2. HannOVER Heat - Steintor's heat islands

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Abstract

The expanses of climate change are diverse and several. Cities are facing the impacts of global warming and need to adapt to these changes. Like most cities, Hannover is also affected by the results of climate change. Areas in the city centre, like Steintor, are profoundly influenced by higher temperatures compared to non-urban areas, which disturb the district's functionality. This paper is analysing the existing phenomenon of heat islands in Steintor and the surrounding areas by suggesting different level solutions in order to defuse this challenge. The identification of the existing weaknesses and opportunities of the district led to the development of a strategic concept for the area. In order to achieve a more integrated response, the suggested ideas include proposals of governance as also more operative solutions; like the enforcement of the existing vegetation, the creation of shading and the unsealing of pavements. These solutions were implemented separately or combined in the district of Steintor and the surrounding area.

1. Introduction

Climate change has been a topic of rising importance for the world in the past four decades (Bulkeley 2013: 5). The impacts of global warming are becoming more and more visible in all continents, and especially in more urban districts.

It is believed that climate change is today's greatest threat faced by societies. Urban areas appear to be firstly and mostly affected by the results of global warming (White et al. 2005). According to the Department of Economic and Social Affairs of the United Nations (2014: www), the world's population is continuously increasing with about half of it living in urban areas. This increase has as a result that the needs of these densely populated cities rise rapidly, partly leading to lack of sustainability in their development (ibid.). Therefore, these areas become less resilient to upcoming threats that are connected to climate change.

The impacts of climate change are of a wide range, but for the societies they are mostly visible on two different levels; firstly, in the rising number of health problems faced by the population which are linked to the changing climate conditions (EEA 2016: 11f), and secondly, through the multiple chain reactions caused by global warming as rising sea level which result in problems that influence the functionality of cities (Globalchange.gov n.d.: www).

The kind of impacts that every city experiences are the conditional factors of history, geography, economy and society of each city (Bulkeley 2013: 7). Therefore, different cities are not experiencing the results of climate change in the same manner. However, some patterns can still be identified regarding the type of impacts a city-group faces. For instance, coastal areas tend to be more affected by results as flooding (National Geographic 2019: www) as, on the other hand, densely populated urban areas face problems related to heat islands (Álvarez 2013), and air pollution (EEA 2016). Nonetheless, there are also cases where a city may face multiple challenges. One such case is the city of Hannover.

2. Background

Hannover is dealing both with the problem of flooding, due to its closeness to sore located areas, as well as with heat islands, especially in the city centre. Although the problem of flooding has been a well-known problem for many districts of the city (Region Hannover 2013: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019: www), heat islands are a more recently added challenge (Deutscher Wetterdienst 2019: www).

The global warming-related heat islands, in the centre of Hannover, decisively affect the quality of the region's core. Furthermore, it is expected that the problem will become more intense in the next years. Therefore, it can be said that heat islands appear to be one of the most significant challenges faced (at least) in the city centre (Bayerischer Rundfunk 2019: www; Deutscher Wetterdienst 2019: www; Region Hannover 2017: www).

Areas in the centre that are densely built with lacking vegetation and shading appear to suffer the most from the phenomenon of heat islands (Bayerischer Rundfunk 2019: www; Deutscher Wetterdienst 2019: www). One of the most central areas of Hannover that is profoundly affected is the district of Steintor and its surrounding areas (Region Hannover 2017: www; Hannoversche Allgemeine Zeitung 2019: www).

Steintor is one of the most famous areas of Hannover city; it is located in the north-western part of the city centre (see Figure 1). Steintor is a very vibrant area by combining opposites, like residential areas, the old city part and different kind of enterprises. However, this district is increasingly suffering from the rising temperatures in the summer months (ibid.).

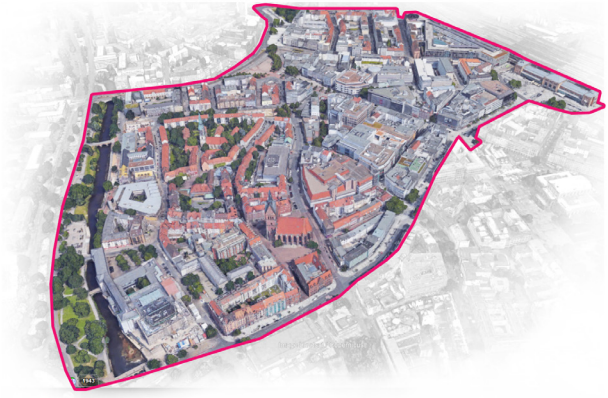

Fig. 1. Depiction of Steintor and the main areas (own depiction (Data Source: Google Earth 2019: www))

In the purpose of analysing this profoundly affected central area as also some surrounding areas of Steintor, in terms of heat islands, different methods and steps were used. The first used method was a qualitative analysis of the existing measures taken by the responsible authorities for the governance of heat islands. In the next step, in situ data was collected, followed by a SWOT analysis. In order to display the collected data, maps depicting the affected area were created. Finally, with the help of further qualitative analysis, suggestions were composed to help to respond to the problem of heat islands in Steintor and its next by located districts.

3. Perception of heat islands in Hannover

3.1 Action taken by the responsible authorities

The qualitative analysis of the action taken by the responsible authorities showed that the importance of this steadily upcoming threat had been recognised. The authorities tried to adopt measures to contempt the problem resulting from rising global warming levels, both on the federal state as on city level.

The regional authority of Hannover has been very active regarding the phenomenon of climate change by releasing multiple action strategies through the years, as by analysing the problems and the existing conditions and promoting changes (State Capital Hannover 2012; State Capital Hannover 2018). The authorities recognised that in order to contempt the impacts of global warming successfully, multiple parties have to work together. There appear to be three essential teams that need to participate in the process; the administration, the scientific community and finally, the economy/companies' level (State Capital Hannover 2018: 9). These three parties are originating both from the region and the city. The two authorities of Hannover, region and city, are trying to face the challenges related to global warming by making use of different kind of tools. On the one hand, the regional authorities, with the Climate Protection Agency, aim to create more general frameworks and provide a more global analysis of the phenomenon in the area. On the other hand, the city authorities, with their Climate Control Department, focus on solving the problems on a microscale level though introducing more direct measures, like increasing the energy standards for new buildings and creating more green surfaces (Landeshauptstadt Hannover 2012; State Capital Hannover 2012; State Capital Hannover 2018).

Nonetheless, one of the most important plans created to restrain the impacts of climate change in the city is the Masterplan, which was created by the city of Hannover in cooperation with the regional authorities (Landeshauptstadt Hannover 2012; State Capital Hannover 2018). The Masterplan brought together scientists and experts from different sectors and targeted to create measures by launching the Action Programme.

The Action Plan contains different acts against the impacts of global warming in Hannover. These measures can be categorised into three types. Firstly, measures that are taken on the planning level, such as Climate-appropriate Town Planning & Construction and Specific Map Climate Adaptation. Secondly, by raising the awareness of the public. Finally, with more specifically directed measures as creating flood protection and preventive soil & groundwater, greening roofs, managing rainwater, and planting climate-appropriate vegetation (Schmidt 2019: 14).

The Action Plan is simultaneously combining the strategic and operative level. The implementation of those measures can alleviate the problems arising from climate change in Hannover, both short- and long-term. The exact type of measures and the way of implementing those has to be defined in every case differently since the specifications of each area have to be taken into consideration.

Hence, in the case of Steintor and its surroundings, the adapted measures have to comply to its needs. However, there appear to be some main concepts in the Action Plan that are able to contribute significantly in the efforts to offer some relief to the district, and generally the city centre (Schmidt 2019: 14ff).
These strategies can be summarised in unsealing areas and restoring the natural soil by also bringing natural elements into the scene, creating shading, and enforcing with climate-appropriate vegetation (ibid.).

3.2 Weaknesses and strengths of the examined area

The in-situ data collection revealed that the areas, of Steintor and its surroundings, are “divided” in different sub-areas. This separation is enforced by the different functions that seem to exist in each sector. Four main categories of functions can be

identified in the examined district (see Figure 2); the shopping area (depicted in pink colour), the office area (in purple), the residence area (in green) and lastly one of the most infamous areas in Hannover (yellow).

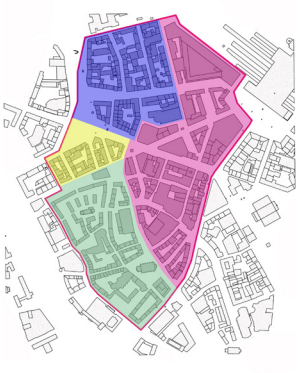

Fig. 2. Depiction of the sub-areas of Steintor (own depiction (Data Source: Cadmapper 2019: www))

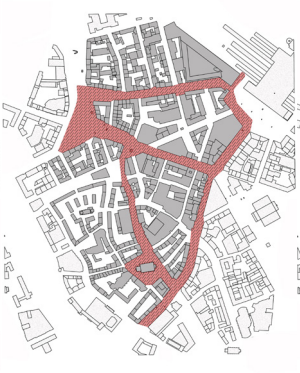

Fig. 3. Illustration of the most vulnerable areas of Steintor (own depiction (Data Source: Cadmapper 2019: www))

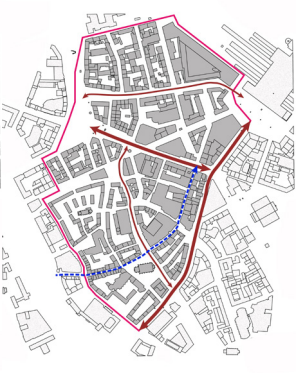

Fig. 4.Illustration of the pedestrian flow in the district of Steintor (own depiction (Data Source: Cadmapper 2019: www)

The sub-area depicted in pink colour, shopping area, connects to the central station on the north-eastern part (see Figure 2). The shopping-area includes big malls as the Ernst-August Galerie in the north and other smaller malls and stores. The shopping area is composed mostly of more modern buildings as the above-mentioned big mall. This composition, however, has also some negatives since these building's facades consist mostly of glass which reflects the sunlight and causes the increase of the temperature of the nearby ground level. Furthermore, most of the pedestrian streets in this area are sealed, which causes further rising of the ground and air temperature (Edmondson et al. 2016).

Vegetation also appears to be almost wholly lacking in Steintor. The people flow in this part of the centre is one of the highest of Steintor (see Figure 4; thick red line), the Kurt-Schumacher-Straße connects the two most central spots of the city centre, the central station plaza and the Kröpcke plaza (see Figure 1). The phenomenon of heat islands was strongly noticeable in these two plazas through the enormous scale of the surface combined with missing shading.

The purple depicted area hosts offices and commercial areas. Some supermarkets and hotels can also be found in this sub-area (see Figure 2). Comparable to the shopping's district, the pavement is mostly sealed, and vegetation is missing (see Figure 3). However, the pedestrian flow is not as high as referred to in the shopping area. Trams and buses are crossing this area; vehicles are also prohibited (thin red line).

One of the most interesting spots of this district is the Steintor plaza (in the south-western part of the examined area) (see Figure 1). The Steintor plaza is the landmark of Steintor. This square is mostly sealed through a stone road, some vegetation exists, moreover, a strong people flow was noticeable.The green illustrated area includes mostly residentials. Cafés, restaurants and also some small stores can be found in the area (see Figure 2). The most significant characteristic of this district is the old city. This district indicates great contrasts in the types of buildings. New buildings with green yards coexist thus with older structures in the narrow stone-paved streets. Differences can also be seen in the vegetation; some streets lack it entirely, although, others are above average. Lack of shading is also one main problem in some streets, like the Schmiedestraße and the Marktplatz (see Figure 1; Figure 3). The observed people flow in this area is also not profoundly high (see Figure 4).

Lastly, the yellow depicted area is a rather infamous area of Hannover (see Figure 2). This district hosts sex trafficking and prostitution. The pedestrian flow in this district is very low; the north-western part of this sub-area is crossed by vehicles and public transport (see Figure 4).

However, specific potentials can be found in the examined area.

Fig. 5. Depiction of the potentials of Steintor (own depiction (Data Source: Cadmapper 2019: www))

The development of those could contribute to addressing the heat island phenomenon in this district. The identified potentials can be categorised into two; the buildings' flat roofs and the existing vegetation (see Figure 5).

Flat roofs could mostly be seen in the shopping sub-district as in the office sub-area. Some of these roofs have already been greened, although further potential exists.

The existing vegetation, as seen in Figure 5, can hardly be characterised as sufficient, especially in the bigger plazas as Steintor, Marktkirche and Kröpcke (see Figure 1). Nonetheless, there are parts mainly in the residential sub-area, which can be seen as an example of adequate greening. Moreover, the Georgstraße has already some existing vegetation which can be developed.

4. Governance of heat islands

4.1 Strategic and operative level

In order to achieve successful governance of heat islands in Steintor and the surrounding areas, actions have to be taken both on the strategic and operative level.The authorities' promoted measures that aim at restraining the impacts of climate change. However, the implementation of those appears to be partly inefficient due to two main facts; firstly because of the very slowly proceeding of the implementation of those steps and secondly because of the enormous time gap between the strategies release (every four years).

The impacts of global warming are starting to escalate; they are almost unpredictable, and changes in the world happen at a rapid speed. A phenomenon like heatwaves has become more than twice as likely as it would be without climate change (Carrington 2018: www). Therefore, the adaptation to urban climate change is a necessity. Although planning measures need more time to be implemented and aim at long term solutions, they still have to be more up to date; since the problems the city faced in 2012 are not the same as the ones in 2018. The faces of global warming change rapidly, and the authorities' strategies have the obligation also to do so for the wellbeing of their citizens.

Furthermore, an essential point that appears to be absent from both the Strategies as well as the Action Plan are regulations

regarding the buildings in the heatwave zones. As analysed, many of these buildings are covered with glass in their most significant part, causing reflexion of solar radiation and the increase of the ground temperature. The authorities should promote the design of buildings according to climatic zones since their adaptations to the surrounding urban landscapes are required to manage a heat reduction (Carter et al. 2015: 15ff). Moreover, as already foreseen for pavements in the Action Plan, similar directions regarding the colours are needed for the buildings. Building materials have, in general, the tendency to insult and absorb the heat; light coloured materials on the surfaces are able to reflect rather than absorb a high proportion of solar energy (Klima 2012: www).

Undoubtedly, local administrations are struggling to face urban climate change. In order to strengthen as to improve the outcomes of these efforts, it is essential that higher levels of authority contribute to those efforts. Germany has been one of the first countries creating initiatives like the Klimazug, which aim to create the needed knowledge background to tackle the impacts of changing climate (Carter et al. 2015: 1ff). However, it is still a necessity that these programmes are created as a cooperation between more countries in order to reduce sensitivity and to build capacity for urban adaption.

Finally, cooling locations for citizens need to be created. Especially more vulnerable community members need access to cooling locations that can provide relief from the extreme temperatures.

4.2 "In situ"

In an effort to apply the proposed measures of the Action Plan and also some further recommendations to reduce the heat island effect in the districts around and in Steintor, a concept was created. The main proposal includes the enforcement of the existing vegetation as also the addition of new one, the creation of shading through mostly green elements and lastly the unsealing of pavements (see Figure 6). Four central spots of these districts have been chosen in order to apply these ideas; the Kröpcke-plaza, the Georgstraße, the Steintor-plaza and lastly the Schmiedestraße.

These chosen central areas of Steintor and the surroundings are all profoundly affected by heatwaves. However, it should be mentioned that the degree of exposure of these areas to heat islands is proportional to their infrastructure (Palomo 2018: www); meaning that the chosen areas are not affected in the same extent or in the same way.

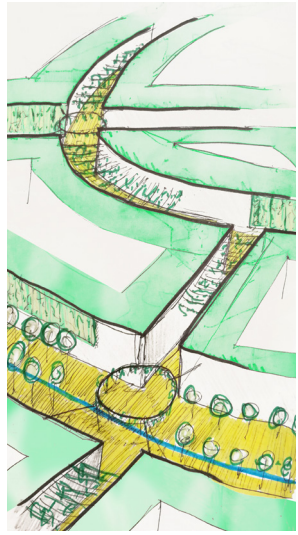

Fig. 6. Illustration of an extemporary paradigm of the concept (own depiction)

For instance, spatial characteristics as the landcover and density of one area strongly affect the intensity of heatwaves in it (Álvarez 2013). Therefore, the need for an increase in the resilience levels of each of the chosen four areas differs.

Nevertheless, all four have some factors more or less in common which are; the sealed pavements, nearby prominent glass facades, lacking vegetation, missing shading (combined in the case of the plazas with their enormous scale) (see Figure 7). The measures included in the concept for the examined district have taken into consideration the particularities of each of these four areas. The actions have been adjusted accordingly, although, by still reflecting the primary principals of the concept's ideas.

Fig. 7. Example of a sealed pavement, lacking vegetation and shading in the Markt-plaza which is located at the Schmiedestraße (own depiction)

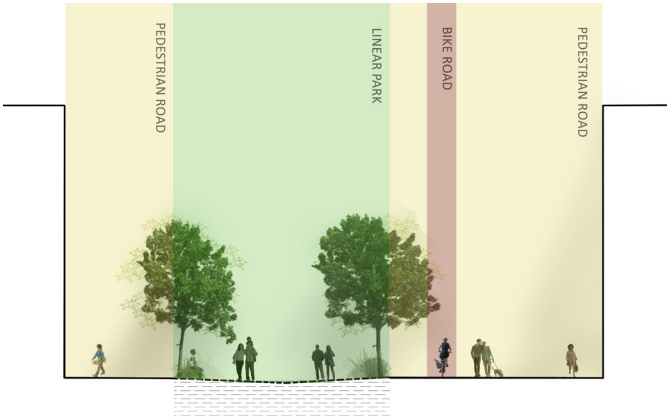

Fig. 8. Illustration of the new Georgstreet - sectional view (own depiction)

The first measures towards creating a more resilient city centre district were set in the Georgstraße. The transformation concept for this important street of the city includes partly unsealing of the pavement and enforcement of the vegetation (see Figure 8; Figure 9).

The newly added pavement is planned to be of higher albedo (higher solar reflectance) values compared to the conventionally used paving. This characteristic of the new adding would enable the draining of the water, which in case of heatwaves would evaporate and lower the temperature of the pavement (Musco 2016: 125f). Researches at Lawrence Berkeley National Laboratory have proven that an estimated 10% increase in the amount of solar reflexion of the used pavements and roofs is able to decrease the surface temperature up to seven degrees; whereas an increase of 10-35% of reflectance of the pavements would result in a drop of one degree in the air temperature (Huber 2017).

Particular attention was given in maintaining the accessibility of the area to all members of the community. Therefore, only the central strip of pavement (between the trees) was unsealed. The remaining two sides (left and right of the unsealed strip) are preserved in the natural state.

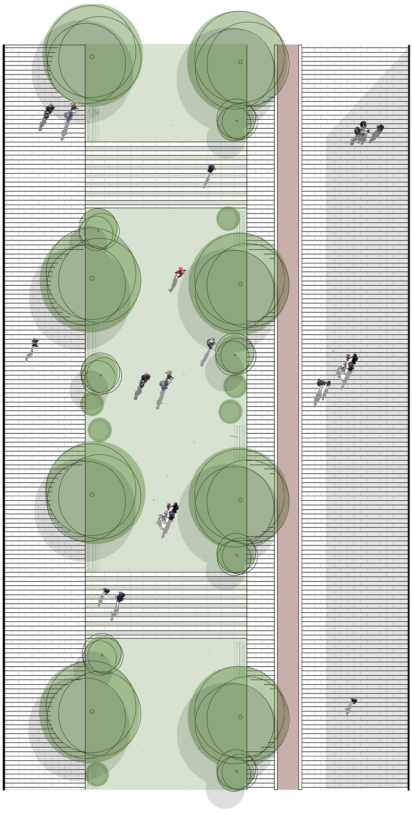

Fig. 9. Illustration of the new Georgstreet - floor plan (own depiction)

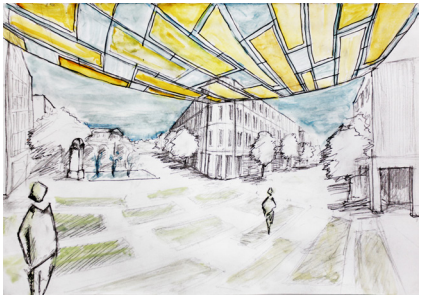

Fig. 10. Depiction of the planned construction for the Kröpcke square (own depiction)

Furthermore, some vegetation as trees and bushes were added to the scene (see Figure 8).

The principle of evapotranspiration was used in the case of Kröpcke. The created concept for this plaza includes the creation of a roof construction which will provide shading to the square. The added element is estimated to reduce the air temperature at the ground level and create a more pleasant atmosphere in the Kröpcke-plaza. The used construction is designed to be made out of a light material which will absorb less heat compared to other materials (like glass) (see Figure 10). Other additions are not planned for this spot since the square has to remain accessible for events which take place throughout the year.

A comparable construction is planned for the Schmiedestraße and the Markt - plaza. Although, in this case, the roofing has been planned to consist of vegetation (see Figure 11). As in the example of Kröpcke, the construction shall provide shading to mitigate the problem of heatwaves in the area. Implementing green infrastructure has shown to reduce temperatures both of the ground and the air. The vegetation stores and re-radiates less heat compared to build materials and building's surfaces (Armson et al. 2012: 245ff; Gill et al. 2007: 115; Hall et al. 2012: 411ff); moreover it reduces the nearby air temperatures also through evapotranspiration (O'malley et al. n.d.: www; Benedict & Mcmahon 2012; Musco 2016: 125f).

Fig. 11. Depiction of the planned construction for the Markt-plaza (own depiction)

Lastly, the suggested concept for the Steintor plaza includes the creation of a vertical green wall at the northwestern part of the square. The aim of this construction is, on the one hand, to reduce and cool the air, and on the other hand, to filter it from the created emissions of the crossing street. Additionally, the existing tree vegetation of the square has been reinforced in order to create a more shaded surface (see Figure 12).

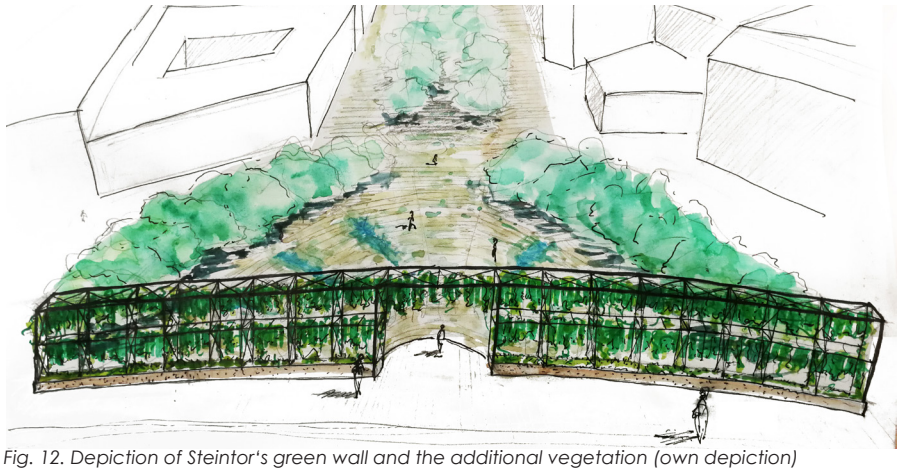

Fig. 12. Depiction of Steintor's green wall and the additional vegetation (own depiction)

5. Conclusion

This paper assessed the heat islands in the district of Steintor and its surrounding areas by analysing the situation, qualitative and in-situ. Heat islands are a rising threat for the centre of Hannover affecting the quality of the city core. Furthermore, it is expected that this problem will be intensified in the upcoming periods, requiring immediate solutions.

Although authorities have proceeded in creating strategies to relieve the effects of climate change, the results appear not to be efficient enough. Therefore, the most important aspects of critic in this paper are related to the governance of heat islands by the authorities, and especially the Action Programme.

The proposed suggestions aim to improve the efficiency of the existing measures. Moreover, the recommended practical actions target in improving the microclimate of Steintor and its surrounding areas and relief from heatwaves. The main used tools include the creation of shading, vegetation and alternative types of pavements. These mitigating elements were chosen due to their potential to generate cool spots. The suggested measures aim to make improvements both on short- and long-term basis.

As the research demonstrates, it is necessary that further investigation regarding the impacts of the changing urban climate take place. The range of the different effects is still unknown complicating the efforts to operationalise resilience within cities.

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