Scientific aspects

Content

1. Description of the research programme

1.1 Problem definition, aim and central research questions

Despite all international, national and local initiatives to mitigate climate change, a certain degree of climate change is unavoidable. Urban environments in particular seem vulnerable to its consequences: increased risk of flooding, droughts and heat waves. How can cities as dynamic systems, where most people live and work, prepare for such changes in climate?
In this respect the proposed research programme aims at: “strengthening the adaptive capacity and reducing the vulnerability of the urban system against climate change and to develop strategies and policy instruments for adapting our cities and buildings”.

In order to reach this aim, this research programme addresses the questions:

- how and to which extent do Dutch cities influence the local climate themselves?
- how vulnerable are Dutch cities to climate change and what will be the impacts of future climate change?
- which measures and strategies are available and effective to improve the adaptive capacity of cities?
- how to implement adaptive measures in urban areas?

As cities are a focal point for all kinds of societal and urban design issues, successful implementation of climate adaptation policies will require integration with other policy and spatial planning questions in the urban area. Therefore collaboration between many scientific disciplines is needed. This consortium gathers

engineers, designers, natural scientists, physical planners and political scientists to interact in workpackages and cross-cutting case studies that will link scientific knowledge with research questions in the hotspots Haaglanden, Rotterdam, Amsterdam, Brabantstad/Tilburg, and the urban region Arnhem/Nijmegen/Tiel.

1.2 Programme outline and research approach

In the Netherlands, research on urban climate and on adaptation to climate change in urban areas has started only recently. At this moment little is known about the possible impacts of climate change in our cities and the effectiveness of measures. This hampers sound policy making. This programme aims to provide the stakeholders in the Knowledge for Climate research programme (KfC) with factual and targeted information that can be used in developing adaptation policies.

This programme has been designed taking into consideration that urban adaptation cannot be studied in isolation, if the outcomes are to be useful for policy development. Adaptation to climate change in the urban environment is governed by three boundary conditions: first the amount of global climate change we will face, second the environmental, social and economic dynamics and complexity of urban development and third, urban governance (see Figure 1). This research proposal aims to answer a number of questions on the urban climate, on its impacts and on possible responses, but it will always take the larger system into account.

In comparison with other countries, little is known about the urban climate in the Netherlands. This knowledge is, however, key to make cities climate proof. Apart from the fact that global climate change influences the urban climate system, cities themselves influence the local and regional climate. Land use and material use in urban areas lead to an urban heat island effect, which might be strengthened by climate change. As part of measuring and modelling the urban climate, the first stage of this proposal includes research on the influence of various urban components and factors on the local climate (see top left box in Figure 1).

When we will have better knowledge about the development of climate related variables, the next question is: And does that matter? To answer that question, additional information is needed on the sensitivity of cities to the various influencing factors and on the possible impacts. A wide range of effects need to be considered. Sometimes impacts cause damage (for instance to building materials or properties in case of flooding), some impacts influence health and well-being of the population (for instance in heat waves and smog episodes). Another question is how business parks and cities can maintain their attractiveness under changed climatic conditions.

A quantification of sensitivity, the impacts and the resulting vulnerability is necessary for providing guidelines for adaptation solutions, for the mapping of vulnerability of neighbourhoods and prioritization of measures. As impacts differ, such a quantification needs to be made on various scales: from buildings, in terms of heat, moisture or salinization impact, to the level of neighbourhoods and cities for impacts of flooding and heat waves.

A typology of cities and neighbourhoods according to their vulnerability to climate change summarising this information is a useful tool to enable policy makers to judge the urgency of action and to prioritise between areas and possible measures.

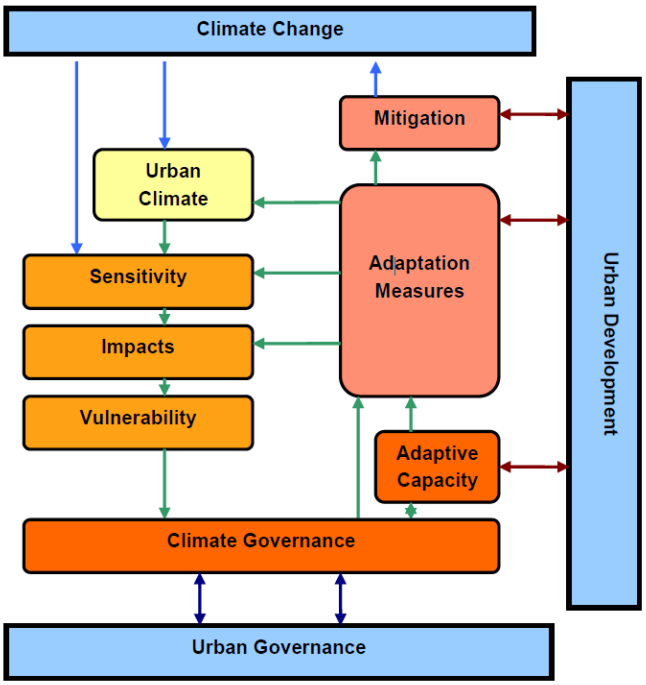

Figure 1: The research proposal within the larger system

Very prominent in this proposal are the adaptation options. In this programme, research on adaptation measures is closely linked with the quantification of impacts, as this provides the priority setting and the requirements to the respective solutions. In cooperation with the hotspots and other cities involved a number of case studies will be identified that will allow for developing adaptation measures for real life situations. In general, the research on adaptation measures will focus on buildings and street-level components that will be able to cope with changed heat stress, more precipitation extremes, salinization, while at the same time reducing the demand for energy and improving indoor air quality, on neighbourhoods (providing design guidelines for layout, use of materials, green spaces and water), and on adaptation in the energy and water infrastructure. The motivation to pay special attention to linking water and energy is that measures to absorb excess water, from rainfall or from other sources, offer opportunities for synergies with decentralized energy provision and closing of water cycles, two other topics for making cities more sustainable. The assessment of costs and benefits (for local climate), and co-benefits (for climate change mitigation and other urban issues) is part of all research on adaptation measures.

When we know “why” (impacts) and “what” (measures) to do, the remaining question is “how” (the low-end boxes in Figure 1). There is factually no experience in the Netherlands and hardly any in the world with adaptation policy. Science can, however, support the development of strategies and policies with insights in the necessary cooperation between governmental agencies, business society and civic organizations (NGOs). Three areas stand out where improved knowledge can support adaptive policies. One is the

building sector, where many of the measures will have to be taken, but where also many problems can be expected (as they are apparent with climate mitigation policies now). The others are the restructuring of post-WWII estates including the policy aim to construct more new houses in cities, and the redevelopment of business parks. These are large-scale ongoing developments in which adaptation elements can be introduced. The main issue will be to integrate adaptation in other policies and programmes. As adaptation can have spatial consequences, special attention will be required for the physical planning. Linked to the governance aspect (the „how to" questions) is the issue of adaptive capacity. This links the knowledge base on impacts and adaptation measures with the capacities of societal actors to bring about changes. For complex urban systems with multiple stakeholders it is important to study the various stakeholders in the decision-making process and determine the capacities needed to implement adaptation policies.

Finally all the information resulting from the research outlines above needs to be integrated and made useful for actual policy making. In the coming years the international modelling community will generate new global climate change scenarios. In theme 6 of the Knowledge for Climate programme and related research activities, these will be translated into regional scenarios. The current programme will take these and establish the impacts on Dutch cities. For the different scenarios, adaptation strategies will be developed together with the stakeholders. Integrating all knowledge of this research programme then comes down to providing information to policy makers on the costs of inaction, the priorities for action, the different options for adaptation measures, their costs and the governance needed, for each of the scenarios. As policy interest in climate change adaptation in cities is rapidly growing, regular reporting of the outcomes of the research programme to stakeholders and policy makers is envisaged.

We will collect this information through a systems approach. As there are many interdependencies in adaptation to climate change in cities, the research projects in this proposal are linked to each other and build upon each others" results. Researchers throughout the programme will cooperate in interdisciplinary teams. This programme thus builds bridges between the various faculties and research institutes, and supports developing common approaches and a common language in this new field of study.
We will use a multi-scale approach in each of the workpackages. In each of the workpackes there will be attention for processes happening on the levels of „buildings", „neighbourhoods1" and the „city". In practice this will be realised by executing the research in a number of case studies addressing issues on different scale levels. The location and precise topics of these case studies have resulted from extensive discussions with the hotspots and other cities involved (see Figure 2).

[1] The term neighbourhood is used in this proposal to indicate parts of cities that are not necessarily conforming to administrative boundaries.

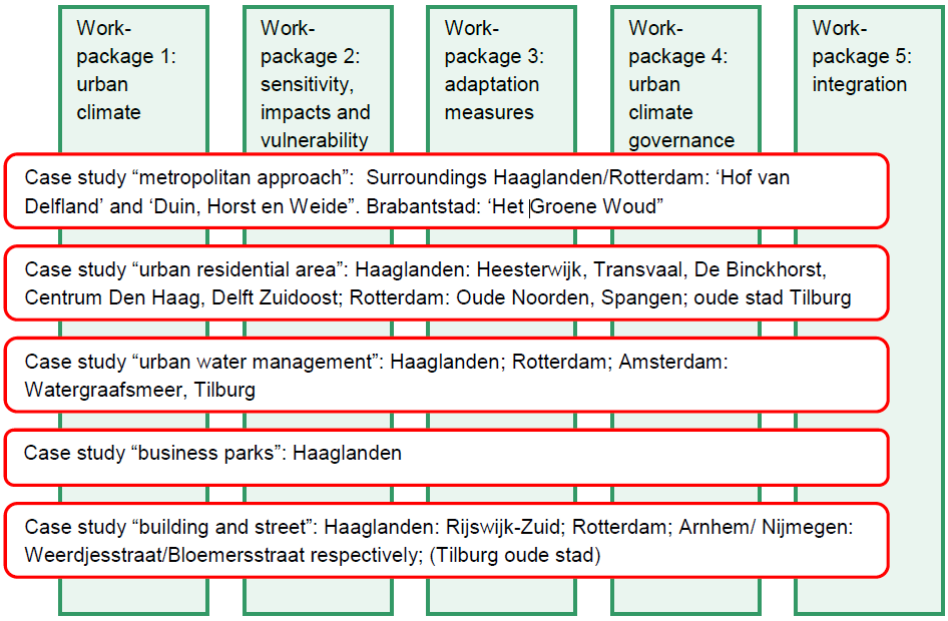

Figure 2: The link between case studies and workpackages.

1.3 Innovative aspects and scientific output

Research on adaptation to climate change in cities is still in its infancy. This programme provides the unique opportunity to address the major aspects in a systematic way and to provide integrated knowledge on the whole chain from urban climate and climate change impacts in cities, to the governance needed for implementing adaptation measures. The integrated view on the topic that characterizes the whole programme can also be seen in the individual workpackages:

- ∇ we will link meso and micro modelling of the urban climate with the outcomes of global climate models;
- ∇ we will quantify the sensitivity for and the impacts of climate change on Dutch cities, providing a vulnerability typology that can be used for all cities in the Netherlands;
- ∇ we will use meso and micro models to evaluate the effectiveness of a range of adaptation measures, providing urgently needed knowledge on what works and what does not work in the Dutch context;
- ∇ we will study the integration of adaptation measures in complex urban development processes.

This programme covers vulnerabilities, adaptation measures and governance from the level of individual buildings to the metropolitan area of the Randstad. The explicit focus on buildings is new.
Having such a wide scope, this proposal will widen the circle of those working on adaptation to climate change to disciplines as (building) engineering, physical planning and political sciences.
The results of the various projects will lead to a number of dissertations at the end of the programme period. In the meantime and in addition results will be published in peer reviewed journals as indicated by project in Appendix 2.

1.4 Relevance of the research programme in an international context

Apart from the fact that more than half of the world‟s population lives in cities, a figure that is expected to rise quickly, and that climate change impacts can be felt globally, this programme deals with a topic that is quickly rising in policy attention worldwide. Recently the WorldBank devoted one of its yearly urban research symposia to cities and climate change (Marseille, June 2009). This research programme adds to the still small body of literature on climate change in cities, especially in developed countries.
Compared to foreign research, this programme stands out because of the influence of water in Dutch cities. Until now research on the urban climate has been undertaken in fairly „dry" cities. Dutch cities provide a case for testing the effect of water in the city in all its aspects. This research programme is also relevant because of its strong focus on the building itself, which is still underrepresented in the literature.

1.5 International cooperation

The main foreign research partner, the University of Manchester, plays a key role in the EPSRC (Engineering and Physical Sciences Research Council) programmes. Professor John Handley will directly participate in consortium management meetings and provide signposting to research experience and researchers within the UK climate adaptation research programmes. Knowledge exchange will be fostered through two „high level" research workshops, exchange visits for students, academic and/or research staff and a research student Summer School to be hosted at Manchester. The University of Manchester (UoM) will participate in the research tasks and links to the WPs1-4 through staff with expertise in climate science, building engineering, climate risk and vulnerability assessment, climate adaptation and urban planning:

a) Input to WP1: Urban Climatology - through comparative work between the meso-scale models developed through the ASCCUE and SCORCHIO projects and the meso-scale models to be developed through the CPC project.

b) Input to WP2: Sensitivity, impacts and vulnerability –comparative work of climate related risk, vulnerabilities and opportunities for adaptation along a climate gradient, taking in case studies from NW UK through to the case study areas in the Netherlands. The focus of this work will be on urban heat and air quality. In addition comparative work will be undertaken to assess differences in methods and findings from building simulation work in UoM which have used alternative simulation software (such as Design Builder) to estimate the relative contributions of different building types to the Urban Heat Island (UHI) effect

c) Input to WP3 Adaptation measures and strategies - UoM will assist in the process of collating findings from WP1 and 2 in order to build appropriate adaptation plans at a variety of scales. CURE will also disseminate relevant findings from research carried out within other UK programmes, including EPSRC‟s BKCC, SKCC, ARCC and the JRF CCP.

d) Input to WP4 Governance and adaptive capacity - in cities and metropolitan areas - CURE will contribute to this work through its expertise with working with local and regional government in initiating climate related adaptation planning.

The Meteorological Institute of the Albert-Ludwigs-University of Freiburg has a longstanding experience in both monitoring and modelling the effects of urban elements on the thermal and air pollution component of urban climate. The institute is especially known for the development of (i) thermal indices for the perception of the thermal environment at exposed sites by citizens and (ii) air quality indices. The Institute coordinated the KLIMES project (Development of strategies to mitigate enhanced heat stress in urban quarters due to regional climate change in Central Europe) under the German research programme klimazwei and is involved in the REGKLAM project, which is part of the German research programme KLIMZUG and related to the region Dresden.

The Competence Centre for Climate Change Mitigation and Adaptation of the University of Kassel (CliMA) is a new cooperation body within the University to deal with the challenges of Climate Change in a multidisciplinary way. The centre has specific expertise in cities, covering the urban climate and climate mapping, thermal comfort and thermal indices, adaptation in buildings and transport and logistics, as well as expertise in societal research fields including governance. The centre provides an entry into the German research programmes Klimazwei (esp. the Klimes project) and KLIMZUG (espec. the KLIMZUG-Nordhessen project)
The role of the Universities of Kassel and of Freiburg in the programme will be to provide expertise by participating in workshops, and to provide access to knowledge and experiences obtained in relevant German research projects.

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2 Interdisciplinarity

This proposal is designed as an interdisciplinary project. In the first place this is reflected by the choice of consortium partners. The consortium brings together engineers, climate scientists and urban designers from the technical universities, with urban planners and urban managers from the general universities, with a variety of other disciplines from the participating knowledge institutes. Secondly we have defined the workpackages described in Appendix 1 in such a way that they require contributions from different disciplines, and that each workpackage builds on information from other workpackages. The workpackage on the „urban climate system" requires the interaction between meteorologists and climate scientists with hydrologists and with those using their information: engineers and urban designers. The „impacts" workpackage requires on the one hand the input from meteorologists and climate scientists, while on the other hand engineers are needed to define the effects of climate change on materials and constructions, health scientists are needed to establish the effects on human health and well-being, and economists are needed to quantify the economic damages and positive impacts of climate change. The „measures" workpackage builds on the results of both previous workpackages. Within this workpackage cooperation is needed between the engineering sciences and the urban designers. The „governance" workpackage uses as input information on the seriousness of impacts and characteristics of various adaptation measures, which requires communication between engineering and design, and the social and political sciences. Finally, the workpackage on integration aims at combining expertise from all disciplines in the programme. Interdisciplinary teams will be created for the execution of the research programme because a considerable part of the research will be executed in case studies. By stimulating integrated approaches in the case studies, the consortium will encourage cooperation between researchers.

3 Coherence between and synthesis of outcomes from the individual work packages

The description in Section 3A2 demonstrates that workpackages, although they are executed in parallel, build on each other (see Figure 3). As data and information from each workpackage become available, they will be used in the other workpackages to substantiate working assumptions and replace these for scientifically underpinned variables. To enable this, a constant flow of information and regular progress meetings between the various workpackages will be organized.

The practical organisation of this will be through the execution of a number of case studies in the hotspots and other cities involved. Through the cooperation in case studies, projects in each of the workpackages will be linked (see Figure 1 and 3). In discussion with the hotspots and other cities involved, the following cases have been identified (see also Table 1 and figure 2):

- Physical planning on the level of the metropolitan area (with case study areas around Haaglanden/Rotterdam and Tilburg);
- Urban residential areas (with a focus on existing neighbourhoods, case study areas in various cities);
- Urban water management (case study areas in Haaglanden, Rotterdam, Amsterdam, and possibly Tilburg);
- Business Parks (case study in Haaglanden);
- Building and street, including city components, such as green roofs, waterbodies, individual buildings,(case study locations in Haaglanden, Rotterdam; Arnhem/ Nijmegen and Tilburg).

The cases cover different scale levels in cities, enabling a cooperation between all the projects defined (see table 2)

Table 1: Interest in the case studies

	Haaglanden	Rotterdam	Amsterdam	Stadsregio Arnhem/Nijmegen	Brabant stad/Tilburg
Metropolitan approach/climate buffers	X	X			X
Residental areas	X	X	X		X
Urban water management	X	X	X		X
Business Parks	X				
Building and Street (City Components)		X	X	X	X

Table 2: Involvement of projects in each of the case studies

	WP 1	WP 2	WP 3	WP4
Metropolitan approach/climate buffers	1.1, 1.2		3.3, 3.4, 3.6, 3.7	4.1
Residental areas	1.1, 1.2	2.3, 2.4	3.1, 3.3, 3.4, 3.6	4.1, 4.4
Urban water management	1.1	2.3	3.1, 3.2, 3.3, 3.4	4.1
Business Parks	1.1, 1.2	2.3	3.3, 3.4, 3.6	4.5
Building and Street (City Components)	1.1, 1.3	2.1, 2.2	3.1, 3.2, 3.5	4.2, 4.3

Depending on the case study a dedicated structure of cooperation between the involved researchers will be created. It is envisaged that the PhD students that are working together on a case will be physically hosted together for at least two days a week in the city involved or at one of the participating institutions. They will be regularly joined by other researchers working on the case. The guidance of the PhD and other projects will be done in close cooperation between the various departments of universities and knowledge institutes. The results of case studies will be reported as separate reports to the stakeholders involved.

For the overall synthesis of knowledge generated by the programme we have designed workpackage 5 (see Figure 2). This workpackage will bring together the outcomes of the various workpackages and cases in a way that is useful for policy making. This policy relevancy requires an integration of the outcomes of the current programme, but also the use of information from other KfC themes when that is necessary (see Figure 3). Workpackage 5 also includes the development, together with the urban stakeholders, of the integrated assessment framework that will be able to answer policy questions on a strategic level.

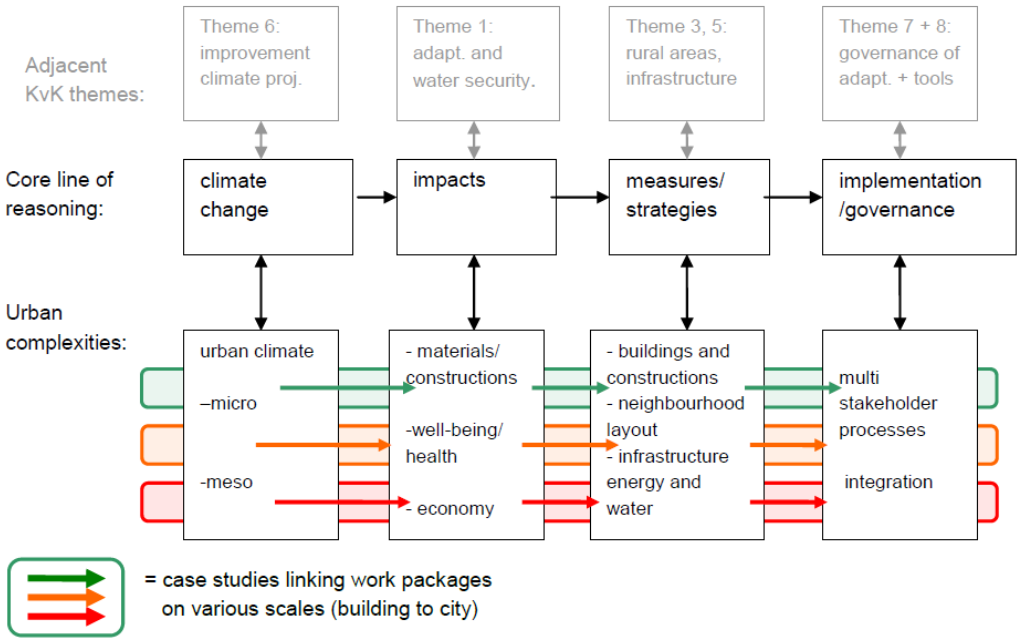

Figure 3: Coherence in the structure of the research programme

4 (Expected) cooperation and coherence with other research themes

The main area of cooperation is with theme 6 (improving climate projections), where we expect to receive regional climate scenarios from theme 6 that will be the basis for estimating impact scenarios for Dutch cities and to develop proposals for adaptation strategies. At the same time we would like to try to link the macro-modelling developed under theme 6 with the meso (city level) modelling developed in workpackage 1 in this research proposal.

Intensive cooperation and dialogue is also envisaged with theme 7 (governance of adaptation). The difference between the theme 7 and workpackage 4 in the current proposal, apart from the focus on urban governance in our wp 4, is that we will study urban adaptation governance from the starting point of specific

problems for which solutions are needed, such as how to integrate adaptation in urban renewal. Theme 7 will focus on the fundamental knowledge on how adaptation can be promoted in general.

Active cooperation with theme 3 is envisaged for WP3, project 3.7 (urban design and spatial planning for cc adaptation in metropolitan areas), which deals with the rural area surrounding cities. Theme 3 envisages to link the "new" land use options that will result from project 3.7, with new functions of the countryside and from there with possibilities of new sources of rural income.

With the other themes there are connections that are currently defined as demarcations in the work executed, but where at the end of the programme results will complement each other.

Theme 4, "Climate proof cities", does not deal with water safety in cities due to large scale flooding, as this topic belongs to theme 1. At the end of the programme the lessons on zoning and building requirements from theme 1 that are valid for a larger area than cities alone, can be added to the body of knowledge on adaptation in cities for those cities that face such risks.

With theme 5 (infrastructure) there will be complementarity of adaptation measures, as both theme 4 and theme 5 deal with the adaptation of activities in urban areas. We will consider to share our insights in the urban climate, although for theme 5 information on the occurrence of wind and fog will be more important than it is for theme 4. With theme 2 there seem to be few connections. Theme 2 deals largely with rural fresh water supply.

With theme 8 we will follow the development of tools in that programme, as theme 8 is expected to deliver inputs for the integration work package (WP5). Currently most tools proposed in theme 8 are not immediately applicable in the urban context; we expect this to change and we will feed the programme under theme 8 with ideas and suggestions for possible tool development. In the course of the project we will evaluate possibilities for applying the tools developed (WP5, project 5.2).

5 Connection to finalized and current projects in KfC and other research programmes

Important projects in the KfC and the Climate changes Spatial Planning program for this research programme are:

HSRR01, 05 and 09 (Hotspot Rotterdam area)

Urban development (HSRR01) - Urban water systems. Possible challenges related to climate change and urban developments stimulate the development of adaptation strategies for the design and management of future urban water systems in the Rotterdam area. The project aims to open a research window for the development of an adaptive and flexible water system for the future. The current proposal builds upon this project in various parts of workpackage 3, especially project 3.3 on coping with extreme precipitation and urban flooding.

Heat stress in the city of Rotterdam (HSRR05) - In this project the Urban Heat Island effect over Rotterdam will be measured and analysed for the first time to determine the magnitude, the causes and the

mechanisms and frequency of occurrence. Subsequently some first estimates will be made of the implication of heat on energy consumption, thermal comfort and public health. At last options to reduce the Urban Heat Island effect, heat stress and its consequences will be explored. This project is considered a main predecessor of the current proposal. We aim to continue and deepen the monitoring that has been set up under this project in workpackage 1, and elaborate on the impacts in workpackage 2.

Adaptive building (HSRR09) - Rotterdam plans to transform areas outside the dikes to intensively used residential and working areas. This project will provide insight into adaptive development strategies. As mentioned before this project is included here for completeness sake. Further research on water safety and building in areas outside the dikes is included in KfC theme 1.

HSHL05, HSRR04, HSMS02 (Hotspots Haaglanden, Rotterdam and Schiphol)

Region specific climate information on the hotspots. Aim of the projects is to make climate data and information on the current and future climate more specific for the hotspots. We expect to profit from these projects in various parts of workpackage 2 and 3, where already from the start of the project information that is as detailed as possible is needed on future changes in the urban climate.

Supporting studies in the CCSP program have been the following dialogue and definition studies:

- A17 - Dialogue climate change and cities
- COM22 - Heat in the city, definition study
- COM23 - Water resilient building, definition study
- COM29 - Climate in the urban environment

Finally important is a study commissioned by the Dutch Environmental Assessment Agency on “Building blocks for making the Netherlands climate proof”. In this study, fairly general assessments have been made of the possible impacts of climate change in a number of cities. Although data were scarce at the moment of the execution of the study, the current programme will build upon the general approaches used in this study.