Knowledge for Climate

Midterm Review Report

Hotspot Haaglanden Region

KfC 66/2012

Mid term report Knowledge for Climate:

Hotspot Haaglanden Region

September, 2012

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Contents

Part I – Ambitions, KfC Research and Approach RAS Haaglanden

1 Introduction

The high degree of urbanisation and high economic value of the region make Haaglanden a unique area, both nationally and internationally. And yet this region is also vulnerable to the consequences of climate change. For instance, the expectation is that extreme rainfall will occur more often in a densely populated area and intensively used greenhouse areas, and dry periods will also occur more frequently. Moreover, an increased temperature in the city may lead to a decrease of quality of life. Climate change not only brings adverse consequences that need to be dealt with but also opportunities to realise the ambitions of the Haaglanden region.

The Haaglanden region is one of the eight hotspots within Knowledge for Climate (KfC). Knowledge is developed in practice-oriented projects in the field of climate adaptation which ultimately contributes to the hotspot's end product within the Knowledge for Climate programme: A soundly-based and widely supported Regional Adaptation Strategy (RAS).

This report has been written for the Knowledge for Climate Midterm Assessment and provides an insight into the state of affairs regarding the research carried out in Hotspot Haaglanden (HSHL). It consists of two parts. Part I provides insight into the ambitions of the hotspot, KfC research projects in Haaglanden, and the process of developing regional adaptation strategy (RAS) Haaglanden which is currently being formulated in association with the various stakeholders in the region.
Part II sets out the current state of knowledge about climate change and the possible effects for the Haaglanden region: What will the region be faced with? Which threats and opportunities will arise from climate change for the three most important types of area in Haaglanden; 'grass' (soil-bound agriculture, nature and coast), 'city' and 'glass' (greenhouse horticulture)? What are the adaptation options for the various utilisation functions, and what do we know about the effectiveness of various technical, societal and economic measures? Part II is based on a first inventory of the results of KfC and other research such as the Waterkader Haaglanden knowledge programme. The overview includes the 'building blocks' for the regional adapaptation strategy (RAS) Haaglanden and will be further elaborated in the RAS process as described in chapter 3.

1.1 Haaglanden Region

The Haaglanden region is a unique area: this region comprises the The Hague conurbation and a substantial concentration of greenhouse horticulture, bordering on the North Sea. The area has an approximate population of 1 million and land use here is very intensive: the built-up area covers 40% of the area, 30% is used by greenhouse horticulture and 30% is greenery such as dunes and (peat) meadows. The area itself makes a significant contribution to the Dutch economy (10% contribution to the GNP, approximately 50 billion Euros). Metropolitan landscapes, in combination with the green-blue veins running through the entire area fulfil a significant role in terms of the liveability and attractiveness

of the whole region. The region still entails major spatial tasks in order to continue accommodating economic growth and the increase in population. In this respect the decision was made to restructure and condense the existing urban and greenhouse area with a focus on multifunctional land use and limiting further land surfacing. This is necessary to continue guaranteeing the area's liveability, which is already under pressure. To further improve the quality of the living environment investments will also need to be made in realising and maintaining a regional green structure and better connections between the coast and the surrounding countryside and city-rural transitional areas, respectively. This has been laid down by the nine Haaglanden municipalities, in intensive collaboration with the water boards and the provincial authority, in the integrated environment vision Regional Structural Plan Haaglanden 2020 (RSP). The key values referred to in this plan for the three types of areas glass, grass and city are: a *vital innovative greenhouse sector*, an *attractive and accessible green area and coastal zone*, and *liveable cities*.
Climate change gives rise to threats for creating conditions for the economic development of the region. At the same time, climate change and climate adaptation can be latched onto as an opportunity for the region regarding the ambitions of the three types of area glass, grass and city. It is laid down in the RSP that a Regional Adaptation Strategy must be drawn up in order to prevent problems from arising in consequence of climate change, to utilise economic opportunities, and to raise the quality of life in the region to a higher level (see textbox next page).

As one of the effects of climate change, extreme rainfall, combined with the increasing extent of metalled surfaces in the Haaglanden region, led to serious flooding at the end of the 1990s and the beginning of this century. That flooding not only resulted in considerable damage but also to the awareness that extra water storage is essential and to supports being given to a climate-related approach taken by the municipal authorities and water boards. Together with Delfland Water Board, Stadsgewest Haaglanden (The Hague Region)intended to look into the realisation of a sustainable water system that could be effectively linked to other spatial tasks. The collaboration between Stadsgewest Haaglanden, the Province of South Holland, Delfland Water Board, knowledge institutes and municipal authorities was established in 2003 and given the name of Waterkader Haaglanden (*see section 1.2 Waterkader Haaglanden*).

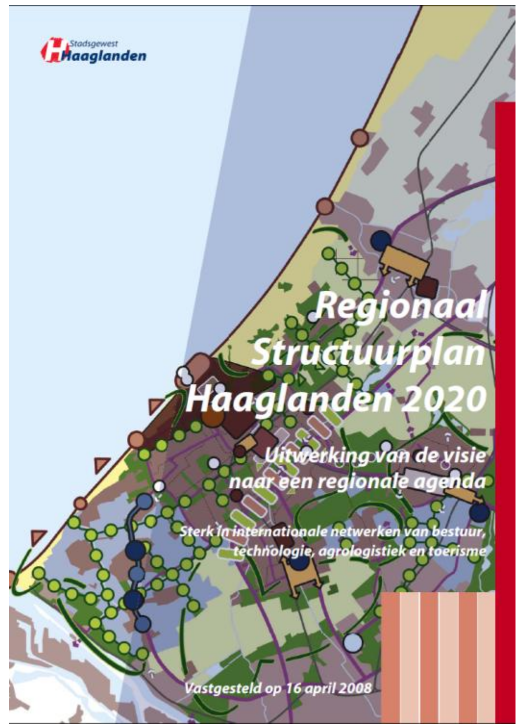
Ambition

- *A broad, socially supported regional climate adaptation strategy will be applied in 2030 as a basis for decision-making on spatial investments in which climate (change) is expressly taken into consideration in the decisions.*

RSP strategy

(..) Knowledge about specifically regional climate effects and climate adaptation is brought into current (spatial) decision-making processes via the Knowledge for Climate Programme. A start will be made on implementing water quality measures for the Water Framework Directive in the period 2009-2015. For the implementation process as much synergy as possible is sought with the realisation of the water quantity task.

Subsequently (2015-2030) an administrative philosophy regarding climate adaptation in the region will arise (from the knowledge and experience gained in the short to medium term). This administrative philosophy will be worked out in a broad, socially supported regional climate adaptation strategy, which will serve as the basis for further decision making on spatial developments. The changing climate is structurally taken into account in all (spatial) investment decisions. Depending on climate scenarios and spatial developments in Haaglanden – which lead to an increase in the economic capital that must be protected – it can become necessary to make the safety standards more stringent. Additionally, investments made in climate-proofing the spatial layout can in due course lead to a further rise in (water board) costs. These aspects must also be included in the adaptation strategy. The established Water Framework Directive goals will be realised in 2030.



While a great deal has been achieved over the past few years in the field of the water task, further deepening is still required by the administrators. Further knowledge development in the field of climate adaptation is essential, not only on the themes of flooding and urbanisation, but also sewage and groundwater management, fresh water supply for water level management and water quality (salinisation and algae) in dry summers, the safety of peat dykes, regional effects and the likelihood of longer hot periods for health, liveability and productivity, and last of all, subsidence in the peat meadow areas and the future of land-linked agriculture there.
Also, valorisation and the development of knowledge in the region, the export of knowledge and an international profile in the area of climate adaptation and mitigation are significant starting points for the administrators in the region. This has led to a large number of questions being addressed within the Knowledge for Climate (KfC) programme by various research groups. The Haaglanden region, with its large number of stakeholders, provides co-funding for the various research projects within the Hotspot Haaglanden Region (HSHL).

1.2 Waterkader Haaglanden

The collaboration between the Delfland Water Board, the provincial authorities, Stadsgewest Haaglanden, knowledge institutes and the municipal authorities was established in 2003 and given the name of Waterkader Haaglanden (WKH). This teamwork originated after repeated flooding in the region and after discussions about the integration of a plan of action for a sustainable water system in the new Regional Structural Plan Haaglanden which was established in 2002. The intention to join forces with Delfland to look into the realisation of water storage – which would be effectively harmonised with other spatial tasks – was then incorporated in this structural plan.

In 2006 this collaboration process led to the **Regionaal Bestuursakkoord Water** (Regional Administrative Agreement on Water); an agreement between the parties on how the water task would be tackled in the region; the aim was to achieve sustainable solutions at the lowest cost. This agreement not only set out the acknowledgement of the problem, but also the starting points, ambitions and arrangements concerning how the costs would be shared. In addition to the importance of collaboration between the different authorities and other stakeholders on how to tackle the water task it was also ascertained that innovations were necessary due to the high costs of the water task in a highly paved and urbanised area. To boost innovations with subsidies contact was established with the former Ministry of Transport, Public Works and Water Management and a FES grant programme was framed. The knowledge and innovation programme "Ruimte voor water en economische ontwikkeling in Haaglanden" (Room for water and economic development in the Haaglanden) started in March 2006 and the WKH Programme Office was formed. During the period 2006-2011 the programme focused on developing and realising innovative solutions in the field of water management and spatial development in the Haaglanden region. In addition to a number of generic projects, the knowledge programme concentrated on seven pilot areas in five of the participating municipalities where work was carried out on concrete solutions in the (peat) meadow areas, greenhouse areas and urban areas. Appendix 1 includes an overview of the pilot areas and the most significant results. In November 2010 the Waterkader Haaglanden steering committee decided to close down the Waterkader Haaglanden Programme Office on 1 January2012 due to the lack of funding to maintain the Programme Office and the closing date for FES grants.

During the implementation of this knowledge programme, in 2009 – after the administrative establishment of an initial document on climate adaptation in March 2008 – an affiliation was realised with the national FES programme Knowledge for Climate in order to utilise supplementary implementation subsidies for projects in the region and the pilot areas. Haaglanden region was designated as *one* of the eight hotspots in the KfC programme in 2009. This gave rise to a wider orientation than water management and spatial development alone; themes such as urban climate and heat stress were now also given attention.

There was now intensive collaboration with Knowledge for Climate in the WKH knowledge programme. The knowledge generated in WKH is largely continued in KfC, among other things in the development of a regional climate adaptation strategy (RAS) for the Haaglanden region.

1.3 Climate adaptation strategy development

Haaglanden has been working for some time now on mapping out the consequences of climate change and adaptation options. The necessity for climate adaptation for Haaglanden has been demonstrated over the past few years in climate effect studies which were carried out under the authority of Delfland Water Board, Rijnland District Water Control Board and the provincial authorities of South Holland. Follow-up steps were also taken after defining the term ‘adaptation’, such as in the “Beleidskader ten behoeve van adaptatie aan klimaatverandering, 2008” (Policy framework for adaptation to climate change, 2008) of Delfland Water Board and the “Actieprogramma Klimaat en Ruimte” (ARK) of the Province of South Holland, 2009. The Hague council is currently working on the development of a sustainability programme, a part of which is devoted to climate adaptation: “Uitvoeringsplan klimaatbestendig Den Haag 2012” (Implementation Plan Climate-proof The Hague 2012).

Strategies in the field of climate adaptation at national and provincial level set the framework and direction (like the Delta Programme), but overall do not have the level of detail required to make the step to practical implementation in the region. At the regional level, Haaglanden does not have a coherent, implementation-focused vision of a future-proof development. Setting up a widely supported and practice-oriented regional adaptation strategy (RAS) is one of the ultimate goals of the Hotspot Haaglanden within the KfC programme. This RAS will be drawn up on the basis of the knowledge and experience gained from various processes such as the drawing up of the previously mentioned policy documents and the research conducted in Waterkader Haaglanden and Knowledge for Climate. Moreover, a connection is made with the agenda of the RSP2020 with the following three main objectives:

1. An internationally competitive region;
2. A well functioning regional urban network and
3. Good quality of housing conditions and living environment.

Chapter 3 sets out the process for drawing up the Regional Adaptation Strategy Haaglanden based on the knowledge and experience obtained to date.

2 KfC research within Haaglanden

2.1 Hotspot HSHL and organisation

The most important knowledge users within Hotspot Haaglanden Region (HSHL) are:

- Stadsgewest Haaglanden (The Hague region)
- Delfland Water Board
- Province of South Holland
- Nine Haaglanden municipalities (The Hague, Delft, Leidschendam-Voorburg, Midden-Delfland, Pijnacker-Nootdorp, Rijswijk, Wassenaar, Westland and Zoetermeer).

Figure 1 Location of the nine Haaglanden municipalities

At the start of the KfC programme the hotspot was coordinated by the Waterkader Haaglanden programme office. The WKH programme office facilitated the stakeholders within Haaglanden with the phrasing of their questions related to research via Knowledge for Climate.

After the discontinuation of Waterkader Haaglanden in 2011 the general hotspot coordination was brought under Stadsgewest Haaglanden. The practical coordination and management of research projects within HSHL has been divided: Stadsgewest Haaglanden coordinates all activities concerned with the development of the RAS, and Delfland Water Board coordinates all projects concerning water management and innovations.

2.1.1 Collaboration with other KfC hotspots

Hotspot Haaglanden primarily works together with Hotspot Rotterdam Region (HSRR). The Delfland Water Board plays a role in both hotspot teams and is therefore an important connecting link. HSHL has intentionally not planned certain research given that HSRR does not take the lead in that research and the knowledge is made available through the Delfland Water Board. For the remaining research, the two hotspots coordinate the programming, implementation and dissemination with each other.

Hotspot Haaglanden and Hotspot Rotterdam Region are engaged in discussions on the feasibility of a joint Regional Adaptation Strategy. The Province of South Holland is also a potentially important link in this respect, among other things thanks to the active involvement this authority has with the two KfC hotspots since the beginning. The challenge of a joint regional adaptation strategy for HSHL and HSRR is a topical subject in the light of the discussion on a metropolitan area in the south flank of the Randstad which is increasingly catching on. At the same time, the dynamism of this political context leads to the usual uncertainties on the regional and national level. The ambition of both hotspots is to have completed the main lines of their own strategy by the end of 2012. From 2013 an attempt can be made to integrate both strategies into a joint strategy for the whole metropolitan region.

2.1.2 Collaboration with the Delta Programme

The municipalities affiliated with the hotspot and Delfland Water Board have their contacts with the Delta Programme, especially where the coast, fresh water supply and new construction and restructuring are concerned. There are no structural ties with the Delta Programme at hotspot level. Although in the Delta Programme the Haaglanden region does not have a counterpart in the form of a Sub-programme that focuses on this region, it is estimated that there is enough room for the two parties to work together from now on. For instance, developments in the projects of HSHL in the third tranche in the field of 3Di, floating greenhouses and innovative storage of irrigation water can be of interest for the Delta Programme.

2.2 Approach and projects

The research carried out within Knowledge for Climate is done in three tranches: The first tranche addresses the first urgent knowledge questions and foresight studies by the hotspots, 2) the second tranche concerns in-depth and long-term studies into a number of important themes for climate adaptation, 3) the third tranche concentrates on the regional adaptation strategies.

2.2.1 1st tranche

The research projects from the hotspots were formulated and put out to contract by private tender in the first tranche. This research mainly related to projects with a short and medium term duration, focused on the most urgent needs for knowledge within the hotspot. The first tranche projects of Hotspot Haaglanden Region were formulated on the basis of the initial document for the approach taken by the hotspot drawn up by Delfland Water Board and Stadsgewest Haaglanden in March 2008 and approved by the WKH steering committee.

The first tranche projects (co-) initiated by Hotspot Haaglanden are:

Project code	Name of project – hyperlink to research	Parties involved
HSHL01	Climate in spatial decision making http://knowledgeforclimate.climateresearchnetherlands.nl/nl/25222946-HSHL01A.html	Arcadis, Deltares, Erasmus University Rotterdam, Dura Vermeer, Triple E
HSHL02	Future of the fen meadow area http://knowledgeforclimate.climateresearchnetherlands.nl/nl/25222947-HSHL02.html	DHV, Wageningen University, Delfland Water Board
HSHL05/ HSRR04	Region specific climate information for Haaglanden and Rotterdam http://knowledgeforclimate.climateresearchnetherlands.nl/nl/25222948-HSHL05_HSRR04.html	KNMI, Wageningen University, Delfland Water Board, Stadsgewest Haaglanden, Rotterdam council
HSHL06_12	Broad, region specific reconnaissance of effects of climate change in relation to future scenarios and trends http://knowledgeforclimate.climateresearchnetherlands.nl/nl/25222949-HSHL06_HSHL12.html	Deltares, TNO, Wageningen University, Alterra Geodan Next, HKV
HSHL08	Demonstration project multifunctional landuse for water storage in the greenhouse sector http://knowledgeforclimate.climateresearchnetherlands.nl/nl/25222950-HSHL08.html	Delfland Water Board, Deltares, Westland council, Stichting Waalblok
MSZD01	Fresh water supply in South-West Netherlands Delta	Acacia Water BV, TNO, KWR, Wageningen University, Deltares

All first tranche projects have been completed by now. More information about the projects and the final reports and other documentation is available via the KfC website[1]. Results of the projects are included in Chapters 5 and 6 in Part II of the Midterm report.

2.2.2 2nd tranche

While the first tranche projects were in the start-up stage, the hotspots were requested to join several send tranche research themes. The project proposals in the second tranche are drawn up by the research consortia (knowledge institutes and universities) and not by the hotspots. A choice was not only made for cohesion between generic and area-specific knowledge questions but also for cohesion between different disciplinary and sectoral lines of knowledge.

[1] http://knowledgeforclimate.climateresearchnetherlands.nl/hotspots/haaglanden-regio

In the autumn of 2009, Hotspot Haaglanden decided to take part in four themes. The partners in Waterkader Haaglanden took upon themselves the task to co-finance research in these two themes with each other. On the basis of interests in the region and the (limited) financial means, choices were made in association with the stakeholders within the collaborative arrangement of Hotspot Haaglanden to participate in the following consortia:

- Theme 2 – Climate Proof Fresh Water Supply[2]
- Theme 4 – Climate Proof Cities[3]
- Theme 7 – Governance of Adaptation[4]
- Theme 8 – Decision Support Tools[5]

Below is a summary of the research and the HSHL-related cases within the various themes. More information about the research results is contained in Chapters 5 and 6 in Part II of the Midterm report.

Theme 2 Freshwater Supply

One of the reasons for Haaglanden to commit to this theme was the conclusion that the current supply of fresh water for Haaglanden/Delfland could be endangered by decisions taken within the framework of the Delta Programme and by the salinisation of the Haringvliet. Delfland and the greenhouse area is strongly dependent on the supply of fresh water from the Brielse Meer (Lake Brielse). Suggestions that the greenhouse horticulture could become self-sufficient in terms of the water supply were being heard more frequently, but the question was whether that was realistic. There was also the question whether there was sufficient fresh water available to maintain the quality of the water and to provide the (peat) meadow areas with enough water during dry periods. It was therefore essential to gain insight into the demand for fresh water from Delfland, especially in the greenhouse area and in relation to the supply of fresh water from the Brielse Meer.

In theme 2 work is carried out within Hotspot Haaglanden on a case related to the supply of fresh water in the greenhouse area and the area’s future demand. Various innovative technologies are being investigated. This regional case is guided by the Delfland Water Board and Westland Council. Feedback goes through the Stadsgewest Haaglanden. A study was also made into the underground storage of water near greenhouses via the so-called Aquifer Storage and Recovery (ASR) system. In the second tranche the most suitable locations for ASR were studied; the study was continued and the technology was implemented in the third tranche, project HSHL3.2.

[2] http://knowledgeforclimate.climateresearchnetherlands.nl/climateprooffreshwater
[3] http://knowledgeforclimate.climateresearchnetherlands.nl/climateproofcities
[4] http://knowledgeforclimate.climateresearchnetherlands.nl/governanceofadaptation
[5] http://knowledgeforclimate.climateresearchnetherlands.nl/decisionsupporttools

Thema 4 – Climate Proof Cities

The Haaglanden region is highly urbanised. In accordance with policy, the decision has been taken to condense further urban densification and to keep the large green areas in the surrounding areas. Integrating climate adaptation within the urban areas is therefore a complex and long-term task. Waterkader Haaglanden has already carried out a great amount of research in this respect, where the water task is concerned. Within Knowledge for Climate and the Climate Proof Cities consortium research is now underway into the need for a better understanding of the problems of heat in cities, and the role that green areas could play therein. The question in this respect is what type of urban development will ensure a pleasant living environment in the future. An additional question is what to do in districts that need to be restructured.

Within the framework of Climate Proof Cities suitable case studies were looked for as well as co-financing in The Hague. This turned out to be difficult due to the low level of interest among the project organisations which had also been affected by the economic crisis. Research into the significance of large green areas to lower the heat in cities was then focused on, as well as on effective urban typologies in the regional context. For the water task a case location is sought in The Hague, where work can be carried out on linkage to the sewage task and groundwater task. This case is part of an extension proposal in work package 3 of CPC in association with Delfland, The Hague and Rijswijk and following on from the 3Di research programme.

A study of the literature was made into the heat aspects of the Transvaal neighbourhood and a comparison was made with a neighbourhood in Utrecht ('Case study designs for two neighbourhoods in the Netherlands', Laura Kleerekooper and Andy van den Dobbelsteen, Delft University of Technology.) The results of the CPC consortium to date are being used for internal presentations in HSHL as well as information for municipalities and water boards. The "Kennismontage hitte en klimaat in de Stad[6]" (Knowledge Assembly heat in the city) that was carried out by the CPC consortium in 2011 was very useful in this respect.

Work is also underway into the regional context of greenery and urbanisation. The urban conurbations of Amsterdam, Haaglanden/Rotterdam and Brabantstad are involved in this study in order to make a comparison within the Netherlands. At present work is in progress to map out the heat problems in The Hague and environs in this project so that urban development and social planning can tackle the issue on time. The GGD The Hague (Area Health Authority) is also involved in this study. Among other things, use is made of satellite images and monitoring equipment is being used in the Haaglanden and Westland region to obtain a better understanding of the distribution of heat. In the CPC work package a question has been formulate as to whether the greenhouse area experiences a different heat problem than in the city. Data is limited and the models have not been tested in these areas.

[6] http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=5643&GUID=1ff31c92-dfec-416d-a837-aa7fb4e1827a

Theme 7 Governance

Considering that a strong focus was already on governance aspects in Waterkader Haaglanden, HSHL decided to latch onto this theme in the second tranche of Knowledge for Climate. However, because of the scientific and abstract character of the research phrasing in this theme it turned out to be difficult to find concrete cases within Haaglanden and no direct connection has been laid to date. In the oncoming period it is probable that a connection will be established by involving researchers working on this theme in the RAS process.

Theme 8 – Decision support tools

A great deal of experience has been gained from the pilot areas in Waterkader Haaglanden by using interactive tools with stakeholders in regional development processes. The region and the water board feel very strongly about the development of new tools, partly because of the economic effects of new products for the region and for the Netherlands. Because of this, and also because of ideas regarding possible building blocks for adaptation strategies by a consortium of the Groningen University, Delft University of Technology and UvA (University of Amsterdam) , we joined this theme.

On the basis of the need for support when drawing up a regional adaptation strategy, the co-financing of research in Theme 8 was made available from the knowledge programme Waterkader Haaglanden. The consortium of Theme 8, together with Waterkader Haaglanden, then developed a proposal on advice and support for the adaptation process, and the tools for workshops with civil servants and administrators to be introduced in that process. Two workshops, one on Heat and one on Flooding, were organised in 2011 in consultation with Haaglanden (report '*Naar een regionale adaptatiestrategie klimaat voor Haaglanden*' 2012 [Towards a regional adaptation strategie climate for Haaglanden]). The consortium provided input on heat maps Haaglanden, the spatial translation of the socioeconomic PBL scenarios for Haaglanden, an SCBA tool for the optimal timing of storage measures and the working of the 3Di tool in area processes. In the follow-up to the RAS process (HSHL3.4) the consortium will be involved to utilise the knowledge generated therein in the official and administrative process, e.g. in workshops. Monitoring tools and the TouchTable being developed and used within this consortium can possibly be used more often in other regional development processes in Haaglanden over the next few years.

Other KfC Themes

Another research theme which is relevant for HSHL is Theme 5[7], infrastructure and Networks (INCAH consortium). Hotspot Rotterdam Region is the case area for this theme. Hotspot Haaglanden is indirectly involved with the study and attends the consortium workshops and meetings to bring up questions and to gain results. Research questions for this theme from HSHL are about, for instance, building requirements for tunnels within the framework of climate adaptation.

[7] http://knowledgeforclimate.climateresearchnetherlands.nl/infrastructurenetworks

2.2.3 3rd tranche

In the third tranche the focus is on whether an icon project could be submitted for the types of area glass, grass and city. In addition, a large part of the third tranche consists of research the development of the regional adaptation strategy (RAS).

Stakeholders in the meadow area indicated that there was a need for an pilot area project in which farmers could work on education and experiments with underwater infiltration and agricultural recycling in Midden-Delfland. There was a strong need for an experimental polder in the area. This idea was accepted with open arms at a board conference but there was insufficient manpower to take up the idea in the short term. See report 'Gouden ideeën voor Hof van Delfland' work conference Hof van Delfland, November 2011.

Also investigated was whether a ring main for delivering heat and cooling in the city centre of The Hague could contribute to the adaptation strategy to prevent air-conditioning costs and energy consumption and to optimally utilise the substratum for storing heat and cold. Here too was it difficult to get co-financing given that the project idea itself was already a subsidy project. The orientation would then be more on the governance aspects to accomplish such a system with the Government Buildings Agency, housing corporations and other investors in the centre.

Finally, the possibility was explored for Haaglanden to join a proposal put forward by the IVAM, Grontmij and Wageningen University concerning a planning tool for the earning effects of adaptation measures. The Rijswijk Council wanted to participate as a case study area for a new construction location, Rijswijk Buiten. Also the Rotterdam Council were interested, but Haaglanden was unable to take care of additional co-financing and guidance. This proposal might possible be submitted via Hotspot Rotterdam following their SCBA study for measures in the city.

Ultimately, the following projects were formulated:

Project code	Project name	Project leader / parties involved
HSHL3.1	Experiment on water management and governance in a case of large floating construction: Floating Roses	Tauw, Dura Vermeer
HSHL3.2	Optimized Aquifer Storage and Recovery (ASR) of freshwater in saline aquifers	KWR Watercycle Research Institute
HSHL3.3	3Di water management applicable for end users	Nelen en Schuurmans, Delft University of Technology, Deltares
HSHL3.4	Regional Adaptation Strategy (RAS) Haaglanden	Stadsgewest Haaglanden

3 Towards a Regional Adaptation Strategy Haaglanden (RAS)

HSHL expects to have and get the required knowledge to develop a regional adaptation strategy (RAS) from the finished and ongoing research in the 1st, 2nd and 3rd tranche. This does not mean that there are no more knowledge gaps (see also management summary HSHL06/12 pp. 26-30) but they are not necessarily an obstacle on the road towards the regional adaptation strategy. More crucial is the process in which the strategic and political component comes into view. The project HSHL3.4 RAS Haaglanden, which is currently in preparation, is intended to accommodate this process to establish a practicable regional adaptation strategy supported by the various parties.

It is important to reach an administrative document in consultation will all stakeholders in the area, in which the choices and prioritisation are substantiated for the continued effect of a strategy in the day-to-day work of the various organisations. The roles and responsibilities of the different specific organisations will also be worked out. For this project, Arcadis has drawn up a draft action plan which, in consultation the municipal and provincial authorities and the water board will be worked out to a third tranche proposal HSHL3.4.

The Stadsgewest Haaglanden is designated as the body responsible for drawing the RAS. The municipals, water boards and provincial authorities concerned are closely involved in this process and the representatives of these organisations have united themselves in an Official Coordination Committee (OCC) on Climate Adaptation [*in Dutch*: Ambtelijke Coördinatie Commissie (ACC) KlimaatAdaptatie]. Where possible, affiliation will also be sought with the OCC Environment of Stadsgewest Haaglanden within the framework of embedment in the region's sustainability strategy, and the roles of the municipalities therein. In preparation of project HSHL3.4 RAS Haaglanden the expectations and needs of the OCC members were catalogued regarding the form, content and process of the RAS. A summary follows:

Starting points

- The RAS of the Haaglanden region establishes a connection between the local and the regional tasks. In this respect it is important that the parties in the region really stand behind and propagate it.
- A very large amount of information is available; the RAS must first and foremost combine, funnel and internalise available knowledge (including the 1st and 2nd tranche KfC, WKH, Hotspot Rotterdam/Rotterdam urban district);
- Concise clear-cut strategy, not drawn out narratives;
- It must be in line with the Regional Structure Plan Haaglanden 2020;
- It must provide an adequate number of handles for conversion into implementation in practice (concrete projects, experiments, etc.);
- First and foremost the RAS will focus on Haaglanden, up-scaling to the metropolitan region can be done where possible;

- It is a dynamic document.
- It provides insight into the consequences (and the impact) of climate change for the region, as well as the necessary measures to deal with them;
- It provides region-specific clarity, structure and an overview of what is needed to render the spatial development of Haaglanden climate proof;
- It is complementary to existing adaptation strategies and current policy through the area-specific line of approach and the connection established with the anticipated autonomous spatial development of glass, grass and city;
- It identifies, lists agenda items and addresses knowledge questions that are still open;
- It identifies and plans suitable solutions and measures;
- It determines the regional effort and provides input to (inter)national processes (such as the Delta Program and European Adaptation Strategy).

For whom?

The RAS must a readable document for citizens, entrepreneurs and policy makers. It must also be the guiding principle and sufficiently concrete to achieve integration in policies (and their implementation) of the various parties. Climate adaptation is not a goal in itself, but must be in line with the spatial and economic policy (and strategy) of the Stadsgewest Haaglanden: A dynamic urban district. It is important that the issue of limiting the risk (high costs for the government) and limiting the consequences (acceptance and the ability to do things independently) are addressed: the message is that the government is unable to cover all the risks. It goes without saying that express attention is devoted to the opportunities that really are available (e.g. for the greenhouse horticulture sector and its competitive position with regard to Southern Europe or for tourism to the coastal areas or the nightlife in the city).

What's in it?

The framework: Haaglanden is a dynamic urban district in 2050: an internationally competitive region, a well-functioning regional urban network which offers high quality housing and a high quality environment to live in.

What was the situation in the field of climate and adaptation policy, what has been done to date, where do we want to go; from flooding, via Waterkader Haaglanden to Haaglanden climate proof.

A document in which all relevant available knowledge is brought together, combined, funnelled and internalised.

The RAS will be elaborated on the basis of:

1) Regional division; a division in three types of area:
    a. Liveable cities
    b. Vital innovative greenhouse horticulture sector

c. Attractive and accessible green area and coastal zone (including the farmer as the carrier of the landscape), i.e. a combination of grass, art and nature.

2) Translate goals of the RSP into subjects per sub-area:
   - Coastal development
   - Urban development
   - Agricultural and greenhouse horticulture sector development
   - Welfare
   - Water and Nature Development
   - Infrastructure and networks
   - Energy

Link up with the RSP agenda with the objectives:
- an internationally competitive region ;
- a well functioning regional urban network;
- high quality housing and a high quality environment to live in.

3) Relevant threats

These differ per theme/playing field per part of a region: The Haaglanden partners find the threats printed in bold type the most important:
   - **Increase in flooding risk;**
   - **Heat stress in urban areas;**
   - **Higher demand for water;**
   - Increase in the chance of quay deformation;
   - Drop in water quality;
   - Increase in salinisation via groundwater and inlet points in the main water system;
   - An increased risk of faster subsidence;
   - Changing groundwater levels in urban areas;
   - Nature values decrease;
   - Agriculture as the carrier of the landscape comes under pressure;
   - An increase in exotic species and types of infestations.

4) Opportunities
   - Competitive position of the greenhouse horticulture sector;
   - Coastal tourism;
   - Hotel and catering industry: more pleasant summer evenings;
   - A shift in energy consumption from winter to summer;
   - New international organisations in the field of climate in The Hague, city of peace and justice.

Along with the threats and opportunities, the scale level of the RAS comes into the picture: City, neighbourhood, street and building, polder, company. An assessment must be made as to which level of scale solutions can best be brought to conclusion and in which way opportunities must be utilised. When this is translated into a regional adaptation strategy, then a translation can be made into the implementation in practice with concrete examples. Converted into a table it looks more or less as follows:

Parts of regions	Relevant Themes	Threats	Opportunities	Adaptation pathways/ Choices/Strategy
Urban district				
City (Neighbourhood, street, Building)	Coastal development			(integrate to an unequivocal strategy for the region with other accents in city, glass and green)
	Urban development			
	Welfare			
	......			
Glass (polder, businesses)	Greenhouse sector development			
	Infrastructure			
	Energy			
	.....			
Green (polder, businesses)	Coastal development			
	Nature development			
	Development of land-linked agriculture			
	......			

Comments with regard to the table: The yellow section is in line with the Toolbox climate adaptation of Rotterdam. The strategic framework and choices are missing in this toolbox; these are added to the RAS. An option is to include levels of scale as a 3D image.

How is the process progressing?

Based on the starting point of a three-stage rocket:

1. Work is carried out on an overarching document which is supported by the governments;
2. subsequently propose this document to important sectors (including the greenhouse horticulture sector, LTO and housing corporations) and
3. after an evaluation/consultation draw up a final RAS.

Given that the RAS is meant for the region, it is suggested to also consult with the region as much as possible on the content of the chapters. There is a large amount of material and it must be condensed into a strategy that also fits into the policy of the various parties. This midterm report (especially Part II) is an important document in this respect.

Other important documents that can be used for the RAS are:

- KfC HSHL06-12 final report
- "Uitvoeringsplan Klimaatbestendig Den Haag" (Implementation Plan Climate-proof The Hague)
- "Beleidskader ten behoeve van adaptatie aan klimaatverandering (Delfland Water Board)

4 Collaboration between science & practice: evaluation and conclusions

Waterkader Haaglanden, as initial coordinator of the Hotspot Haaglanden, brought a great deal of knowledge and experience from the pilot areas study (Appendix 1) into the first phase of Knowledge for Climate. Important lessons from the knowledge programme of Waterkader Haaglanden are (see Van Buuren et al., 2012):

1.) Combining problems encourages innovation
2.) Innovation requires time and as well as pressure of time
3.) Innovation is a failure if no lessons have been learnt
4.) Innovation is impossible without exciting teamwork
5.) Official commitment is required for pilot areas and programme
6.) The willingness to take just that extra step
7.) Stimulate continuous improvement instead of enforcing innovation

(Derived from Van Buuren et al., 2012, Innovatie in regionaal waterbeheer: Lessen uit het kennisprogramma Waterkader Haaglanden, Water Governance, 01/2012, pp 20-31)

In turn, the parties in the Haaglanden region have also been able to learn from the knowledge and experience within KfC. Especially the balance sought for within KfC between social relevance and scientific excellence, the research has not only taken it to a higher plain, but has also acquainted the parties concerned within the Haaglanden with new angles of approach, authorities and individuals. The teamwork between the Haaglanden and Knowledge for Climate illustrates the reciprocal learning at organisational level despite the administrative complexity that is characteristic of the area. Or maybe exactly thanks to...

The Haaglanden region has always been a proponent of learning by doing (a clearer link with practice), something that you can now clearly see returning in the goals of the third tranche (less of a scientific orientation, much more focused on knowledge valorisation and concrete projects/business cases). In this sense, KfC has learned from the experiences of our knowledge programme “Ruimte voor water en economische ontwikkeling in Haaglanden” (Room for water and economic development in the Haaglanden).

On behalf of Hotspot Haaglanden, the knowledge cluster Delft/Rotterdam is working together more intensively, and that has led, inter alia, to the Valorisation Programme Water and Delta Technology (among others, Delft University of Technology, the municipal councils of Delft, Rotterdam, Dordrecht, HHD, HHSK, UvW, Kennisalliantie, Deltares, TNO, Unesco-IHE, Hogeschool Rotterdam, WiBos, BAM Infraconsult, Alert Solutions, DeltaSync, Tygron). The main objective of this programme is to realise projects as the final step towards introduction to the market. In other words, practice and science work together in this programme. The process is now being organised via the “watertafel” (water table) under the direction of the water board.

The various knowledge institutes that participate in Knowledge for Climate are being informed by the Hotspot about the issues that play a role in the region. An interaction is created by means of workshops, contact with individual scientists and the meetings of the various consortia, which is appreciated by all the relevant parties. The two workshops in the Haaglanden on heat and flooding, partly organised on the basis of Theme 8 made a good contribution to formulating the main direction for the RAS.

However, one problem is how to guide the numerous scientists in the direction of a practicable process with municipal authorities and other stakeholders. Science has its own dynamism and the municipal authorities and stakeholders search for concrete products that can be applied quickly. It must easily fit into the work process. Science has its own goals and its own work processes. This means that there is frequently a lengthy period between establishing the first contact and the next, and thus progress does not seem all that clear.

Also, co-financing is an additional threshold to taking the plunge with scientists, considering that it is not often clear in advance what the result of the research will be. In the Haaglanden region it proved so difficult to find case areas for CPC where the researchers could get down to work.

However, it can be ascertained that a strong project management in which the governments and scientists work intensively together on a concrete product, delivers the most results. Project HSHL02 demonstrates how this process works so well. This does however require a great deal of extra effort on the part of the participating parties. That effort is often difficult to arrange within the daily work carried out by the municipal authorities, provincial authority and the water board, Teamwork calls for a strong leader for the process and the duration must be calculable.

It is also important that a good summary is made of the research, in which the main points for policy are set out and shared among the governments concerned. The management summary of HSHL06_12 as such has had a great influence on the administrative support for further investments in climate adaptation.

Part II – Research results and building blocks for RAS Haaglanden

5 Climate analysis Haaglanden region: what's heading in our direction?

Area-specific effects of climate change in relation to the anticipated socioeconomic trends for the Haaglanden region were studied in Knowledge for Climate project HSHL06. The result is a frequently used document on the specific opportunities and risks of climate change in the Haaglanden region. The project forms a major step in the development of regional adaptation strategy and the executive summary has turned out to be an important document for placing climate adaptation on the agenda at the official and administrative level in the region.
The KNMI'06 scenarios[8] were taken as the point of departure for the climate effect study. However, these scenarios were drawn up for the whole of the Netherlands and lack differentiation with regard to the different regions in the Netherlands. KfC project HSHL05/HSRR04 'Region-specific climate information for the Haaglanden and the Rotterdam region' was dedicated to filling these knowledge gaps. The end results of this project (section 3.3) were not yet available when carrying out the climate effect study. This was the reason for using the KNMI'06 scenarios as the staring point. Regional characteristics were added based on information taken from the so-called Climate Sketchbook[9], converted data from local weather stations and directional intermediate results of HSHL05/HSRR04 concerning urban heat and precipitation.

The conclusions on climate change and the effects thereof in the Haaglanden region set out in this chapter were mainly derived from the final report[10] and executive summary[11] of HSHL06_12, and the final report of HSHL05/HSRR04[12].

5.1 Climate change in the Haaglanden region

The main factors of climate change for the Haaglanden region are the increase in both the amount and intensity of rainfall and the rising temperature.

Extreme rainfall occurs more frequently in West Netherlands than elsewhere in the Netherlands (see Figure 2). For the Haaglanden adaptation strategy, account must be taken with an increase in the number of days of heavier rainfall. The number of days with a precipitation above 15 mm will increase from an average of 11 days a year now to 14 days a year in 2050. The number of days with a

[8] www.knmi.nl/klimaatscenarios
[9] 'Klimaatschetsboek Nederland' (KNMI, 2009) A description of the regional differences in climate in the Netherlands.
[10] http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=7151&GUID=9e6d6535-ebae-424b-b39e-2928cd21f883
[11] http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=7147&GUID=b7d7ed10-74d9-4495-9c39-0493a177041a
[12] http://knowledgeforclimate.climateresearchnetherlands.nl/hotspots/haaglanden-regio/HSHL05-HSRR04

precipitation above 25 mm could be doubled from an average of 2 per year now to 4 per year in 2050. While these might seem minor increases one must not forget that changeable annual variations can be hidden behind an average increase. In other words, there will still be years with few or no water problems, but if no adaptation measures are taken flooding will be more frequent and severe in other years.

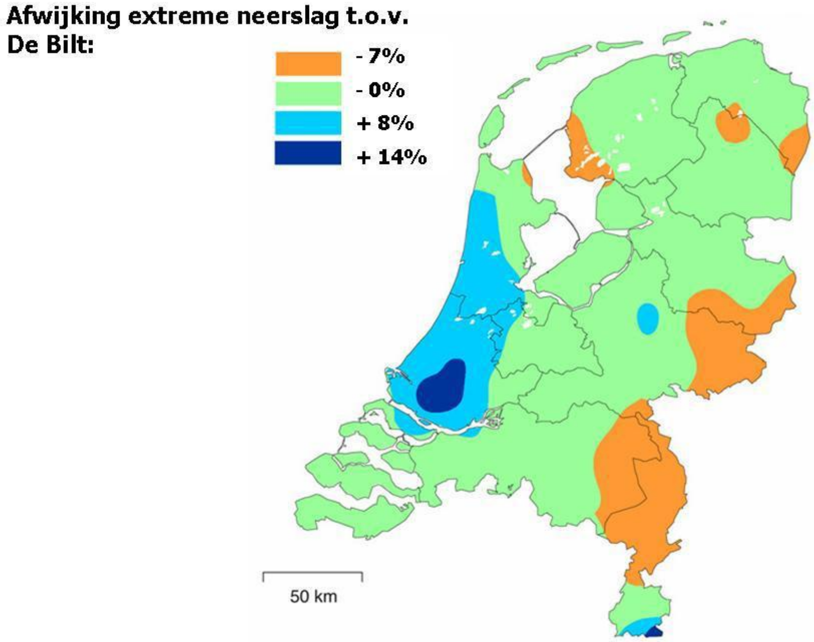


Figure 2 Regional differences in extreme rainfall compared to De Bilt (source: KNMI)

The heat wave in the summer of 2003 resulted in approximately 1,400 to 2,200 heat-related deaths in the Netherlands. It is expected that if the average global temperature will rise, heat stress will occur more often. Urban areas will be the hardest hit in this context; there is a relationship between building density and the degree of heat stress. A relative heat increase in the greenhouse farming area is also a point that must be given attention. The number of days with a temperature above 30°C can increase by an average of 2 to 10 per year (W+ scenario, 2050) in the Haaglanden region.

Another prominent driver of the climate effects is the lack of precipitation. Around 2050 this will strongly increase in the summer period of the G+ and W+ scenarios. A summer like 2003, which was seen as a particularly dry period, will become quite normal around 2050 according to the W+ scenario. This will have major consequences for the water supply, flushing and water level management.

The KNMI'06 climate scenarios report an absolute sea level rise along the Dutch coast in 2050 varying between 15 and 35 cm. Around 2100 the sea level rise will vary between 35 and 85 cm. The absolute rise in sea level is the same along the whole of the Dutch coastline. However, the swell caused by wind and storms can differ along the coastline.

Potential effects of the rise in sea level for the Haaglanden region are seen in the field of groundwater problems (see 5.2.2) and water safety. The risk of flooding due to the failure of coastal defences or primary barriers due to the rise in sea level and storm floods is part of the Delta Programme and is not dealt with specifically in the Hotspot Haaglanden projects within Knowledge for Climate.

5.2 Climate effects on the physical system

On the basis of an earlier study[13] conducted by Delfland Water Board, and with today's knowledge generated by the HSHL06_12 consortium and stakeholders who were interviewed, a selection was made from those climate effects on the physical system that are now regarded as relevant for the Haaglanden region and consequently relevant for the regional adaptation strategy.
The following sections provide a summary of the main conclusions for the potential impact on the physical system in the Haaglanden. The significance of these climate effects and adaptation options for the three types of area grass, glass and city is then dealt with in the next chapter.

5.2.1 Soil subsidence

Soil subsidence will be intensified as a result of lower groundwater levels. In Midden-Delfland and in the polder areas around Zoetermeer, soil subsidence can increase up to more that 0.5 meter even without climate change. In the W+ scenario, soil subsidence in these areas is even stronger.

In Midden-Delfland the accelerated soil subsidence will lead to extra risks considering that the expected subsidence (without climate effect) here is relatively great compared with the current ground level in the polder vis-à-vis the water courses. In the event of dyke failure, the raised water level in the polder is therefore significantly higher.

Along the edges of the deep polders of the Haaglanden region, especially in the polders near Zoetermeer, the burst risk of brackish or saline groundwater is relatively high. As a result of climate change the number of wells in ditches and on the land increases along the edges of the deep polders in The Hague Region. This results in an increase in salinisation of ground water, and the stability of fluvial sand foundations can decrease.

5.2.2 Groundwater level

Regarding the problems of high groundwater levels due to climate change effects, a differentiation is made between the direct effects in the form of increased precipitation in the winter, and the indirect effects of sea level rise.
As a result of the increased precipitation during the winter months the groundwater level will be higher throughout the whole year. This applies particularly to infiltration areas in the dune areas whereby adjoining, relatively lower areas suffer groundwater level problems. The areas than must be given

[13] "*Inventarisatie van de effecten van klimaatverandering op fysiek systeem Hoogheemraadschap van Delfland*" (Van Ek et al., 2007)

attention are the eastern part of The Hague, Voorburg and Leidschendam and WKH pilot area Noordpolder.

The influence of sea level rise and soil subsidence on the groundwater levels in the first aquifers occurs mainly in the higher, drier parts of The Hague. The influence in the inner dune edge remains limited. The effect of sea level rise and coastal expansion on the groundwater level is uncertain.

5.2.3 Stability of water barriers and safety risks

This relates to the stability of outlet/polder embankments and peat dykes. The safety aspects in relation to the coast and primary water barriers are investigated in the Delta Programme.

Because of the growing economic value of areas, the importance of water barrier stability is constantly increasing. Land subsidence is also causing higher risks in the event of dyke failure. As a result of (more rapid) land subsidence in polders with a peat bed, the level in the polders becomes lower than the water courses in the area. The result is an increase of the water depth in the polder in the event of water nuisance.

A large part of the Haaglanden region is protected by polder and outlet embankments, most of which are probably built from peat. The stability of these water barriers can be affected by a variety of different mechanisms. Climate change can exacerbate *one* or several of these mechanisms. The saturation effect on the stability of (peat) dykes during the winter periods will be stronger according to all climate scenarios, and also during the summer periods in scenarios G and W. The effects of dehydration on the stability of peat embankments are more intense during summer periods in scenarios G+ and W+.

This point for attention is already on the agenda in the Delfland Water Board policy framework for climate change (2008). Other points that must be given attention that have already been included in this policy framework, and which are considered advisable for other parts of the Haaglanden region to place them on the agenda, or to attune policy to them are:

- In the testing height of water barriers we must anticipate an increase of stronger winds and higher waves.
- (A part of) the solution for potential instability can be achieved by reserving space. To this end, Delfland Water Board follows a restrictive policy regarding building on peat embankments (Van Ek et, al., 2007).
- Peat dykes are not (always) suitable for compartmentalisation.

5.2.4 Water nuisance (surface water)

The variation of water task in the control area of Delfland under the various KNMI'06 scenarios has been defined in order to investigate the effect of climate change in terms of water nuisance. Figure 3 shows the result of this if the control area is seen as a whole. A positive change indicates a potential shortage of storage space and consequently a heavier task.

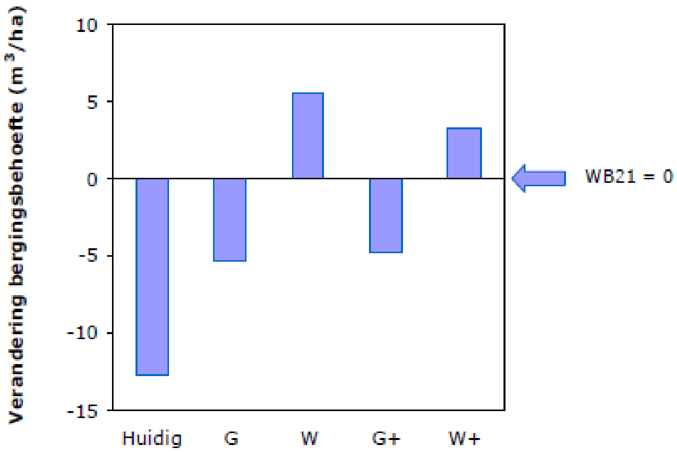


Figure 3 Change in the need for water storage in different climate scenarios in m3/ha vis-à-vis the WB21 Middle climate scenario. The current water task focuses on the Middle scenario. Current means the current climate. The change relates to the whole of Delfland and differs per sounding area.

Because the Delfland Water Board took the WB21 Middle scenario into account when determining the measures to solve the water task, these measures are in line with the G and G+ scenario and differ very little from the W and W+ scenario. This conclusion applies if the situation is looked at globally over the entire control area.

However, the bandwidth in the water task / need for storage space is extensive for the individual sounding areas. The change in the water task in the W climate scenario vis-à-vis the WB21 climate scenario can be as much as +20 m3/ha for some sounding areas. The wide bandwidth is due to 1) the complexity of the hydrology of greenhouse farming, urban area and grassland, 2) the diversity in the water systems (variations in combinations of pumping-station capacity and storage capacity and 3) the presence of several functions with different water problem norms within a single sounding area. When choosing (adaptation) measures to limit the water task, effective solutions will need to be sought that are specific to the areas concerned.

In the climate scenarios the water task increases more strongly in terms of percentage than the increase in rainfall. Given that the storage space in the current situation has largely been used up, the increase in rainfall in the future scenario almost directly implies an extra shortage of storage space.

5.2.5 Fresh water supply

Climate change has two prominent effects regarding water quantity:

1. There will be a higher water demand
2. The supply of fresh water will decrease

The demand for water will mainly be influenced by the degree of drought, a resultant of temperature and precipitation deficiency. The availability of water depends on internal buffers (soil moisture content, irrigation water basins, etc.), and particularly on the inlet of water from the main water system. In turn, inlet possibilities depend on the degree of salinisation resulting from the changes in sea level and river discharge. Irrespective of the climate scenario, both drought and salinisation circumstances will occur more frequently. The increase in dry situations in both the G+ and W+ scenarios is very large. It may be assumed that the likelihood of salinisation in these scenarios will also be relatively substantial.

For the Haaglanden region the following supply routes/agreements are relevant.

- The Brielse Meer pipeline
- The Water Agreement Rijnland-Delfland
- The Small-scale Water Supply Amenity Midden-Holland (Kleinschalige Wateraanvoervoorziening Midden-Holland, KWA)

Under normal circumstances, Delfland works with the supply of water from the Brielse Meer and Rijnland. Water from the Brielse Meer is preferred because of its higher quality. Under particularly dry circumstances, the KWA comes into operation. That was the case in 2003 when the low river level caused salinisation at the inlet point at Gouda. Thanks to the Brielse Meer and the KWA, Delfland had no problems in 2003. For other areas, the limits of the supply options did come into view in 2003.

An analysis of the climate resilience of the inlet points Gouda and Bernisse shows that both are highly sensitive to a change in climate in a G+ or W+ scenario. In W+, in a year such as 1996, the obstruction duration in Gouda will increase from the current 0 days to 76 days in 2050. Obstruction at the inlet point Bernisse will increase from 1 to 46 days. In a year comparable with 2003 this duration will double, reaching 143 and 95 days respectively. The reasons for this sensitivity differ. For Gouda the reason is the increasing level of salinisation from the sea in combination with the reduction in river discharge.

An indirect cause is added for the Bernisse inlet point. This inlet point is affected to a higher extent by the effect of interventions taken elsewhere in the Northern Delta basins. Without these interventions, the inlet point would theoretically be able to function longer. This would certainly be the case if the decision is taken to raise the chloride norm and the maximum permitted duration of obstruction can be extended. Nevertheless, it is improbable that interventions, partly taken from the viewpoint of climate change, will not be executed. Therefore, on the one hand it is a question of controlling the functionality of the inlet point by collaborating in planning studies elsewhere in the Delta, and on the other hand focusing on additional or alternative supply routes of fresh water (to the Brielse Meer) as an insurance policy.

5.2.6 Water quality

Climate change will lead to fluctuations in water quality. Sensitivity to climate change varies per type of water. Small, fresh and isolated waterbodies, for instance, will be effected more than vast bodies of water.

There are a number of points of concern that can be affected by climate change:

- **More frequent sewer overflows with more serious effects:** The expectation is that climate change will lead to an increase in the number of peak showers and the intensity thereof. This will also lead to an increase in the volume of water overflow. In turn, this leads to a heavier burden on surface water with oxygen-consuming substances. Furthermore, less oxygen is dissolved in warmer water. This leads to a more frequent, more rapid and higher reduction of the oxygen concentration in surface water as a result of sewer overflows. Low concentrations of oxygen and lack of oxygen leads, among other things, to decomposition, fish mortality, odour problems and an increase in blue-green algae. The low availability of water for flushing will amplify the decline in water quality.

- **Advance of exotic species:** The rise in surface water temperature will boost the chance of successful establishment of exotic species in the aquatic system. This will probably lead to problems.

- **The risk of a negative perception of water in the urban area:** Bottlenecks regarding how water is perceived in the urban area are mainly connected with blue-green algae and faecal pollution. Blue-green algae will occur earlier in the year, be more intense and last longer than before. As a result of the decrease in water replacement caused by the increased level of drought, faecal pollution of water can also increase.

- **Swimming locations under pressure:** The adverse effects regarding water quality lead to pressure on swimming water locations. The increase in the demand for recreation will also come under pressure. Swimming prohibitions will be brought into effect earlier.

5.3 Spatial differences in climate effects

The HSHL05/HSRR04 project – jointly carried out for the hotspots Haaglanden Region and the Rotterdam Region – investigated the spatial differences in temperature, precipitation, evaporation, wind, radiation, atmospheric humidity, etc., in the Province of South-Holland, the province that accommodates both regions. This project provides the availability of region-specific climate information in order to better support decisions regarding spatial planning and investments. Two subjects given a great deal of attention in the area and in various sectors were investigated in depth: extreme rainfall and the Urban Heat Island (UHI) effect.

Differences in climatology within the Netherlands will be due to:

1. relatively large-scale processes as a result of land-sea interfaces and differences in altitude. These differences can be seen in the observations from KNMI stations and are depicted in the Climate Atlas (www.klimaatatlas.nl). For instance: because of the proximity of the sea, the average temperature in South-Holland is higher in the winter and lower in the summer than it is more inland.
2. local surface characteristics (on a scale from metres to several kilometres) such as the presence of buildings, vegetation. These local characteristics are not equally important for each climate variable. While precipitation is not affected by very local surface characteristics, temperature and wind is.

On the basis of a literature study, an overview is given of the spatial differences in climate variables in the Province of South Holland. The main conclusions are:

- While the KNMI observations show many of the spatial differences in climate in the Netherlands, they do not show all the minor differences. Local differences in surface characteristics can lead to considerable differences only a short distance away (a few metres to kilometres), especially in temperature and wind;
- In the climate of the future the relative differences within the Netherlands will not change to a great degree given that the main reasons for the current spatial differences will not change very much. For instance, the average temperature in the coastal region in the future will also be lower in the summer and higher in the winter than the average temperature more inland. However, climate change can have a slight effect on the relative spatial patterns: the temperature gradient from the coast may, for instance, increase or decrease slightly. Also changes in local surface characteristics (e.g. urban expansion, nature area rewetting) may have a slight effect on the relative spatial patterns.

5.3.1 Extreme rainfall: Rainfall sequences in today's and future climate

Because of the large percentage of paved area and the high population density, heavy rainfall causes water nuisance relatively often. There are no lengthy time series of hourly rainfall for South-Holland (approx. 100 years) that water boards can use to estimate the likelihood of water nuisance. Different methods for drawing up region-specific lengthy time series for rainfall for the current and future climate are compared in qualitative terms as to their advantages and disadvantages. For the current and future climate, a single method is worked out each time that has advantages above the currently used method. The main conclusions on extreme rainfall in today's climate:

- The method developed for generating region-specific long periods of rainfall series on an hourly basis for the current climate shows most precipitation characteristics better than the method used to date (De Bilt + 10%): annual precipitation, annual cycle, length of dry and wet periods, multi-day extremes. While the method overestimates the extreme hourly rainfall less than the current method, the extreme 24-hour rainfall is underestimated.
- More research is needed to determine whether the new method described above gives adequate added value for water management.

Both the current method and the method explained here fail to present the current climate well. This is because of the trend seen in measurements taken over the past 100 years, and they are too short to make a good estimate of extremes that occur once every 100 years. The development of a precipitation generator on an hourly basis could alleviate these shortcomings.

The main conclusions on extreme rainfall in the future climate:

- A method has been developed by which precipitation time series on an hourly basis can be generated for the future and in which the extreme hourly rainfall can increase more than the extreme daily rainfall. The method is comparable and consistent with the programme for generating time series on a daily basis.
- Little is known as yet about the change in hourly rainfall in the future. However, feasible ranges have been indicated for this purpose for use in sensitivity analyses.

5.3.2 Urban climate: Effect of urban characteristics on temperature

Over the past few years a start has been made on developing knowledge in the field of heat problems in urban areas. Recent KfC studies and overview reports referred to in this Midterm Report are:

- Region-specific climate information for the Haaglanden and Rotterdam region (HSHL05/HSRR04)[14]
- Heat stress in Rotterdam (HSRR05)[15]
- Knowledge Assembly Heat and Climate in the city [Kennismontage Hitte en Klimaat in de stad][16]; executed by the KfC consortium Climate Proof Cities (Theme 4) on the instructions of the Alliantie Klimaatbestendige Steden [Alliance of Climate-proof Cities] (collaborative project between Amsterdam, Rotterdam, The Hague and Utrecht) and the Ministry of Infrastructure and the Environment.
- Climate-proof cities: Progress Report Climate Proof Cities 2011.

More hot days

Climate change will bring more warmer summers and milder winters to the Netherlands. The KNMI'06 scenarios indicate that the average summer temperature in the Netherlands around 2050 will have risen by 0.9 to 2.8°C compared to the current climate (1990). Another expectation is that the number of heatwaves will also increase. The exact increase in frequency and duration of heatwaves is at present difficult to determine. Nevertheless, it is known that in the future there will be more tropical days (the maximum temperature is then above 30°C). In 2050 an average 7 to 15 tropical days will occur per year in comparison with the average 4 in today's climate. The average summer temperature and the number

[14] http://knowledgeforclimate.climateresearchnetherlands.nl/hotspots/haaglanden-regio/HSHL05-HSRR04
[15] http://knowledgeforclimate.climateresearchnetherlands.nl/HSRR05
[16] http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=5643&GUID=1ff31c92-dfec-416d-a837-aa7fb4e1827a

of tropical days in the coastal area will be slightly lower than more inland. (Source: CPC Knowledge Assembly)

Urban Heat Island effect

On average it is warmer in cities than in the outskirts due to the Urban Heat Island (UHI) effect. Urban conditions that promote the UHI effect are: a highly concentrated infrastructure with buildings constructed from heat-retaining materials; an extensive surfaced and impermeable surface resulting in little water to evaporate; dark surfaces (asphalt, roofs) that reflect little sunlight. Because of the increase in urbanisation and urban concentration, the expectation is that the UHI effect will also increase. Moreover, an increase in the number of hot days from climate change will more often lead to the UHI effect in Dutch cities.

In the HSHL05 project, an estimation of the UHI effect in the Netherlands was made on the basis of measurements taken by amateur meteorologists and other studies carried out in the Netherlands. The outcome was that the UHI effect is strongest in the summer, and much less or almost absent in the winter. The UHI effect is stronger at night time than it is in the daytime. The urban configuration (incl. highly concentrated infrastructure) has a clear effect on the scale of UHI effect. The population density of a neighbourhood gives a better relation with the scale of UHI effect than the number of inhabitants in a city. The most significant conclusions from HSHL05 are that during nights with tranquil weather conditions (clear sky and little wind) the UHI effect in the most densely population neighbourhoods in the Netherlands (25,000 inhabitants per km2) can increase up to 8-10°C, in residential areas this is usually 5-7°C. On average, the UHI effect in Dutch cities is much lower. It is also evident that the scale of the UHI effect in the Netherlands is more or less the same as in other European countries.

Satellite images were analysed, various measurements were taken at various locations, health effects identified, reasons for the Urban Heat Island effect were sought for and measures were listed and assessed as to their potential effect in the heat stress project in the Hotspot Rotterdam Region (HSRR05). A policy workshop was also held during which research results were discussed and recommendations were formulated.

The study showed that there is an UHI effect in Rotterdam during the summer months. During calm nights the difference in temperature between urban and rural areas is 8°C. Among other things, the air temperature was measured with the assistance of a mobile weather platform. This showed that the coolest areas are in the somewhat older low-rise neighbourhoods with a large amount of greenery (such as Kralingen). It is warm in the highly urbanised areas such as the city centre and (Kop van) Zuid. The surface temperature was also analysed with the assistance of satellite images. Neighbourhoods with a great deal of buildings in the vicinity of high industrial activity appear to have a high average surface temperature.

(Source: HSRR05 final report)

Heat maps of the Haaglanden region

The results of the heat study in Rotterdam were used by the KfC consortium 'Decision Support Tools' (Theme 8) to construct so-called heat maps for the Haaglanden region.

Wageningen University took measurements of the difference in temperature between the city and rural areas. Using delivery bicycles with measuring equipment the different weather conditions were mapped out in Rotterdam. These differences were then correlated with the various statistics stored in land use databases. This showed a strong relation with both the amount of greenery at local level and the percentage of asphalting/paving at regional level. By confronting these relations with land use databases it became possible to draw up UHI maps. An average UHI effect of 3.5 degrees as measured in the summer of 2010 was taken to do this modelling. Historical KNMI time series of minimum temperatures were then used to express this UHI percentage in the number of days in which the temperature rose above 20 degrees. With the assistance of the KNMI conversion programme, this number of days was made specific for various climate scenarios. Account was also taken with the natural course of the average minimum summer temperatures in the Netherlands. Ultimately, this presented maps that gave an indication of the number of days with a minimum temperature of 20 degrees.

In consultation with the stakeholders in the Haaglanden region, maps were made that link the various urbanisation scenarios from the Netherlands Environmental Assessment Agency (PBL) to the UHI effect on the basis of the percentage of greenery and asphalting/paving, and checked against practical measurements taken in Rotterdam neighbourhoods. The effects of climate scenarios were also processed. On the basis of effects on humans with respect to liveability, the number of nights per year in which the temperature rises above 20 degrees is shown in colour, distributed over the region. Different forms of presentation were discussed with policy-makers, but the region chose for a presentation that immediately illustrates where the effects of concentration and climate change are the largest by using colours (Figure 4). The map supports the choices made in the spatial policy to retain the open green areas in the region, and calls for attention to be given to the greening of public space in highly built-up areas.
(Source: Hasse Goosen)

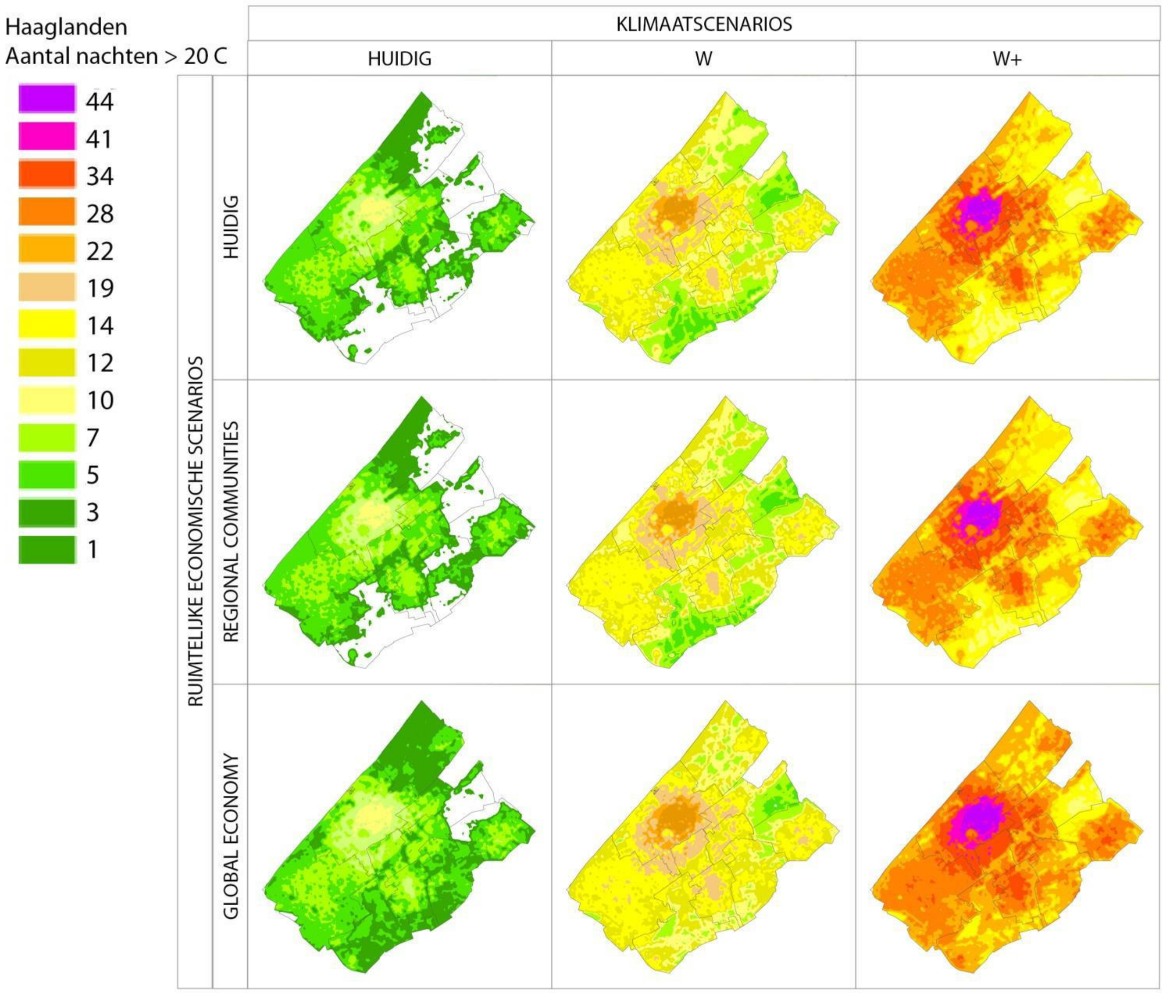


Figure 4 Potential Urban Heat Island effect in the Haaglanden region. These maps (de Groot, 2011) are the result of a correlation between measurements of the UHI effect taken in the City of Rotterdam (Heusinkveld, ten Hove, 2010) and parameters of the UHI effect (Koekoek and Jacobs, 2011) which were subsequently extrapolated to spatial-economic scenarios (Dekkers, 2011) and climate scenarios (KNMI, 2009).

6 Tasks, opportunities and adaptation options

The core values in the Haaglanden region for the types of area grass, city and glass in the Haaglanden region are *an innovative greenhouse horticulture sector, an attractive green area and coastal zone, and liveable cities*. At the same time the region is faced with a huge densification task. In the HSHL06_12 project, potential spatial developments were mapped out on the basis of a trend variant and a policy variant. This shows that when the ambitious goals in the current policy of densification have been achieved, the spatial structure in the region will remain more or less unchanged. If this is unsuccessful, the socioeconomic trends will ensure a further advance of urbanisation and have consequences for agriculture (dispelling agriculture). A further densification will make climate adaptation in urban areas more urgent. Climate-proof urban densification is a difficult task to tackle given that most measures need extra space to fight urban climate effects such as heat stress and water problems. The way in which at the local level account is taken with the preservation and development of green-blue structures when concentrating the urban area determines the climate resilience and habitability of these areas.

The following sections go deeper into the specific spatial developments in the areas of grass, city and glass in relation to climate change and adaptation. The effects of climate change, as set out in the previous chapter, not only give rise to threats with regard to creating the conditions for economic development, but also give opportunities for the ambitions of the three types of area. On the basis of completed and ongoing projects and case studies within Knowledge for Climate, the current state of knowledge is outlined as to the possibilities of adaptation (technical, economic and societal measures) for the different use functions of grass, city and glass.

6.1 Grass: An attractive green area and coastal zone

6.1.1 Climate effects on agriculture, nature and recreation

‘Making green areas more attractive and accessible’ and ‘combining the water task with the development of green features and combating landscape jumbling’ are tasks that were described in the RSP2020 to benefit a well-functioning regional urban network.

During a workshop (Arena, within the framework of project HSHL06_12) with the regional stakeholders, the objectives for the grass area were formulated concisely in three statements:

1. Agriculture – ‘the cow must keep its place in the meadow’
2. Nature – ‘the orchid must keep its place in the countryside’
3. Recreation - 'we keep the tourists on bicycles’.

A study was made into how far climate change will have an effect on achieving these objectives. The conclusions for the different sectors are as follows:

1. The competitive strength of land-linked agriculture will probably diminish due to climate change. Extreme weather events will increase, especially in the heat scenarios. In the W+ scenario, prolonged arid periods and heat will lead to crop losses, and spraying will need to carried out more often. Moreover, the acreage of land-linked agriculture will dwindle further (from 10,000 ha to 7,500 or 6,000, depending on the scenario), plus a water storage task in the order of 100-200 ha.

2. Nature values will probably decline due a further lowering of groundwater levels, the increasing influence of area-foreign, more saline water, and the increasing level of mineralisation. On the other hand, an increase in the acreage of greenery in both spatial scenarios (from 5,000 to a maximum of 8,000). On the whole, in the policy scenario we see a total increase of approximately 500 ha of non-built-on countryside and grass area. In the trend scenario we see a loss of 2,000 ha nett in built-over countryside and grass area.

3. The number of tropical days could rise from an average of two per year in the current climate to roughly 25 in 2100 W+. This means that the demand for cooling and outdoor recreation will grow. Yet at the same time we detect a shortage of recreational space. Finally, we see a reduction in the provision of recreational facilities due to climate change (swimming water, less agricultural acreage and a deterioration in the quality of the countryside).

6.1.2 Seizing the opportunities

Climate effects result in closely interconnected tasks in the grass area. There will also be opportunities that can taken advantage of within the different sectors.

In the first tranche project HSHL02 an overview was drawn up of potential tasks and points that demand attention with regard to the peat-meadow area. In the 'Tasks checklist' in Appendix 4 of the *Werkboek Toekomst Veenweide*[17] these are set out per theme. In summary:

- Safety: giving attention to primary and secondary dykes, particularly peat dykes, and to compartmentation and disaster control. The latter two subjects have not generally been crystallised at polder level. Primary barriers do not play a direct role in Midden-Delfland.
- Land subsidence: tasks connected with the drop in ground level are mainly determined by the costs ensuing from ground level drop and by the wishes and possibilities to preserve peat (see Appendix 5 HSHL02 'Dilemma: to preserve peat of not?').
- Water system: this task looks at the general management aspects and flooding, water shortage (ground moisture), water inlet, water quality and water infrastructure.

17 http://promise.klimaatvoorruimte.nl/pro1/publications/show_publication.asp?documentid=6959&GUID=ff6c2ee1-927f-4e02-bbd0-df170da07961

- Heat stress: is a potential point to be considered for virtually all functions: ecosystems, living, working, recreation, agriculture, infrastructure and mobility. The threats caused by heat for the green area appear to be better than expected, heat mainly presents opportunities.
- Collaboration: opportunities for collaboration between sectors, businesses and areas. This category serves particularly to investigate the opportunities in chains; energy, water collection and water supply, services, are looked into.

In project HSHL06_12 solution alternatives are described in recommendation of the regional adaptation strategy, particularly on the basis of dealing with the water system and multifunctional land use.

Strong connection with the water system
Climate resilience of the grass area is strongly related to the organisation and management of the water system. An increase in rainfall adds to the risk of water problems. On the other hand, longer periods of aridity and a higher level of evaporation will increase the demand for water. Making the grass area more climate-proof is therefore more concerned with the temporary storage of peaks in rainfall and preventing soil dehydration and parching of the wildlife area by retaining water longer in the area. Bear in mind the wide variations in the supply and the quality of water when arranging new nature areas. Making the nature goals flexible helps in this context. Focus on creating preconditions for nature, in which the type of nature that develops is left blank.

Transition to multifunctional outskirts
The autonomous trend is that the acreage of green areas is diminishing further and the quality of these green areas will be put under pressure by climate change. There is a functional task set aside for the Haaglanden region to further develop the grass area as a multifunctional landscape in which agriculture is not only a producer, but also a provider of major nature, landscape and recreational values.

Potential adaptation strategies for the outskirts are related to the character of a region (urban or rural), and the degree to which agriculture produces primarily for the world market or also retains its competitive strength by way of ‘widening’. On the basis of this body of thought we expect that the land-linked agriculture in the Haaglanden region will be able to partly cushion the blow from the negative consequences of climate change by focusing on services in an urban environment. For instance: recreation, care, regional products and services to the benefit of nature and water.

The transition to a multifunctional landscape is also attractive from the recreation perspective. Due to the great demand for recreational space, especially in the *Zuidvleugel* of the Randstad, and the high urban demands, a transition to a more wider agriculture with the accent on nature, landscape and recreation is only obvious. For instance, stimulate the use of green areas in and around the city for recreational purposes and boost transition to a multifunctional consumption landscape.

6.1.3 Feasible measures

HSHL02 The *Inspiratieboek Toekomst Veenweide* presents an overview of 'climate adaptive building blocks'. It makes a distinction between building blocks that expect adaptations in the water system, and adaptations in functions (Figure 5).

What the influence is on the 'climate effects', and on what scale the measure can be applied is indicated per building block. What the measure means, how the measure works and what information on the measure is available (research reports and websites) are explained.

WATERSYSTEEM

peilbeheer en peilvakken
- peilvakken vergroten
- flexibel en dynamisch peilbeheer
- slootpeil verhogen
- cascade

natuurlijke inrichting en waterkwaliteit
- natuurvriendelijke oevers en filters
- waterkwaliteitsbeheer

meer open water, koelte en buffering
- nieuwe en grotere plassen
- verbreden van de watergangen

bodem en bodemvocht
- onderwaterdrains
- greppels, broedpeilen en bodemvocht

FUNCTIE

landbouw
- zorg en recreatie
- groen- blauwe diensten
- toemaakdekken
- robuuste en bestendige gewassen
- energie produceren
- heterogene drooglegging
- verzekeren en combineren

natuur
- robuuste onderwatertopografie
- weidevogelgebieden

bouwen
- waterbestendig bouwen

stad-land
- stad-land waterrelatie

recreatie
- heerlijk helder zwemwater
- schaduwrijke koelte

Figuur 5 24 'building blocks' for climate adaptation in peat meadow areas, from *Inspiratieboek Toekomst Veenweide* (HSHL02)

6.1.4 Relevant studies other than Knowledge for Climate

WKH pilot area Midden-Delfland green-blue services

The agricultural sector has provided ecosystem services or 'green services' in the form of (paid and unpaid) management of nature and the landscape for dozens of years now. Over the past few years, blue or green-blue services have gained in popularity: services in the domain of water quality and water quantity, or in the wider sense: services provided to water boards. Experience has meanwhile been gained at various locations in the country. One of the WKH pilot areas is Midden-Delfland, where opportunities for green-blue services have been investigated. Various sub-projects have been executed:

Delfland Water Board has shown an interest in green-blue services for some time now. In 2007 an initial foresight study was carried out into a limited range of services. One of the ideas from the foresight study was to draw up a concrete 'polder offer' as a finger exercise. Such a fictitious offer, later called an 'area offer', should make it clear how to do real business: it contains an elaboration of services, preconditions and prices. In the context of Waterkader Haaglanden and the EU project Aquarius, an area offer has actually been realised. The report '*Gebiedsofferte groenblauw diensten Midden-Delfland – Bouwstenen voor mogelijke afspraken tussen Vockestaert en Delfland (2011)*' sets out the findings of the process to realise an offer and a concrete (but fictitious) offer for a select number of services.

The '*Kansen groenblauw diensten Midden-Delfland – Handreiking binnen wettelijke kaders en regelingen*' is a product of the research project '*Catalogus groenblauw diensten*'. This project had the goal of investigating which green-blue services are of interest to be included in the Dutch Catalogue of Green-blue Services[18]. The scope of the project has been widened by the foresight study into possible regulations to realise green-blue services in Midden-Delfland.

The final report '*MKBA open waterberging Midden Delfland' (2011)*' presented the outcomes of a study (conducted by Ecorys) into the societal costs and benefits of constructing an open water storage area as a possible solution for the water storage task in grassland polders in the Midden-Delfland area. This study showed that indemnifying farmers for watering the grassland is more favourable in terms of costs and effects than realising extra open water storage to meet the water storage standard, given that this involves withdrawing agricultural land from production.

Research Aquarius: Farmers as water managers

Aquarius is an INTERREG IV subsidy programme in which Delfland, together with the North European countries Norway, Sweden, Denmark, Scotland, Germany, the Province of Drenthe and Hunze and Aa's water board, is looking into the possibility of collaborating with 'farmers as water managers'. The programme is allied to the WKH Pilot Area Midden-Delfland.

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[18] Catalogue of green-blue services (2011): http://www.groenblauwediensten.nl/pages/home.aspx

In June 2010 the Aquarius partners came to Delft to visit the pilot area Midden-Delfland and exchange views on financial and collaboration methods. The knowledge shared and the experience gained at this meeting are set out in the reports "Farmers as water managers - Financial Methods" and "Report on Participatory Planning". The latter report was drawn up in association with the Province of Drenthe. The first report looks into four different financial models, and an investigation was made into the economic preconditions. With the assistance of a strengths and weaknesses analysis, the report on participatory planning looks at methods that could encourage collaboration between water control authorities and farmers. This can be done, for instance, by introducing initiatives that are well in line with the economic goals of the parties concerned (win-win) and do not conflict with European legislation and regulations (state support).

6.2 City: Liveable cities

6.2.1 Climate effects in the urban area

The city accommodates many different functionalities related to living, working and transport. The Haaglanden region has set out the lines for the development of these functionalities in the 'Regional Structure Plan Haaglanden 2020 (RSP, April 2008). This document defines the previously mentioned ambitions:

- Further developing the four international specialisations that form the economic heart of the Haaglanden (peace, justice and safety; knowledge, innovation and technology; Greenport Westland-Oostland; tourism)
- Improving the regional networks for greenery, water and traffic
- Continuing to work on attractive housing conditions and a pleasant environment

To realise these ambitions account must be taken with climate change and the positive or negative influence thereof on the city's various functionalities. The enormous challenge in this respect is how inner city compaction can be combined with making the city climate proof, and still give the aspects of liveability and health top priority.

The **increase of water problems** and **heat stress** are the main effects of climate change that have both a direct and indirect influence on the living, working and transport functions in the Haaglanden region. The following sections go deeper into these themes.

Other potential effects of climate change (from HSHL06_12) which are relevant in the urban area (seem better than expected / only a limited amount of research conducted in this respect) are:

- *Subsidence of buildings and roads and foundation damage due to drying out:* Shrinkage and subsidence can cause cracks in walls and foundations. Drying out leads to a drop in water levels, and in turn leads to the wooden piles, as were used in historic town centres, being exposed to oxygen and disintegration due to fungi.

- *Decline in the safety of buildings due to changing climatic circumstances:* Wind and temperature increases could lead to a decline in the safety of buildings because buildings are simply not designed and built to cope with these changing circumstances, but the risks are uncertain and for the time being regarded as minor. The risk of roofs collapsing under extreme rainfall/snow is seen to be more realistic. Especially flat roofs and industrial units are vulnerable, as also are the greenhouses.
- *Weathering of buildings and roads:* Winter frost damage is generally greater than summer heat damage. A shift to warmer winters and summers will consequently most likely lead to a saving in costs on road repairs. It also seems probable that solar gain, salt penetration and the development of harmful organisms will damage old buildings in particular, while in this respect the fewest measures are available.
- *Increase in the vulnerability of other infrastructure:* The main effects of climate change on the supply of drinking water at DHZ in the Haaglanden will occur in long periods of drought and relate to a lower dilution of point source discharge and a higher risk of cyanobacteria thriving at high water temperatures. No significant effects are anticipated on the remaining infrastructure such as the energy supply.
- *Local disruption of mobility:* Mobility can be disrupted as a result of flooded roads in the lower-lying areas on the south-eastern side (Delft, Pijnakker, Zoetermeer and Leidschendam).

6.2.2 Water nuisance

As described earlier (section 3.2.4), in terms of percentage water nuisance increases in the climate scenarios stronger than the increase in rainfall. Given that the storage space in the current situation has mostly been used up, the increase in rainfall in the future scenario is almost directly translated as an extra shortage of storage space.

If measures for the short term are dimensioned on the G and G+ scenario, then these measures may be regarded as no-regret measures. It will then be possible to make adjustments in the future should it appear that the climate scenarios are more extreme. The policy pursued by the Delfland Water Board, as set out in the '*Kadernota 2011, Delfland op weg naar de toekomst!*', has been attuned to this.

Climate change will have an effect on the functioning of sewage systems; they will need to convey large volumes of rain more often. If the current sewage systems have to deal with this change, then the frequency of water problems on the streets, and the associated nuisance, will increase. These effects will occur more often in the known problem areas. Depending on the spread of precipitation, new and varying problematic locations will arise.

Basically, street flooding can happen everywhere in the area. To determine the current situation it is evident that establishing the nuisance caused – on the basis of reports from inhabitants – give the most reliable picture. Computer simulations often fail to represent the actual situation of the system and therefore forecasts are incorrect. Moreover, street flooding is extremely local and depends on the specific situation. It is therefore impossible to make general quantitative statements on the effects of climate change on flooded streets. Nevertheless, it is clear that the nuisance at existing problem areas will become more intense.

Limiting the nuisance caused by water on the streets can be reduced in various ways. Significant options are to be found in local solutions. Options are (including Rioned):

- raising the inhabitants' 'acceptance' of water on the streets (this is easier if the water concerned is clean rainwater as opposed to water gushing up from the sewage system)
- disconnecting the paved surface at the drainage points of the sewer system
- underground storage, by laying on larger sewage systems and detention and settling basins (disadvantage: higher costs)
- bringing pumping stations into operation (limited benefits from pre-pumping, or from retaining water in upstream areas where there is adequate storage capacity longer, by ensuring a delay before the pumping station comes into operation)
- better maintenance, especially with a view to preventing blockages by installing catch basins, etc.
- reducing the use of (semi) closed asphalt on private land to achieve more rainwater infiltration
- heightening kerbstones and lowering the street level to store water on streets in order to prevent nuisance in dwellings
- storing water in public space such as green areas
- more open water for extra water storage
- protecting buildings from flooding e.g. by making entrances to buildings higher.

(Source: HSHL06_12 final report)

Climate in spatial choices (HSHL01)

The consequences of climate change on water management are often not taken into consideration adequately when choosing locations for new functions or when (re)organising existing locations. A sound assessment is essential in economic and societal terms to keep down the future costs of water management. In the project '*Klimaat bij ruimtelijke keuzes*' HSHL01[19] researchers, governments and hands-on partners developed the DAK: Dialogue supporting assessment framework. DAK must increase transparency, provide space for interdisciplinary and multidisciplinary research, encourage participation and interaction, and last but not least, to better communicate results and insights of planning processes to the outside world. Moreover the DAK can help when drawing up spatial plans by giving fast and clear consideration to the long-term effects of climate change on water management.

The DAK method has been tested in Rijswijk-Zuid (now called Rijswijk-Buiten): the last large-scale building location in the Haaglanden region. According to the initiator, the growth of the region and the cluttered character of Rijswijk-Zuid calls for an adjustment. According to the plan, former greenhouse

[19] http://kennisvoorklimaat.klimaatonderzoeknederland.nl/hotspots/regio-haaglanden/HSHL01A

areas and the remains of greenery and allotments will make way for a new neighbourhood with houses and businesses in green, park-like surroundings. The main question for the Rijswijk-Zuid case is how tenable is the Masterplan for Rijswijk-Zuid in terms of climate change. Is Rijswijk-Zuid immune to future water problems or problems of drought? The answer to these questions was sought by using the dialogue supporting assessment framework (DAK). The stakeholders indicated that this method was highly theoretical, but that the approach did help to streamline and guide the discussions.

A list of climate effects and potential indicators which could be of particular relevance to the Haaglanden region was also drawn up within the project on the basis of expert judgement and a literature search. This list can be found at http://public.deltares.nl/display/CAW/WIKI-klimaateffecten. The actual report layout is still such that it cannot be used adequately as a tool by municipal authorities in area processes or zoning plans. A visualisation step and a concise, clear description of the approach is still needed.
(Source: HSHL01 final report)

3Di water management (third tranche project HSHL3.3)
Urban and rural drainage systems need to be constantly adapted to spatial planning and climate changes. 3Di is an instrument for developing and evaluating adaptation strategies. Traditional measures, such as more open water, have proven difficult to realise due to the limited amount of available land space, lengthy legal procedures and high investments. The water board and municipalities in the densely populated Hotspot Haaglanden are therefore searching for new methods and smart solutions to deal with the aforementioned issues.

3Di Water Management has developed a new high-definition water space oriented water model that makes large-scale and detailed computations and realistic 3D visualisation of water possible. Due to it rapid computations it is possible to use the model in interactive way as a design instrument, whereby the impact of measures can be visualised within minutes, instead of days.

This project that will start in the autumn of 2012 aims to make the 3Di model applicable for end users, both spatial planners and water managers. Therefore a set of user interfaces for various types of end users are to be developed that allows them to design tailor-made solutions for water management problems. Moreover, the 3D visualisation will be extended with spatial rainfall visualisation.

To enable its use as a design tool it is necessary to link the spatial model to 1D sewer flow and 1D channel flow, including structures. The project includes valorisation by two pilot studies. The first pilot is related to the complete outlet channel system of Delfland and the second pilot focuses on an urbanised polder. The pilots lead to concrete adaptation strategies in which the benefits of the new instrument are clearly demonstrated in practice.
(Source: project proposal HSHL3.3)

Dealing with extreme rainfall (CPC WP3.3)
Phase 2 of the KfC study *'Omgaan met extreem neerslag en benutting in stedelijk gebied*' is now being completed. The study (project 3.3) is part of Climate Proof Cities (Theme 4). Hotspot Haaglanden has not yet been acquainted with the results. Work is in progress on a manual for the water manager with calculating tools to quantify the effect of measures. These tools are being tested in Oude Noorden in Rotterdam and Watergraafsmeer in Amsterdam. The Haaglanden region would very much like to use these tools to further detail the RAS and use the knowledge generated by Hotspot Haaglanden. (Source: Progress Report Climate Proof Cities 2011 December 2011)

As a follow-up to project 3.3, the CPC submitted an extension proposal *'Afwegingsinstrument voor maatregelen bij extreme neerslag in stedelijk gebied*'. The City of Rotterdam and Waternet (case holders of the location in project 3.3) and the Hotspot Haaglanden are interested in a set of tools that can be used to assess adaptation measures in urban water management on the basis of the available research results (see also the previous section *3Di water management*). To be more specific, this relates to measures for improving the processing of extreme rainfall. The assessment relates to visualising the spatial impact of measures and the costs and benefits.

An affiliation will be entered into with the research programme 3Di Water Management[20] to develop this set of tools. In this programme different (ICT) products are being developed for water managers, spatial developers and calamity organisations. These products make it possible to forecast water problems more accurately and much faster. 3Di Water Management provides:

- Detailed information on water problems resulting from heavy rainfall and flooding;
- Direct insight into the effects of measures;
- Real-time information, made public through an interactive web portal;
- A clear insight into water problems by means of lifelike 3D animations.

The research will ultimately lead to:

1. A prototype of a set of assessment tools in which specific urban systems can be configured, and by which a climate adaptation strategy can be developed through participative modelling sessions.
2. Three configured assessment, one for each case area (oude Noorden in Rotterdam and Watergraafsmeer in Amsterdam, and an area yet to be designated in Haaglanden).

(Source: extension proposal CPC 3.3 '*Afwegingsinstrument voor maatregelen bij extreme neerslag in stedelijk gebied*')

Pilot Areas Waterkader Haaglanden
A great deal of knowledge and experience has been gained in the Pilot Areas of Waterkader Haaglanden on how to tackle the water task in urban areas, especially in the following pilot areas:

[20] www.3di.nu

- Rijswijk-Zuid – *integrated design*
- Noordpolder The Hague – *dynamic modelling of water nuisance*
- Plaspoelpolder Rijswijk – *industrial estates*
- The new water Westland – *floating houses*
- Delft TUNoord – *water games in regional development processes*

The main innovative results in the WKH pilot areas are summerized in Appendix 1.

6.2.3 Urban climate and heat stress

On the basis of heat studies in Rotterdam, heat maps have been produced for the Haaglanden region to support decision making in spatial development to keep the green areas in the region open and to devote attention to the greening of public space in densely built-up areas (see section 3.3.2).
To date, no research has been carried out into the specific consequences of heat stress and feasible measures in Hotspot Haaglanden. However, research was carried out within the framework of Knowledge for Climate in Rotterdam (HSRR05), and generic and location-specific research is carried out into heat in the city in the second tranche in Climate Proof Cities. As one of the stakeholders, Hotspot Haaglanden has the opportunity to utilise this knowledge. The Haaglanden is associated with a study to visualise vulnerable areas in terms of heat problems by using map images. One of these maps has been developed into a promising example for Amsterdam.

Impact

According to HSHL06_12, one of the most important issues regarding the aspect of liveability in the urban areas in the Haaglanden region is heat stress. In the Haaglanden policy scenario, the urban area is compacted and this leads to an extra risk in terms of heat stress (in consequence of the UHI effect) and air quality. The impact of heat stress is probably exacerbated given that water will become more scarce (in terms of quality and/or quantity). On the other hand, the Haaglanden region is located favourably on the coast with sufficient access to cooling (sea) water.

It is concluded in CPC's Knowledge Assembly that the research to date has mainly been focused on mortality and health issues caused by heat stress where the consequences of urban heat are concerned. In the event of heat stress, the heat causes a rise in the body's temperature and leads to sickness and death. Moreover, heat stress can influence sleep and behaviour. The elderly are the most vulnerable group in this respect because of their lower level of temperature perception and a diminished desire to drink, use of medication, presence of diseases and disorders, plus a lower ability to perspire. Research into the aspect of mortality due to heat in the Netherlands shows that the death rate rises by 12% (40 deaths a day) during a heat wave. Most of these victims are above the age of 75. Children are apparently no more vulnerable than adults.

In addition to heat stress, other consequences of urban heat are the effect on:

- thermal comfort (indoors and outdoors)

- energy consumption
- air quality
- labour productivity
- the attractiveness of the city's climate to make one want to stay there, recreate, live and work there

(Source: Knowledge Assembly heat, CPC)

Measures

Measure taken against heat in the city should be restricted to no-regret measures. This means measures that do not lead to cooling in the winter, have no adverse side-effects and are not permanent (neither in time nor location). In CPC Knowledge Assembly, potential measures were described in the field of green, water, buildings, urban structure and human behaviour. The most significant conclusions of the Knowledge Assembly per theme:

Green in the city provides a cooling effect in three ways:
- active cooling over day by evaporation through leaves (evapo-transpiration)
- passive cooling in the daytime by providing shade
- relatively little heat absorption as opposed to stony surfaces

The effectiveness of greenery as a heat measure depends on the type and density of the vegetation, the location and size of green areas. To date, little is known about the quantitative effectiveness; the available knowledge is based on computer simulations and a limited number of local measurements.

To provide evaporation cooling, plants and trees must have easy access to water. During hot periods it is therefore important to ensure sufficient irrigation.

Green areas in the city, such as parks and gardens, provide local cooling, and the difference in air temperature between a park and its surrounding area can vary from 1 to 6°C. Also, green areas can have a cooling effect on their surroundings. The cooling effect of trees in streets is mainly from the shade they provide to both humans and buildings. Outer walls with plants growing up them also have a cooling effect thanks to the shade they provide, as well as the evaporation cooling of the plants near the building. The layer of air between the plants and the building's shell also provides extra insulation and consequently lower indoor temperatures when it's hot, the same as green roofs do. Green roofs also play a significant role in holding water during peak in rainfall. The direct cooling effect of green roofs at street level is very limited. If planted on a large scale, 'intensive' green roofs (with a thick layer of substrate) can limit the UHI effect.

Water has a cooling effect on the air temperature by evaporation and by absorption, and possibly by transporting heat. The effect of surface water on the temperature just above the water surface is big,

but at street level this is limited to the street where the water is located. Flowing water has a better cooling effect that still water. Spraying, e.g. by atomisers and fountains, has the greatest cooling effect. Temperatures at street and building level can be lowered by spraying streets and roofs, the quantitative effectiveness of such methods in the Netherlands still has to be studied.
One of the main consequences of climate change at **building level** is the increase of overheating inside buildings. The relation between indoor and outdoor temperature in hot weather depends on many factors (surrounding buildings, shade, building geometry, insulation, amount of sun through windows, user behaviour, etc.). Little is known about this relation regarding the types of buildings in the Netherlands but it is quite clear that to an increasing extent buildings will become more sensitive to overheating. Mechanical cooling or air conditioning will probably become a significant part of climate adaptation. This results in higher energy consumption. One of the most important building parameters that can be used to limit overheating or to reduce the demand for energy for cooling purposes is by increasing the albedo or reflection value of the roof surface and outer walls. Research shows that light-coloured wall and roofing materials can reduce sun load considerably.

Urban structure has an influence on the UHI effect and heat perception in the city by the specific size, building density, composition and geometry of a city. If, when erecting buildings in the environs account is taken with cooling, then sun and wind orientation are essential factors. One way to improve natural ventilation is to adjust the street profile by means of optimal height/width ratios, The low albedo (reflection) and slow cooling down of frequently used materials in urban areas lead to the accumulation and retention of heat and are therefore partly the cause of the UHI effect. Studies carried out abroad show that raising the city-wide albedo by e.g. lighter-coloured outer walls, roofs, paving and building materials can result in a significant effect on a city's air temperature.
Not only physical interventions can be taken to prevent the adverse effects of heat in the city. Also anticipating the behaviour and adaptability of the inhabitants can be effective in counteracting the negative consequences of heat, especially where the most vulnerable group is concerned: the elderly. Recommendations regarding behaviour during heat waves are made in the National Heat Plan. A growing number of municipalities use this and other aids in their communications with citizens.

Many measures taken for cooling the outdoor and/or indoor climate (such as green roofs or evaporation cooling) also lead to energy saving and consequently reduce greenhouse gas emissions. These measures therefore not only have an adaptive, but also a mitigating effect. **Synergy between adaptation and mitigation** can help when formulating so-called no-regret measures and can be a strong argument for introducing specific heat measures. When making choices it is also important to take the opposite effect into account; adaptation measures such as mechanical cooling systems (air conditioning) can have a negative effect from the mitigation point of view.

(Source: CPC Knowledge Assembly)

Recommendations on taking measures to mitigate or prevent the negative consequences of urban heat from the heat stress study in Rotterdam (HSRR05):

1. Considering the necessity and obvious effectiveness, start by taking restoration boosting measures indoors (see e.g. www.ggd.rotterdam.nl).
2. Take proactive measures that help people to adjust their behaviour to the hot circumstances and therefore prevent or reduce heat stress (finding cool places, wearing appropriate clothing, encouraging fluid intake, etc.).
3. Reduce the heat load on building level by improving the indoor climate (insulation, ventilation, fixed blinds on walls facing south, movable blinds on walls facing east and west).
4. Make a choice from a whole range of measures that have a positive effect on city temperature, no cooling effect in the winter and can relatively easily be reversed, such as: fountains and small-scale greenery, creating green roofs and walls, installing temporary shaded areas in streets and spraying roofs, walls and streets. Where possible, use as much rainwater as possible, rather than drinking water.
5. If necessary, take additional large-scale measures such as creating space for more wind, adapting roofing, outer wall material and paving, or cleverly introduce open water areas.

The policy workshop resulted in a few more tips of a more process-technical nature:

6. Because of the uncertainties involved, and also – and especially – the possibilities, continue to search for coupling opportunities.
7. Do not forget the sharing of responsibilities and show the inhabitants that they can do a great deal themselves.
8. Focus on the opportunities (pleasant thermal comfort) instead of bringing bad news (the number of premature deaths) without losing sight of mortality and health issues.
9. Cherish the adage from the Sustainability of the Rotterdam Municipality Programme Office "Learning by doing". There is still a great deal that is not known precisely, but there is also a great deal that is obvious. Set to work on this basis and keep in mind the advances made in insight.

(Source: HSRR05 final report)

A great deal of research into water problems and potential measures has been carried out within the region by the Waterkader Haaglanden project. That led to an administration agreement Water and Climate Table of 16 November 2011 where the focus was more on a risk approach and proactive linkage in area processes with stakeholders. To do this, tools such as 3Di must be used to fine-tune the water problems and to find smart solutions for storing water in the public space in order to achieve flexibility. Much has been done to tackle the discharge and storage of water by means of municipal water plans. In practice, retention could contribute a great deal to cushion the burden from extreme rainfall. This calls for projects to make inhabitants aware and accept a certain amount of hindrance. How this must be organised must be worked out in the RAS process. With regard to heat, the focus is on pleasant surroundings with large green areas and the coast. Include greenery where possible in the area processes for public space. Where possible, housing and office space can be designed and/or renovated in such a way that heat problems will not arise. A good understanding as to in which dwellings and offices this can be done is important. Consideration is also being given to measures that combine heat and cold storage.

6.2.4 Regional climate buffers

Where measures against the effects of climate change in the urban area are concerned, besides options within the city other options further afield can be considered. Also the city outskirts can play a role in climate adaptation. Climate Proof Cities drew up an inventory of the regional adaptation strategies that have been proposed and realised around the world which shows that there are numerous options for tackling climate adaptation at regional level, but that specific use of the available means depends on the local circumstances. One point of attention in this respect is the influence of the urban shape that differs per area. Urbanised Brabant is characterised by a row of larger and smaller town spread over a large area, while the Randstad consists of various compact city conurbations situated closely together. There are also differences in soil composition and the relation between water, green and urban surface; this makes a comparison interesting. It is still unclear how the different types of area relate to one another. (Source: CPC annual report 2011)

The CPC research programme takes a look at (packages of) measures and strategies for regional tasks and projects, or local measures that can be up-scaled to the regional urban level. Central in this respect is the phenomenon of urban heat and the relation with aridity and precipitation.

Hotspot Haaglanden is part of CPC's regional case study. As requested by the Haaglanden region, the focus in this study is on verifying different strategies with regard to 'urban green'. Is it effective to encourage the development of municipal parks, like the Zuiderpark, or is it better to focus on maintaining green areas, such as Midden-Delfland? Development of the 'Hof van Delfland' plays an important role in this question. The role of the Westland is also specifically looked at, as also are pre-war neighbourhoods as the most compact areas of the city. An impression has already been created for Amsterdam, so that a comparison with the Haaglanden region is possible when this project has reached completion. For the Westland there is the question whether the greenhouse farming area has the same characteristics as the city in terms of heat balance. WP 1 of the CPC has been requested to look into this by taking aerial measurements along specific routes.

6.3 Glass: An innovative greenhouse horticulture sector

Climate effects on the greenhouse horticulture sector will not only occur in the Haaglanden region but also elsewhere (probably to an even greater extent). This could mean that despite the predominantly unfavourable effects on crops, there is still a (relatively) beneficial effect for the sector, and export opportunities for the greenhouse horticulture sector in the Netherlands and the Haaglanden region. One significant conclusion from project HSHL06_12 is that climate change will most probably lead to opportunities for the greenhouse horticulture sector in the Haaglanden region. However, attention must be given to the water supply, infrastructure, water problems and damage prevention.

Although the greenhouse horticulture sector in the Haaglanden region will shrink, the sector is still characterised by a great organisation ability with knowledge networks such as market gardeners' associations, pilot projects, etc. Climate change is a gradual process and therefore there is ample time and space for adaptation. There will, however, be pressure, i.e. on the water supply in the area. But many new research and development projects are in place to find solutions that should increase the sector's self-sufficiency. (Source: HSHL06_12 final report)

The most important threats for the greenhouse horticulture sector set out in HSHL06_12 are:

- *Urbanisation:* A spatial threat is the strong pressure of urbanisation and the associated restriction on expansion possibilities and the enforced small-scale aspect.
- *Limitations on water supply:* The risk of arid conditions will increase. Although a growing number of greenhouse farming businesses have their own back-up water supply, there is still a certain dependence on surface water. An increase in the demand for water, and a possible reduction in the availability of water from the surface water system must be anticipated.
- *Space for water storage:* Under the influence of climate change, the storage capacity of the Haaglanden region will change (in the negative sense). The chance of large volumes of rainwater and peak showers will increase. This will imply that a larger storage capacity is needed than is the case today. The pressure placed on the aspect of space will entail heavy investments to create extra space (by way of regular measures). Especially in the lower-lying areas it will be more difficult to realise adequate water storage space. This will increase the risk of water problems. No intensification of water problems is expected in the key glass areas.
- *Extreme weather and operational safety:* Extreme weather types (hail) forms a threat for the sector in connection with the increasing risk of (and also incremental) damage and problems with taking out insurance.
- *Disease and infestations:* An increase in diseases and infestations can probably be expected. Nevertheless, the trend is that greenhouse farming businesses are changing over to closed cultivation methods and therefore this effect need not be significant.
- *Energy supply and demand:* The energy demand of and the supply of energy to greenhouse farming businesses will certainly be affected. The exact effect is not evident because while a

saving can be made on heating, on the other hand cooling will cost more energy. Nevertheless, the effects are expected to be much smaller than the energy goals planned by the sector in which tens of percentages are claimed. Those goals call for new (also climate robust) greenhouse designs, whereby use will be made of energy storage and supplies to third parties, etc. An increase in the atmosphere's CO2 content is not a problem given that greenhouse gas is useful for production. The sector could possible score in this respect with image projects.

6.3.1 Multifunctional land use for water storage in the greenhouse area

In the Waalblok polder within Haaglanden region and the Westland municipality an innovative solution to realise water storage was investigated in the demonstration project HSHL08[21]. This connects with the restructuring process and with an innovative concept for water chain connection, the so-called '4B concept' in which waste water from industry is purified for use as irrigation water. An agreement has been reached with the private entrepreneurs in this polder that part of the water storage task will be solved by a multiple use of space. Such a solution, a cellar underneath a greenhouse, has not been used before. The greenhouse farming area in the Westland has a water storage task of approx. 525,000 m3. Approximately 45% of the water storage task are being solved by innovation in the Waalblok polder. Considering the strongly dynamic greenhouse farming area and the huge task involved there are opportunities to achieve a wider application. In this respect it is important that the learning experiences regarding all relevant aspects – technical, process, legal and financial – are monitored, shared and disseminated, and that the cellar as a demonstration project is accessible for interested parties.
The final report of this project contains a handbook that sets out what such an innovative project entails.

The Waalblok project has been very productive. Providing not only a solution for the surplus water in the polder, but also providing a great deal of knowledge and expertise. A summary of the conclusions of this final report, the recommendations and the learning experience:

Technical aspects

- The investigated control of the constructions situated in the Het Waalblok area leads to a huge improvement in system behaviour.
- Due to a limited power of control the occurrence of large increases in the water level cannot be prevented in very extreme situations, especially in the low level area and in the upstream part of the Waalblok.
- If the glass surface connected to the cellar is expanded to 10 ha, then the effectiveness of the storage cellar (as a water retention basin) rises considerably. A further increase of the connected glass surface will ensure further improvement
- The storage effect is comparable with that of retention.

[21] http://kennisvoorklimaat.klimaatonderzoeknederland.nl/hotspots/regio-haaglanden/HSHL08

- If the integral control is combined with the extended retention variant, i.e. with a larger connected glass surface, retention is expected to be the most effective.

Construction and management

- This integrated project shows that input in terms of expertise from the parties directly involved is essential. Combining knowledge in the field of greenhouse construction, the associated concrete work, hydraulic engineering works and civil engineering is also essential.
- During the construction stage, one party, preferably the greenhouse builder, must be made responsible for the total dimension of the project.
- Project progress must be discussed during construction team meetings, and plan monitoring must be in line with the grower's cultivation schedule.
- It is an enormous challenge for the greenhouse horticulture sector, the municipality and water manager Delfland to solve the policy and juridical issues of multiple use of space in order to realise the advantages of this kind of use.
- A cellar can only be installed underneath a greenhouse with a 'tidal' cultivation bed.

Communication

- Keep communication activities and communication tools as practical as possible and appropriate for the target groups. Work on the basis of a practical process and communication calendar.
- Invest in good relationships between project management and communication advisers.
- Create a sense of 'we' between all those involved in the project.
- Celebrate successes to keep those involved in the project highly motivated.

Legal aspects

- The type of water storage area as used in this Waalblok project is apparently not included in the Law on Water. It is therefore preferable to not (exclusively) choose for the tools governed by public law, but to focus on achieving private-law agreements with the owners (of the greenhouse).
- The Law on Water regulates that the governments involved must collaborate to reach an appropriate execution of the tasks. That sets the parties the task of how to deal with the risks of innovative solutions that cannot be fully covered by everyone's individual (legal) instruments.
- In addition to the private-law track with individual owners, for a wider application of such multiple use it should be looked into how the tools of – especially the water board and the municipalities – can be optimally geared to one another. For the municipalities, this relates to the zoning plan, the water plan and the municipal sewage plan. For the water board it mainly concerns the water plan drawn up by the municipal authority concerned, and the policy and policy rules.

Process

- An area process of some scale and complexity, such as the 4B Waalblok, calls for an independent process manager.

- It is recommended to use the discussions about substantial solutions in the initial phase chiefly to get the parties moving and to keep them moving.
- To keep the parties motivated during the process it is important that there is continuous insight into how the development of knowledge contributes to solving the acute issues of the parties and the dynamism of the process. That calls for flexibility, not only in dealing with knowledge questions, but also with those of the researchers. Joint entrepreneurship helps to achieve consensus on the outcomes.
- The relation with external programmes such as Waterkader Haaglanden is best when work is carried out bottom-up. In other words: When the area processes steer the programme's goals.
- In area processes in which innovations are looked for, it is regularly seen that existing policy, for example that of a water board, does not make provision for this, especially if that existing policy defines (physical) solutions. What can help is to specify the tasks and interests in a project more specifically so that the focus is changed from output (the measure) to the outcome (the effect) and ensures that besides regulation the goals in particular remain central.
- A monitoring board would seem for area processes such as 4B Waalblok to be a role that fits in well in an executory government such as a water board that has to realise its tasks in collaboration with other official bodies.
- For a municipality such as the Westland, which has a much wider responsibility (including the responsibility for spatial and economic development) and with more policy freedom, a wider range of administrative styles are available.

(Source: HSHL08 final report)

6.3.2 Aquifer Storage and Recovery (ASR)

In the third tranche of the Knowledge for Climate programme, the project 'Optimized Aquifer Storage and Recovery (ASR) of freshwater in saline aquifers- pilot for the greenhouse sector in the region Haaglanden' (HSHL3.2) will be carried out.

The Haaglanden region is an intensive horticulture area with a brackish-saline groundwater system. In its freshwater supply, the sector largely depends on the use of rainwater. However, there is an increasing mismatch (time, location) in the freshwater demand and supply, which is accentuated by climate change. A regional adaptation strategy is to enlarge the self sufficiency of the water demand of the horticulture sector in the Haaglanden. Optimisation of rainwater use by seasonal storage may contribute to achieving this goal. Aquifers offer a suitable storage medium, as shown in more inland regions where ASR (Aquifer Storage and Recovery) is already being applied. ASR is, however, not yet applied in the more coastal Haaglanden area, due to the presence of brackish groundwater and strong regional groundwater flow. This implies a risk of loss of stored water due to mixing with native, saline groundwater and loss by bubble drift (lateral flow and density-driven buoyancy effects).

The objective of the third tranche KfC study HSHL3.2 is to optimise and validate the injection, storage and recovery of freshwater in these saline aquifers. Modelling results (using SEAWAT, correcting groundwater flow for density differences) performed in Knowledge for Climate (theme 2, (Zuurbier et al., 2011; Zuurbier et al., 2012)) indicate that a robust ASR system can be established by the use of Multiple Partial Penetrating Wells (MPPW, multiple filtered intervals in one borehole with separate well casings). This well configuration can be combined with an adapted operational scheme, where injection takes place primarily in the lower part of the aquifer, whereas the water is recovered at the aquifer top. Simultaneous extraction of brackish water during the final stage of fresh water recovery (to be desalted with RO) further improves the recovery of the injected fresh water (Freshkeeper concept (Stuyfzand and Raat, 2010)). The aim of this study is to validate the model results of the previous studies in a field-scale experiment in close cooperation with four tomato growers and the Product Board Horticulture (Productschap Tuinbouw) in the Haaglanden region. This field trial will be used to calibrate the SEAWAT ASR groundwater model, which will be applied to further optimise the ASR scheme, to develop a risk analysis, and to produce a feasibility map of optimised ASR systems for the Haaglanden region.
(Source: project proposal HSHL3.2)

6.3.3 Floating greenhouses (Floating roses)

Floating roses (HSHL3.1) is a third tranche project in Lansingerland in which an attempt is made to realise a floating greenhouse in collaboration with trade and industry. Floating greenhouses could be a solution in storage areas for the water storage issue. Research into the effect on water quality is essential in this respect. Also, the success factors for market introduction must be investigated in order to make knowledge validation possible.

6.3.4 Freshwater Supply (KfC Theme 2)

Taking the developments within the greenhouse horticulture sector itself into account, the future water demand of the glass farming businesses in the Haaglanden are studied in KfC theme 2. It is important here that the supply of fresh water is properly organised for this sector and that the costs are shared fairly. A good connection with the Delta Programme is also important. This calls for the attention of the researchers and stakeholders.

6.3.5 Greenhouse cooling

The subject of cooling greenhouses has up to now been a subject that has been given little attention, but the expectation in the sector is that the costs involved will only increase in the future now that the greenhouses are constantly becoming more efficient and the crops are highly sensitive in this respect. Within the framework of the RAS, the adaptation options should be studied further.

6.3.6 Waterkader Haaglanden

Apart from in Waalblok, in the Westland's Oranjepolder experiments are also taking place with area processes by making use of 3Di together with stakeholders. This has led to smart measures being taken to prevent water problems in greenhouses.

In consultation with the greenhouse horticulture sector a process has also been started on how to handle the risks of water problems given that space for open water storage is not available due to the space taken up by the greenhouses.
Other projects have also been started to combine irrigation water for crops with the water collected during extreme rainfall in order to temporarily retain the water before it enters the surface water system.
Finally, the water storage polders for discharging the polder outlet, also deserve mention. These meadow polders were recently realised in the Woudse polder, the Hoekpolder and the Berkel storage polder outlet. Only in the event of disasters are these polders used for storing water temporarily. They apparently work well in practice.

Appendix 1 – WKH pilot areas

Waterkader Haaglanden – overview of the pilot areas and most important outcomes
(Derived from Van Buuren (2012) Waterproeven in Polderland – Eindrapportage evaluatie kennisprogramma Waterkader Haaglanden)

Pilot area	**Innovative yield**
Waalblok (glass)	A water storage cellar is being realised underneath a greenhouse in the greenhouse horticulture sector (initially for peak storage only, but in due course also for the preparation of irrigation water) with the associated legal tools and agreements as to how the costs will be shared.
Plaspoelpolder (city)	Aquapiek concept developed (not applied): Public-private management organisation for storing water on (private) company grounds. A mix of technical and organisational / legal innovations in which the realisation of water storage was linked to the private wish for restructuring. Innovative forms of problem analysis (inundation study) were used, comparable to the Noordpolder.
Rijswijk-Zuid (city)	Reflecting on the synchronisation of procedures in the water and spatial domain. Reflecting on the application of thinking in terms of multi-layer safety and types of adaptive building. Investing in system knowledge parallel to the design process, to enable organisational options to be made on the basis of knowledge of the (water) system.
Noordpolder (city)	The application of dynamic modelling to calculate the effects of floods (improving problem investigations for tackling the water task) which showed that there was hardly mention of flooding. Investigating innovative – small-scale – options for storing water. Contribution to a reversal from a standard-oriented to an effect-oriented approach in regional water management in which the actual impact of flooding comes first and foremost.
Net Nieuwe Water (city)	Plans for depolderisation for a floating residential area: Combination of regional development and water storage. Delayed due to the housing market crisis.
Midden-Delfland (grass)	Area offer in which farmers set out which green-blue services they wish to provide and at what price. Insight into the preconditions for green-blue services by means of a catalogue of green-blue services. Insight into the legal dos and dont's.
Oranjepolder (glass)	The usefulness and necessity of different interventions in the water system have been looked into on the basis of simulating the effects of precipitation on the water system. Various cost effective innovative solutions were developed for the definitive measures.