Heat Retreat Locations in Cities – The Survey-Based Location Analysis of Heat Relief

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Abstract. The adaptation of cities to climate change effects is one of the major strategies in urban planning to encounter the challenges of climate change (IPCC 2014). One of the fields of climate change adaption is dealing with heat events that occur more frequently and with greater intensity. Cities in particular are vulnerable to these events due to high population and infrastructure density. Proceeding urbanization calls for the existence of sufficient heat retreat locations (HRL) to enable relief for the population from heat in summer. This is why an extensive analysis of HRL is needed. This paper aims at the development of a survey-based location analysis of heat relief by identifying user groups, locations and characteristics of HRL based on a home survey that was conducted in three German cities. Key results of the study show that the majority of the participants of the survey are users of existing HRL, are affected by heat, and perceive heat as a burden in summer. Moreover, HRL that are located in close proximity are preferred by most users while their effect depends on the regional context that has to be considered in the analysis. Hence, this research presents an approach to heat relief that underlines the importance of HRL in cities by referring to selected examples of HRL types in densely populated areas of cities. HRL should especially be established and secured in densely built-up areas of cities. According to results of the survey, most HRL are located in public spaces, and the overall accessibility of HRL turned out to be an issue.

1. Heat in cities

Due to climate change, the world is changing. The IPCC (Intergovernmental Panel on Climate Change) defines climate change in its Fourth Assessment Report “Climate Change 2007” (AR4) as long-term changes in climate, regardless of whether this goes back to natural or anthropogenic causes 0. At the latest since the publishing of AR4 the topic has become a focal issue in the context of planning sciences and, next to this, is also given increased attention in media and among the population 0. Certainly, weather- and climate-effects are prominent but the dynamics of these mentioned effects is changing 0.

The IPCC Fifth Assessment Report (AR5) conveys that the main cause of current global warming lies within the human-induced increase of greenhouse gas emissions with a probability of 95 to 100 % 0. Ongoing greenhouse gas emissions will lead to further warming and long-term change regarding all components of the climate system 0. Moreover, compared to earlier millennia, rapid and greater climate change is being observed. This is why mankind and environment have to adapt to the altered conditions more quickly 0.

Dealing with the consequences and effects of climate change will be one of the major challenges of the 21st century. Climate change will influence the living conditions of people in urban as well as rural areas 0. With regard to the population, the World Health Organization (WHO) assumes a causal relationship between mortality and heatwaves. “Studies published in Europe between 1993 and 2003 from several European cities attributed a change of between 0.7% and 3.6% in all-cause mortality to a 1 °C increase of temperature above a certain threshold (e.g. Kunst et al., 1993; Ballester et al., 1997; Michelozzi et al., 2000; Basu & Samet, 2002, Hajat et al., 2002, Pattenden et al., 2003)” 0. On a global scale heat waves have occurred more often towards the end of the 20th century and the IPCC expects...
that heat waves will increase in duration, intensity and frequency, which probably will lead to a higher number of heat-related mortality in the future. With regard to Germany, the current climate projections indicate that until the year 2100 temperatures will increase by 1.5 to 3.7 % of the mean annual temperature and the number, duration and intensity of summer days will increase. Seasonal shifts regarding the precipitation regime will occur, and more frequent and intense extreme events (especially heat waves, heavy precipitation, and storm) will follow. An increase in intensity and duration of extreme heat events therefore leads to a climate change related intensification of overheating tendencies of urban areas and thereby also to an increase in the number of people affected by heat. On the one hand, such negative developments require adjustments of the housing structure and the infrastructure in densely built-up and populated areas with already existing high environmental burdens and on the other hand the aspect of local recreation becomes more crucial. Since the need for heat relief during heat waves is obvious, “further research on the spatial distribution and use of cool spaces within neighborhoods – including parks, air conditioned stores, public buildings and pools – may help identify and characterize resources [...] for citizens able to leave their homes”.

Therefore, the objective of this research consists in the survey-based location analysis of heat relief to support the significance of local recreation. Since there are numerous studies about encumbered locations, like hot spots or urban heat islands, there is a need for research following a new approach that sheds a light on locations within cities that serve as locations of relief during heat waves. There is a strategic importance for locating hot spots – this is due to the fact that there have always been hot spots in cities. However, since hot spots have been a characteristic of urban climate, it has also been difficult to find measures to diminish them. This is especially the case in the context of the forecasted development concerning duration, intensity and frequency of heat waves.

This paper is aimed at identifying user groups, location and characteristics of HRL, based on a home survey that was conducted in three case studies (Remscheid, Solingen and Wuppertal) as part of the project ‘BESTKLIMA – Implementation and quality assurance of the climate adaptation concept in the Bergisches Städtedreieck’. The potential user types, the location of HRL with a focus on inner city areas, and the characteristics they display will be developed theoretically in the subsequent chapter of the article. Based on a thorough literature study, the authors analyse who could be potential users of HRL and what interests they might have in terms of heat relief. In addition, potential locations of HRL are investigated and their characteristics are examined. After that, the data of a quantitative home survey will set out to validate the outcome of the literature study. Furthermore, these combined results of the literature and the survey build a practical base to support the understanding of HRL – also putting a focus on the users of HRL, their whereabouts and characteristics. In the end, the theoretical basis and the results of the empirical study are concluded into a survey-based location analysis of heat relief followed by advice for integrating the scientific insights into planning practice.

2. The theoretical context of local recreation: Users, locations and characteristics

First and foremost, the potential users of HRL are risk groups in the face of heat waves. These include citizens that suffer particularly from heat and therefore are in need of heat relief. Several studies have identified “individual risk factors for vulnerability” to heat waves. A part of society is at particular risk of heat stress, counting small children, obese people as well as outdoor workers. “Those over 65 years of age and people with pre-existing cardiovascular and/or respiratory illnesses are recognized as especially vulnerable population” 0. Moreover, containing healthy climatic conditions that meet all needs of the inhabitants also applies to a less sensitive but still affected part of the population 0. The human being is closely connected to the atmospheric environment via his or her heat management, due to the fact that the organism is in constant conflict with the thermal conditions 0. Consequently, it is vital to inform every individual about how to curtail the menaces and to generate larger awareness of the threats caused by heat-waves. Possibly every citizen is at risk of heat-related illness, and – as mentioned above - death can be a consequence.

Suitable locations for heat relief within cities are those where the surface supports pleasant conditions that provide cooling. In this context, location characteristics such as the degree of sealing, surface roughness, colour, water supply as well as the alignment to the solar radiation and thermal conditions decide over biometerological location qualities as well as over how much energy is absorbed by the surface, passed on to the subsoil or is reflected back to the atmosphere. Generally, locations could be suited that lie beyond the urban heat island (UHI). This term describes a mostly insularly occurring urban overheating that differs from the cooler surrounding area. Its intensity is, for instance,
characterized by the positive horizontal temperature difference between city and surroundings 0. “The urban heat island is, to some extent, an inevitable consequence of urban development, but appropriate urban planning can reduce its magnitude”[17]. Measures, with the aim to reduce the urban heat island, focus on raising the number of patios, green and open spaces, the planting of trees in streets as well as an increased ventilation and air flow between buildings 0. Heat island intensity is spatially assorted in urban areas, so that during a heat wave some parts of a city can be significantly cooler than other areas 0, 0. The urban heat island intensity is the “difference between background rural and highest urban temperatures” 0.

According to research in the field of urban climate, green and open spaces as well as pools and public stretches of water are already considered as locations of heat relief 0, 0, 0. Especially intra-urban green areas can prevent or reduce thermal burdens of the built-up area, provided air exchange is made possible between the former and the latter. Obstacles like walls and high house fronts which separate green areas from their surroundings prevent such climate-relieving effects in the city. According to 0, however, only green areas with a minimum size of 50 ha have climate-improving features with long-distance effect. The larger the area, the stronger the long-distance effect. Yet, also smaller areas can have health benefits [17] as well as a positive impact on the environment if connections are facilitated between different types of green space over a combined system such as air channels. The effect of water elements and water bodies in cities is manifold. They can slightly influence the urban wind field and can support the formation of characteristic humidity fields. The influence of water bodies, however, depends on their proper features and those of the surroundings. The installation of proper features is not only dependent on the size, depth, course and location of a stretch of water in the city, but also on whether it is a stretch of running- or standing water. Obstacles with a height of 5 to 10 m can influence the desired temperature effect considerably. Furthermore, also the type of embankment has an influence on the range of the inflowing water 0. Finally, 0 suggests air conditioned stores and public buildings as locations of heat retreat. Therefore, the central questions of the conducted survey are:

- Does the population perceive heat as stressful?
- Which HRL are accessible for the public and which are effectively frequented by the population?
- Are there any barriers that keep the population from accessing certain HRL?
- To what extent do the mentioned HRL provide relief from heat?
- How can these locations be improved?

The survey was conducted both online and on paper by using the sheets in the survey package that was distributed to every household within the survey areas. There was one survey area in each of the three cities (Remscheid, Solingen and Wuppertal). The areas within the cities were chosen by several criteria using a multi-stage procedure. In the course of this procedure, large-scale inner city areas were a matter of discussion. In these areas certain heat stress problems have been detected because of location, constructional situation and prevalent sealing. However, there is also notable potential for urban planning here. The target group of the survey consisted of all inhabitants within the three areas. In this paper the results are not interpreted city-relatedly but on an inter-municipal level to develop transferable outcomes. Overall, 5426 survey sheets were distributed and the analysis is based on a response rate of 10.3%. The response rate was enhanced by two measures: public relations work and a raffle.

3. Insights about HRL

3.1. User Types of HRL

Although risk groups in the face of heat waves are known, every citizen is potentially affected and HRL are generally used by all inhabitants, also for reasons other than heat relief. Therefore, the survey intended to collect data from all age groups. While the age group 18-34 years’ accounts for 22%, the group 35-54 years’ accounts for 28% and the group 55-64 years amounts to 17%. The age group 65-75 years’ accounts for 2% and the last 18% are made up by the age group >75 years.

More than half of the survey participants are retirees (37 %) or full-time employees (28 %), whereas the part-time employees and the self-employed make up a share of 10 % and 9 % respectively. Students account for 7.5 % of the mention and the unemployed account for 4.5 %. Others make up a small share of 1.3 %, whereas 2% did not provide an answer. According to results of the survey there is a great dominance of households which are composed of one to two persons (81 %). About 87% of the participants live in apartments in multiple dwellings. These inhabitants do not have a private garden available to recover from thermal stress and therefore are particularly interested in HRL in public spaces.
Almost all the participants (94%) of the survey have been living in the area for more than a year. Accordingly, they have sufficient knowledge and awareness of HRLs in their surroundings to be able to choose between them.

The majority of participants perceive heat waves as stressful (69%). Furthermore, all age groups feel almost equally stressed by heat and verify results of other studies (see chapter 2). The group with the highest percentage of assent is the youngest group of the participants (see Figure 1).

3.2. The locations of HRL

A high share of mentioned HRL are within the survey participants’ private spaces. They include balconies, terraces, apartments, houses, basements, private green and open spaces as well as private spaces that belong to family and friends. These types of HRL will not be further examined in the context of this analysis since municipal governments cannot influence HRL in private spaces. Popular HRLs in public space include green and open spaces (parks, forests), catering trade locations, commerce locations, (outdoor) swimming pools and public stretches of water (see Table 1). In this context the survey corresponds with former studies in this field.

Another aspect of the survey dealt with the assessment of the intensity of relief HRLs can yield during heat waves. Results show that public green spaces (parks, forests) provide great and moderate relief. Retail shops, the catering trade and market spaces as well as pedestrian zones are considered to be just as relieving as public green spaces (see Figure 2).

The participants were asked whether there are sufficient HRL within the area in order to obtain an overview regarding the overall provision of HRL. Over 66% of the participants stated that the number of HRL outside their apartment is not sufficient. In order to receive an impression of the quality of HRL and the expectations of the participants towards the HRL, the participants of the survey were asked to articulate suggestions for improvement. A larger percentage of the sample stated that there is no need for improvement. Most of these answers referred to private HRL, however.
Table 1. HRL in public space

| Types of HRL                                    | Mentions in % |
|------------------------------------------------|---------------|
| public green spaces (parks)                     | 28.8          |
| public green spaces (forests)                   | 20.8          |
| catering trade locations                        | 14.5          |
| market spaces/pedestrian zones                  | 8.0           |
| (outdoor) swimming pools                        | 7.4           |
| public stretches of water                        | 6.7           |
| commerce locations                              | 4.6           |
| public outdoor spaces                            | 3.7           |
| playgrounds                                     | 3.5           |
| Other                                           | 1.9           |
| Sum                                             | 100           |

Figure 2. Intensity of relief for different types of HRL

More interesting and relevant for urban planning entities may be the fact that there is a great agreement among participants on measures such as “more green and open spaces”, “more trees and shades”, “more stretches of water and wells” and “more seating”. In contrast, the proposal “more information signs and warning signs” is considered less significant. Further proposed measures that were recognized but are less important involve “cleanliness and care” as well as the maintenance or establishment of outdoor swimming pools (see Table 2).

Table 2. Suggestions for improvement of HRL

| Type of HRL                          | Suggestions for improvement                          | Number of mentions (multiple choice answers) |
|--------------------------------------|------------------------------------------------------|---------------------------------------------|
|                                      | cleanliness and maintenance                         | 33                                          |
| Private HRL                         | structural improvements of buildings                 | 43                                          |
| Private HRL                         | Air conditioning and fans                            | 51                                          |
| Public HRL                          | swimming pools and public stretches of water         | 53                                          |
|                                       | other                                                | 69                                          |
| Public HRL                          | more seating                                         | 80                                          |
|                                       | no improvement needed                                 | 116                                         |
| Public HRL                          | increase of green and open spaces                    | 121                                         |
3.3. Characteristics of HRL
To locate and characterize HRL, the participants were asked to name the facilities and places they visit to seek heat relief. In addition to the HRLs within the survey area, further HRLs were mentioned that are located beyond the survey area. These HRL were categorized according to their distance to the survey area. Although the participants visit HRL in different distances, the majority of the mentioned HRL are located within a distance of 1000m from their places of residence. This shows the importance of HRL in close surroundings for inhabitants (see Figure 3).

![Figure 3. Distance to HRLs](image)

Due to the fact that the majority of mentioned HRL are located in proximity of the place of residence, knowledge about possible obstacles that prevent visiting these HRL is crucial in order to find ways that help improve or facilitate accessibility. In this case, distance to the location is considered the main barrier to accessing HRL (see Table 3).

Table 3. Barriers of accessing HRLs

| Barrier                        | number of mentions (multiple choice question) |
|-------------------------------|---------------------------------------------|
| missing accessibility         | 21                                          |
| bad accessibility             | 33                                          |
| opening hours                 | 49                                          |
| high expenses                 | 84                                          |
| missing cleanliness           | 105                                         |
| 'I don’t leave the house'     | 132                                         |
| missing amenity value         | 186                                         |
| great distance                | 232                                         |

4. Heat relief in cities
Due to climate change, urban planners and other planning specialists have to face various challenges. A likely increase in heat waves is just one of many. One measure to tackle this challenge in the context of climate change adaptation is the establishment and preservation of HRL that help the inhabitants of cities to obtain relief in their daily lives of today and in the future. Thus, this research aims to reflect on HRL, in particular its location and characteristics, and the identification of the user, especially in dense urban areas.
4.1. The integrative understanding of HRL

The characterization of users of HRL is based on the participants of the survey. They represent the risk groups in the context of heat waves. Beyond that, the perception of heat as a burden is articulated by a great majority of survey participants. While the personal impact of heat differs widely, the sensitivity of people is high throughout the sample. Especially senior citizens are at risk since they might be less able to protect themselves sufficiently during heat waves. In consequence of their limited mobility, the access of HRL is a challenge to senior citizens. The risk group of full-time employees depends on HRL in proximity to their home and/or workplace due to their temporal limitations. The same applies to inhabitants of multiple dwellings which are typical in dense, urban areas. Since private recreation locations, e.g. balconies and terraces are often missing in this kind of housing, publicly accessible HRL play an important role.

The HRL mentioned most are located in the private surroundings. Since urban planning cannot directly influence these, this research focuses on HRL in public areas. Public HRL mentioned most frequently include green and open spaces, catering trade locations, commerce locations and (outdoor) swimming pools and public stretches of water. Public HRL that provide the highest relief during heat waves are defined as public green spaces (parks, forests), (outdoor) swimming pools and public stretches of water, catering trade locations, commerce locations as well as market squares and pedestrian zones. The survey shows that the overall number of these kinds of locations is not sufficient. Suggestions of the inhabitants concerning a potential improvement of mentioned HRLs include measures such as more trees and other shade installations, more seating, more public stretches of water and wells as well as cleanliness and maintenance. Other proposals include the preservation of an outdoor swimming pool or an optimized access to the river ‘Wupper’. Other HRL that are not located within the close surroundings are located on a regional or national level. Types of HRL on the latter spatial levels match the previously mentioned: public open space and stretches of water play a central role as well.

Regarding the characteristics of HRL, the close surroundings are the preferred spatial context. Therefore, HRL in close proximity play an important role as recreation and relaxation retreats in urban settlement areas and therefore have to be provided thoroughly in the urban area. The strongest barriers concerning the access of HRL include the distance to the place of residence and the missing amenity value of certain locations which can be optimized by a standard level of maintenance.

In this sense, this research aims in supporting the value of HRL in urban development. Further research could address the visualization of HRL on maps for further spatial analysis. Additionally, the fact that retail shops and catering trade locations are favoured as HRL leads to the questions whether there are any economic potentials for HRL in business and if so, how they can be opened up.

4.2. Transferring scientific insights into planning practice

The key findings of the survey lead to a number of insights that should be taken into account for a sustainable urban planning in the context of climate change.

- Green public space, as an important HRL during heat waves, should be deliberately developed and designed.
- HRL in dense urban settlement areas should be established and preserved. When dealing with conversion, options regarding the development of green areas should be considered as well as options encouraging green roofs, walls and facades, which do not only have positive effects on the individual project but also on the urban climate and the microclimate.
- HRL should be analysed in a regional context.

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