Reasons to adapt to urban heat (in the Netherlands)

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1. Introduction

Dutch urban professionals understand the need for climate adaptation, but have indicated that they need arguments and appealing examples to convince others of the urgency to adapt to urban heat risk. In recent years, considerable research has been conducted in the Netherlands into the impacts of climate change (extreme precipitation, summer droughts and rising temperatures) and into the increased risks for urban areas. From these studies, the need for climate change adaptation in urban environments has become evident at national level. As a result, the Dutch Delta Programme 2015 states that by 2050 the Netherlands must be as much climate-proof and water-robust as is possible (Delta Programme, 2015). However, at the local (municipal) level, climate adaptation is not always obvious. Local governments particularly struggle with defining the urgency of heat stress and finding good arguments for the need to adapt to rising temperatures in urban environments. With the aim to help them get the message across, we reviewed national and international policy reports as well as scientific literature. From the results of this investigation we created an overview of arguments and facts that stress the impact of rising temperatures and extreme temperature events. Questions that were raised, and that we expected to answer in this literature study, were: How is the urgency of urban adaptation to rising and extreme temperatures assessed in the Netherlands, in Europe and worldwide? What arguments play a role? What are the explanatory facts and examples that support the notification that rising temperatures call for urban adaptation? The overview of arguments and facts was discussed with a group of urban planners and local water professionals to investigate their usefulness for local practice. This paper summarizes and discusses the results of this study.

2. Reasons for adaptation to heat stress

To identify the reasons why cities need to adapt to rising temperatures, we studied many scientific reports and papers. We have grouped the arguments and results that we identified for the Netherlands, Europe and outside Europe.

2.1 Reasons in the Netherlands

At a national level, the urgency for a climate-proof and water-robust Netherlands has been stated in the Dutch Delta Programme (2015). This programme concludes that built-up areas may be seriously disrupted by heat-stress in the future due to rising temperatures and the urban heat island effect. The severe impacts of rising and extreme temperatures that are highlighted in the report are:

- A decrease in comfort and liveability of cities
- An increase in heat-related disease and mortality, especially among elderly people (75+)
- An increase in hospital admissions
- A decrease in sleep quality
- A decrease in labour productivity

Some of these impacts have been quantified thoroughly in scientific reports, especially the impact of heat on mortality. For instance, it has been estimated that the heat wave of 2003 resulted in 1400 to 2000 excess deaths in the Netherlands (Garssen et al., 2005), and about 1000 people died due to the heat wave of 2006 (UNISDR, 2007). Remarkably, this latter number resulted in a 4th place position of the Netherlands among the worldwide deadliest natural disasters for 2006, as can be seen in Table 1. This table indicates that heat waves can have a major impact in the Netherlands, comparable to other worldwide natural disasters, which in itself clearly expresses the urgency of the situation. On the other hand, we found during our roundtable discussions that many question the validity of the data in this research. The lack of justification for the mortality figures mean that it is difficult to use this information for promoting the adaptation message.

Huynen et al. (2011) investigated the relationship between temperature and mortality in the Netherlands and showed that mortality increases by 12% during a heat wave day, which amounts to 40 extra deaths per day. Huynen et al. (2008) also indicated that by 2050, increased heat stress could imply hundreds of extra deaths per year in the Netherlands. Another study (Rovers et al., 2015) concluded that during heat waves, excess mortality in the Netherlands increases by 8 extra people for every degree above 20 °C.

Top 10

Natural disasters by number of deaths - 2006

Earthquake, May	Indonesia	5778
Typhoon Durian, December	Philippines	1399
Landslide, February	Philippines	1112
Heat wave, July	Netherlands	1000
Heat wave, July	Belgium	940
Typhoon Bilis, July	China, P Rep	820
Tsunami, July	Indonesia	802
Cold Wave, January	Ukraine	801
Flash Flood, August	Ethiopa	498
Typhoon Samoai, August	China, P Rep	373

Table. 1 Top 10 Natural disasters by number of deaths for 2006 (Source: UNISDR, 2007).

In addition to the heat-related-mortality, Daanen et al. (2013) quantified the economic impacts of increased temperatures in the Netherlands. The focus of this study was on economic damage related to health and productivity. An economic cost model was developed for mortality (how many people die), morbidity (how many people enter emergency care) and productivity in the Netherlands. The total economic costs were estimated at 100 million Euro per year by 2050. The most important factor in these costs is the decreased productivity as a result of rising temperatures. The costing-calculation was based on the work of Seppänen et al. (2004), who concluded a decrease in productivity within buildings of 2% per °C temperature rise above 25 °C. The costs due to decreased productivity were partially compensated by the lower costs of decreased mortality and morbidity due to less cold winters in the future climate.

Further impacts of heat on comfort and liveability have not yet been explored in detail for the Netherlands. However, Steeneveld et al. (2011) did some preliminary investigations on the impacts of rising temperatures on comfort and heat stress in cities, based on data from weather hobbyists. Their results showed that in 50% of the Dutch cities, heat stress occurs during 7 days every year. In Rotterdam, this number rises to 15 days per year because of the larger urban heat island effect. A different study carried out in Rotterdam based on meteorological measurements indicated an average of 28 days of moderate to strong heat stress in Rotterdam for current climate conditions with a possible increase to 45 days by 2050 (Rovers et al., 2015).

On a regional level, the adaptation strategies of The Hague (Stadsgewest Haaglanden, 2011) and Rotterdam (City of Rotterdam, 2012) describe heat stress as one of the important issues of their climate adaptation strategies. Apart from the impacts that have been listed above, these strategy reports state further consequences of rising temperatures and heat stress:

- A decrease in comfort in houses, offices and other buildings
- An increase in energy- and water demand for cooling
- Changing patterns in flora and fauna (for example an increase in mosquitoes, ticks, and blue algae)
- A decrease in water quality (surface water, swimming water and drinking water)
- Damage to infrastructure (malfunctioning of bridges and railways, melting asphalt)
- An increase in the vulnerability of the utilities, ICT networks and data centres

The climate change adaptation strategy of Rotterdam illustrated the impacts of heat by stating the following facts: the second heatwave in 2006 resulted in 41 excess deaths for Rotterdam. In addition, the hot summer of 2006 led to 600 heat-related reports at the general practitioners in the region of Rotterdam.

The adaptation strategy of region the Hague (Stadsgewest Haaglanden, 2011) also explicitly listed the positive consequences of rising temperatures in their adaptation strategy, being:

- An increase in recreation near lakes and along the coast
- An increase in use of outdoor spaces

Apart from these regional adaptation strategies, the Climate Proof Cities (CPC) research programme that was recently finalized in the Netherlands (Rovers, 2015) yielded much insight into the causes, impacts and measures that can be taken to reduce heat stress. The policy summary of the research programme stresses that it is **now** time for urban areas to adapt to climate change and rising temperatures, because of two reasons. The first is that investments that are currently being made in the urban environment will result in buildings and infrastructures that will still be in use over the next fifty years. The second is that both national and international studies show that the costs of adjustments made now are limited compared to the damages that can be caused by climate change and extreme weather in the future.

2.2 Reasons in Europe

For Europe, the European Environmental Agency extensively described reasons, challenges and opportunities for cities to adapt to higher temperatures and more heat wave periods in their report 'Urban adaptation to climate change in Europe' (EEA, 2012). In this report, the impact of heat on mortality is a strong argument for the urgency of urban adaptation to climate change. Table 2 shows that in Europe heatwaves have caused most human fatalities of all natural disasters in the recent decades (Table 2). EEA (2012) also describes the August 2003 heat wave, that caused up to 70 000 excess deaths in Europe. This is probably the most frequently mentioned heat wave in reports and scientific literature to illustrate the impact of heat waves on social life. It is often used as the major reason to adapt cities to heat stress. The number of deaths due to the heat waves of 2006 and 2007 together was less and was estimated at about 3000 in Europe (EEA, 2010).

Hazard type	Recorded events	Number of fatalities
Storm	155	729
Extreme temperature events	101	77 551
Forest fires	35	191
Drought	8	0
Flood	213	1 126
Snow avalanche	8	130
Landslide	9	212
Earthquake	46	18 864
Volcano	1	0
Oil spills	9	n/a
Industrial accidents	339	169
Toxic spills	4	n/a
Total	**928**	**98 972**

Table. 2 Overview of the major natural hazards in Europe between 1998 and 2009 (Source: EEA, 2010 and EEA, 2012).

The European Environmental Agency thus clearly states that the number one most dramatic impact of heatwaves is:

- An increase in mortality rate

Other by EEA reported negative impacts of exposure to hot weather are (EEA, 2012):

- A decrease in health and well-being, like psychological impacts, increased violence and social unrest
- A decrease in water resources (water pollution and shortage)
- An increase in economic costs and damage to infrastructure. Some examples are reduced productivity, pressure on health care and emergency services, failure by transport networks, increase in cooling demand, and failure of power supplies.
- Changes in patterns of vector-borne diseases

Among the European cities, Copenhagen is one of the leaders in climate adaptation. In 2011, Copenhagen published the Copenhagen Climate Adaptation Plan (Copenhagen, 2011). This report concludes that more and heavier downpours in the future and higher sea levels are the primary climate challenges for Copenhagen. Since Copenhagen very rarely presents periods of prolonged heat waves in the current climate, the climate adaptation plan of Copenhagen does not consider heat as a major issue at this moment. However, it is expected that temperature rise may pose challenges in the city in the future due to the impacts of increasing temperatures. The impacts that are explicitly mentioned are:

- A decrease in the quality of life for Copenhagen population
- An increase in expenditure on energy consumption and health care

Copenhagen also argues that if it continues along the current climate adaptation plan and promotes solutions that work with cooling, shading effects and air circulation, it is expected that Copenhagen's climate will remain pleasant, also in the future. Therefore, Copenhagen shows a low level of urgency for adaptation to heat.

Yet, London emphasizes another aspect of urban adaptation to heat (Greater London Authority, 2011). In their climate adaptation plan, reference is made to the lack of knowledge and the uncertainty to clearly define the risk of heat for cities. In this report, it is stated that the risk of overheating has only recently been recognized and is therefore relatively poorly understood and managed. Mapping the overheating risk is more difficult than mapping flood risks, since its vulnerability varies from location-to-location, building-to-building and person-to-person. Still, the consequences of rising temperatures and heat periods for London have been described, and like in many other adaptation strategy reports, the risk of overheating has been illustrated with the number of excess deaths due to the August 2003 heat wave (Figure 1).

The adaptation strategy of London pointed out two other negative consequences of overheating, in addition to the impacts of heat that the EEA (2012) reported, being:

- An increase in social inequality relating to those who live in poorly designed houses and have little capacity to take measures to reduce the heat
- An increase in fire-risk for green spaces

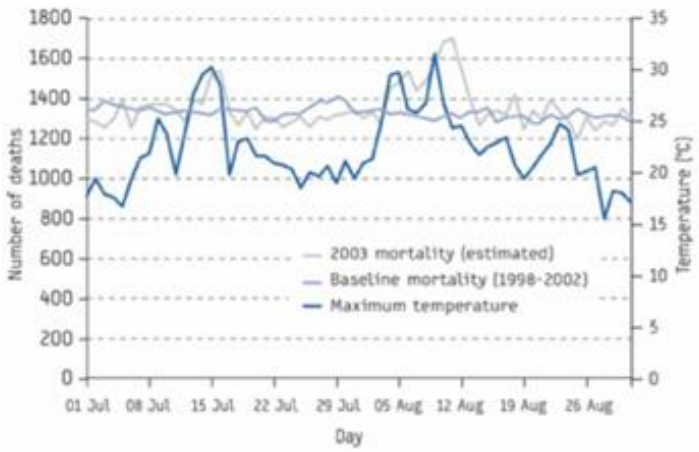

Fig. 1 Number of excess deaths and maximum temperature in England and Wales during 2003 heatwave in August is 2003 (Source: Greater London Authority, 2011).

2.2 Reasons outside Europe

Outside Europe, the leading cities in climate adaptation are among others Vancouver, New York and Melbourne. In the climate change adaptation strategy of Vancouver (City of Vancouver, 2012), the most relevant climate change impacts the city will experience have been listed as flooding and inundation from sea level rise, flooding due to extreme precipitation events, damage from wind and rain storms, and health impacts from more days of extreme warm temperatures. The impacts of hotter and drier summers with more heat waves that are mentioned, are:

- A decrease in health and safety of vulnerable populations
- A decrease in water supply
- An increase in vectors for disease and respiratory illness
- Maladapted new and existing buildings
- An increase in maintenance and replacement costs for urban forests and green spaces

The report indicates that the heat wave of 2009 caused about 122 excess deaths in Vancouver and many emergency room visits.

The adaptation strategy and action plan of Melbourne (Australian Government, 2013) also lists four climate change risks for Melbourne: less rainfall and more droughts, extreme heatwaves and bushfires, intense rainfall and storms, and sea level rise. Risks for extreme heat have been rated. The major risks identified, are:

- An increase in heat stress related death and illness among risk population groups
- An increase in stranded passengers as trains are delayed or cancelled in hot weather
- An increased chance of energy blackouts
- An increase in violence and anti-social behavior causing public nuisance and hospital admissions
- An increase in maintenance costs of assets and infrastructure

The number of deaths attributed to extreme heat in Australia was investigated by Coates et al. (2014). They concluded that from 1900 to 2011, 4555 deaths were attributed to extreme heat. This is more than the total of deaths from all other natural hazards (Table 3), illustrating the enormous impact of extreme heat in Australia in terms of mortality.

In 2008, the Environmental Protection Agency of the U.S.A. reported on the causes and impacts of summertime urban heat islands in the United States (EPA, 2008). Interestingly, and in contrast to most previous findings, the EPA does not mention human health and comfort as the primary reason to be concerned about heat. The increase in energy demand for cooling and the accompanying increase in air pollutants and greenhouse gases are the foremost reasons to reduce urban heat islands. The negative impacts from elevated temperatures listed in this report, include:

- An increase in energy consumption
- An increase in emissions of air pollutants and greenhouse gases
- A decrease in human health and comfort

- A decrease in water quality

The increase in energy demand for cooling was illustrated in this report by a relation investigated by Sailor (2006). It shows an increase of about 3% percent in urban electric demand for each °C increase in summertime temperature, based on data from New Orleans. The impact of heat on mortality was demonstrated by the fact that heat exposure contributed to over 8,000 premature deaths in the USA between 1979 and 1999. Again, this number of heat-related mortality exceeds the fatality resulting from other natural hazards (hurricanes, lightning, tornadoes, floods, and earthquakes combined).

Natural hazard	Deaths 1900–2011	% total natural hazard deaths 1900–2011
Extreme heat	4,555	55.2
Flood	1,221	14.8
Tropical cyclone	1,285	15.6
Bush/grassfire	866	10.5
Lightning	85	1
Landslide	88	1.1
Wind storm	68	0.8
Tornado	42	0.5
Hail storm	16	0.2
Earthquake	16	0.2
Rain storm	14	0.2

Table. 3 Comparison of fatality totals with other natural hazards (Source: Coates et al., 2014).

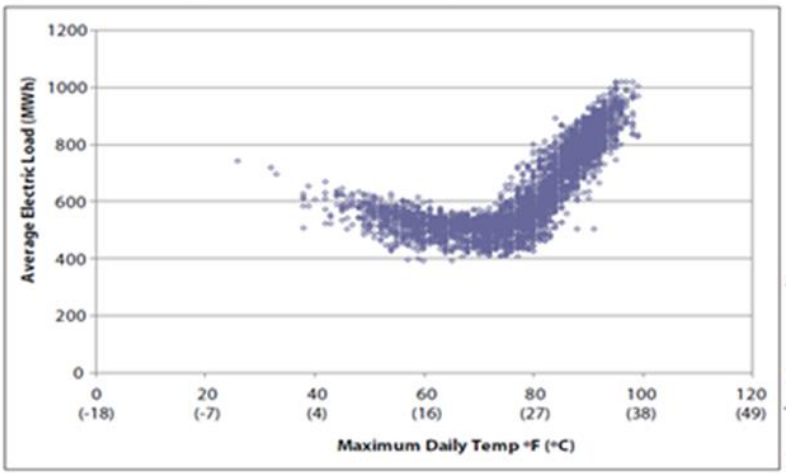

Fig. 2 Relation between power load and maximum temperature based on data from New Orleans. The peak urban electricity demand increases about 3% for each °C in summertime temperature (Source: Sailor,2006).

3. Discussion and conclusions

This literature study summarizes arguments and appealing examples from national and international climate adaptation strategies and scientific literature that emphasize the impacts of rising temperatures and extreme temperature events for urban environments. Frequently, human health and heat-related mortality appear to be the number one reasons to adapt urban environments to rising temperatures. Heat-related mortality has been thoroughly studied in many scientific papers, and its impact can be illustrated with appealing facts and figures. Apart from this, a large variety of other arguments exists to adapt cities to rising temperatures, ranging from a decrease in comfort and quality of life to energy blackouts and decreases in water quality. These impacts are often to a lesser extent supported by facts from scientific literature.

Since the aim of this study was to provide urban planners and professionals with arguments and appealing examples, the question is whether the results of this study really support local professionals to convince others of the need for climate adaptation to extreme temperatures. Are the identified arguments helpful to express the urgency of urban adaptation to rising temperatures and heat stress? We have discussed this issue with a group of urban planners and decision makers from local governments. The outcomes showed that the right arguments and scientific facts are often insufficient to get the message across. Convincing others within or outside the municipality is also a political matter that needs to fit within the political ambitions of the local governments. Besides, it is an issue of budgets and finances. Furthermore, the present and future occurrence of extreme

temperature events is subject to substantial uncertainty, which impedes decision makers to take climate adaptation measures.

To support the message, the following recommendation were made:

- Quantify the impacts of heat stress and rising temperatures for the local level (city or neighborhood) in order to achieve more understanding of the local impacts.
- Distinguish the impacts of gradual temperature rise from the impacts of extreme temperature events.
- Clarify the 'problem owners' of the heat stress risks. This also touches on a study of Runhaar et al. (2012), who found that heat stress hardly seems to be perceived as an urgent problem by Dutch urban planners mainly because there is no clear 'problem owner' for the heat stress risk. Other reasons they found for the absence of urgency are the lack of legal obligations and unawareness of the heat stress problem.
- Couple the message to examples of recent events and hazards.
- Learn from and show how cities in other (warmer) climatic regions have adapted to periods of heat.
- Couple the climate and heat stress adaptation goals to other (political) aims.
- Present the impacts of heat together with possible climate adaptation measures and perspectives.
- Combine the negative impacts of rising temperatures with the positive effects.

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