GOVERNING CLIMATE CHANGE RELATED RISKS IN THE NETHERLANDS: CHALLENGES AND RESPONSES OF URBAN PLANNERS

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Keywords: climate change, adaptation, urban planning.

Climate change is associated with various risks, such as flooding and heat stress. Thus far most research has concentrated on the identification and quantification of these risks as well as the development of adaptation measures. Yet much less is known about how planners actually perceive and deal with climate change. This paper focuses on governance of two climate change related risks in urban areas in the Netherlands, namely heat stress and flooding from rainfall and rivers. Exploring the ways in which urban planners frame the two climate change related risks and the contingencies that they face when developing adaptation strategies not only fills a knowledge gap, but also may facilitate science-policy interfaces in this area: to what extent is knowledge about the two risks and their characteristics adequately communicated and to what extent do the proposed measures fit into the planning context in which they have to be implemented?

1. Introduction

Climate change is associated with a number of risks, such as flooding, heat stress, storms and vector- and rodent-borne diseases (Butler and Harley, 2009; Huynen en Van Vliet 2009; PBL, 2009). While in most cases climate change will amplify (mostly already existing) risks, in some cases a decreased risk is envisaged

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(e.g. reduced winter mortality due to higher temperatures; Kabat et al., 2005; PBL, 2009). The general impression in the scientific community however seems to be that, overall, climate change requires the timely development of adaptation[6] plans (e.g. Adger and Barnett, 2009; Kabat et al., 2005; PBL, 2009). Referring to the Katrina hurricane example, Kabat et al. (2005) claims that the economic consequences of not being prepared to changing weather patterns may be huge, in particular in densely populated, economic areas.

In this paper we focus on climate change related impacts on urban areas in the Netherlands and in particular on how urban planners (i.e. politicians and their staff) actually perceive and deal with climate change. Literature suggests that urban planners have not (yet) been very active in recognising the impacts of climate change in their territories and in developing adaptation strategies. For instance, Mulder et al. (2009) wonder why heat stress has not been much of an issue in the Netherlands, especially after the 2003 heat wave. Groot et al. (2008) observe that adaptation is not an issue in the Dutch construction sector. Also outside the Netherlands, urban planners seldom have adequate plans for climate change related risks, such as heat stress or intensified storms (e.g. Bernard and McGeehin, 2004; Bulkeley, 2009; Repetto, 2009). Sweden seems to be an exception in this context (Langlais, 2009).

In the academic literature however thus far little has been written on how urban planners perceive and deal with climate change and how that can be explained (Van Nieuwaal, 2009). In this paper we analyse how urban planners in the Netherlands deal with two climate change related risks in urban areas, namely heat stress and flooding from rainfall and rivers. These risks are considered two of the main challenges in urban areas in the light of climate change (PBL 2009), but with different societal consequences (i.e. health versus material damage). Two questions are addressed in this paper: a. To what extent are the risks of intensified heat stress and flooding recognised as urgent by urban planners and what factors contribute to successful agenda setting? b. How can the governance strategies on heat stress and flooding employed by urban planners be characterised and what factors stimulate or hamper successful implementation? This study not only fills a knowledge gap, but also may facilitate science-policy interfaces in this area: to what extent is knowledge about the two risks adequately communicated and to what extent do the proposed measures fit into the planning context in which they have to be implemented?

In section 2 we summarise the projected impacts of climate change regarding heat stress and flooding in Dutch urban areas. In section 3 our analytical framework is presented. In section 4 we present our empirical findings from case studies as well as from 'helicopter interviews' with experts. We discuss our main conclusions in section 5.

[6] Adaptation is "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits mutual opportunities" (IPCC, 2007: 869, in: Davoudi et al., 2009: 16).

2. Heat stress and flooding: expected challenges for urban areas in the Netherlands

2.1. Heat stress

Small changes in mean temperature can result in larger changes in extremes (IPCC, 2007). Climate change projections foresee increases in the frequency, duration and intensity of warm spells and heat waves (IPCC, 2007; Meehl and Tibaldi, 2004). This can have consequences for heat stress: heat-related mortality, disease and discomfort (sleep deprivation, e.g. affecting labour productivity). The relation between daily temperature and daily mortality is roughly V-shaped, with for the Netherlands a present day optimum of 16.5°C and increasing mortality with higher and lower temperatures (Huynen et al., 2001). Yet, warm and sunny weather also tends to worsen air pollution, which may furthermore interact with heat stress to produce a greater health impact than each factor acting alone (Fischer et al., 2004). A substantial proportion of the excess deaths of the Netherlands 2003 summer may be attributable to reduced air quality (Fischer et al. 2004).

The 2003 European heat wave, resulting in some 40,000 excess deaths (García-Herrera et al., 2010), exemplifies an extreme event that may become more frequent if warming continues. In the Netherlands, an estimated excess of some 1,000-2,000 deaths occurred during that summer, approximately 500 of which during the fourteen-day August heat wave[7] (Fischer et al., 2004; Garssen et al., 2005). Dutch heat waves during 1979-1997 caused about 40 excess deaths per day (+12%)(Huynen et al., 2001; 2008). Part of these people would have died shortly anyway, referred to as the ‘harvesting effect’ or ‘mortality displacement’. Estimates of the magnitude of this effect diverge greatly (Huynen and Van Vliet, 2009), whereas the effect has not been observed for all Dutch heat waves (Huynen et al., 2001). It should also be noted that the impacts of the 2003 heat wave in the Netherlands were less dramatic than those in for instance France. This may be due to overall lower temperatures and the highest temperatures occurring in relatively less densely populated areas, while in France, the heat wave mainly hit urban areas (Garssen et al., 2005) where heat stress risks are greater (Huynen and Van Vliet, 2009).

Visser (2007) claims that both the frequency of high temperatures and heat-related excess mortality in the Netherlands increased over the past half-century. The KNMI’06 climate scenarios (Van den Hurk et al., 2006) project a further increase of +0.9-2.8°C for summer average temperatures in the Netherlands in 2050 (assuming +1-2°C globally). For the 10% warmest summer days +1.0-3.6°C (+1.0-3.8°C for the warmest day) is projected (Van den Hurk et al., 2006). Projected changes in the number of tropical days (≥30°C) are also larger than in summer days (≥25°C)(cf. Gupta et al., 2008). Factors such as humidity, wind speed, long/shortwave radiation, clothing, activity, air conditioning prevalence, and housing characteristics are also relevant for ‘thermal comfort’ and the health impact of heat waves (e.g. Matzarakis and Endler, in press).

[7] The Royal Netherlands Meteorological Institute defines a heat wave as a period of at least 5 days, each with a maximum temperature ≥25°C, and at least 3 days with a maximum temperature ≥30°C.

Huynen et al. (2008) indicate that by 2050 increased heat stress in the Netherlands could imply hundreds of deaths per year. Changes in morbidity may be proportional or greater (MNP, 2005), although considerable uncertainties remain (e.g. due to difficulties of downscaling global projections to local impacts). Vulnerable groups include the elderly, chronically ill (e.g. cardiovascular and respiratory diseases, diabetes), socially isolated people, those with a lower socio-economic status, and possibly very young children (Huynen et al., 2001; IPCC, 2007; García-Herrera et al., 2010). Hospital admissions and heat-illnesses also increase, notably for adults (Kovats and Ebi, 2006).

Heat stress varies with the so-called 'urban heat island' effect, referring to urban temperatures tending to be higher than rural temperatures, increasing the number of hot days (and nights), duration of heat waves, and subsequent mortality (e.g. Arnfield, 2003; Salcedo Rahola et al., 2009). Relevant factors in urban heat include material reflectivity (albedo) and thermal characteristics, evaporation (water, plants), shading, building density, wind patterns and blocking of 'urban ventilation', and heat-producing activities.

2.2. Flooding

Another potential impact of climate change on Dutch urban areas is through increasing precipitation extremes, resulting in local superfluous water after downpours (small-scale, short-term) or in river flooding (larger scale, longer term)(cf. IPCC, 2007). The occurrence of both forms of flooding is expected to increase as a consequence of climate change, with largely comparable societal effects. Flooded streets may result in nuisance and traffic disruption, while flooded buildings result in material damage. In addition, many urban drainage systems are connected to the sewers, and sewage overflow can have health and ecological implications (Huynen et al., 2008). In extreme situations impacts of flooding (and evacuations) may include deaths and injuries[8], societal disruption, property damage, mental health impacts, respiratory problems (mould in damp homes), economic damage due to production standstill, indirect damage for economically connected areas and industries, and possibly and risks of exposure to infectious diseases and contaminants (e.g. Huynen et al., 2008). The Netherlands contains extensive areas below sea level and forms the delta of the Rhine (and its branches) and Meuse rivers. Approximately 59% of the Netherlands is flood-prone and, due to increasing urbanisation and value-at-risk, the potential economic damage is projected at +100-250% in 2040 compared to 2000 (PBL, 2010).

During the past century, mean yearly precipitation has increased by +18% (primarily in winter, autumn and spring)(KNMI, 2009). The number of days with considerable precipitation has increased as well (MNP, 2005). Year-to-year and interregional variability, however, is large. The KNMI'06 scenarios project an increase in mean winter precipitation of +4-14% in 2050. Changes in daily and longer-period extremes in

[8] In Europe, floods are the most common natural disasters. Since 1998, about 100 extreme floods have occurred, resulting in some 700 deaths (Huynen et al., 2008).

winter are of similar magnitude; e.g. +4-12% for the 10-day precipitation sum that is exceeded once per ten years. The number of wet days (≥0.1mm) may increase in winter (+0-2%) and decreases in other seasons. Changes in summer precipitation are uncertain; -19 to +6%. However, the intensity of showers is expected to increase; e.g. +5-27% for the 1/10 yr daily precipitation sum. For the coastal regions, where many of the largest Dutch cities are located, the upper two scenarios with regard to precipitation (+13-27%) are seen as most realistic due to the effect of the nearby sea. Changes in the hourly intensity may be of similar magnitude (KNMI, 2009).

Discharge levels of the Rhine and Meuse rivers are expected to increase in winter and decrease in summer. Peak discharges (winter), related to multiple-day intense precipitation in the river's basin, are projected to increase as well. This could lead to increased flood risks for cities in the lower-rivers (particularly in combination with sea level rise), upper-rivers and IJsselmeer regions (MNP, 2005). The formal design discharge corresponds to a 1/1250-yr. event (presently: Rhine: 16,000m^3/s at Lobith, Meuse: 3,800m^3/s at Borgharen). For 2050, the 1/1250-yr discharge is expected to increase by 3-10% and 5-20% for the Rhine and Meuse respectively (MNP, 2005). The so-called Delta commission projects theoretical Rhine discharge to increase to 16,500-19,000m^3/s (+3-19%) in 2050, but notes that flooding upstream in Germany could limit this to 15,500-17,000m^3/s (-3-+6%)(Vellinga et al., 2009). A 1/50-yr discharge, which led to flooding along the Meuse and near-flooding and evacuations along the Rhine in 1995 (although dike conditions have improved strongly since then), could become 1/10-yr in 2100 assuming the upper KNMI'06 scenario (Vellinga et al., 2009).

The magnitude and impacts of river flooding depend on geographical position (e.g. altitude of the land relative to the peak water level of the river, nearness to rivers), the predictability of the timing of the flood, the number of people in the area, whether the water velocity is sufficient to make buildings collapse, the speed by which the water level rises, the final water level, and the possibilities and organisation of evacuations (Jonkman and Cappendijk, 2006). Additionally, aspects such as the locations of critical and vulnerable objects and infrastructure, reactive capacity to quickly changing situations, and ease and speed of water removal and recovery are important in the degree of damage and societal disruption (Wardekker et al., 2010).

In contrast, the magnitude and impacts of downpours depend on drainage systems (sewerage). Current systems often cannot (and were not designed to) cope immediately with large amounts of water, resulting in local flooding (RIONED, 2007a; CROW, 2010). In practice, many municipalities apply the guiding principle that a maximum of two of such floodings a year is acceptable and base their sewerage capacity on this principle. Ten Veldhuis (2010), however, argues that many local flooding events are maintenance-related (e.g. blocked drain or pipe) rather than due to lack of drainage-capacity. Other factors that influence the degree or impact of flooding include, for instance, surface water capacity, the infiltration capacity (e.g. hard surface vs. soil/plants but also sand versus clay), buffer and drainage capacity of open water and public spaces (squares, parks, streets), building materials used (e.g. easy/difficult to damage, clean), and street profile/configuration (e.g. flat versus lowered; usable or not when flooded)(e.g. RIONED, 2007a; CROW, 2010).

3. Governing heat stress and flooding: an analytical framework

In this section we will set out our framework for analysing and explaining why and how urban planners (fail to) govern heat stress and flooding. Governance starts with the recognition of these risks (Jordan et al., 2010), in other words: do urban planners consider heat stress and flooding problematic and – perhaps more important - are they considered *public* problems? This requires insight into how urban planners frame the two risks as well as insight into stimulating and impeding factors for putting increased risks of heat stress and flooding on the political agenda.

Governance of heat stress and flooding in addition includes the way in which urban planners (foresee to) act upon these risks. What plans are envisaged? Two dimensions are relevant. The first dimension is about steering: which actor takes the responsibility of developing and implementing adaptation plans and how are other actors involved? Analytically, distinction can be made between three steering strategies:

- Top-down steering: government-centred activities with government in a hierarchical relationship to other actors. Think for instance of construction regulations for dwellings;
- Interactive steering: adaptation plans developed in interaction between government actors, market actors and NGOs. This may take the form of covenants in which for instance municipalities and project developers agree to develop plans;
- Bottom-up or self steering: adaptation plans being developed by actors such as project developers, social housing corporations, dwelling owners, retirement homes en nursing homes etc. Note that urban planners may deliberately choose for this form of governance.

The second dimension of adaptation plans considers the concrete adaptation measures considered. For a classification of these, the following dimensions seem to be relevant:

- Time scale: proactive versus reactive plans. Proactive plans include retrofitting existing buildings and sewerage systems, whereas reactive plans include disaster contingency plans and warning and information campaigns;
- Spatial scale: individual buildings, street/quarter level or city level.

Tables 1 and 2 below specify adaptation measures that were identified in the literature. Some measures are contradictory; for instance compact building has the advantage of using shading from buildings, but at the same time reduces wind speeds and, with that, urban ventilation. Other measures are adequate for adapting to both heat stress and flooding (e.g. green roofs). In particular in plans for new construction, opportunities are foreseen for adaptation measures (e.g. CROW, 2010), although also in existing neighbourhoods adaptation measures may be implemented.

Table 1: Adaptation measures for heat stress

	Building	**Street/quarter**	**City level**
Proactive measures	• Insulate buildings • Cooling systems (e.g. heat pumps) • Sun screens, blinds and shutters • Provisions for heat disposal (e.g. chimneys) • Building orientation (reduce sun exposure) • Heavy building materials (high solar thermal mass) • Green roofs (i.e. plant cover) • Green facades (i.e. plant cover) • Increased reflecting levels of roofs (albedo) • Insurances (building owner)	• Open water, fountains etc. • Vegetation (cooling due to evaporation) • High albedo pavement instead of asphalt • Creating optimal shading in building orientation, compact building and (big leaf) trees • Orientation and profile of streets regarding wind direction (affecting wind speed and urban ventilation) • Replacement of vulnerable groups • Monitoring and inspection • Warning systems and disaster contingency plans	• Anticipate possible peaks in deaths and hospitalisations (access to/capacity of medical care) • Further: see under 'street/quarter'
Reactive measures	• Cooling (air conditioning) • Medical care (building owner)	• Wetting streets and roofs	• Information campaigns • Further, see under 'street/quarter'

Sources: CROW, 2010; Davoudi et al., 2009; De Bruin et al., 2009; García-Herrera et al., 2010; Groot et al., 2008; Huynen et al., 2001; 2008; IPCC, 2007; Kovats and Ebi, 2006; Matzarakis and Endler, in press; PBL, 2009; Salcedo Rahola et al., 2009.

There are various ways in which these measures may be implemented. Regarding the three modes of governance discussed above, one can think of regulations, investments by municipal authorities, covenants, voluntary measures etc. It is imaginable that urban planners consider in particular adaptation measures at the level of neighbourhoods or the city as their responsibility and opt for self-governance regarding measures at building-level.

Table 2: Adaptation measures for flooding

	Building	**Street/quarter**	**City level**
Proactive measures	Downpours: • Water proof building, e.g.: o floor level above street level o high thresholds o no crawl spaces o waterproof plaster and membranes on walls o waterproof floors • Green roofs (i.e. plant cover) • Green facades (i.e. plant cover) • Water drainage (drainage in gardens, gutters etc.) • Unpaved gardens (infiltration, water retention) River flooding • 'Floating' buildings • Pile-dwellings	Downpours: • Seeping water 'screens' • Water permeable pavement instead of asphalt and other measures for better infiltration and water outlet • Lower water tables River flooding: • Enhancing capacity of sluices and weirs • Elevate urban areas • Additional flood defences (dikes or buildings) or re-enforcing existing ones • Replacement of vulnerable buildings and infrastructures • Disaster contingency plans (e.g. temporary dikes) River flooding and downpours: • Monitoring and inspection • Water storage facilities (open water such as pools) • Increase sewer capacity or enhanced maintenance • Drainage systems	River flooding: • Options for water storage and retention in or near city • Evacuation plans • Ban on building in flood-prone areas • Compartmentalisation River flooding and downpours: • Information campaigns • Further: see under 'street/quarter'
Reactive measures	Downpours: • Green roofs (i.e. plant cover) • Green facades (i.e. plant cover) River flooding and downpours: • Insurances (building owner) • Medical care (building owner)	River flooding and downpours: • Warning systems • Evacuation plans • Dry pumps and other provisions for water discharge and clean-up • Recovery plans	River flooding and downpours: • See under 'street/quarter'

Sources: CROW, 2010; Davoudi et al., 2009; De Bruin et al., 2009; Groot et al., 2008; Huynen et al., 2008; PBL, 2009.

The literature referred to in the introduction suggests that not all municipalities actively anticipate heat stress and flooding associated with climate change. On the other hand there are municipalities that do. Stimuli for and barriers to the recognition of heat stress and flooding and the development of adaptation plans may exist in the various stages of the planning cycle (Jordan et al., 2010). In this section we discuss possible stimuli and barriers to adaptation mentioned in literature. We draw from adaptation literature (e.g. Vellinga et al., 2009) as well as more theoretical planning literature (e.g. Baumgartner et al., 1993). Table 3 summarises the incentives and barriers identified, which are sometimes interrelated and may re-enforce or weaken others.

Table 3: Stimuli for and barriers to adaptation

	Stimuli	**Barriers**
Problem recognition	• Growing scientific evidence • Calamities (e.g. floods in the UK, 2003 heat wave) • Physical and geographical characteristics, such as: o Located near river o Altitude (below sea level) o Density of buildings and other factors contributing to 'heat island' effect or vulnerability to flooding o Concentration of vulnerable groups • Public or political support or pressure • Leadership (an actor taking the lead) • Political will • Subsidies from central government	• Uncertainties in scientific evidence • Denial of climate change (climate cynics) • Lack of insight into local impacts/difficulties in translating climate change to the local level • Lack of political will (short-term politics) • No clarity about responsibilities for adaptation/ framing adaptation as a private problem • Competition from other planning problems • Institutional fragmentation • Budget cuts • Lack of pressure from citizens or NGOs • Lack of resources (in particular for small municipalities)
Development of adaptation plans	• Problem recognition and sense of urgency (see above) • 'Windows of opportunity' (e.g. plans for new construction) • Public or political support or pressure • Leadership (an actor taking the lead) • Political will • Subsidies from central government	• No problem recognition or sense of urgency (see above) • Distribution effects (winners/losers) • Inflexibility of urban area and high costs associated with adapting existing buildings and public space • No clarity about responsibilities for adaptation • Lack of insight into possible adaptation measures • Lack of resources (in particular for small municipalities) • No clarity about who or how adaptation should be financed • Institutional fragmentation • Lack of cooperation from actors within the municipality or outside it/lack of possibilities to steer these internal and external actors • High costs/budget constraints • Path dependency (e.g. contracts with project developers that need to be reopened) • Lack of public or political support

Sources: Baumgartner et al., 1993; Birkland, 1997; Gupta et al., 2008; Heinrichs et al., 2009; Jordan et al., 2010; Langlais, 2009; PBL, 2009; Van Nieuwaal et al., 2009; Vellinga et al., 2009.

4. Governance of an intensification of heat stress and flooding in practice

In this section we discuss how urban planners perceive and deal with adaptation to heat stress and flooding. We draw from two data sources. 'Helicopter interviews' with experts and presentations and discussions during workshops and conferences provided us with a general impression. More in-depth and contextualised insights were obtained through in-depth interviews with urban planners. Some of these municipalities are considered 'active adapters': they have recognised increased risks of heat stress or flooding due to climate change as a policy problem and activities have been undertaken to assess and map these risks and to develop adaptation strategies. The helicopter interviews in an overview of active municipalities. We also interviewed planners from municipalities that have not (yet) been active in adaptation to heat stress and flooding. These municipalities are as far as possible comparable to the first set of municipalities in terms of vulnerability to heat stress and flooding as well as size[9]. By comparing the two samples of municipalities, we hoped to get a better insight into stimuli and barriers, as discussed in section 3.2. Semi-structured interviews were conducted (June 2010), in which respondents were asked to spontaneously mention the most important stimuli for and barriers to adaptation. See Annex 1 for a specification of our sources.

Table 4: Case study municipalities

	Heat stress	**Flooding** **(caused by river flooding and heavy downpours)**
Active	• Arnhem (145 574 inhabitants) • Rotterdam (587 134 habitants) • Tilburg (203 464 inhabitants)	• Dordrecht (118 408 inhabitants) • Rotterdam (587 134 habitants) • Tiel (41 070 inhabitants)
Other	• Amsterdam (755 605 inhabitants) • Breda (171 916) • Hengelo (80 925 inhabitants) • Lelystad (73 848 inhabitants)	• Amsterdam (755 605 inhabitants) • Geldermalsen (26 289 inhabitants) • Lelystad (73 848 inhabitants)

Inhabitants per January 1, 2009. Source: CBS (2009). The sample includes large, medium-sized as well as small municipalities in the Netherlands.

4.1. Heat stress

Although heat stress is not a new phenomenon in the Netherlands, urban planners in the Netherlands generally are not aware of it, let alone perceive it as a problem. This seems to be primarily related to the available knowledge on heat stress, which is characterised by a high level of abstraction (not allowing for local projections) and large uncertainties. Therefore the effects at city or neighbourhood level are generally unknown. However, also the benefits – a reduction in adverse health effects – are difficult to quantify and are not considered to be of primary interest to local politicians. In addition, some municipalities (e.g. Breda and Hengelo) only very recently became aware of heat stress or the possible need for adaptation strategies to climate change in general. Limited interaction between producers of knowledge on heat stress and urban planners contributes to the unknown character of heat stress. Municipalities such as Amsterdam, Hengelo and Lelystad do no expect that heat stress will occur because of low building density or the presence of much open space or open water. Finally, lacking national regulations regarding heat stress do not provide an incentive to be active regarding this phenomenon (although Amsterdam and Breda intend to explore the issue in the near future). Project developers and social housing corporations do not pay much attention to heat stress, either, mainly because they are not familiar with this concept and its relation to buildings. Mitigation

[9] Regarding vulnerability to heat stress we mainly considered building density (see section 2.1.). Regarding vulnerability to flooding we focussed on positioning above/below sea level and nearness to rivers (see section 2.2.). In addition, comparability regarding size was considered relevant as in particular small municipalities were expected to have few resources available for adaptation; (see section 3).

by enhancing energy efficiency receives more attention. These actors face few incentives to actively deal with heat stress; neither urban planners nor potential buyers or renters of houses explicitly ask for heat stress resistant buildings. Moreover, measures for reducing heat stress imply additional costs and it is doubted to what extent buyers accept these if these measures do not contribute directly to a higher comfort. Finally, the provision of green space or open water is commercially less attractive than building houses. Since there are no formal regulations regarding heat stress, project developers and social housing associations will have to implement measures for adapting to heat stress on a voluntary basis. The expectation is that this will not take place at a large scale.

The few municipalities active in the area of heat stress are in a stage of problem exploration and knowledge creation. In Rotterdam and Arnhem for instance a heat island effect of up to 7 degrees difference in temperature between city centre and outskirts was measured. Only in Rotterdam, estimations have been made about health impacts of (future increases in) heat stress. These estimations point to about 36 premature deaths annually because of heat stress; this number could double by 2050. There is no insight into the magnitude of other heat related health impacts such as sleep deprivation. Stimuli for Rotterdam and Tilburg to be engaged in heat stress are twofold: one, climate change was already on the political agenda and heat stress could easily be linked to ongoing activities related to mitigation and adaptation and two, both municipalities had access to funding from national research programme on climate change. Additional stimuli for Tilburg were the existing ambitions to be a frontrunner regarding mitigation and adaptation and concerns of the municipal medical service about heat related problems for elderly people. Arnhem's interest in heat stress originates from curiosity about the relevance of, and opportunities for, adaptation to climate change. Heat stress was focused on because it was a relatively new and unknown phenomenon. Similar to Rotterdam, money and knowledge made available in a research programme further stimulated the exploration of the impacts of (future increases in) heat stress.

Yet, heat stress is not considered as an urgent policy problem in the above three municipalities. The problem is nuanced as citizens do not consider heat stress a problem. In Arnhem, heat stress is not expected to increase in the next two decades or so. In addition heat stress only takes place in a short period of time and only a small area is vulnerable to heat stress (namely, the city centre). In all three municipalities, other problems, such as unemployment and traffic safety and mitigation, receive more political attention and are considered more urgent.

Despite the lack of a sense of urgency, Arnhem, Rotterdam and Tilburg anticipate the implementation of measures aimed at reducing (future increases in) heat stress, in particular when restructuring areas sensitive to heat stress. These measures relate primarily to neighbourhoods and the city as a whole, namely the provision of more public green space and vegetation and open water. In Rotterdam already green roofs (i.e. a measure at building level) are stimulated by means of subsidies. Yet the above measures are not meant to be dedicated measures for heat stress alone. More green space is considered a 'no regret' measure as it also contributes to improved spatial quality, environmental quality and (as for green roofs) to water storage. A reduction in heat stress is only considered as an additional benefit. Finally, in Rotterdam the municipal medical service provides medical advice to general practitioners on how to deal with heat stress and heat related diseases; in Arnhem this measure is considered but not yet implemented.

Barriers that the three municipalities face regarding the implementation of measures that, mainly as a side effect, may reduce heat stress are a lacking sense of urgency on the part of politicians and citizens and budget constraints.

4.2. Flooding

The Netherlands has an international reputation regarding water management (Meyer, 2009). Water management plans are common in Dutch municipalities. About 60 percent of Dutch municipalities claim to anticipate increased flooding risks due to climate change (RIONED, 2007b). Yet the impression is that most municipalities are not very active in developing concrete adaptation plans and if they do, their plans relate primarily to sewerage systems (RIONED, 2007b). Some generic barriers that are observed include:

- The problem is not recognised, because of unawareness, its complexity and uncertainties, or a cynical attitude towards climate change;
- A lack of political priority due to the presence of problems that are considered more urgent (e.g. Amsterdam);
- A lack of resources (also due to budget cuts and a reduction in income from selling land and houses as a result of the economic recession);
- A lack of opportunities to combine measures for adaptation to new spatial developments (e.g. in the municipality of Geldermalsen);
- The expectation that problems related to heavy downpour will not occur (at least in the near future) e.g. due to a large capacity of the sewerage system or because in the past land has been elevated (e.g. Amsterdam, Lelystad, Geldermalsen);
- High costs associated with adaptation to flooding, in particular in existing areas. Adaptation to flooding is therefore expected to be probably combined with other large-scale investments (e.g. new construction or restructuring of existing areas);
- A lack of incentives in terms of regulations or perceived benefits.

In addition, small and medium-sized municipalities often lack the financial resources, capacity and know-how to develop explicit adaptation plans. This was for instance explicitly mentioned by Geldermalsen, a small municipality located in a flood prone area.

Nevertheless, several municipalities were found to actively anticipate future increases in flooding as a consequence of heavy downpour or river flooding. Urban planners in Dordrecht, Rotterdam and Tiel frame it as follows: climate change will re-enforce an already existing problem. The cities are located near rivers and below sea level. In Tiel, the impacts of climate change on flooding from rivers and rainfall are even expected to turn nuisance into a large problem (in terms of safety and material damage). Yet, in all three municipalities adaptation to an increased risk of flooding is explicitly framed as an opportunity: measures such as more public green space and open water are expected to result in improved environmental and spatial quality[10]. In the case of Rotterdam, innovative adaptation measures such as multi-purpose dykes and floating buildings are considered useful for profiling the city for her water management expertise as well as maintaining its attractiveness as a location for companies; long-term investments of companies may be replaced to less flood-vulnerable areas if they consider cities as inadequately prepared for increased flood risks (also see De Graaf and Van der Brugge, 2010). In all three cities additional stimuli were 'windows of opportunity' in the form of plans for restructuring or new construction in flood-prone areas and money and knowledge made available in (inter)national research programmes, apart from past experiences with floodings from rivers and rainfall. Additional stimuli for Tiel included a mandatory 'water assessment' of a new construction area, pointing to large water problems (seeping water, infiltration capacity of urban surface and sewerage capacity) and complaints of inhabitants in a quarter that was built in the fifties in a period that water was banned from the built environment. Finally, Tiel did not expect other actors to act. Project developers namely were opposed to changing their construction and restructuring plans. Citizens seemed reluctant to take measures at building level (e.g. reduce the amount of paved surface on their territories) – in addition, the municipality feared that citizens would hold her responsible in the case of future flooding.

Measures that the three municipalities envisage (and partly already planned) are primarily at neighbourhood level, such as additional open water, drainage systems and elevation of land. Long term plans also include measures for the existing urban area, such as climate proof dykes, water permeable pavement, water squares, more green public space, high capacity sewerage systems or a decoupling of rain water and sewerage systems and elevating land in new construction areas. Regarding areas outside dykes, formally citizens are responsible for any damage due to flooding. However, both Rotterdam and Dordrecht feel they have some responsibility in these areas as well, because they have planned construction there and because damage is not

[10] In this context, it is interesting to note that in Amsterdam, despite a lacking sense of urgency to adapt to an increased risk of flooding due to climate change, the provision of more open water and green public space is considered – primarily in order to enhance spatial and environmental quality, but the additional benefit of creating water buffers in the case of floods is explicitly recognised.

covered by insurance companies. Measures at building level are considered more complex to implement, as project developers and social housing corporations can not be forced to implement these.

Plans are partly developed in cooperation with other actors; regional water boards (Tiel, Rotterdam, Dordrecht), and with other stakeholders as well (Dordrecht). Yet in all three cities, thus far, the municipality is the main responsible actor regarding adaptation to flooding. A legal responsibility for rain and sewage water management is one of the reasons. Another reason is that actors other than water boards are not expected to act actively. In particular citizens are expected to be hardly aware of the problem, except perhaps for people living in areas outside dykes[11]; also, there is scepticism among citizens about climate change.

A sense of urgency and political support were important stimuli for developing the above plans; the other stimuli were discussed above. In Rotterdam, the plans for dealing with increased flooding are embedded in the already existing water management plan and the so-called Rotterdam Climate Proof programme, initiated in order to profile Rotterdam internationally as a city with expertise in water management. The municipalities however also face a few barriers, including uncertainties about the projections of increased flood risks, institutional fragmentation within the municipal organisation (in Rotterdam), the inflexibility of existing urban areas, the high costs involved in combination with budget constraints and shortage of staff (in Tiel).

5. Conclusions

Despite scientific concerns, Dutch urban planners do not perceive heat stress (as such, as well as a possible increase as a consequence of climate change) an urgent problem. In part this has to do with the science-policy interface: either urban planners have never heard of heat stress or the available knowledge is too abstract to allow for assessments at city level. For another part, the absence of explicit heat stress plans is explained by the absence of a clear 'problem owner'. Project developers, social housing associations and house owners and renters do not consider heat stress a problem (or, al least, *their* problem). However, also municipalities that have actively explored the phenomenon conclude that heat stress is not a problem. Health impacts are considered to be limited and other problems on the societal and political agenda are more urgent. The main stimuli for these municipalities to explore heat stress were: curiosity; climate change was already on the political agenda; heat stress could easily be linked to ongoing activities related to mitigation and adaptation; access to knowledge and funding from research programmes.

In contrast, flooding from rainfall and rivers is more often recognised as a (potential) problem. The responsibility that municipalities feel for rain and sewage water management is probably an important

[11] It should be noted however that owners of land and buildings also have a legal responsibility regarding the management of rain water and protection against flooding.

explanation. A majority of municipalities indicates taking into account future impacts of climate change on flooding from rainfall and rivers. Yet, this mainly applies to sewerage systems and not to public space in general. Unawareness, high costs, a lack of opportunities to take measures and other political priorities were found to be the main barriers inhibiting explicit adaptation plans. In municipalities were the impacts of climate change on flooding from rainfall and rivers is considered problematic and where adaptation plans are anticipated that go beyond sewerage systems, there usually is a history of (near) floods (they are usually located in flood-prone areas). Climate change therefore re-enforces an already existing problem, helping to create a sense of urgency.

Adaptation measures envisaged or planned in the light of increased risks of heat stress and flooding mainly relate to the level of streets/neighbourhoods and cities and are predominantly proactive (see Table 1 and 2). Actors who are directly responsible for possible measures at building level namely appear (or are perceived) to be reluctant to take measures. Measures that are most often mentioned are more public green space and more open water. This is in line with Matzarakis and Endler, in press, who suggest: *"Simple and less expensive adaptation strategies, especially in urban areas where humans spend their time, have not only to be seen from the point of view of climate change discussion but also generally for improved climate conditions in urban areas"*. Yet, to some extent, the rationale for considering these measures in the Dutch practice is not that they are proper means to realise certain goals (i.e., reduced heat stress and flood risks), but vice versa: heat stress and flooding are additional justifications for investing in more public green space and open water – measures that contribute to environmental and spatial quality. We may add this stimulus to the list of potential stimuli and barriers to recognise and adapt to increased heat stress and flooding as a consequence of climate change (Table 3).

We recognise that our research provides a snapshot picture of how urban planners currently deal with (increased risks of) heat stress and flooding. In particular heat stress is a new phenomenon. We therefore advise longitudinal research into how urban planners deal with heat stress and flooding (and other climate change related risks, such as increased risk of droughts), not only in the Netherlands but also abroad. We think that in such a study the analytical framework developed in this paper may provide a useful starting point.

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ANNEX 1: SOURCES SECTION 4

Case studies

Heat stress

Amsterdam: mr. C. van Drimmelen (senior planner)

Arnhem: mr. H. van Ammers (senior policy advisor public space; project leader heat stress project)

Breda: mrs. A. van Galen (policy advisor public space)

Hengelo: mrs. W. Hendriksen (team leader sustainability)

Lelystad: mr. H. Rienks (policy maker climate change)

Rotterdam: mrs. L. Nijhuis (advisor sustainable development)

Tilburg: mr. P. Biemans (programme manager energy and climate)

Flooding

Amsterdam: mr. C. van Drimmelen (senior planner)

Dordrecht: mrs. E. Kelder (strategic policy advisor)

Geldermalsen: mr. M. Laureij (legal advisor environmental planning)

Lelystad: mr. H. Rienks (policy maker climate change)

Rotterdam: mr. D. Goedbloed (advisor water management) and mr. P. van Veelen (coordinator adaptive construction)

Tiel: mrs. I van den Hurk (project leader urban development) and mr. I. van der Valk (programme manager).

Respondents 'helicopter interviews'

Mr. H. Gastkemper (director RIONED; chair CROW working group adaptation public spaces) (heat stress and flooding)

Mr. V. Kuypers, M.Sc. (researcher Alterra, Wageningen; independent consultant) (heat stress and flooding)

Prof. Chr. Zevenbergen (Dura Vermeer; Delft University of Technology) (flooding)

Workshops and conferences attended

Rotterdam, 20 May 2010, Het Groene Lente Festival, parallel session on climate adaptation strategies for municipalities and project developers, organised by NEPROM, association of Dutch project developers (heat stress and flooding)

Arnhem, 26 May 2010, Hitte eiland en hitte stress in Nederland, Villa Sonsbeek, Arnhem, organised by the municipalities of Arnhem, Nijmegen, Rotterdam and Tiel, CROW, the National Research Programme Knowledge for Climate and the National Research Programme Climate changes Spatial Planning (heat stress)