Climate Proof Cities
Knowledge for Climate

Interim findings climate adaptation in urban areas

Management Summary Progress Report Climate Proof Cities 2013

Climate and city

Due to global warming it is possible that in the future, hot summers and extreme rainfall will occur more often in the Netherlands. The urban environment is especially vulnerable to this because it retains heat and has a higher percentage of impervious surfaces, allowing water build up faster in the streets during heavy rainfall. In short, pluvial flooding and high temperatures can ensure that in the future, the quality of life in the city will decrease.

Furthermore, cities have a high density of inhabitants, goods and infrastructure as well as an important share in the economy, which means that extreme weather conditions can have a significant impact on cities.

Since the investments that are currently being made in the urban environment, such as renovations or the construction of new buildings, determine the existence of buildings and infrastructure that will still be there around fifty years from now, it is already important to consider whether it is possible to accommodate for future climate changes. There are also adaptations that can be made in the urban environment which could minimize the inconvenience currently caused by extreme weather conditions.

There is a wide range of possible options for adaptation, but because we are still uncertain about exactly how the urban climate works and how it is influenced by climate change, the effectiveness of these measures is still unclear.

The research programme Climate Proof Cities (CPC) aims to provide the knowledge required to make well-considered decisions about the need and timeliness of adaptations to climate change (see text box). The CPC consortium's research focuses on reducing heat strain and water nuisance. This management summary gives an overview of the preliminary results halfway through the programme. The full progress report (including citations and bibliography) can be downloaded on the website (in Dutch).

The conclusions in this summary are based on interim results which are subject to change during the course of the programme. Therefore the use of these results is one's own responsibility.

Climate Proof Cities

Climate Proof Cities (CPC) is one of the themes within the national research programme Knowledge for Climate. The CPC research provides knowledge to allow cities and the urban environment to function sustainably under changing climate conditions. The four-year research programme studies the phenomenon of heat in the city because of the increasing risk of lengthy hot spells, and water nuisance due to more frequent and more intense rainfall events.

In order to answer five main research questions, researchers with diverse backgrounds and from different research institutes are working within the consortium on around twenty sub-projects. To enlarge the practical applicability, the researchers are collaborating on 4 case studies in different Dutch urban areas: Rotterdam, Haaglanden, Amsterdam, Arnhem/Nijmegen, Brabant and Utrecht.

www.knowledgeforclimate.org/climateproofcities

Summary

1. How does the local climate work in Dutch cities?

During heat waves it is warmer in every Dutch city, big or small, than it is in the surrounding area. This Urban Heat Island effect (UHI) is noticeable in everyday life and is caused by the heat absorption of the (stony) materials, the lack of evaporation and the emission of heat related to the use of energy ('anthropogenic heat').

During the day, the dry and stony surfaces in a city take in most of the sunshine. When the sun sets, the buildings continue to emit the absorbed heat, so that the temperature of the air in the city stays high. The absorption of sunshine due to reflections between buildings turns out to be the driving force behind the UHI effect.

The atmospheric UHI, the difference in air temperature between the city and its surroundings, is at its highest point after sunset, and the city does not cool down until the end of the night. The effect is greater in the summer than in the winter and on warm days it can reach up to 9 °C in the evening.

However, the extent of the extra heat shows great variation within a city and is dependent on local features. The amount of paved surfaces turns out to be the most determining factor for UHI intensity. Aside from this, the proportion of built-up areas and urban greenery and the height of the buildings are of great influence on the UHI effect.

Open water turns out not to have an unambiguously cooling effect on its surroundings. When the water warms up during the summer, its cooling capacity decreases.

The perception of heat in a city depends on more factors than just temperature. The so-called 'Physiologically Equivalent Temperature' (PET) is a measure for thermal comfort and is calculated using information about air temperature, atmospheric humidity, radiation and wind speed. The more limited exposure to solar radiation in the city (due to shadows from buildings) compared to the surrounding areas is favourable for thermal comfort; the lower wind speeds in the city actually have a negative effect. It is still unknown which role the variations in atmospheric humidity play. Due to the UHI effect, urban areas experience more days of heat stress than in the countryside.

In order to have an indication of the urgency of the heat problem in relation to climate change, the temperature sequences of the urban location of southern Rotterdam and a reference location in the countryside have been transformed into temperature sequences for 2050 and 2100 (figure 1). This indicates that heat stress can become an important issue for many cities in the coming decades.

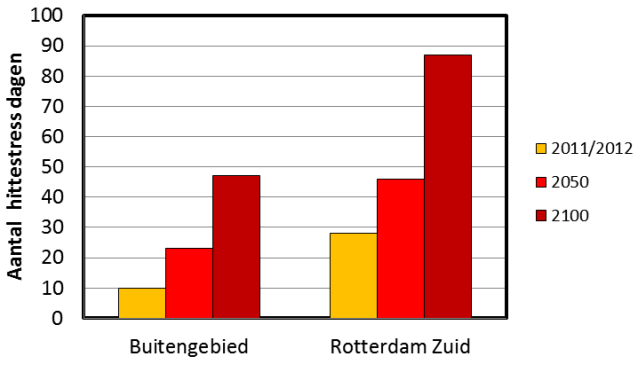

Figure 1 The number of days with moderate to high heat stress for two locations: the countryside (left) and 'Rotterdam South'(right), calculated for the current situation, halfway through this century, and at the end of it with the (W+) KNMI'06 scenario.

2. How vulnerable are Dutch cities to the effects of climate change?

Sensitivity of humans to heat stress or that of investment goods to flooding form the basis for an analysis of urban vulnerability.

Water nuisance

Objects that are sensitive to material damage due to pluvial flooding are buildings (and interiors) and electricity switch boxes. Economical damage can also occur through interruption of business, traffic disruption and power cuts. In addition there are costs for mobilizing emergency services and there are social implications if hospitals etc. function below par or are less accessible. Risks and damage due to extreme rainfall are generally dependent on a threshold value that differs per object, for instance, the height at which switch boxes are mounted. Decreasing exposure during extreme rainfall can be achieved locally by ensuring that the water remains below the threshold value (by increasing storage area and infiltration) or by increasing the threshold value (for instance higher doorsteps, mounting switch boxes higher up).

Heat stress

The elderly over the age of 75 are especially sensitive to periods of heat stress and can become ill or even die. In the Netherlands the death rate increases by 12% during heat waves (approximately 40 extra deaths per day). Their body temperature can become higher than 38 °C during periods of heat. In an attempt to study whether they would be able to prepare for an approaching heat wave in a climate test chamber, it emerged that a warning period of three days is too short for both young people and the elderly to acclimatize.

Buildings can decrease the exposure to heat. Unfortunately it turns out that, based on the KNMI'06 climate scenarios, overheating (an indoor temperature of over 25 °C) will be more frequent and will last longer in a large proportion of Dutch buildings. Using building simulations, research has been done on the sensitivity of types of houses for indoor heat during increasing outdoor temperatures. This showed terraced and semi-detached houses are less often exposed to high temperatures and experience fewer hours of overheating than detached houses and corner houses.

Productivity can also dip when the temperature indoors rises above 25 °C. An indication of the damage caused by lower productivity inside non-air-conditioned buildings and outside buildings depends on the climate scenario, but can amount to dozens or even hundreds of millions of euros per year.

In addition, as we have seen in section 1, certain urban characteristics can lead to more or less heat in a neighbourhood.

Information about the location of sensitive groups, such as the elderly, is combined with their living conditions (quality of housing and neighbourhood characteristics as measure for exposure). The result is a vulnerability map, such as this one of Amsterdam (figure 2). The map indicates which parts of the city are vulnerable to heat stress. In the capital city it turns out that areas for special attention can be identified in the western part of the city, but also in the north, east and southeast.

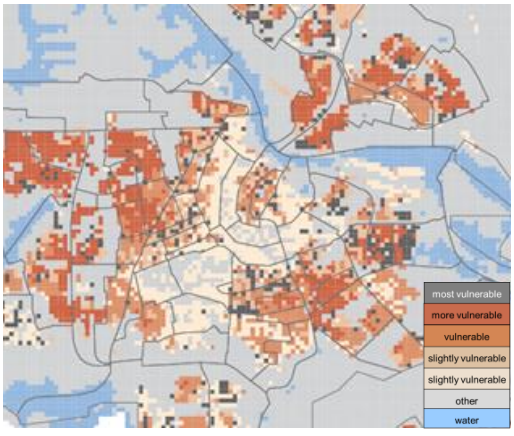

Figure 2 Vulnerability map of inhabitants of Amsterdam with respect to heat stress.

3. Which measures can be taken in order to better adapt cities to a future climate?

At CPC, measurements, computer simulations and street interviews are carried out to gain insight into the effectiveness of individual measures and combinations of measures for different scales. This knowledge will be translated into design guidelines in the last year.

From building to street

In the prevention of indoor overheating a distinction can be made between new and existing housing. Simulations for a terraced house show that newly constructed (well insulated) housing benefits most from blocking out sunlight in the doorways and windows and from creating natural ventilation by opening windows. In older housing extra insulation can have a significant effect, but often in combination with other measures, such as opening windows and increasing the reflection coefficient (albedo). In addition, a building's orientation is an important factor in reducing the number of hours of overheating in the house. In the summer months houses facing east and west experience the largest number of hours of overheating.

From street to neighbourhood

Measures that effectively lower the temperature of the air at street level are increasing the reflection coefficient (albedo) of the roof, higher buildings, and adding vegetation.

In terms of vegetation it is preferable to plant rows of trees rather than install green facades and roofs. Green roofs are mainly effective for buffering rain water. In addition, it turns out that people feel more thermally comfortable in streets with a lot of greenery and also appreciate it from an aesthetic point of view.

In order to make the urban water systems stronger in the face of flooding, many measures are available to increase the storage or transport capacity, both above and below ground level. An application known as 3Di has been developed in CPC, which gives insight into the effects of adaptation measures in water management and spatial development. As such, the instrument helps identify measures that improve how extreme rainfall in a particular urban environment is dealt with.

From neighbourhood to urban region

The climate in a city is partially determined on a scale that supersedes individual buildings, streets and neighbourhoods. Therefore research has been carried out on so-called 'coolspots' near cities. The first results indicate that much of the surface area coolspots is taken up by vegetation and that they are usually in use as meadows or fields (see figure 3). The soil type also seems to be an important aspect of 'coolspots', while the groundwater level does not seem to play an important role

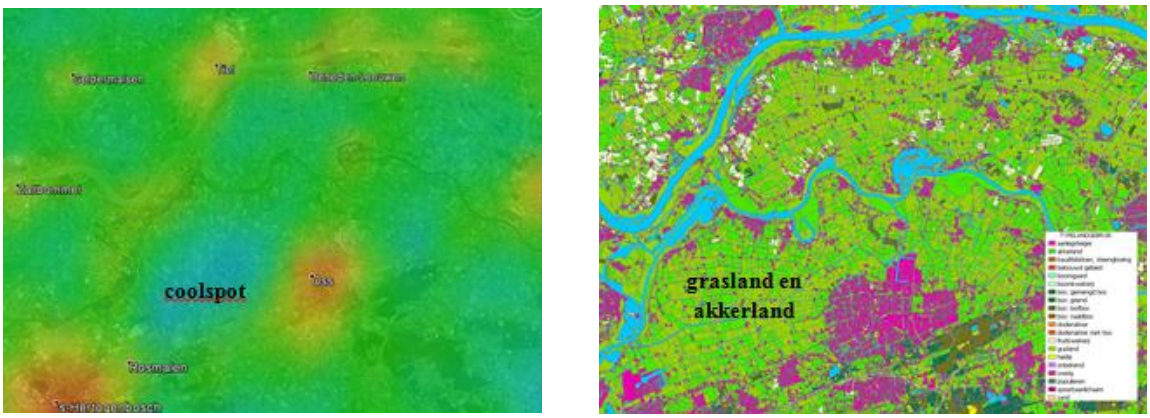

Figure 3 The 'coolspot' near Den Bosch corresponds to the use of the land, as 'meadows and fields' (in Dutch: 'grasland en akkerland').

4. How can these measures be implemented in urban areas?

In order to link the proposed climate proof solutions to the problem of 'climate change', the way in which parties deal with the subject of climate change must be altered ('governance').

Municipalities

The research focusing on municipalities shows so far that there are two approaches: 'mainstreaming' and a 'dedicated approach'. Both have positive and negative consequences. A dedicated approach entails that decisions are made quickly, but there is also a chance of inefficient policy. On the other hand, mainstreaming is often ad hoc and based on well-considered decisions. A combination of both can conceivably lead to more optimal results. In addition, the use of "Tax Increment Finance" in the public domain can potentially ensure an increase in financial capacity by using future property tax income.

Housing associations

Chain cooperation is proposed in order to allow climate change to play a role in the development of housing, whereby housing corporations and the construction industry are responsible for constructing housing.

The construction industry does not limit itself to carrying out the corporation's commission, but has an active role in the initial stages. In this way, the knowledge of the construction companies is used in the process, which makes it easier to realistically integrate climate proof measures in the construction process at an early stage.

Citizens

Aside from this, it has also turned out that citizens can play a role in the realization of the climate proof city. To be able to link the climate interests of public parties to civilian initiatives, the local government should find a new way of working, in which current routines are abandoned. A flexible attitude, where local government policy adapts to local initiatives (co-evolution), can potentially lead to better results.

To allow the implementation of climate measures to be successful, it is especially important that a connection is made between the various parties within the process (figure 4). Government, citizens and private parties must work together on the realization of the climate proof city.

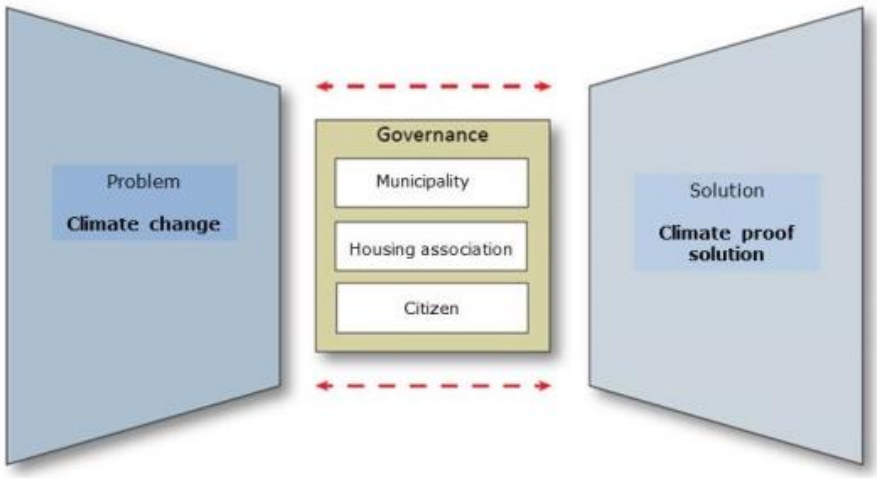

Figure 4 The parties within the governance process ensure a connection between the problem and the solution.

5. What is the final cost-benefit balance of the adaptation measures?

Two related approaches are possible in the implementation of the results of the research programme. There is a classical approach according to causal reasoning from within climate change through effects, vulnerability, adaptation measures and their implementation, and an area-specific approach. The latter assumes an area-specific problem where the plan is to improve a neighbourhood and make it more future-proof. Each approach follows a number of steps that entail specific "tools" for analysis, communication and dialogue; "indicators" in order to show the consequences of climate change for a city; "mapping" of exposure, sensitivity and adaptability in order to discover the vulnerability in detail (possibly combined as a 'stress test'); and "tables and diagrams", as a basis for choosing adaptation measures.

In an area-specific approach, "sketching workshops" have been initiated in Bergpolder Zuid (Rotterdam) as a means of sourcing different types of knowledge (research, sectors, area and policy), to integrate them and translate them into policy recommendations (figure 5). In Dordrecht, research was done on the "linking method" as an instrument supporting dialogue in the restructuring of a neighbourhood.

In general, an all-encompassing cost-benefit analysis is not always important. For an area-specific approach for instance, where the emphasis lies on co-benefits, it is no longer strictly necessary to have a breakdown of the specific costs of climate adaptation and the specific climate benefits. An overview of possible damage due to climate change is seen as motivating in order to draw attention to climate adaptation. However, calculating the costs of the damage in different climate scenarios in a city requires a lot of data, part of which is only available on a national level. Of course, for each policy decision, information is needed about the costs that policy or specific course of action entail. Considering climate adaptation measures in an urban environment are diverse and often contextually determined, this framework must be built up from within the local situation.

Figuur 5 Map of Bergpolder Zuid with adaptation measures

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