Midterm Review Report

Climate Proof Cities

(Knowledge for Climate Theme 4)

Utrecht, 16 August, 2012

Midterm Review Report Climate Proof Cities

Knowledge for Climate Theme 4

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Climate Proof Cities Consortium

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Vision on the Climate Proof Cities (CPC) programme

Central vision

The global climate is changing. Although mitigation measures on a global scale can slow down climate change, the continuing growth in global emissions will result in rise of global average surface temperatures towards the end of the century. Sea level rise, changes in precipitation patterns, and of course higher temperatures will exert their influence on cities. More frequent heat waves, extreme rainfall events and extended dry periods will influence the economy and living conditions in Dutch cities. Cities are especially vulnerable to the impacts of climate change due to the high concentration of people and capital goods. Urban areas can well be adapted to the impacts of climate change, especially when planned in advance.

In these circumstances city authorities and other relevant decision makers should be able to provide a safe and comfortable environment for inhabitants and visitors. Part of adapting to climate change happens –naturally and gradually– in our minds and our behaviour; the planned part of adaptation needs to be implemented in the most cost efficient way when opportunities appear. Buildings and infrastructures are built with life times of at least 50-100 years. Taking the future climate into account in their design will limit future costs. Adaptation measures can easily be included in new constructions, in renovation of buildings and restructuring of neighbourhoods and business parks, provided that climate adaptation is one of the design criteria. Although the climate is changing slowly, it is now time to act for all new developments. Seen in this way, the adaptation imperative offers many chances for new economic activities and employment in cities.

Mission of the CPC consortium

The CPC consortium, a group of scientists from a range of disciplines (engineers, urban designers, physical planners, meteorologists, etc.) working in close cooperation, has developed into the main national knowledge consortium for urban adaptation. Our research is highly demand-driven, and in our cooperation with stakeholders we demonstrate how much progress can be made by well programmed science – policy interaction. The CPC consortium provides the underpinning of a range of adaptation options including their – positive and negative – side effects.

Mainstreaming adaptation in various urban policies will be necessary to realize adaptation measures. By executing our research in the urban areas and by disseminating our findings we contribute to awareness raising among those that need to take the impacts of climate change into account in their plans and decisions. By providing facts, figures and tools we enable authorities to climate proof every urban development.

The CPC consortium provides the information necessary for understanding the impacts of climate change in Dutch cities, the effectiveness of possible adaptation measures, and the urban governance needed for implementation. In reporting the consortium aims to strike a balance between scientific publications in English and accessible reports in Dutch for our stakeholders.

Scientific and societal goal in 2014

The scientific goal of Climate Proof Cities is “to strengthen the adaptive capacity and reduce the vulnerability of the urban system against climate change and to develop strategies and policy instruments for adapting our cities and buildings”.

Ambitions in relation to the scientific and social debate are:

- to provide quantitative and qualitative information about threats and risks that cities are facing. This information can support creating awareness at public, private and policy levels about the urgency of certain adaptation measures.
- to provide a better understanding of the sensitivity and vulnerability of physical and social (and economical) elements of the urban system, to allow policy makers to set geographically specified priorities.
- to provide solutions, measures and strategies to improve the resilience of cities to climate change.

An important focus in the CPC research program is the applicability of results in practice and effective implementation of adaptation measures and strategies through urban governance. The consortium recognizes the value of stakeholder involvement and aims at effective knowledge dissemination to ensure the social relevance of the research programme.

Research approach

The research framework

The design of the research program of Climate Proof Cities is based on questions from practice. Cities defined their main issues concerning climate adaptation, including water and heat issues, questions on problem recognition, adaptation measures and governance. These questions were summarized into five main questions for CPC:

- how and to what 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?
- what measures and strategies are available and effective to improve the adaptive capacity of cities?
- how to implement adaptive measures in urban areas?
- what will be the balance of urgency, costs and benefits?

These five research questions have been translated into five work packages, see the conceptual model given in figure 1 and see box 1 for a short description of the work packages. Climate adaptation is seen as one of the factors in the dynamics of urban development and urban governance. The CPC program has been designed taking into consideration that urban adaptation should not be studied in isolation, if the outcomes are to be useful for policy development. As shown in figure 1, the research framework of CPC considers a larger system that is governed by three boundary conditions: 1) the amount of global change we will face, 2) environmental, social and economic dynamics and the complexity of urban development , and 3) urban governance.

Box 1 Work packages in CPC (see also annex 4

- ***WP1:*** Urban Climate System. To ensure that effective and coherent adaptation measures and strategies are being developed for the urban environment, a thorough understanding of processes of the Urban Climate System (UCS) is essential. This includes understanding of weather, air quality and climate phenomena from meso-scale to micro-scale. In addition, more quantitative information regarding the UCS is needed. The aim of WP1 is to provide this information, both from observations and model simulations.
- ***WP2:*** Sensitivity, Vulnerability and Impacts. The aim of WP2 is to analyse the sensitivity of buildings, neighbourhoods and people, and their vulnerability to the expected climate changes. This knowledge is used to answer the questions: What are the potential impacts of climate change, considering the important uncertainties involved, and when and where are adaptation measures needed? This work package is driven by the KNMI climate change scenarios and their supplements, and is especially intended as a supporting work package to WP3.
- ***WP3:*** Adaptation measures and strategies. The main research question in WP3 is: Which measures can be taken for climate robustness of cities, neighbourhoods and buildings, and what is their efficiency and effectiveness? The themes for this work package aim to cover the entire range of measures for climate robustness: green interventions, dealing with precipitation at the buildings and city level, the combined approach to water and energy, and spatial and technical design measures at various scales. Resulting measures imply climate adaptation, climate mitigation and an approach we could call climate pro-activation, i.e. utilizing climate characteristics optimally in the urban and building design.
- ***WP4:*** Governance and adaptive capacity in cities and metropolitan areas. The central aim of WP4 is to provide new insights in the way climate adaptation can be introduced into the existing spatial planning processes. Research is based on the knowledge that urban planning is in itself a highly complex process in which a lot of significant and (mostly) conflicting interests of different actors are competing, and that climate adaptation measures do not represent a so-called 'strong interest' whose integration into urban processes need no support.

- ***WP5:*** Integration. To be useful for policymaking, the results from work packages 1-4 and the different cases have to be combined and included in an integrated assessment of the need and possibilities of adaptation in cities. WP5 brings together information on a suite of policy questions: What is the impact of global and regional climate change scenarios on Dutch cities, in other words, "what would it cost if we would do nothing?"; what are appropriate policy responses in each of these scenarios, and how much would these cost; and what would be needed to implement adaptation strategies?

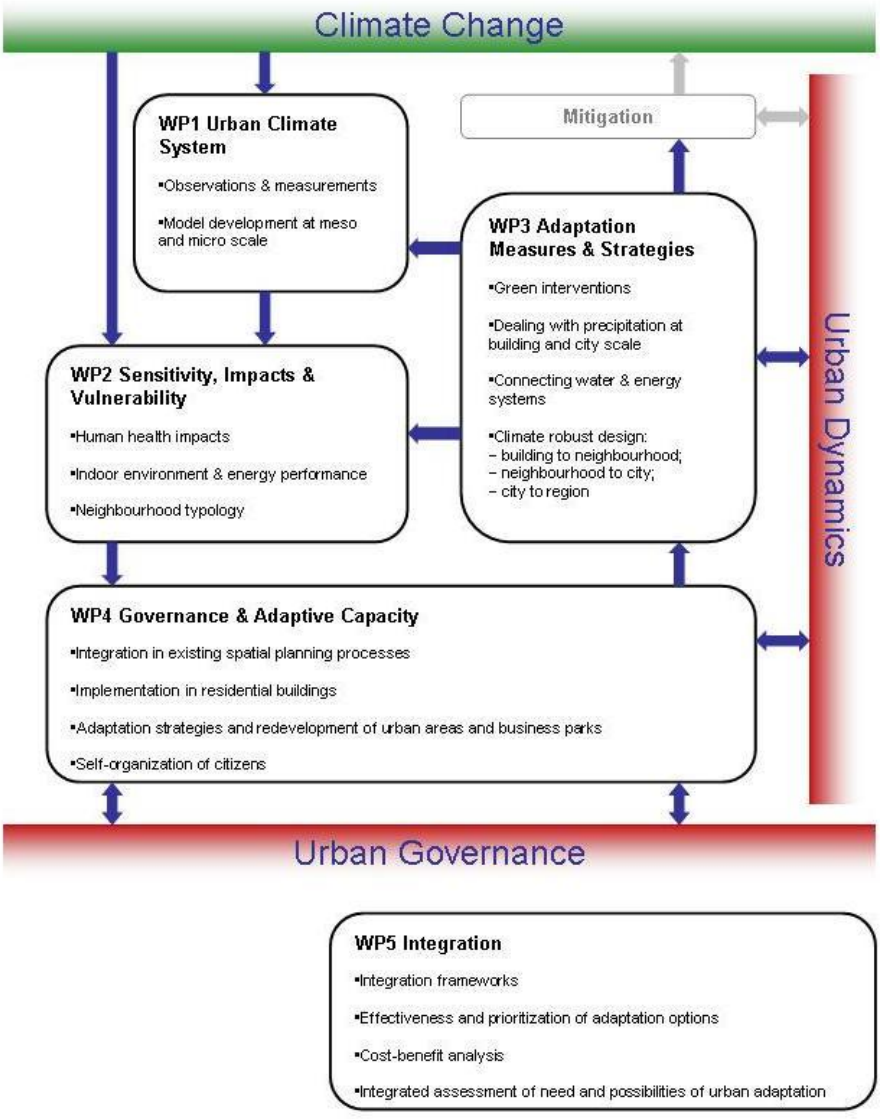

Figure 1 Framework of Climate Proof Cities

The research program is organized in 22 projects that will deliver information on:

- Measurements of climate parameters in cities (stationary and mobile monitoring). These data will be used to support the development of models and to estimate the effects of climate adaptation measures.
- The effects of heat waves on the indoor climate and its effect on the health of especially older people.

- The sensitivity of different neighbourhoods for extreme heat and extreme precipitation: this will result in a typology for neighbourhoods to provide quick impression of the vulnerability of different neighbourhoods.
- Quantitative data and models on the effectiveness of measures and strategies at building, street, city and regional level resulting in cost abatement curves
- Knowledge and handouts for a governance approach of climate proofing in urban renewal projects for housing associations and of restructuring of business parks and of urban renewal in general.

The cases: how to link practice and theory

The research program of Climate Proof Cities intends to connect stakeholders issues with scientific research questions. As far as possible researchers work on real life problems. In order to increase the applicability of the scientific outcomes, researchers are working in close cooperation with stakeholders in case studies in several urban areas in The Netherlands. The cases and related projects can be distinguished by four scales: building and streets, integrated water management, neighbourhoods and regional cases, see figure 2.

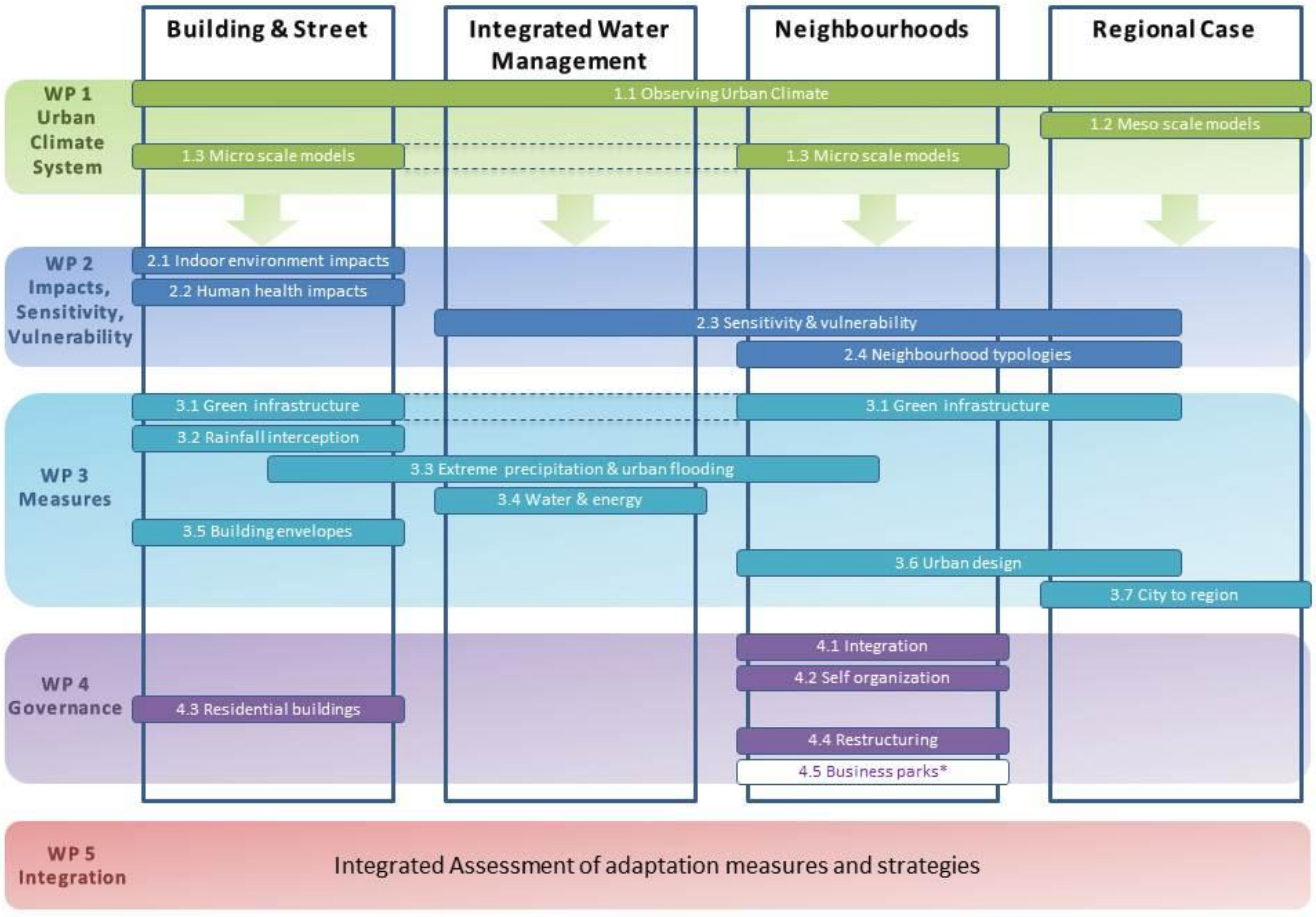

Figure 2 The link between case studies and work packages

Depending on the case, different research locations have been identified in hotspot Rotterdam, hotspot Haaglanden, Amsterdam, Arnhem/Nijmegen, Noord-Brabant/Tilburg and Utrecht (figure 3).

Figure 3 Dutch cities participating in the CPC programme

The consortium

The CPC consortium comprises the most relevant Dutch universities and knowledge institutes in the field of Climate adaptation and urban areas, and comprises a broad field of expertise and disciplines (engineers, designers, natural scientists, physical planners and political scientists). The partners from

the Netherlands are: TNO, Delft University of Technology, Eindhoven University of Technology, Wageningen University, Deltares, Utrecht University, University of Amsterdam, Radboud University Nijmegen, KWR and UNESCO-IHE (see Annex 1). With a budget of about 7,8 mln Euro the research program comprises 12 PhD students and 3 Post-docs working on climate adaptation.

To benefit from knowledge and experiences from other European countries there are three foreign partners included in the consortium: the University of Manchester, the University of Kassel and the University of Freiburg. The main foreign research partner, the University of Manchester, participates in consortium management meetings and is involved in research tasks related to work packages 1-4. The University of Manchester contributes to the CPC research through staff with expertise in climate science, building engineering, climate risk and vulnerability assessment, climate adaptation and urban planning. The role of the Universities of Kassel and of Freiburg in the programme is to provide expertise by participating in workshops, and to provide access to knowledge and experiences obtained in relevant German research projects.

Stakeholder involvement

As the practical implementation of scientific research is an important feature of Climate Proof Cities, the involvement of stakeholders is crucial. Stakeholders have been closely involved in developing the research program, formulating research questions and defining the case studies. Meetings were held in the various cities to explore local questions and options for climate adaptation.

In the original hotspots of Climate for Knowledge (Rotterdam and Haaglanden) a cooperation between local stakeholders more or less existed. In the other cities that became involved in Climate Proof Cities meetings with local stakeholders (municipal departments, the water boards, district councils and health services) have been organized. Often resulting in local coordination.

The hotspots are co-financing (in Euros or in kind) the CPC program. At the time the program started the economic crisis struck and budget cuts became acute for municipalities, water boards and provinces. A lot of extra effort was needed to ensure the co-financing and because of repeating discussions as stakeholders at first were not able to participate because of budget cuts but joined again later. As the participation of the stakeholders in the program took place within the case studies the practical consequence was that some case studies had to be redefined over and over again.

Now the program is running, stakeholders (hot spots) are actively involved in several ways:

- Hands-on involvement of the stakeholders is organized along the lines of the case studies. For each case study a stakeholder group has been established, consisting of a selection of representatives of the involved hotspot(s). There are minimally two meetings per year for each case study where this guidance committee and the researchers involved discuss the progress. Of course, more regular communication or cooperation is established with stakeholders at the project level, depending on the set-up of individual research projects.
- Participation in the plenary consortium meetings (2-3 a year) where the latest results are being exchanged. At every meeting about 30 of our stakeholders are present.
- Membership of the Steering Committee of Climate Proof Cities. This committee, with an independent chairman, has a formal role. It forms a sounding board for guarding the main

orientations and coherence of the programme, and for the translation of the programme results into practice.

- In the program there has been a reservation for ad ad-hoc funding. The steering group (stakeholders) can decide on the use of this budget. This has led to an extension of the research on urban flooding and integrated water management.

Integration and coherence

Being a large research program, with a many researchers from a broad range of disciplines involved and including a large group of stakeholders, the Climate Proof Cities consortium has developed a number of features to control the coherence and to be able to achieve integrated results at the end.

First of all, the case studies in itself provide a dedicated structure for cooperation between the researchers in different work packages. Through regular progress meeting, data and information from each work package is being exchanged, enabling a constant flow of information between the various work packages. Since the parallel executed work packages build on each other, these new data can be used in the other work packages to substantiate working assumptions and replace these for scientifically underpinned variables. Examples are the use of monitoring data in the modelling projects, the use of the neighbourhood typology project for the regional design project, the cooperation between indoor environmental impacts in one project with building envelopes research in another project.

For the overall coherence and synthesis of scientific knowledge generated by the programme we have designed work package 5 (see Figure 2) on integration. This work package brings together the outcomes of the various work packages and cases in a way that is useful for policy making.

Work package 5 includes the development, together with the urban stakeholders, of the integrated assessment framework that will enable to answer policy questions on a strategic level. For the development of this framework and to build up experience, an integration case has been defined. Bergpolder Zuid, part of Oude Noorden in Rotterdam, integrates the various scale levels of CPC on one location. In this integration case the Consortium advises stakeholders in Bergpolder Zuid (the borough, the housing corporation) about the best adaptation strategies for a major renovation project.

Another part of work package 5 is the development of guidelines, a few of which have already been published within the consortium. The internal publication of guidelines is meant for researchers of CPC to use a common language and similar procedures for expressing cost-effectiveness of adaptation options. Until now the following guidelines have been written or are being prepared:

- Guideline Vulnerability terminology (Pásztor & Bosch, Guideline Vulnerability terminology, 2011),
- Guideline Costs of Adaptation Measures (Bosch, Pásztor, & Rovers, to be published)
- Relevant Terms and Definitions (Pásztor & Bosch, Relevant Terms and Definitions, to be published).

A start has been made with a guideline for common units in which the final research results will be expressed (with the work title: Common units for Effectiveness). Scientifically it will be progress if we will be able to compare the effectiveness of a wide variety of adaptation measures. It will help policy makers by enabling them to compare and evaluate possible measures.

Yearly reporting is used as an evolving way to develop integrated results fit for the stakeholders. At the end of 2011 the CPC consortium produced her first Yearly report (Rovers, Bosch, Pásztor, & Albers, 2011). This is an integrated report that shows how far the individual projects have come, what results they have achieved and how it fits in the programme and how it connects to the other research results. This report is used as an integration tool as well. For 2012 and 2013 actualized editions of this report are planned.
Next to the above initiatives , a number of 'cross-thematic' meetings have been organised to enhance coherence in the programme:

- Meetings within the work packages.
- Consortium meetings are held three times a year.
- A spring school and a summer school have been organized for the researchers.
- For overseeing the overall coherence, core team meetings with participation of work package leaders and case managers are held every two months.

In the first year an integrated research framework was written in which the theoretical background of integrated research is explained, the objectives and the programme design of CPC are set out, and the integration activities within and beyond science are described. Climate Proof Cities: an Integrated Research Framework (Döpp, 2011).

Connection with other KfC research themes

The relation of Climate Proof Cities (theme 4) with the other themes within Climate for Knowledge is described below, also see figure 4.

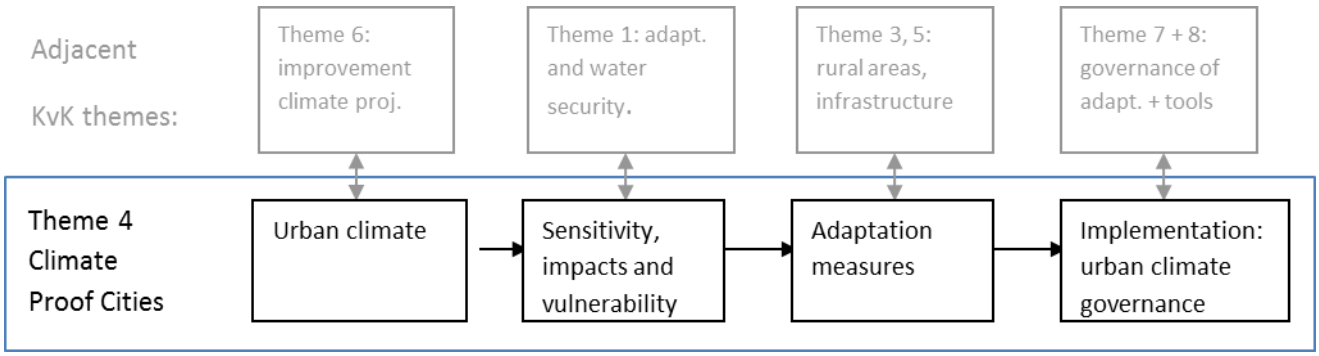

Figure 4 Coherence in the structure of the research programme and connection with the other research themes of Knowledge for Climate.

Theme 1 (Climate Proof Flood Risk Management) deals with water safety in cities due to large scale flooding. 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.

Theme 2 (Climate Proof Fresh Water Supply): there are little connections as theme 2 deals largely with rural fresh water supply.

Theme 3 (Climate Adaptation for Rural Areas): active cooperation is envisaged for CPC 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.

Theme 5 (Infrastructure and Networks): as with theme 1, information on infrastructure that is relevant for urban areas can be added to the body of knowledge on adaptation in cities.

Theme 6 (High Quality Climate Projections): from this theme we expect to receive regional climate scenarios, 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 work package 1 of CPC. Theme 6 organizes a summer school about dealing with uncertainty, in which several of our researchers plan to participate.

Theme 7 (Governance of Adaptation): the most interesting of links are with other KfC themes are with theme 7. The theme 7 project on the design of financial instruments; the project on multifunctional land use and the project on multilevel governance are of great relevance for the CPC research. PhD students from both consortia have been encouraged to be in contact. The general principles investigated on theme 7 could be a good background for the practical work in CPC.

Theme 8 (Decision Support Tools) can be supportive to CPC in several aspects. New insights of theme 8 on visualizing research results will be shared with CPC in order to enhance the effect of the results and the PhD student involved intends to use CPC outcomes as test material. In theme 8 a review will be made of the CPC guideline on ‘costs of adaptation measures’. Also, researchers form theme 8 will be invited for the CPC discussion on adaptation costs to share their thoughts and ideas.

Results

The programme started in 2010/early 2011, therefore only a first impression of research results can be given. A more detailed overview of the preliminary results can be found in the yearly progress report (Klimaatbestendige steden, voortgangsrapportage Climate Proof Cities 2011, December 2011). Below we give an updated and actualized overview of the main results. Research is now fully underway and we expect lots of new information and valuable outcomes of the research projects in the coming years. The research results are shown in four categories related to the research questions: the assessment of the problem that urban areas are facing, the vulnerability of urban areas, what needs to happen to climate proof the city and adaptation policy and its implementation.

Climate and city; what is the problem?

Because of compact built environments, extreme precipitation and heat waves cause more nuisance and damage within cities than in their surroundings. The high percentage of impermeable surface, for example, makes it difficult to discharge the large quantities of water during heavy rainfall events. Buildings are also known to retain heat well, leading to the so called urban heat island effect. Because of climate change, the temperature is expected to rise further and the possibility of extreme precipitation will increase, increasing the frequency of inconvenient situations in cities.

To improve our understanding of the urban climate, temperature related aspects are being monitored in the city of Rotterdam in various ways (by static measurement stations, fibre optic cables, scintillometers and mobile measurements using planes and bicycles). Some first results are:

- The 24-hour mean temperatures for measurement stations within the city are 2,5 to 10% higher than those of the reference stations located outside the city boundaries;
- Under favourable meteorological conditions, i.e. under calm and clear (cloudless) conditions a considerable UHI_{max} exists in densely built areas in the Netherlands during nocturnal hours, with 95 percentile values ranging from 3 to 8 ˚C;
- Highest temperatures are recorded in the city centre and in Rotterdam Zuid, reflecting the highest concentration of buildings. The difference with the reference for radiation, wind velocity and air humidity is also largest in these areas;
- Because the heat island effect seems biggest in Rotterdam Centrum and Zuid, the data of these two stations will be used to develop the urban climate models in the program;
- Preliminary measurements of the Physiological Equivalent Temperature (PET) in Rotterdam, a measure for thermal comfort based on the human heat balance, also seem to point out that the number of hours classified as “heat stress hours”, is higher in the urban area than in the surrounding rural area during warm and hot days;
- Rotterdam appears to experience more heat stress days than other foreign studied cities suggesting that current thermal comfort may already be critical in many urban areas in the Netherlands.

Vulnerability of cities; how big is the problem?

If we are able to understand the future urban climate, we may quantify the impact of climate change on the society (in terms of damage and victims). Preliminary findings regarding extreme precipitation are that:

- Heavy rainfall does not necessarily lead to traffic jams, nor does street inundation, as long as alternative routes are available;
- The costs for dealing with flooding increase along with the quantity of precipitation.

Regarding heat it seems that:

- The urban heat island effect creates large differences in local exposure within cities due to specific neighbourhood characteristics;
- The percentage of impervious surface of a neighbourhood appears to be the mayor factor of influence to predict daytime surface temperatures. Other factors include water, skyview factor, albedo, traffic area and Leaf Area Index (LAI);
- The most important factors to explain the night time air temperature appear to be (in order of importance): Soil Adjusted Vegetation Index (SAVI), distance to the IJsselmeer, skyview factor, albedo, wind and impervious surface;
- Also, differences in the socio-economic structure between physically equal districts in different cities, affect the sensitivity of the inhabitants and the means to cope with climate change;
- 19% of the elderly people experience serious nuisance during warmer periods caused by heat;
- Heat related mortality may also strike healthy elderly people;
- A three-day period of acclimatisation, approximately the period a heat wave can be predicted in advance, appears insufficient for elderly as well as for young females to adapt to heat;
- At building level, detached and corner dwellings are more vulnerable than semi-detached and terraced houses for heat accumulation indoors during heat waves.

Climate proof cities; what needs to be done?

Adaptation actions may be applied to prevent extra warming in cities or to reduce the impact of heat and heavy rainfall events on the community. Possible actions and their effectiveness are being investigated. A selection of first indications:

- The effect of an adaptation action depends on many aspects like, location, size, orientation, etc. and the effect may vary on different scales and on different moments during the day. Trees, for example, mainly have a cooling effect during the day, while a stretch of grass provides cooling after sunset.

- If extreme precipitation events will occur more often, increasing the water retention and storage capacity and the internal transport capacity is the only solution to keep streets from flooding.
- For developing adaptation actions for the building envelope the upper corners of the building are important, since these seem to be the place where most heat is transferred to the building.
- The number of overheating hours (> 25 ˚C) in a building can be decreased by implementing adaptation measures. Models show that the potential reduction of overheating hours differs significantly between measures:
    - Increasing the insulation of the façade and roof up to ≈5.5 m^2KW^{-1} leads to a reduction between 0 – 20%;Increasing the thermal mass with 100% (doubling of wall thickness of inner and outer facade leaf) leads to a reduction between 0 - 10%;
    - increasing the albedo value up to 0.8 can result in a decrease of overheating hours between 20 – 50%;
    - implementing an overhang up to 1 m can result in a decrease of 40 – 100%;
    - Opening windows at an indoor temperature of 24˚C leads to a decrease of 80-90%;
    - and the implementation of green roofs with a Leaf Area Index of 5 can result in a decrease in overheating hours of 15-50%.

  Note: all results for a standard terraced house (36.5% of dwellings in the Netherlands).

Adaptation policy: how to implement these measures?

Despite the increased level of knowledge about climate change and the possibilities to reduce its impact, adaptation measures are not yet applied on a large scale. First research results show that the most important barriers for implementation are due to the political, institutional and financial context of urban politics. Underlying this is, most probably, a lack of awareness and urgency.

Scientific output and the international scientific climate debate

The PhD students, post- docs together with the other researchers are expected to publish in international scientific journals and present their results at relevant conferences. As the program is under way for somewhat more than one year the scientific output is still limited. See for a list of publications annex 5.

CPC fits in the general development of urban adaptation science regarding vulnerability and the effectiveness of adaptation options on the detailed level of buildings, public spaces and neighbourhoods. We are outstanding because of the scale of the research programme, which allows us to bridge between various scale levels (from humans, through buildings to cities). The fact that many research projects are executed in real-life case studies with a multitude of data will make our publications more attractive than many more theoretical papers, or papers that are based on a limited selection of (urban climate or vulnerability) data.

To give a number of examples:

- The development of the vulnerability classification of neighbourhoods for heat takes into account the physical and socio-economic characteristics of neighbourhoods, the quality of the buildings and the sensitivity of the population. The methodology developed is unique in considering the interactions between these scales, where the current literature often only focuses on selected aspects of vulnerability.
- Unique is also the scale and degree of integration of the micro-meteorological measurements in especially the Rotterdam region. Mobile measurements with a pushbike (sometimes combined with face-to-face interviews on the individual appreciation of thermal comfort), with a railcar, and on an airplane are combined with results from fixed stations, scintillometer data, temperature measurements with an optic fibre cable and sap-flow measurements. The comparison and integration of data will lead to improved understanding of the radiation balance of the city.
- The ample availability of monitoring data will allow us to make considerable progress on model validation both for the meso-scale model and the micro-scale model that are under development.
- In CPC research, for the first time, BES (building performance simulation) models are being employed to investigate vulnerability to heat (or more precisely the heat transfer between outside and inside) of buildings to complete building stocks. In our research we have so far covered about 73% of the Dutch building stock. This approach allows for a far larger variability of buildings to be assessed. Also new is the coupling of these results with the outcomes of climate scenario's to simulate the number of overheating hours (or other impact variables) for the whole or parts of the buildings stock in the future.
- The realization that elderly over 75 are at risk during heatwaves, made us investigate if heat acclimation might be acquired during the short period preceding a heatwave, after authorities have given a heat disaster warning. An experiment was conducted to evaluate if high intensity heat acclimation may lower thermal strain in subjects over 75 years of age. Results have been submitted for publication in the European Journal of Applied Physiology.

As illustrated by these examples an important contribution of CPC to the adaptation debate will be to strengthen the factual basis, which is much needed for global assessments such as IPCC's AR5-WGII report or the Second Assessment Report of the Urban Climate Change Research Network. These insights, in turn, will lead to a better understanding of more theoretical issues such as the time dependence of urban adaptation interventions, inter-policy synergies or the role of urban land use and -planning in climate issues.

To facilitate and encourage the use of international knowledge, our international partners were closely involved in organizing summer (spring) schools. In 2011 the spring school, a two-day event, was held in Utrecht with participation of foreign partners to present information from UK and German research programmes and discuss PhD proposals. A second spring school was hosted by the University of Manchester between 1st-5th April 2012. It was attended by almost all PhD researchers from the Netherlands and also from about a dozen PhD students (not directly involved in CPC research projects) of the University of Manchester and two PhD students (also not directly involved in CPC research projects) of the University of Freiburg. Lecturers of these universities gave

presentations along with several key speakers in the area of climate adaptation (from among others the UKCIP, the Tyndall Institute and stakeholders like the Environmental Agency, representatives of boroughs and companies like ARUP). Various panel discussions with stakeholders have taken place that were of high relevance to the group, especially to find out how to communicate the research results to policy-makers and practitioners. As one of the follow up activities the University of Freiburg will give a workshop on modelling, which will be organized by the WUR.

Chao Ren and Edward Ng from the university of Hong Kong not being part of the CPC consortium were pleased to present the advanced level of climate adaptation in Hong Kong urban planning at the plenary consortium meeting in April 2012.

Social and scientific impact

The climate is changing and more and more cities are becoming aware that there is a need to prepare for what might come. Climate change and impacts do not appear uniformly over the world or even regions. This is partly due to regional variation in climate change but also due to the local regional aspects like the availability of water and the influence of hills and mountains and to the urban design.

This increasing awareness resulted in a number of conferences and documents to inform cities and stakeholders on the latest scientific information and to urge for action, like:

- Fifth Urban Research Symposium: Cities and Climate Change: Responding to an Urgent Agenda, World Bank, Marseille, 2009.
- Climate Change and Cities, First Assessment Report of the Urban Climate Change Research Network, 2011.
- Cities and Climate Change, Global Report on Human Settlements 2011, United Nations Human Settlements Programme (UN-Habitat), 2011.
- Urban adaptation to climate change in Europe, Challenges and opportunities for cities together with supportive national and European policies, European Environmental Agency, 2012.
- ICLEI (Local Governments for Sustainability) Resilient Cities conferences, Bonn 2010-2012.

These efforts certainly stimulate cities to assess their vulnerability and to develop adaptation strategies, but so far fall short in providing the information and guidance needed for practical implementation. By trying to fill this information gap, CPC hopes not only to motivate cities to increase their climate resilience, but also provide the building blocks for strategies and action plans.

In the Netherlands research and policy development on adaptation to climate change had mainly been concerned with flood protection with no specific focus on urban issues, until the start of the Climate Proof Cities program. However, it was increasingly recognized that cities are highly vulnerable to climate change. When CPC started, some first studies in the Knowledge for Climate research program and its predecessor The Climate Changes Spatial Program were published. There was a growing concern within a number of cities about the impacts of climate change to local communities. Many measures were suggested without a proper underpinning of their effectiveness in the local Dutch circumstances. As Climate Proof Cities wanted to tackle that lack of knowledge, many stakeholders showed their interest to participate, which resulted in a much broader participation of stakeholders than the original hotspots from the Knowledge for Climate program.

The joining of a motivated group of stakeholders, that are keen to use research results in their daily practice of developing urban adaptation strategies and plans, with a substantial number of enthusiastic researchers, is expected to have lasting impact. The first signals of this can be found in the awareness raising of the issue: municipalities use the fact that this research is being executed to create publicity around adaptation in cities (see under “press releases” and “media attention” in annex 5 and 6). Another signal is the eagerness to receive results of the research projects as expressed by the CPC steering committee. When results will become available it can be expected

that these will be used in urban adaptation strategies and other more practical applications of adaptation knowledge.

A community of practice

Although the research program only started at the end of 2010, in the first half of 2010 stakeholders and researchers have been cooperating closely together within the Climate Proof Cities Framework in defining the subjects of research and developing case studies. By meeting on regular basis a community of practice has grown where experiences and knowledge are actively exchanged. This community comprises researchers from the knowledge institutes and universities of the consortium and stakeholders such as water boards (Delfland, Waternet, Hollandse Delta, Schieland en Krimpenerwaard), STOWA (Foundation for Applied Water Research), cities (Rotterdam, The Hague, Amsterdam, Utrecht, Arnhem, Nijmegen, Tilburg and Rijswijk), the province of Brabant and the national government. See the paragraph on stakeholder involvement for a description of their active involvement.

Each time about 30 of our stakeholders (municipalities, provinces, water boards, the Ministry of Infrastructure and the Environment, the Municipal (or Public) Health Service) are present on our consortium meetings (2-3 times a year). They also participate in the case meetings. For us this confirms that the CPC research programme has a continued relevance for our stakeholders.

Dissemination of knowledge to (potential) stakeholders

Working with stakeholders in cases and concrete projects is one direct way of disseminating knowledge. However the scientific and societal insights we collect in the Climate Proof Cities program is meant to be spread outside the consortium and to other interested stakeholders.

On local level we support the development of a Rotterdam Adaptation Strategy (RAS) and the adaptation strategies for the Rotterdam and Haaglanden regions. The objective of these adaptation strategies is protecting the city from high waters and prepare for the consequences of climate change, like more heat waves, salination of groundwater, changing possibilities of transport on waterways, and more changing groundwater levels. This strategy's aim is to make Rotterdam climate proof in a proactive way.

On the national level we work closely together with the Ministry of Infrastructure and the Environment and more specific the Deltaprogramma Nieuwbouw en Herstucturering (DPNH). The involvement with the Deltaprogramma has materialized in different ways:

- Exchange between the project teams of DPNH and CPC in order to optimize the use of CPC scientific knowledge in the Deltaprogramma.
- Knowledge assembly Heat (S. Döpp et al, 2011, Kennismontage hitte); an additional project for the Deltaprogramma. This document that brings together the existing knowledge on heat, proved important in the raising of awareness of the problem. It explains that in cities the impacts of the changing climate are enhanced by the urban heat island effect. The urban heat island in turn, is caused by the many stone-covered surfaces and little green in the cities. Heat is a stress factor, certain groups, like babies and elderly are especially vulnerable

to it. It is possible to generate information on the vulnerable city parts by connecting different types of maps, like climatological, geographic and city planning maps, but there is no general method yet. It is possible to find combinations of city characteristics that react to heat in the same way. Possible adaptation measures are being presented by theme: green surfaces, water, buildings, city structure. Other important factors in the planning of the resilient city are: size, building density, compilation and geometry. Also human behaviour plays a very important role in making cities resilient. There is more information needed about the vulnerability of city elements and on the effectivity of adaptation measures. Partly due to this fact and to the existing lack of awareness there is also a lack of heat- and climate adaptation policies in cities.

- CPC delivered building blocks for the Problem Analysis of DPNH (Fysieke bouwstenen voor de knelpuntanalyse Nieuwbouw en Herstructurering (Bosch, Hoogvliet, Goosen, & Van der Hoeven, 2011)). An overview was made of the current knowledge on the effects of climate change on cities and on the choices that have to be made for adapting built up areas to climate change. It appeared that there is a lack of knowledge about the urban area. What we know now about soil and groundwater in urban areas is often derived from rural areas. We know that the circumstances in cities are much more complex and locally determined.

Besides these direct contacts CPC was and is actively involved in a number of dissemination meetings, such as:

Workshop on Climate Adaptation in Cities by the Dutch Network of Environmental professionals, Den Bosch , 13th October 2010. This side event on a market exhibition of environmental technologies informed a number of stakeholders from different backgrounds on the state of knowledge.

Knowledge and Networking Day on adaptation in cities (Kennis- en Netwerkdag), Arnhem, 14th April 2011. This event brought together a great number of researchers and stakeholders. The initial aim of the gathering: establishing a stakeholder group of leaders in climate adaptation, was not achieved. The event was nevertheless successful in dissemination of knowledge, learning about projects and research methods applied in cities and expanding and strengthening the network of researchers and stakeholders in the urban environment.

Plans for a **CPC conference**. To further raise awareness of the implications of the changing climate for the urban area, we are organizing a conference to be held in the beginning of 2013. The goal is to further widen the network of stakeholders from municipalities and water boards, and to disseminate knowledge. We especially target those within municipalities and water boards whose work portfolio is in the area of public space, green, infrastructure and as such are confronted with climate adaptation. Urban problems like heat, drought and water nuisance will be addressed. We are organizing this conference together with the Ministry of Infrastructure and Environment and STOWA (Foundation for Applied Water Research).

Communication of results in- and outside the consortium

CPC does have a communication plan and different ways of communicating research outcomes to the hotspots and the targeted audience. Like a website, an external newsletter twice a year, consortium days, a yearly report, mailings, and of course our articles in popular scientific journals.

We see our chance to reach our targeted audience in emphasizing the chances we got with the changing climate, the possibilities to enhance the cities' liveability. We are still looking for the best ways to reach this communication target.

Coverage of our research has taken place in newspapers, on television and on the radio. See annex 5 and 6 for a detailed overview.

Conclusions and outlook

The two main features of Climate Proof Cities are the broad range of scientific disciplines (engineers, urban designers, physical planners , meteorologists , etc.) involved and the very active and intensive participation of stakeholders. About 12 PhD students, 3 post-docs and a number of other researchers are active in the program.

In the Netherlands, at the start of the programme, the issue of climate adaptation of urban areas was a new topic. Many senior scientists had limited knowledge on the issue. However, they combined prominent and relevant knowledge on for instance construction of buildings, urban planning and governance and were willing to expand their scope to climate adaptation. Contrary to researchers on, for instance, water management with a long adaptation tradition, scientists starting in the field of urban climate adaptation had to take more time to start, while building on (limited) foreign experiences.

With the programme starting at the end of 2010 / the beginning of 2011, research is at still somewhat in a beginning stage. Therefore the number of scientific publications at the moment is still limited. First results on vulnerability, the extent of the problem regarding precipitation and heat, the course of action to climate proof cities and implementation of measures, are being reported. The results are presented and debated at conferences and consortium meetings, with participation of leading institutes and scientists. Internationally an active role for the international partners has been established.

Simultaneously with the development of the research programme, the awareness among stakeholders of possible impacts of climate change in cities is growing. In the Netherlands, research and policy development on adaptation to climate change had mainly been concerned with flood protection with no specific focus on urban issues, until the start of the Climate Proof Cities program. It is now increasingly recognized that cities are highly vulnerable to climate change. Many adaptation measures are being suggested without a proper underpinning of their effectiveness in the local Dutch circumstances. As a primary aim of Climate Proof Cities is to tackle that lack of knowledge, many stakeholders showed their interest to participate, which resulted in a much broader participation of stakeholders than the original hotspots from the Knowledge for Climate program.

Climate Proof Cities provides information for answering questions of the cities themselves, based on case studies in the participating cities. Through this action oriented research Climate Proof Cities hopes not only to motivate cities to increase their climate resilience, but also provides the building blocks necessary for developing strategies and action plans.

In the short time of its existence, Climate Proof Cities has evolved into an active community of practitioners in The Netherlands on climate adaptation in urban areas, involving the most relevant Dutch universities and knowledge institutes and actively involving a large number of stakeholders (municipalities, water boards, district councils, provinces and national government). What binds us is the common understanding that climate adaptation should be part of broader urban development and governance. Stakeholder involvement is organized in case studies, meetings, membership of the steering committee, and the delegated power to decide on an ad-hoc research budget.

Being a large group of scientists representing different backgrounds and involving a variety of stakeholders asks for a good structure of Climate Proof Cities to ensure integration and coherence in the research, to bridge the scientist-stakeholder gap and to keep both groups at the table. For the moment the cooperation of researchers from different disciplines in case studies in various cities with accompanying case meetings and consortium meetings seems to be a good model to keep the exchange between science and practice going.

The consortium will reach its scientific goals through the set-up of interlinking work packages and case studies, linking theory and practice in accordance to our mission. Coherence in the program is established and safeguarded by a separate integration work package and an integrated case, and by frequent (plenary) meetings, a common framework and guidelines, and working together towards an integrated overall report by yearly reports.

The consortium will continue the involvement of partners and stakeholders and will further strengthen the established community of practice. CPC is defining ways of further enhancing international cooperation within the consortium. CPC will carry on disseminating the knowledge that is being generated in this programme to raise awareness and the sense of urgency, delivering valuable information to our stakeholders. CPC has yet to find the best way of communicating research results in an appealing way to everyone who can use them to ensure societal relevance. A conference dedicated to the findings of Climate Proof Cities will be held in January 2013 organized together with the Ministry of Infrastructure and Environment/Deltaprogramma and STOWA.

Annex 1: List of research partners

1 TNO: contributes its expertise in integrated assessment, as well as specific expertise in urban heat, impact assessment, stakeholders involvement and human physiology with regard to heat.

2 Delft University of Technology

Urbanism Department and Green Buildign iNnovation Department, Faculty of Architecture provide instruments and methods for sustainable urban and landscape analysis and design.

Department of Housing Quality and Process Innovation of the OTB Research Institute for Housing, Urban and Mobility Studies provides its expertise on policy instruments and procedures, for building and maintenance.

Clouds, Climate and Air Quality Group (CCAQ), Department of Multi-Scale Physics has an expertise in fluid mechanics and turbulence, especially of atmospheric boundary layer processes and CFD of the urban environment.

3 Eindhoven University of Technology

Urban Planning Group, Department of Architecture, Building and Planning, Smulates user behavior and response to external (environmental) change, linking these models to models of physical processes and developing dynamic models of the use of the built environment

Building Performance Simulation, Unit Building Physics and Systems, Department of Architecture, Building and Planning contributes with computer simulation for performance based building and systems design.

Urban Physics, Unit Building Physics and Systems, Department of Architecture, Building and Planning, Investigates urban heat and mass transfer at the micro-scale and their interaction with heat and mass transfer in the indoor environment using CFD and HAM models.

4 Wageningen University

Meteorology and Air Quality (MAQ) Main player in The Netherlands in measuring and modelling the urban climate.

Earth System Science and Climate Change (ESS CC): This group is responsible for interrelations and integration, linking to climate change scenarios as well.

Landscape Architecture for research and design of adaptive green elements in the city.

5 Utrecht University is the main focus for research on adaptation governance in the context of urban, regional and infrastructure planning.

6 University of Amsterdam specialist in and the institutional capacity for realizing adaptation measures.

7 Radboud University Nijmegen brings in their experience in the research on the governance of business parks to explore new financial instruments for adaptation.

8 Deltares National institute for urban water management, Climate change and adaptation, Integrated coastal zone and water resources management, Flood risk analysis, engineering and management.

9 KWR Watercycle Research Institute. Focuses on: supply of drinking water, human health, wastewater collection and treatment.

10 UNESCO-IHE Flood Resilience Group In the context of urban flood management systems focusing on vulnerability of urban systems to climate change impacts; floods and extreme events, effective interventions and their impact on the resilience of urban flood management systems.

Foreign research partners

1 University of Manchester

School of Environment & Development, Centre for Urban and Regional Ecology, (CURE) has research projects in many of the CPC themes. Leading institute in UK urban adaptation research programmes. The University plays a key role in the EPSRC (Engineering and Physical Sciences Research Council) programmes.

2 Albert-Ludwigs-Universität Freiburg Longstanding experience in both monitoring and modelling the effects of urban elements on the thermal and air pollution component of urban climate. Development of thermal indices for the perception of the thermal environment. The Institute coordinated the KLIMES project part of the German research programme Klimazwei and is involved in KLIMZUG-REGKLAM programme.

3 Universität Kassel The Competence Centre for Climate Change Mitigation and Adaptation (CliMA) has specific expertise in cities in: urban climate and climate mapping, thermal comfort and thermal indices, adaptation in buildings, societal research including governance. CliMA provides an entry into the German research programmes Klimazwei and KLIMZUG.

Annex 2: List of hotspots and stakeholders

Stakeholders and their financial contribution (euro)

Gem Rotterdam	175.000	
Waterschappen R'dam	75.000	
HH Delfland	40.000	
Gemeente Den Haag	100.000	
Gem Rijswijk	80.000	
Amsterdam	140.000	(Gem Amsterdam 40k[1] , Amsterdam-Oost 50k, Waternet 50k)
Brabantstad/Tilburg	50.000	(Tilburg 5k, Province of Noord-Brabant 45k)
Utrecht	50.000	
Stowa	200.000 [2]	
Total:	*890.000*	

Stakeholders with a contribution in kind:

Stadsgewest Haaglanden	30.000
Arnhem/Nijmegen	45.000

[1] 10.000€/yr., with a reservation for the years after 2012.
[2] Of which 150.000 under the condition that research items identified by STOWA are taken into account.

Annex 3: Structure of CPC and short description of the work packages

WP 1: The Urban Climate System

Work package leader : Prof. Dr. A.A.M. Holtslag

Description work package

1.1 Problem definition, aim and central research questions

To ensure that effective and coherent adaptation measures and strategies are being developed for the urban environment, a thorough understanding of processes of the Urban Climate System (UCS) is essential. This includes understanding of weather, air quality and climate phenomena from mesoscale to microscale. In addition, more quantitative information regarding the UCS is needed. The aim of WP1 is to provide this information, both from observations and model simulations.
In contrast to many countries in the world, where urban meteorology has been studied for more than 3 decades, urban meteorology was not an issue in the Netherlands until recently. However, although foreign studies on urban climate may contain valuable information, they cannot be easily extrapolated to the Dutch situation. There are distinct differences in climatic conditions, urban landscape and geometry, and in building styles and materials. This implies that specific tools to assess the effect of climate change on urban climate in the Netherlands are required. Such tools can then be used to support urban planning, in order to ensure that proper adaptation measures will be taken.
Processes at different scales (metropolitan area, city, neighbourhood, street and building scale) will be studied, to unravel the complex relationships between meteorological processes, urban configuration and geometry, and anthropogenic activities. This knowledge will be integrated in simulation models, covering the different spatial and temporal scales in the UCS. WP1 aims at the development and validation of a model instrumentation with which the effects of current and future climate projections on meteorological variables (radiation, temperatures, air humidity, wind and precipitation) can be studied for urban areas. With this model instrumentation the effectiveness of various adaptation measures to cope with climate change effects in cities, can be assessed (as part of WP5).

1.2 Interdisciplinarity and coherence between the projects

Work package 1 is subdivided into three main tasks which are strongly linked:
1. Meteorological and hydrological observations in the urban environment (Project 1.1)

2. Development of a model instrumentation (Projects 1.2 and 1.3)
Work package 1: The Urban Climate System Extract from full proposal page **2** of **3** In Project 1.1, meteorological and hydrological observations in the Urban Canopy Layer (UCL) and Urban Boundary Layer (UBL) will be carried out. The resulting data will be analyzed to increase process understanding and to develop new model parameterizations. Furthermore, the data can be used to validate the models. Two types of models will be further developed and evaluated:

1. A mescoscale Numerical Weather Prediction (NWP) model, for simulating the urban climate at the regional to neighbourhood scale (Project 1.2)

2. A Computational Fluid Dynamics (CFD) model for simulating the urban climate at the micro (neighbourhood to building) scale (Project 1.3).

The modelling efforts on the mesoscale and microscale require different scientific approaches. Therefore, development of the model instrumentation will take place in two separate projects. With this model instrumentation, the impact of near-term regional climate change, particularly impacts linked to extreme weather events, on the UCS will be studied. This will be performed in WP5, using the results of the scenario studies for regional climate change (KfC Theme 6) as input. The results will

be an essential component for a conurbation-scale risk assessment in WP 2, which in turn is necessary to prioritize and determine the extent of adaptation measures to be taken. In addition, the model instrumentation will be used to assess – in close cooperation with WP3 - the (feedback) effects of proposed adaptation measures and strategies on the UCS, in order to determine their suitability and effectiveness. The aforementioned results are essential to develop a coherent and effective adaptation response.
Both observations and model simulations will initially be focused on the case study areas in the hotspots. The models will be validated and parameterized with in situ meteorological and hydrological observations. However, subsequently, observational data of other urban areas will be used in order to get a more generally applicable model instrumentation.
The University of Manchester will support this work package through comparative work developd through the ASCCUE and SCORCHIO projects and the meso-scale models to be developed through the CPC project.

1.3 Stakeholders
The results of this work package support the following work package but are also of immediate interest to a wide range of stakeholders. Local governments, urban designers and planners, project developers, health services, housing corporations, building engineers, water boards, energy companies.
Specific stakeholders are the hotspots and other cities involved in the programme. The observation and modelling (to a certain extent) will be executed at sites chosen in consulation with the hotspots. Specific questions with regard to these sites can be taken into account.

WP2: Impacts, sensitivity, vulnerability

Work package leader: Dr. ir. B. (Bert) Blocken (TU Eindhoven, Unit Building Physics and Systems)

Description work package
2.1 Problem definition, aim and central research questions
The Royal Netherlands Meteorological Institute (KNMI) has described the expected changes in climate for the Netherlands in terms of four climate scenarios:
- Temperatures will continue to rise; mild winters and hot summers will become more common.
- On average, winters will become wetter and extreme precipitation amounts will increase.
- The intensity of extreme rain showers in summer will increase, however the number of rainy days in summer will decrease.
- The calculated change in wind is small compared to the natural fluctuations.
- The sea level will continue to rise.

In cities, the urban heat island effect (UHI) adds to the temperature rise because of a changing climate. The urban environment is subjected to these changes. This can result in adverse effects including overheating, flooding, drought and related increases in morbidity, mortality and damage to property. Prior to implementing adaptation measures, the potential impact of climate change and the sensitivity and vulnerability of the urban environment to climate change need to be analysed. This analysis is the aim of work package 2, focused on buildings, people and neighbourhoods, and considering the important uncertainties involved. This work package is strongly connected to the work packages 1 and 3. While work package 2 will start using the already existing climate scenarios for the Netherlands, as the KfC program progresses, these will be replaced by the refined regional and local current and future meteorological data, resulting from KfC theme 6 and from the modelling efforts in work package 1. Work package 2 is also, and especially, intended to support work package 3, in which adaptation measures will be analysed. The reason is that knowledge on impacts, sensitivity and vulnerability is needed to determine the need for adaptation measures.

The central research questions in this work package are:
- What are the potential impacts of climate change and the sensitivity and vulnerability of our urban environment to climate change?
- When, where and to what extent will adaptation meaures be needed?
These research questions can be broken down into project-specific research questions:
What are the potential impacts of climate change on the indoor environment and energy consumption of buildings?
- What are the potential impacts on human health (especially the elderly) during overheating episodes?
- What are the potential impacts of climate change on neighbourhoods, in terms of excess rainfall and overheating?
- How sensitive and vulnerable are our urban systems (neighbourhoods, urban functions, public) to the wide range of climate change parameters?
- Can a typological classification of buildings

2.2 Interdisciplinarity and coherence between the projects
To answer these research questions, four projects have been defined. Two of these are specific projects (2.1 and 2.2), addressing physical and physiological parameters at the building and human scale. The two others (2.3 and 2.4) are more general projects, focusing on neighbourhoods or multiple scales. They are for a large extent based on literature overview and are intended to rapidly provide direct tools for the hotspots for practical use as well as tools for other projects in other work packages.
In project 2.1, the effects of increased temperature on the indoor environmental performance and energy consumption of buildings are evaluated. The focus is on indoor temperatures, overheating, thermal comfort and heating and cooling demand of buildings. Measurements as well as numerical simulations are performed for a range of typical buildings in the Netherlands. The results are a sensitivity classification of buildings and an indication of the related indoor environmental conditions and energy performance. It provides information on if, when and where adaptation measures will be necessary at the building scale.
This information is used in project 2.2 to analyse effects of overheating on the most vulnerable group: elderly people. A measurement campaign will document a range of physiological and also psychological parameters to increase our understanding of the actual heat strain that elderly people experience during overheating episodes in buildings. Based on this information, adaptation measures will be contemplated.
Project 2.3 aims at quantifying the sensitivity and vulnerability of urban systems and to analyse how these can be reduced by strengthening the threshold capacity, the coping capacity, the recovery capacity and the adaptive capacity of buildings, facilities, infrastructure and people. Although its main focus is on the neighbourhood scale, it also encompasses other scales.
Supported by the vulnerability analysis in project 2.3, project 2.4 will establish a typology of neighbourhoods in terms of vulnerability to climate change. Its goal is to provide a tool to identify which neighbourhood types should be given the highest priority for the implementation of adaptation measures. This project will also allow for the extrapolation of results and knowledge obtained for a certain neighbourhood to other neighbourhoods with the same or a similar typology.
The University of Manchester will undertake comparative work to assess differences in methods and findings from building simulation work, which have used alternative simulation software to estimate the relative contributions of building types to the Urban heat Island effect in Manchester, and the influence of various building scale adaptations.

A large number of stakeholders can be identified, such as local governments, urban designers and planners, project developers, health services, housing corporations, building engineers, water

boards, energy companies. Specific stakeholders are the hotspots that are engaged in this programme, but also other co-funding parties (Haaglanden, Rotterdam, Amsterdam, Tilburg, Arnhem-Nijmegen). It is important to mention that this work package, although it addresses several hotspot-specific research questions directly, is strongly focused on providing the basis for the projects in work package 3, which are more closely linked to the majority of hotspot questions.

2.3 Stakeholders

The following hotspot-specific questions are addressed in this work package:
Urban residential areas
- Neighbourhood typologies – existing and new neighbourhoods
- Requested fast deliverable: fast scan of sensitivity and vulnerability of neighbourhoods
- Relationship between outdoor and indoor environment in existing buildings – heat stress
- The effect of heat strain on health in the elderly

Building and Street
- Classification of buildings in terms of relationship outdoor-indoor environment
- Heat stress agenda
- Sustainable buildings and street
- Water elements

WP3: Adaptation measures and strategies

Work package leader: Prof.dr.ir. A.A.J.F. (Andy) van den Dobbelsteen (TU Delft, Faculty of Architecture, GBI)

3.1 Problem definition, aim and central research questions

Climate change demands measures at the urban scale, simultaneously dealing with increasing precipitation, drought and extreme heat. Moreover, a more conscientious approach to (waste) energy consumption in urban areas would reduce urban heat islands and CO_2 emissions.
Hence, measures are needed for the adaptation to heatwaves and mitigation of the urban heat island effect and drought on the one hand, and watersheds due to storm water excess or river flooding on the other. These measures are to be found by different means, on different scales (cities, neighbourhoods and buildings), often integrated and serving multiple purposes.
Therefore, measures resulting from this Knowledge for Climate (KfC) programme would partly imply climate adaptation, climate mitigation and an approach we could call climate pro-activation, i.e. utilising climate characteristics optimally in the urban and building design.

The themes chosen for this work package aim to cover the entire range of measures for climate robustness: green interventions, dealing with precipitation at the buildings and city level, the combined approach to water and energy, and spatial and technical design measures at various scales.

Main research question for this work package is:
- Which measures can be taken for climate robustness of cities, neighbourhoods and buildings, and what is their efficacy?

General subquestions are dealt with in the themes mentioned:
- In which sense can green interventions provide solutions against increased temperatures and better retention of rainwater?
- How can rainwater be captured, stored and used in buildings and their direct surroundings, in order to avoid water excess and serve other purposes?
- How can water excesses be tackled on the urban scale, while serving multifunctional purposes?

- How can the combined approach to the water and energy system provide solutions for both climate adaptation and mitigation?
- Which design and technical measures can be taken at the building level to avoid undesired upheating of buildings and to play a role in the urban decrease of temperatures?
- Which spatial and technical design measures for climate robustness can be taken on the neighbourhood to city level?
- Which climate robust planning measures are possible on the city to region scale?

3.2 Interdisciplinarity and coherence between the projects

The seven main themes in this work package were formulated intentionally as such to provide measures at all urban scales and to optimally interlink the projects. Core focus of WP3 is urban design, at the scale of the building, the neighbourhood and the city, each of which requires a different approach but also need cooperation. Closely related to the design themes of projects 3.5, 3.6 and 3.7 are the green interventions of project 3.1 and the measures for precipitation of projects 3.2 and 3.3. The energy and water system project of 3.4 relies strongly on senior experience with water and energy systems. It is obvious that this infrastructural theme is also linked to the design and precipitation projects.

In addition, there is coherence with the other work packages 1, 2, 4 and 5, in order to integrate topics of urban climate, impacts, measures, governance and the integration of all results. Personal involvement and project links will secure collaboration and cooperation between the work packages. For example, project 3.1 will colaborate with Work package 1 for measurements on the effects of green in cities.

The projects within this work package will be executed in practical case studies (details of which are discussed in the project descriptions). In the case studies researchers will actively collaborate with municipalities. Multiple projects will contribute to the research in a case study:

- In the case study Urban Water Management the focus of the cooperation will be between project 3.2 (water system of buildings and streets), 3.3 (water system of district until region) and project 4.1 (policy integration and planning tools). Project 3.4 (water and energy systems) might provide valuable inputs.
- The Building and Street case study will entail collaboration between the projects1.3 (development of a model toolbox), 2.1 (impacts of climate change), 2.2 (human health impacts), 3.1 (green infrastructures), 3.2, (rainfall interception), 3.5 adaptation measures), 4.2 (self-organization) and 4.3 (implementation in residential buildings).
- For the Urban residential areas case, collaboration will be established between project 3.1 (green infrastructures), 3.5 (building to neighbourhood), 3.6 (neighbourhood to city) and 3.7 (city to region).
- In the case study Business parks there will be collaboration with project 3.3 (water system of district until region), 3.4 (water and energy systems), and 3.6 (neighbourhood to city). Project 4.5 elaborates the governance connection.
- The case study regional approach/climate buffers is largely executed by project 3.7 (city to region), with inputs from projects 1.1 (measuring) and 1.2 (meso-modelling), and coordinated with 3.6 (neighbourhood to city).

The University of Manchester will assist in collating the findings from Wp1 and Wp2 in order to build appropriate adaptation plans at a variety of scales. This component of the work has a large lement of knowledge transfer from relevant UK projects and programmes.

3.3 Stakeholders

As this work package adresses the various climate adaptation measures in cities, stakeholders include the whole range of those involved in urban planning and management: municipalities, provinces, water boards, energy companies, drinking water companies, urban planners, architects, landscape architects, building engineers, climate designers, housing corporations, property investors, project developers, end-users, proprietors, etc.
Specific stakeholders are the hotspots and other cooperating cities in this programme (Haaglanden, Rotterdam, Amsterdam, Stadsregio Arnhem/Nijmegen, Brabantstad/Tilburg)
The following hotspot-specific topics are addressed in this work package:

- The development and application of generic principles of the effects of green on the city climate
- Water storage in existing and new urban areas
- Flat roofs/water storage/rainfall peaks
- Dealing with peak rainfall and use of water for cooling in urban areas
- Storage in buildings or gutters
- The effects, nuisance, risks and damage of a high end extreme precipitation event: Rotterdam and others
- Storage and utilisation of water and sequestration of excessive, whilst accomplishing a sustainable, closed total energy system
- Measures to reduce impact of outdoor climate on indoor environment in buildings in existing and restructured neighbourhoods
- Impact of user behaviour
- Green roofs en facades
- Heat stress agenda
- Sustainable buildings and streets
- Diminishment, neutralisation or avoidance of upheating by urban measures
- Climate synergy between greenhouse horticulture clusters and residential and industrial areas
- Synergy Work/Living Areas <> New nature

WP 4: Governance and adaptive capacity in cities and metropolitan areas
Work package leader: Prof. dr. T.J.M. Spit (UU)

4.1 Problem definition, aim and central research questions

In order to study urban governance processes to facilitate adaptive capacity in order to cope with the effects of climate change, this work package relies heavily on **an urban planning perspective**. This implies that apart from a general planning approach on external integration (Project 1), the departing point of each analysis will be on specific issues and cases (Project 2-5). As a large part of adaptation measures in cities will need to be implemented by the housing sector, housing issues have a prominent place in this work package (Project 2-4). Poor performances, bad cooperation between designers and builders and misfits between the design of buildings and the characteristics, preferences and behaviour of occupants are already well-known problems of the sector. The building of climate robust buildings, urban areas and cities needs innovative concepts in order to establish breakthroughs in the housing sector. These projects aim to provide more insight in occupants' behaviour, existing and new coalitions and innovations in the building process and in the effects and contents of regulations and policies.
The massive restructuring of post-WWII estates (built 1950-1975) which will have to take place in the coming years, provides an opportunity to introduce climate proof components. Local authorities,

housing associations and citizens organisations are 'natural' key-actors in these restructuring processes. Based on the general principles of 'external integration' (Project 1), the integration of adaptation within the planning processes and procedures will be elaborated, taking into account their long term and public interest character. This research will provide different perspectives on the planning and organization of these redevelopment processes, both on the level of individual dwellings, as well on the level of entire urban areas. The redevelopment of industrial estates and business parks, a planning program of a similar size, provides an important opportunity to integrate climate proof elements in that type of redevelopment. The project will investigate the various aspects of integrating adaptation in redevelopment programmes.
Therewith, the central aim of this work package is to provide new insights in the way climate adaptation can be introduced into the existing spatial planning processes, based on the knowledge that:

1. urban planning is in itself a highly complex process in which a lot of significant and (mostly) conflicting interests of different actors are competing;
2. climate adaptation measures do not represent a so-called 'strong interest' whose integration into urban processes need no support.

The central research question is: what can be learnt from the way other interests integrate procedural and material (external integration) into urban planning processes and how do they specifically work when on the one hand neighbourhoods and working areas are concerned and on the other hand, individual housing, either owned by the occupant or housing corporation. Theoretically as well as methodologically, complementary approaches are used in the projects, both in quantitative and qualitative terms.

Addressing the central research question also requires knowledge from other projects within the theme. Especially, in the work package 2 (Sensitivity, impacts and vulnerability) and work package 3 (Adaptation measures and strategies) there are direct relations. Noteworthy e.g., is the project on neighbourhood typology (project 2.4) and the governance aspects in urban residential areas when the adaptation towards climate change has to be addressed. But also between the projects on design (project 3.5-3.7) and on the development of urban green (project 3.1), within work package 3 and the projects on urban areas within work package 4. Regular exchange of knowledge between researchers in these projects is foreseen. Less direct, but no less interesting for the proposed projects on urban governance are the projects on specific issues, such as health, flooding, energy and rainfall. In work package 5 (Integration) these issues will be tailor-made exchanged between the researchers in the different projects.

The general knowledge on governance issues (Theme 7) and instruments (Theme 8) are of great importance to this work package on urban governance. An exchange of knowledge is planned on a regular basis.

In addition, the University of Manchester will contribute with its expertise with working with local and regional government.

4.2 Interdisciplinarity and coherence between the projects

This work package consists of 5 interrelated building bricks (see figure 1). The first of which (Project 1) addresses the general issue of external integration. It analyses the possibilities for planning concepts and individual measures to facilitate climate adaptation in general. This can be considered

a 'knowledge umbrella' which is relevant for the analyses in the specific projects, whether they address an entire urban area or individual dwellings. For this general knowledge can be used to expand the specific knowledge generated by the other projects. And the other way around, the specific knowledge in the case of urban areas and dwellings can be used to sharpen the general knowledge derived from the 'external integration' project. Therewith, in this work package general knowledge on urban governance is combined with disciplines such as architecture (Project 2 and 3 on dwellings), urban geography (Project 4 on neighbourhoods) and economic geography (Project 5 working areas). An important aspect of this interrelatedness is the difference of spatial scales. As Project 3 and 4 take the individual dwelling as a starting point, projects 4 and 5 have entire urban areas as a starting point. Yet, it must be clear that urban areas are more than the sum of their components, either dwellings or firms. As project 1 evaluates the usefulness of general spatial planning instruments and regulation towards the adaptation to climate change, this type of knowledge is relevant on all spatial scales.

Because of the interrelatedness of the projects (see figure 1), interaction on a regular basis is foreseen in this work package. It foresees in facilitating learning processes of the researchers within the individual projects and the hot spots Rotterdam, Haaglanden, Amsterdam, Arnhem/Nijmegen, Tilburg, etc. As most of the case-studies will take place within the hot-spots the stakeholders within the hot spots will provide a key role in these learning processes. This particular work package aims at delivering two types of knowledge: process knowledge on adaptation issues, developed in close corporation with the hot spots' stakeholders and scientific knowledge represented in papers for scientific journals and PhD's.

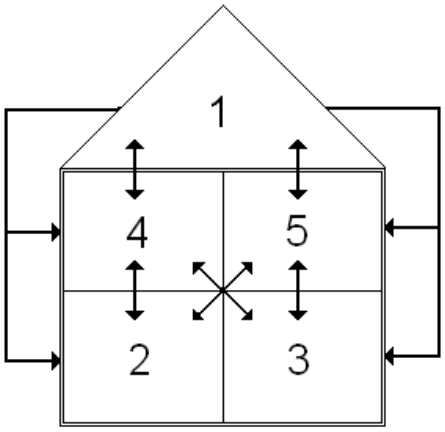

Figure 1: The interrelations between the individual projects in work package 4

4.3 Stakeholders

The stakeholders in the empirical case studies (Haaglanden, Rotterdam, Amsterdam, Arnhem-Nijmegen, Tilburg etc.) are actually part of the research. The stakeholder group consists of the municipalities in the first place, together with, depending on the project, the provinces, housing associations, households, neighbourhood associations, Chambers of Commerce, firms on industrial estates and other institutions.

A specific category of other relevant stakeholders within the Urban Governance work package is involved for specific purposes, like engineering firms (such DHV for the project on working areas) and CROW for knowledge dissemination.

WP 5: Integration
Work package leader: P.R. Bosch, MSc (TNO)

To be useful for policymaking, the answers to the research questions in work packages 1-4 and the different cases have to be combined and integrated.
This final work package will provide the handshake between the scientific results obtained in work package 1 to 4 (and the case studies) and the use of these in policy making on the local and national level. Therefore the results from the previous work packages will be included in an integrated assessment of the need and possibilities of adaptation in Dutch cities. At the same time this work package integrates the information on regional climate scenarios from KfC theme 6 ("improving climate projections") with the city data generated in this programme. A range of climate scenarios will thus be translated into scenarios describing impacts in cities, packages of adaptation measures and policy action needed for each of these. The resulting adaptation strategies resulting from the dynamics of climate change will be matched with information on the dynamics of cities. Information on urban renewal will show the windows of opportunity for integrating adaptation measures in urban processes. The analysis and review of the research information serves to support decision makers to evaluate possible actions and strategies.
Summarised: this work package brings together information on a suite of policy questions: how serious will climate change become for a city without any action?, what are the impacts (costs) on the urban system?, what would be an appropriate policy response in terms of measures and strategies?, how much would these cost?, and what and who is needed to implement them?, and when is the best time?

The activities in this work package come down to bringing the main outcomes of the research programme in a logical framework together and to provide estimates that fill gaps between individual research projects, so that the results of the work programme in total can be used for policy making. The most important piece of information in this respect are those data that help judging the multiple costs of taking action versus the expected impacts of doing nothing. Activities will be aimed at providing the best possible estimates for these, for individual neighbourhoods and for cities.

This work package will be conducted throughout the programme. A main delivery is an integrated view on the state of knowledge which will be delivered at a few moments throughout the running time of the project. Contrary to a cut-and-paste of individual project results, this will be an assessment placing the results achieved at that time in the larger framework of the need and possibilities for adaptation. At the very end of the programme, of course, a full-fledged assessment can be given.

Ad hoc requests:
This work package includes as project 5.4 a reservation for ad-hoc requests of the stakeholders. In a four-year programme further research questions from the stakeholders may appear halfway, and we would like to reserve some capacity in the budget to deal with important new questions. The choice of research topics under the ad-hoc budget will be discussed with, and needs to be approved by the KfC steering committee of the programme.
Criteria for ad-hoc projects are:
- the question should have arisen after the start of the research programme,
- the question should fit within the general scope of the research programme,
- it must be a restricted (in scope, time and budget) research project,

- the focus should be on the use of knowledge of the consortium, or the transfer of knowledge from the consortium
- the ad hoc budget is not for general consultancy for the stakeholders.

The budget for ad hoc requests is intended for work in year 2, 3 or 4 of the programme.

5.2 Interdisciplinarity and coherence between the projects

All partners in the consortium will contribute to the assessment, ensuring that maximum use is made of the multidisciplinary experience gathered.
Project 5.1 is the main engine in this work package. It will provide the integration between future climate projections with expected impacts, and the adaptation measures and strategies needed to prevent these. Project 5.2 supports the information engine (project 5.1) and the report production (project 5.3) with tools and frameworks. It ensures the consistency of outcomes through these projects.
Finally the results of the whole research programme will be reported in an integral way in project 5.3, that relies on inputs from 5.1 and 5.2.

The University of Manchester will assist in collating the findings of the research programme in order to built adapatation plans on a variety of scales. As many of the projects of the University of Manchester have a strong stakeholder component and use case study examplars, the experience of the University in stakeholder processes will be a useful support to this work package.

5.3 Stakeholders

This work package has been specifically developed to provide decision makers with timely, targeted and relevant information. Stakeholders are decision makers, and those who advise them, at local, regional and national level. Specifically: the municipalities, housing corporations, waterboards, and provinces related to the hotspots and the other cities involved in the proposed research programme. On the national level, the ministry of VROM (housing and environment) is the most important stakeholder. It is expected that the stakeholders will actively contribute in work package 5 through participating in science policy interface workshops in which - in interaction with science - most likely adaptation options and strategies are developed for a range of scenarios for future climate change.

Annex 4 : List of communication activities

(individual case meetings are not listed).

16th November 2010, Utrecht, first CPC yearly event, 54 participants. Pitch presentations by all researchers.

10-11 April 2011, CPC Spring School Utrecht, Contributions by University of Manchester (John Handley, Susannah Gill, Roland Ennos, Jeremy Carter, Geoff Levermore, Sarah Lindley, Mei Ren, Yong Wang), and University of Kassel (Sabrina Campe and René Burghardt). Short Presentations by several CPC researchers.

14th April, 2011, Gelredome, Arnhem. Knowledge and Networking Day on Adaptation in Cities for municipalities. Organized together with Future Cities, KvK, CROW. About 100 participants, several presentations by CPC researchers (on measuring urban climate, heat and health, knowledge assembly heat stress, extreme precipitation and the problem assessment for Nieuwbouw en Herstructurering).

1st September 2011, Utrecht University, CPC yearly event 2011, 56 participants. Keynote by Prof John Handley University of Manchester.

13th January 2012, Delft University of Technology, CPC consortium meeting, ca. 40 participants

1-5 April 2012, Spring School Manchester, attendance by all but one of the CPC PhD students, two PhD students from the University of Freibourg and group of Manchester PhD students. Contributions by lecturers form the University of Manchester and Freibourg, the Tyndall centre and UKCIP and a large number of UK stakeholders.

26th April 2012, TNO Utrecht, CPC consortium meeting, ca. 47 participants. Keynotes by Dr Chao Ren and Dr Edward NG from the Chinese University of Hong Kong.

In January 2013 a conference is planned for municipalities and water boards. It is being organised together with the Ministry of Infrastructure and Environment and STOWA.

Annex 5: Publications

a. Boek (Book)	
Editors, Publicatie datum, Titel, Uitgever, ISBN No., Pagina's, Status (in press, submitted, etc)	Projectpartner(s)
Roggema R. & Dobbelsteen A. van den (2011); 'Spatial-Energy Framework Aiming at Breakthroughs Brings Goals beyond Policy Objectives within Reach', in: Jenkins A.L.; Climate Change Adaptation; Nova Publishers	TUD, BK
b. Brochure (Brochure)	
Auteurs, Publicatie datum, Titel, Uitgever, Naam van serie, Totaal aantal pagina's, Status	Projectpartner(s)
Climate Proof Cities brochure in KvK format, beschikbaar in Engels en Nederlands	All
Bert van Hove, Cor Jacobs. Hitte in de stad. In: Staat van het klimaat 2010 (eds. Rob van Dorland, Rob, Wieke Dubelaar-Versluis en Bert Jansen), pp. 49-51. PCCC, Wageningen/De Bilt, 71 pp.	WUR, Alterra
c. Eindrapport van project (Final project report)	
Auteurs, Publicatie datum, Titel, Naam van serie, ISBN No., Totaal aantal pagina's, Status	Projectpartner(s)
NVT	
d. Persbericht	
Auteurs, Publicatie datum, Titel, Status	Projectpartner(s)
Persdienst TU/e http://w3.tue.nl/nl/nieuws/artikel/?tx_ttnews%5Btt_news%5D=9332&cHash=210510be71	
Persbericht Gemeente Arnhem, 6 Juli 2011, Bakfiets meet klimaat van de Van Muijlwijkstraat	WUR MAQ Municipality Arnhem
Persbericht Gemeente Arnhem, 5 September 2011, Onderzoek naar de beleving van warmte in de stad	WUR MAQ Municipality Arnhem
e. Project factsheet (Project factsheet)	
Auteurs, Publicatie datum, Titel, persbericht uitgegeven door	Projectpartner(s)
NVT	
f. Nieuwsbrief van project (Project newsletter)	
Editors, Publicatie datum, Titel, Naam van serie, Totaal aantal pagina's, Status	Projectpartner(s)
Informele nieuwsbrief voor consortium partners en stakeholders, inmiddels 11 edities verschenen van ca. 2 pages. Editor; Sonja Döpp /Vera Rovers.	TNO

• Interne CPC nieuwsbrief editie 14 • Externe CPC nieuwsbrief editie 1	TNO
g. Populair artikel over wetenschap (Popular article about science)	
Auteurs, Publicatie datum, Titel, Media, Editie, Pagina's, Status	Projectpartner(s)
Kleerekoper, L., 17-05-2010, Klimaatrobuuste steden, Cobouw, 113, Pag. 11	TUD
Dobbelsteen A. van den (2011); 'Teeuw & Ravesloot helpen begroeide daken in Nederland naar volwassenheid', op website Duurzaam Gebouwd: http://www.duurzaamgebouwd.nl/expertposts/20110223-teeuw-ravesloot-helpen-begroeide-daken-in-nederland-naar-volwassenheid	TUD, BK
h. Poster	
Auteurs, Publicatie datum, Titel, Lokatie van presentatie, Status	Projectpartner(s)
Standaard poster Climate Proof Cities. Beschikbaar voor diverse presentaties. (al ingezet op Deltaconferentie; Conferentie Belgisch Voorzitterschap Adapting to the changing climate: time to intensify efforts, 23/24 november 2010).	TNO
Uittenbroek, C. (April, 2011) Preparing for heavy rain: Barriers and opportunities for the integration of climate adaptation in urban planning processes. URU dagen, Soesterberg.	UU/UvA
Uittenbroek, C. (June, 2011) Preparing for weather extremes: Barriers and opportunities for the integration of climate adaptation in urban planning processes. AESOP Workshop, Prague.	UU/UvA
Klemm, Wiebke, 1-09-2011, Green interventions for climate-proof cities, CPC Yearly event	WUR
Anita Kokx en Tejo Spit "Adaptation strategies and the redevelopment of urban areas", CPC Yearly Event, Utrecht, 1 September 2011	UU
Roders, M.J. (2011) Governance of adaptation in social housing. Climate Proof Cities Yearly Event, 1 September 2011, Utrecht	TUD
C. Uittenbroek, T. Spit, W. Salet, L. Janssen-Jansen, H. Runhaar, 1 september 2011, CLIMATE PROOF CITIES (project 4.1) barriers to and opportunities for the integration of climate adaptation in urban planning processes, CPC Yearly Event, Universiteit Utrecht	UU/UvA
Van der Heijden, M.G.M., Blocken, B., Hensen, J.L.M., 01-09-2011, Impacts of climate change on the indoor environmental and energy performance of buildings, CPC yearly meeting, Universiteit Utrecht	TU/e
Montazeri, H., Blocken, B., Hensen, J.L.M., 01-09-2011, Rainfall interception, storage and evaporative cooling of buildings and surrounding streets, CPC yearly meeting, Utrecht University	TU/e

Toparlar, Y., 21-01-2012, "Computational Analysis of Climate Change adaptation measures at the building and street scale focused on evaporative cooling: Case study for the city of Rotterdam", Poster Draft 1, Eindhoven	TU/e
Steeneveld, G.J., Koopmans, S., Heusinkveld, B.G., Ronda, R,J., Van Hove, L.W.A., Holtslag, A.A.M. (2011). Quantification of the urban heat island effect and human comfort in the Netherlands using data from hobby meteorologists: role of vegetation in the city.	WUR
P.J.C. Schrijvers, H.J.J. Jonker, S. Kenjeres, S.R. de Roode (2011). Simulations of the urban climate at micro-scale	TUD
Echevarria Icaza, L., Tjon Sie Fat, M., Van der Hoeven, F. (2011). Developing regional adaptation strategies for UHI's.	TUD
Tjon Sie Fat, M., Tillie, N., Van der Hoeven, F. (2011). Neighbourhood typologies – preliminary results.	TUD
Root., L. (2011). Investing in Climate Adaptation in the Context of Urban Brownfield Redevelopment:A study of the potential application of tax increment financing in the Netherlands	RUN
Kleerekoper, L. (2011). Investing in Climate Adaptation in the Context of Urban Brownfield Redevelopment:A study of the potential application of tax increment financing in the Netherlands	TUD
You Peng, C. (2011). Comfort in urban environment: Microclimate, urban form, activity pattern and exposure	TU/e
Haak, A.J.C., Van Hooff, T.A.J., Van der Heijden, M.G.M., Timmermans, H.J.P., Blocken, B., Hensen, J.L.M (2011). Adaptation measures at the building scale: adaptive envelopes and occupants.	TU/e
CPC (2011). Climate Proof Cities – Cases studies	TNO
Pásztor, A., Bosch, P., (2012) Integration in Climate Proof Cities: The cases, for the Spring School of CPC 1-5 April 2012 in Manchester	TNO
Pásztor, A., Bosch, P., (2012), Climate Proof Cities: Research for and with cities for ICLEI, Resilient Cities 2012, Bonn	TNO
i. Proceedings	
Auteurs, Publicatie datum, Titel, Naam Proceedings, ISBN No., Pagina's, Status	Projectpartner(s)
Daanen, H.A.M., Heusinkveld, B., Van Hove, B., Van Riet, N. Heat strain in elderly during heat waves in The Netherlands. In: Kounalakis, S., Koskolou, M. (Eds). Abstract book XIV International Conference on Environmental Ergonomics, Nafplio, Greece, 2011. Page 26.	TNO, WUR

Roders, M.J., Straub, A., and Visscher, H.J. (2011). Climate change effects on living quality; awareness of housing associations. In: J.W.F. Wamelink, R. P. Geraedts, L. Volker (eds.) MISBE2011 - Proceedings of the international Conference on Management and Innovation for a Sustainable Built Environment, Delft: Delft University of Technology. ISBN 9789052693958	TUD
Van Hove, L.W.A. Exploring C.M.J. Jacobs, B.G. Heusinkveld, J.A. Elbers, G.J. Steeneveld, S.Koopmans, E.J. Moors and A.A.M. Holtslag (2011). Exploring The Urban Heat Island Intensity Of Dutch Cities. In: City Weathers meteorology and urban design 1950-2010 (Eds. Michael Hebbert, Vladimir Jankovic & Brian Webb),. pp. 31-38. The Proceedings of the City Weathers Workshop constitute papers presented at the ESRC sponsored workshop on the 23-24 June 2011. Published 2011 by Manchester Architecture Research Centre, University of Manchester http://www.sed.manchester.ac.uk/research/marc ISBN: 978-1-907120-98-5.	WUR
Roggema R. & Dobbelsteen A. van den (2011); Planning for Climate Change or: How Wicked Problems Shape the New Paradigm of Swarm Planning; in: Proceedings WPSC 2011	TU Delft, BK
Kleerekoper L., Dobbelsteen A. van den, Dorst M.J. van & Hordijk G.J. (2011); 'A Heat Robust City. Case study designs for two neighbourhoods in the Netherlands', in Proceedings SB11 - World Sustainable Building Conference, Helsinki	TU Delft, BK
Roggema R. & Dobbelsteen A. van den (2011); 'Swarm Planning: A Unified Approach Dealing with the Two Sides of Climate Change', in Proceedings SB11 - World Sustainable Building Conference, Helsinki	TU Delft, BK
j. Presentatie (Presentation)	
Spreker, Datum, Titel, Gelegenheid, Lokatie	Projectpartner(s)
Bert Blocken, 13-10-2010, “Klimaatadaptatie in gebouwen, straten en wijken”, VVM workshop Klimaatadaptatie in de stad, Den Bosch	TU/e
Peter Bosch, 16-4-2010, “Climate Proof Cities”, Workshop Thermal Comfort and Urban Design, Kassel.	TNO
Peter Bosch, sept 2010, “Integrated assessment of possibilities for Climate Change adaptation in cities”, Delta conferentie, Rotterdam.	TNO
Climate Proof Cities; an integrated research programme in the Netherlands, Sonja Döpp, Peter Bosch, Hein Daanen (TNO), Bert van Hove, Bert Heusinkveld, Cor Jacobs, Jan Elbers, Gert-Jan Steeneveld, Bert Holtslag (Wageningen University) Frans van de Ven (Deltares / TUD), ICLEI, Bonn, 5 juni 2011.	TNO, WUR, Deltares, TUD
Boonstra, B. (2011), Self-organisation by Community Based Networks - and how they engage and challenge planning. Paper presented at the 9th meeting of AESOP Thematic group on Complexity and Planning. Self-organizing and spatial planning. Istanbul, 29th-30th April 2011.	TNO

Meerkerk, Ingmar van, Boonstra, Beitske and Edelenbos, Jurian (2011), Self-organization in urban regeneration – a two case comparative research. Paper presented at the 9th meeting of AESOP Thematic group on Complexity and Planning. Self-organization and spatial planning. Istanbul, 29th-30th April 2011.	TNO
Boonstra, Beitske (2011), Unleashing Self-organising Capacity in Urban Development? The case of Business Improvement Districts in the UK. Paper presented at the COMPACT meeting at Erasmus University Rotterdam. Rotterdam, 23th-25th June 2011.	TNO
Kleerekoper, L., 13-10-2010, Groen en hitte in de stad, Kennisatelier Klimaatgroen, Venlo	TUD
Kleerekoper, L., 12-05-2011, Urban Climate Design Engineering, Bijeenkomst Ministerie van I&M, Den Haag	TUD
Roders, M.J. (18 January 2011). Climate Change adaptations through an innovative building process. Housing Quality research Group TU Delft, Delft	TUD
Roders, M.J. (22 June 2011). Climate change awareness of Dutch housing associations. Conference MISBE2011, Amsterdam	TUD
Dobbelsteen A. van den; 'Waar blijft onze groene revolutie?', Duurzaamheidspaviljoen Bouwbeurs, Utrecht, 11-02-2011	TU Delft, BK
Dobbelsteen A. van den; 'Naar een rode, blauwe of groene stad', Visiebijeenkomst vegetatiedaken, Rotterdam, 02-03-2011	TU Delft, BK
Dobbelsteen A. van den; 'Sustainable building – challenges ahead', Symposium KIVI-Niria, Utrecht, 17-03-2011	TU Delft, BK
Dobbelsteen A. van den; 'CPC in Amsterdam Nieuw-West', CPC-Workshop, Amsterdam Nieuw-West, 12-04-2011	TU Delft, BK
Dobbelsteen A. van den; 'Liberating cities', lunchlezing Energy Club, Delft, 18-05-2011	TU Delft, BK
Dobbelsteen A. van den; 'Merging energy and planning', Symposium ReVISIONS programme, Guildford UK, 26-05-2011	TU Delft, BK
Dobbelsteen A. van den; 'The Amsterdam Guide', MISBE2011 congres, Amsterdam, 22-06-2011	TU Delft, BK
Dobbelsteen A. van den; 'De duurzame stad', Zuiderkerklezing, Amsterdam, 13-10-2011	TU Delft, BK
Dobbelsteen A. van den; 'Ruimte voor de duurzame toekomst', symposium ministerie van I&M, Den Haag, 30-11-2011	TU Delft, BK
Dobbelsteen A. van den; 'De urgentie van echt duurzaam bouwen', Lighthouse Club, Delft, 20-12-2011	TU Delft, BK

Roders, M.J. (2011). Governance tools for Climate Change Adaptation. SENSE PhD Training School on the Human Dimensions of Global Environmental Change, 26-29 september 2011, Amsterdam.	TU Delft
Root, Liz, Planning Resilient Cities, (2011) Birmingham,	RUN
C. Uittenbroek, 20 oktober, 2011, The Dynamic Nature of Policy Integration: Climate Adaptation and Urban Planning, IGS Sense Twente, Universiteit Twente (Enschede)	UU
Van der Heijden, M.G.M., 26-10-2011, Heat wave vulnerability classification of residential buildings, Annex 55 meeting, San Antonio	TU/e
Van der Heijden, M.G.M., 26-10-2011, Heat wave vulnerability classification of residential buildings, College in bachelor course "Introduction to building performance simulation for integrated solutions", TU Eindhoven	TU/e
Montazeri, H., 07-09-2011, DTU, TU/e, TUM, EPFL - PhD Symposium, Munich University of Technology	TU/e
Toparlar Y., 19-01-2011, "Computational Analysis of Climate Change adaptation measures at the building and street scale focused on evaporative cooling: Case study for the city of Rotterdam", Start Colloquium, Eindhoven	TU/e
Reinder Ronda. International Workshop on Urban Weather & Climate, Beijing, China.	WUR
Reinder Ronda. Slotconferentie klimaat voor ruimte 1 december 2011, Amersfoort. Workshop de hete stad in beeld.	WUR
Bert Holtslag. 11th EMS meeting & 10th European Conference on Applications of Meteorology (ECAM)	WUR
Boonstra, Beitske (2011), Unleashing Self-organizing Capacity in Urban Development? The case of Business Improvement Districts in the UK. Paper presented at the COMPACT meeting (EUR), Rotterdam, 23th-25th June 2011.	TNO
Boonstra, B. (2011), Self-organization by Community Based Networks - and how they engage and challenge planning. Paper presented at the 9th meeting of AESOP Thematic group on Complexity and Planning, Istanbul, 29/30 April 2011	TNO
Beitske Boonstra: "Business Improvement Districts UK". Spreker Spontaneous City Seminar, oktober 2011	TNO
Beitske Boonstra: "Anders denken, of: Denken in Verschil". Keynote spreker NIROV jaarcongres Dag van de Ruimte 2011, thema 'Doe Het Zelf', november 2011	TNO
Beitske Boonstra: "Het perspectief van Doe Het Zelf", spreker Masterclass Organische Gebiedsontwikkeling Almere, november 2011	TNO

Bert Heusinkveld. Cor Jacobs, Reinder Brolsma. Kennis & Netwerk dag Arnhem, Future cities, Klimaat voor ruimte, Kennis voor klimaat, CROW, 14 april 2011.Workshop meten van hitte in de stad.	WUR
Bert van Hove. City Weathers workshop 23-24 June 2011, Manchester.	WUR
Bert Heusinkveld en Reinder Ronda. Slotconferentie klimaat voor ruimte 1 december 2011, Amersfoort. Workshop de hete stad in beeld.	WUR
Jacobs, Cor, Bert Heusinkveld en Bert van Hove, 2011. Naar een comfortabele stad! Over het gebruik van metingen aan stadsklimaat. Presentatie tijdens de Kennis- en Netwerkdag Klimaatbestendige Gemeente, Arnhem, 14 april 2011, workshop "Meten van hitte in de stad" www.klimaatonderzoeknederland.nl.	WUR
Kleerekoper, L., 2011, Heat mitigation in Dutch cities by the design of two case studies, 5th AESOP Young Academics Network Meeting 2011, The Netherlands	TUD
Kleerekoper, L., A.A.J.F.vandenDobbelsteen, M.J. van Dorst, G.J. Hordijk, 2011, A Heat Robust City. Case study designs for two neighbourhoods in the Netherlands, Sustainable Building 2011, Helsinki.	TUD
Bert van Hove, Frank van der Hoeven, Andy vd Dobbelsteen, Peter Bosch, 10 november, diverse presentaties over hitte. Overleg stadsdelen, Amsterdam	CPC consortium
k. Proefschift (PhD thesis)	
Auteurs, Publicatie datum, Titel, Tijdschrift, Pagina's, Status	Projectpartner(s)
NVT	
l. Rapport (Report)	
Auteurs, Publicatie datum, Titel, Naam van Serie, ISBN No., Pagina's, Status	Projectpartner(s)
Döpp, S., Klok, L., Janssen, S., Jacobs, C., Heusinkveld, B., Kleerekoper, L., Lenzholzer, S., Brolsma, R., Blocken, B., Bosch, P., Heijden, M. van der, Daanen, H., Timmermans, H., Hensen, J., Broeke, H. ten, Klemm, W., Uittenbroek, C., mei 2011, Kennismontage. Hitte en Klimaat in de Stad, Climate Proof Cities Consortium, Ministerie van Infrastructuur en Milieu, Deltaprogramma Nieuwbouw en Herstructurering, TNO-060-UT-2011-01053, Published	All
P.R. Bosch, M. Hoogvliet, H. Goosen et al.,2011, Fysieke bouwstenen voor de knelpuntenanalyse nieuwbouw en herstructurering. Climate Proof Cities Consortium, Ministerie van Infrastructuur en Milieu, Deltaprogramma Nieuwbouw en Herstructurering, TNO-060-UT-2011-01826.	TNO, Deltares, Alterra
Rovers, V., Bosch, P., Pásztor, A., Albers, R.: Klimaatbestendige steden - voortgangsrapportage Climate Proof Cities 2011.	CPC Consortium

Van Riel, W., 2011.Exploratory study of pluvial flood impacts in Dutch Urban areas. Afstudeerraopport, Deltares, Delft. Riel, W., Stone K., Ven, F van de, 'Exploratory study of pluvial flood impacts in Dutch urban areas'	Deltares
Stone, K. Duinen, R. van, Verbeek, W., Döpp, S., (2011): Sensitivity and vulnerability of urban systems, assessment of climate change impact to urban systems. Report nr 120270-008-BGS-0004	Deltares, UNESCO-IHE, TNO
Van Hove, L.W.A., J.A. Elbers, C.M.J. Jacobs, B.G. Heusinkveld en W.W.P. Jans 2011. Stadsklimaat in Rotterdam. Eerste analyse van de meetgegevens van het meteorologische meetnet. Wageningen Alterra, Alterra-rapport 2192. 32 blz; 10 fig.; 4 tab; 10 ref. ISSN 1566-7197.	WUR
Babajev, Narik (2011) The heterogeneity of the meteorological variables and human thermal comfort in the Rotterdam agglomeration. BSc Thesis report Wageningen University, 36 pp	WUR
Tanis, Hein (2011). The influence of the Sky View Factor on the Urban Heat Island in Rotterdam: An exploratory study based on UHI-measurements by trams and SVF-calculations based on the digital elevation model AHN2. BSc thesis report, Wageningen University, 53 pp.	WUR
Janssen, Stijn J. (2011). The influences of urban morphology on the average temperature of Rotterdam city. Graduation report Technical University Eindhoven, 132 pp.	TU/e
Döpp, S.,Bosch, P. (2011) Climate Proof Cities: an integrated research framework.	TNO
Pasztor, A., Bosch, A. (2011). Guideline Vulnerability terminology	TNO
m. Wetenschappelijk artikel (Scientific paper)	
Auteurs, Publicatie datum, Titel, Tijdschrift, Pagina's, Status	Projectpartner(s)
Kleerekoper, L., 2011, Heat mititgation in Dutch cities by the design of two case studies, 5th AESOP Young Academics Network Meeting 2011, Track B: Resilience Thinking and Climate Change, The Netherlands	TUD
Roders, M.J. and Straub, A., (2011). Corporaties Klimaat Bewust? Rooilijn. nr. 5, p. 362-369	TUD
Boonstra, Beitske and Boelens, Luuk (2011): Self-organization in urban development: towards a new perspective on spatial planning, Urban Research & Practice, 4:2, pp. 99-122	TNO
Meerkerk, Ingmar van, Boonstra, Beitske and Edelenbos, Jurian (2012), Self-organization in urban regeneration – a two case comparative research. European Planning Studies, forthcoming.	TNO
n. Wetenschappelijk artikel peer reviewed (Scientific paper peer reviewed)	

Auteurs, Publicatie datum, Titel, Tijdschrift, Pagina's, Status	Projectpartner(s)
Kleerekoper, L., Esch, M.M.E. van, Salcedo, B. T., 2011, How to make a city climate-proof, addressing the urban heat island effect, Resources, Conservation and Recycling, approved for publication.	TUD
Steeneveld, G.J., S. Koopmans, B.G. Heusinkveld, L.W.A. van Hove en A.A.M. Holtslag, 2011. Quantifying urban heat island effects and human comfort for cities of variable size and urban morphology in the Netherlands. J. Geophys. Res., 116, doi: 10.1029/2011JD015988.	WUR
Kleerekoper, L., Esch, M. M. E. V. & Salcedo, T. B. 2011. How to make a city climate-proof, addressing the urban heat island effect. Resources, Conservation and Recycling. Available online 2 October 2011. In Press, Corrected Proof	TUD
Daanen, Hein A. and Janine Herweijer, 2012. Short high intensity acclimation does not lead to adaptations in young and elderly females. European Journal of Applied Physiology. Submitted.	TNO

Annex 6: Media attention

a. Televisie attentie (television attention)	
Publicatie datum, Titel, Kanaal, Programma, Referentie	Projectpartner(s)
NOS Journaal about research on heat in Rotterdam, dinsdag 12 juli 2011, 20:50 http://nos.nl/uitzending/43069-20110712-200000-nos-journaal-2000-uur.html	TNO, WUR
TV Rijnmond: about measuremnt-cable in Oude Noorden http://www.youtube.com/watch?v=8Q_umQscaFg&feature=youtube_gdata	Deltares
RTV Utrecht: about measurements with the pushbike in Utrecht, 26th July 2012 http://www.rtvutrecht.nl/nieuws/841961/onderzoek-naar-temperatuurverschillen-in-stad.html	WUR
b. Radio attentie (Radio attention)	
Publicatie datum, Titel, Kanaal, Programma, Referentie	Projectpartner(s)
VARA, Vroege Vogels (August 2009). High tech bakfiets meet Rotterdams UHI, augustus http://vroegevogels.vara.nl/Gerelateerditem.150.0.html?&tx_ttnews%5Btt_news%5D=350593&tx_ttnews%5BbackPid%5D=66&cHash=79e23191b1	WUR, Alterra
Klemm, Wiebke interview op 16-09-2011, Bericht over belevingsonderzoek naar warmte in de stad, RTV Arnhem	WUR
c. Publicatie in krant (Publication in newspaper)	
Auteurs, Publicatie datum, Titel, Krant, Editie, Pagina's	Projectpartner(s)
Website: Groen en de Stad, 26-5-2010 , http://www.groenendestad.nl/stad_en_land/nieuws/miljoenen_voor_onderzoek_en_praktijkontwikkeling_van_klimaatbestendige_steden.htm	

• "Fietsend door te stad om het klimaat te peilen". De Gelderlander, 6 juli 2011 •"Help! Wat is het heet in de stad" Volkskrant 12 juli 2011 http://www.volkskrant.nl/vk/nl/2672/Wetenschap-Gezondheid/article/detail/2703832/2011/07/12/Steeds-vaker-hittegolven-en-vooral-in-de-stad.dhtml • "Hete stad heeft baat bij groen" NRC artikel 13 juli 2011 (ook in NRC-next) • "Mathenesse als subtropisch oord" De Havenloods Noord, 22 juli 2011	CPC genoemd, met foto van Bert Heusinkveld.
De Gelderlander, 06-07-2011, Fietsen voor de wetenschap, (bakfietsmetingen Arnhem juni-juli 2011). pag. 21-22	WUR MAQ Gemeente Arnhem
Boonstra, Beitske: Interview in ROmagazine: "Op zoek naar de nieuwe ROmmers, Integraal denken, faciliteren en snel schakelen…" ROmagazine december 2011, p. 8-11	TNO
22 juli 2011, Havenloods. Mathenesse als subtropisch oord. http://www.deweekkrant.nl/artikel/2011/juli/22/mathenesse_als_subtropisch_oord (KvK 1e Tranche)	WUR, TNO
18 juli 2011, Tuin en Landschap. Groen koelt hete stad af http://www.tuinenlandschap.nl/nieuws/4735/aanleg-groen-koelt-verhitte-stad-af (KvK 1e Tranche)	WUR, TNO
12 juli 2011, NRC Handelsblad. De aanplant van groen verlaagt de stedelijke hitte. (KvK 1e Tranche)	WUR, TNO