-Holland will be developing an action programme on Climate and Spatial Planning setting out various principles for making climate adaptation part of the Provincial Strategic Structure Agenda and Water Management Plan. Both provinces have selected various area-specific spatial plans for which the climate adaptation challenge will be investigated and worked up in detail. And both are playing a role in "Hotspot" projects that are being carried out within the framework of the government-funded Climate *changes* Spatial Planning Programme (CcSP) and Climate for Knowledge Research Programme (KfC).

Although Limburg's Provincial Environment Plan (POL) has already been drafted, the approach taken by Groningen and Zuid-Holland seems to be the most suitable here as well. That is first of all because the basic principles and working methods required for climate adaptation appear to correspond well with the principles and working methods of the POL – which focuses on the future and sustainability – and Limburg's area-specific spatial planning programme as defined in the coalition government programme.

The way in which the Province of Groningen has linked knowledge about climate change to the planning process can be adopted for the various area-specific spatial plans being carried out in Limburg at the moment. (See Figure 5.1 below.)

[8] See Chapter 9 in Rob Roggema, 2008, *Tegenhouden of meebewegen, adaptatie aan klimaatverandering en de ruimte*, WEKA/NIBE, Amsterdam/Bussum.

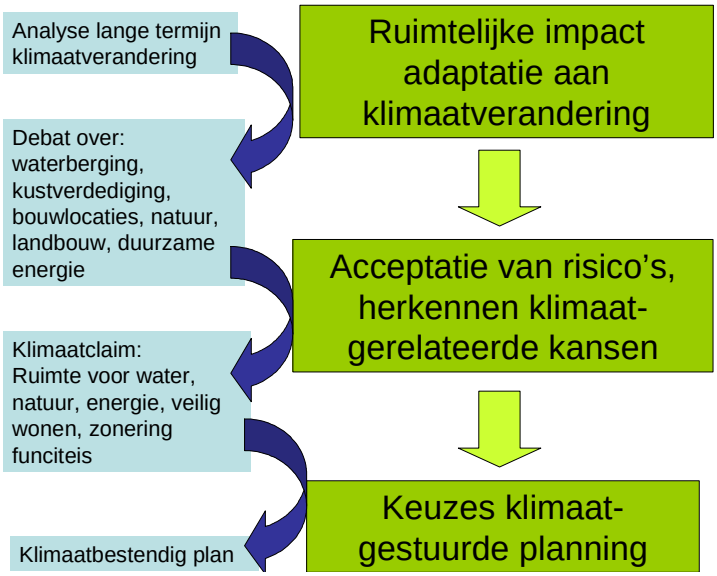


Figure 5.1: Integrating climate adaptation into the planning process (source: Roggema, 2008)

5.2 Advice on developing a climate-proof provincial policy

5.2.1 Process

In this document, *Foresight study on climate adaptation in Limburg*, the Province is continuing the process of developing a climate-proof policy for Limburg. We advise the Province to take the following steps to arrive at a climate-proof policy and its implementation.

Developing a climate-proof policy

Step 1: Fill in gaps in knowledge
Step 2: Take KNMI'06 scenarios as the basis
Step 3: Define climate adaptation challenges
Step 4: Include climate proofing in Provincial policy
Step 5: Implement Limburg's climate adaptation policy
Step 6: Monitor climate adaptation in Limburg
Step 7: Review policy at regular intervals

Step 1: Fill in gaps in knowledge
Determine targets for filling in gaps in knowledge. The Province plans to participate in a project set up by the Association of Netherlands Provinces (IPO) to develop provincial climate sketchbooks. This will perhaps lead to new insights important in determining targets and priorities for climate adaptation.

Step 2: Take KNMI'06 scenarios as the basis
The Province's Executive must decide that all policy shall be based on the KNMI'06 climate scenarios before that policy can be amended.

Step 3: Define climate adaptation challenges
In order to adopt the climate adaptation challenges set out in the present report, the Province must generate support for the same, the role that it must itself play, the selected priorities and the phasing. This means involving the relevant parties and stakeholders.

Step 4: Draw up a climate-proof policy
Climate adaptation should be incorporated into the various policy frameworks. We advise against having a separate implementation programme for climate adaptation. Climate adaptation should ideally be tackled comprehensively and should be added to the agendas of many different policy areas.

Step 5: Policy implementation
The next step is to implement and enforce the policy. This phase is particularly important if the Province depends on third parties for some or all of its policy implementation, but it is also important if the Province implements its climate-proof policy itself. The question is: who will carry out the policy, who has the right knowledge about climate change and adaptation, and who will make sure that the various consequences of climate change are accounted for in decision making?

Step 6: Monitor climate adaptation in Limburg
Researchers are rapidly coming to know more about climate change. The KNMI has already said that it will be publishing a new set of scenarios in 2012. The Delta Commission report will lead to a new Delta Plan with possible implications for Limburg. It is therefore important to monitor when policy will need to be reviewed in the light of new insights. In addition, research will produce a great deal of new information; it is important to keep close track of this flow of data and to use it when reviewing policy.

Step 7: Review policy at regular intervals
The Province's policy will need to be reviewed after the KNMI's new climate scenarios have been published, and possibly after the national government has issued its own policy on climate adaptation.

5.2.2 Organisation

To ensure that the Province follows the steps indicated above and is able to incorporate climate adaptation into its various units and address it in its various roles, it is important to set up a dedicated organisation. We propose setting up a climate adaptation team that will function as a knowledge repository and linchpin between the various provincial departments, programmes and area-specific spatial planning projects.

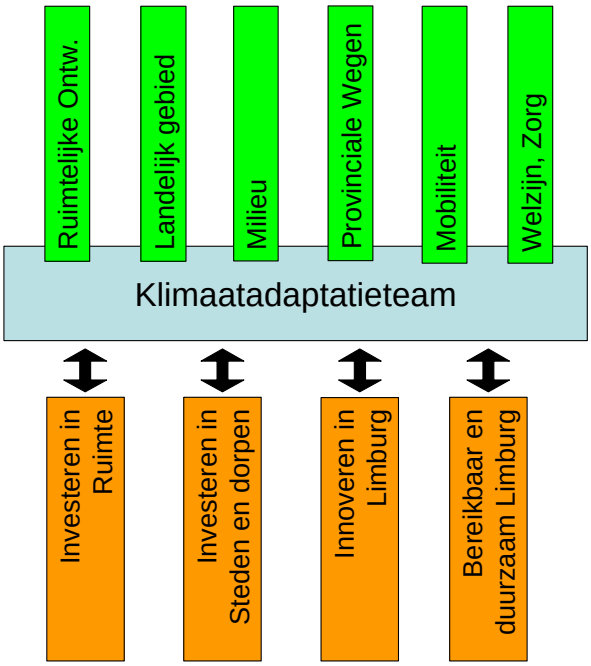


Figure 5.2: DHV recommendations for a climate-proof policy in the Province of Limburg.

Expert team on climate change and adaptation

The Province will set up a team of experts on climate change and adaptation drawn from the various policy areas, for example rural development, spatial planning, water management, agriculture and so on. This team will track developments in climate change and adaptation, as well as new information about these topics. The team will coordinate research on specific gaps in knowledge in Limburg, or conduct such research itself. Where necessary, it will also coordinate province-wide and multi-area strategic agendas (for example, a strategic agenda on improving the climate-proof status of the NEN in Limburg).

The climate team will consult regularly with contacts in the Province's various programmes, for example the coalition programmes and officials active in the Long-range Rural Development Programme. The team will disseminate information on climate adaptation among its contacts. It will also join its contacts in reviewing existing climate adaptation measures (although they may not be referred to as such), risks, requirements and opportunities, and how other measures can be implemented. This will avoid a situation in which climate adaptation becomes a separate programme that attracts little attention; instead, everything necessary will be done through other programmes, where networks already exist that are vital to making climate adaptation an integral part of provincial policy.

The team will also provide information on climate adaptation to the various area-specific spatial planning projects, which can incorporate many of the proposed climate adaptation measures (see also Section 5.3 and Appendix 2). In turn, the lessons learned in the projects can be relayed back to the team. The team can then share these lessons with other area-specific spatial planning projects, resulting in new demands for expertise or the necessity of multi-area strategic agendas.

Coordination with other government bodies and partners

The task of coordinating with other government bodies and partners will be carried out largely via the area-specific spatial planning projects. There may be a greater need to coordinate climate adaptation issues than to coordinate the primary spatial planning tasks. Examples include developing cross-border ecological corridors, a policy on low river discharge levels and the necessary facilities in the Meuse catchment area (including stream valleys), or preventing a heat-island effect in cross-border urban areas. These will often be topics already covered by existing consultation structures and partnerships, which the Province can then join.

5.2.3 Incorporation in coalition programmes

The Province of Limburg's coalition agreement (2007-2011) has identified and implemented five overarching, province-wide programmes. Each one has its own area of concern and network.

Investing in space
This programme was set up to improve the quality of the environment (nature conservation areas/agriculture/landscape/water management). The strategic efforts involved are concentrated in six core areas. A comprehensive area-specific spatial planning project is being carried out in each core area. The areas are:

1. Greenport Venlo ("Four-leaf Clover");
2. Meuse Lakes in Central Limburg;
3. A2 motorway zone between Maasbracht and Geleen;
4. Parkstad Limburg;
5. Maastricht-Valkenburg;
6. Ooijen-Wanssum spatial planning project.

The opportunities for and challenges of climate change within this programme can be found in such areas as flood safety, desiccation, dampness, biodiversity and changes in farm crops. The projects being carried out under Investing in space are also relevant to most other programmes. Appendix 2 lists the plans and developments relevant to climate change in each area and the additional challenges and opportunities that can be addressed.

Investing in towns and villages
This programme is actively primarily in the Meuse Lakes, Central Limburg, A2 Motorway Zone Maasbracht-Geleen and Parkstad regions. It focuses on improving the residential and living environment. The programme could be highly relevant in combating heat stress, air pollution, excess water and water shortages and in improving water quality in urban areas. Climate adaptation issues that can be addressed in this programme are:

- Creating greenspace in urban areas in order to reduce heat stress and excess water.
- Improving the quality and capacity of sewers/drains so that they can cope better with excess water caused by heavy showers. Testing the capacity to cope with rain water against the climate scenarios for 2050.
- Considering the possibility of more serious air quality problems (in particular in Maastricht) caused by more frequent tropical temperatures.

Accessible and sustainable Limburg
This programme focuses on improving access to Limburg (public transport, roads) and on sustainable development, especially mitigation (combating CO2 emissions). The programme is important to climate change because it helps mitigate the challenges of climate adaptation. The programme also covers

investment in infrastructure (roads, public transport). Climate change will also have an impact on the availability and maintenance of the road infrastructure and waterways. Existing and new road routes must be analysed for potential problems resulting from climate effects.

Investing in people
This programme focuses on improving the participation of young people and the elderly in society. It has no direct relevance to climate adaptation.

Innovation in Limburg
This programme focuses on economic growth in Limburg, for example by founding a number of research/expertise centres and tying them to the province. The “High-quality food production and consumption” cluster provides a framework for generating and transferring new knowledge about agriculture and climate change: adapting existing crops and opportunities for new crops.

6 ACKNOWLEDGEMENTS

Cover photographs: Overmaas water board and Jean Slijpen. The photo on the left shows flooding in Itteren, probably Dec. 1993. The photo on the right shows a vineyard in South Limburg.

Province of Limburg/Foresight study on climate adaptation in Limburg

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