3. Coping with the heat island of Raschplatz & surroundings in Hanover, Germany

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Abstract

Heat islands as a modern urban phenomenal problem, is caused not only by the construction and planning but also by the behaviour of citizens. The paper discusses the issue focusing on Raschplatz and its surroundings in Hanover, and uses methods of literature review, site analysis and observation, geographical sketch to figure out the sources and causes of urban degradation in this high-traffic commercial area. As a missing link behind the main train station, the study area of Raschplatz presents the traffic intersection point. Ecological methods and physical remodelling are the primary measures of the renewal design.

1. Heat Island Phenomenon in Hanover

One of the most acknowledged impacts of urbanization are the urban heat islands. These can be defined as city areas having daytime temperature elevation in urban atmosphere, which can go up to four till five degrees higher compared to surrounding non-urbanised areas (Jones et al. 1990). In summertime, occasional heat waves intensify the conditions, making it unbearable for its users and severely affect urban meteorology, environment, energy consumption and human health (Li et al. 2013). Contrary to the common belief that the effect of the urban heat islands remains in the atmosphere, it affects in fact also ground surface temperature and the air near the surface, typically 1-2 meters above ground, where generally outdoor activities take place (ibid.). In heat islands, the near-surface air temperature becomes the hottest by collecting both direct and radiated heat from the ground, affecting mostly human thermal comfort and air quality. Urban atmospheric heat gain increases the demand for additional energy consumption as well as harmful emission (ibid.). This enhances the formation of smog due to air pollutants like nitrogen oxides and volatile organic compounds (Berkeley Lab 2019: www). This phenomenon is more apparent in areas with high density and tall buildings are frequent.

This paper discusses the situation of urban heat islands in the city of Hanover in Germany and analyzes various factors responsible including urbanization, land use planning, urban canyons surrounded by tall buildings that trap the heat and act as a heat pool, then surface and ground quality, traffic and transportation system, use of machinery and air-conditioning systems. A range of observational and simulative researches have been studied from micro to meso level about different strategies to mitigate the impact of urban heat islands; such as emphasizing on urban green infrastructure, use of water bodies, climatically revise urban infrastructure and land use planning. The paper also evaluates the transport-spatial crisis; impact and thermal behaviour based on a specific heat island in the city and comes with potential urban design concepts for the very site. It sums up with a set of general recommendations, developed from the study, in order to mitigate the adverseness of urban heat island effects.

2. Empirical Review of Measures

Urban heat islands as the unintended anthropogenic climate modification factors in cities, are expressed through artificially elevated temperatures. The temperature differences between urban and rural areas can occur on the ground, at the surface and at various heights in the air (Yow 2007: 1227ff). Urbanised regions are measured to be 3.3-4.4°C warmer than surrounding rural areas (Stone & Rodgers 2001: 186). Urban heat islands have a negative impact on human comfort and health, energy consumption, plants & animals and increase the effects of climate change (Yow 2007: 1237f). Responsible factors are mainly the constituents of the urban construction such as asphalt, concrete, roofing tile but also the urban geometry and structure such as the street orientation, height and density of buildings (Stone & Rodgers 2001: 187). The removing of vegetation and instead sealing of the ground plays an important role as well as the absence of water bodies. But also, weather conditions and topography have to be considered (Yow 2007: 1236). The subject of urban heat islands is of growing importance because urban areas are expanding, especially in tropical, less developed countries. The knowledge about how to cope with the problem must be communicated to architects, engineers, planners and citizens and shall be translated into intelligent urban design (Yow 2007: 1227).

3. Methodology: Site Analysis and Observation

In this project, a literature review was used to build a basis of knowledge on the topic itself: the problematics of heat islands and how to cope with the challenges. Accordingly, the professional competence and ability could be increased, thus giving the design proposal an academic background. The goal was to review the accumulated knowledge and to learn from it. Therefore, the research area and its major issues can be presented in a more credible way. The direction of the research as well as the development of the knowledge can be shown outlining the relevance of the research. By summarizing the status quo, it can be demonstrated which questions remain and which hypothesis and techniques are worth to develop further. Also new ideas could be stimulated by the literature review (Neuman 2014: 126).

For the best possible new design concept for the study area, it is important to understand and explore the conditions of the square. For this purpose, it is indispensable to observe and record the current situation through site analysis and to filter out the major conflict points. Site analysis is a method used in architecture, engineering and urban design. The specific site must be placed and understood in its proper geographical, infrastructural, political, historical and functional context. The result is usually presented in a graphical sketch which relates the specific environmental information to the topography and built neighborhood of the site. The outcome serves as a basis for developing environment-related strategies in the upcoming design process (White 2004: 8ff). For this project, the site analysis is seen as an adequate tool to understand the significance and the context of Raschplatz in its built environment. Based on the observation of both physical environment and social context in the area, the site analysis aims to find out the main heat factors. The resulting sketch was helpful for the future design concept.

However, in this project, only slight measures can be taken regarding the public function of this area. The observation and site analysis are limited by the accessibility and cannot be inside of the building energy systems and transportation planning. Specific measurement according to these aspects should be also considered.

4. Analysis of problematics in Raschplatz area in terms of heat islands

4.1 Results of site observation

The study area encompasses the area opposite to the central train station (Hanover Hauptbahnhof), stretching to the Andreas Hermes Platz to reach the shopping street Lister Meile. It includes an open square called Raschplatz, serves as the exit plaza for rear side of the station. For the study, Raschplatz has been acknowledged as an axis characterized by varying urban fabric on both sides of the square.

Fig. 1. Raschplatz: location (own depiction)

In the left side of the axis are the bus terminal, large parking lots, hotels, supermarkets, offices and a few residences. The land use is mixed and the urban texture is mixed and disordered as well. The public buildings like administrative and offices are mostly following the modern style with glass facades and high rise, with little green space. On the other part, there are comparatively older buildings used as offices or residences. With grid patterns in urban planning, the area has better walkability and potential to use the streets as natural air-corridors. In the center of the study area, as the connection to one of the three exits of the main train station, Raschplatz is a hard and non-porous paved square surrounded by high concrete buildings, in which primarily bars, cinemas and casinos are located. The square is divided into two levels: The first level is at the height of the main station exit, the second part is one level lower. The lower part of the square is intersected by the Raschplatzhochstraße, which creates a tunnel-like situation beneath. There is also a big green chunk of area approximately 4.70 km^2 near the research site, within 900 m, a mini forest or expansive city park, called Eilenriede, featuring leafy walking paths, playing fields, ponds, playgrounds & cafes beside the music college of Hanover. In spite of being in such close proximity, it barely has any effect on the researched site, due to poor connectivity and several vertical blockages.

The complex aggregation of uses and core traffic function of the city have part of adverse consequences that subsequently lead to the heat island phenomenon in this area. To summarize, this paper distinguishes the causes of the heat islands related with physical and socio-ecological content based on the study area and analyzes them as follows.

4.1.1 Heat factors related with urban morphology

i) Built structures and infrastructures

The main train station is located in the center of the study area, therefore it has the largest impact on the site's microclimate, in accordance with ***surface and materials***. The station building's surface is light coloured concrete and very little use of glass. Compared to buildings in the west part of the axis, the buildings are mostly used as offices, hotels and supermarkets, and more or less constructed with glass surface. On the east part of the area, buildings with old pattern were built with hard material surface. Extensive use of glass surface can worsen the heating problem. The sunlight directly reflects on the glass surface and radiates back to the atmosphere. Moreover, it increases the surface temperature as well, where this reproduced heat makes the situation more intense. Open spaces like Raschplatz surrounded by tall buildings act as a heat pool on hot summer days, as the reflected heat is trapped into the pit.

Based on the city map, the study area has ***high-density of buildings*** compared to other areas in Hanover. Many of the buildings are using modern energy system. The higher density area is surrounding Raschplatz, with several commercial uses. The distance between the buildings is not enough to act as a buffer area. Later during the analysis, no stated legal regulation could be found on proper set back area to be maintained between buildings. Though, there was a preconceived idea that densely built buildings can refrain sunlight to reach the streets and pavements, and keep it cool. But the idea worn out as the buildings have been getting taller and days are becoming hotter. Rather high density creates more surfaces to absorb heat and also interrupts airflow (Steelconstruction.info n.d.: www).

An intriguing variation of ***heights*** can be found in the study area. In general, Hanover is not known to have large number of skyscrapers or tall buildings. There are a few, mostly located in the business hubs accommodating banks, offices, hotels etc. The study area is one of that. During the analysis, the taller buildings have been identified, that have more than six floors. Though six storey constructions are not conventionally perceived as tall buildings, but this standard applies in the case of Hanover since building heights are relatively low. The tallest building in the studied site is 14 storey, surrounding the aforementioned heat-spot Raschplatz. The impact of building heights in the heat island effect is discussed in the following chapter.

Fig. 2. Raschplatz: hard concrete surface, surrounded by Main train station and other tall buildings, with extensive use of glass facade (own depiction)

ii) Planning

In terms of urban design, the study area is quite monotonous. Whereas, Hanover is considered to be the greenest German city with 11.36 per cent of the green surface cover (Hannover Marketing und Tourismus GmbH 2019: www), the study area has little to none green surface. Though, the area consists of quite a number of large to small squares or open spaces, mentionally Raschplatz, ZOB (central bus station), Contipark parking space and just along with our study area Andreas-Hermes Platz. The presence of vast open spaces may sound as a positive element, however, all these surfaces are covered with hard materials, such as ceramic tiles, concrete blocks, asphalt. The roads are mostly constructed by black asphalt. On the other hand, in the old town area, a few streets are covered with cobblestones. Soft paves cannot be found on the surface throughout the area. Also, any water body, let alone artificial fountain does not exist here.

Traditionally, according to the geographical position, Germany tends to have longer winters than summers. Likewise, there is extensive use of asphalt in hard paving rather than other hard materials, as it absorbs more heat from the sun that can quickly melt ice and snow. As the days are getting hotter, consequently asphalt paving softens in extreme heat (Wolf 2016: www). Artificial surface covers such as concrete and asphalt absorb heat all day long, and act as a giant heat reservoir. Sometimes darker pavements and asphalt street absorb up to 80-95% of sunlight (Berkeley Lab 2019: www). This intensifies the situation in urban heat islands by releasing the heat back in local air, warming the microclimate. About one-third of the whole urban surface are hard, which radiates external heat and results in heat island (Akbari et al. 1999). In worst-case scenario, it can also raise the temperature of groundwater and stormwater runoff, causing evaporation.

The thermal performance of a surface material does not only depend on the ambient environmental factors such as sunlight, wind, airflow and temperature; but also light-colored ones, which means they ab surface temperature influenced by its material properties, like temperature reflectance or albedo, temperature absorbance (NCPTC & NCAT 2013). Dark color materials generally have less solar reflectance values than light-colored ones, which means they absorb more heat and have higher surface temperatures during hot, sunny periods when not shaded by trees or buildings (ibid.). The value of the solar reflectance of asphalt is 0.04 to 0.16 lower than that of concrete that means asphalt streets and paves are hotter and contribute more to heat islands. The study area has some cobblestone streets having value of 0.53, cooler than other surface materials (Pomerantz et al. 2003). So, an approach to reducing heat island absorption could be to consider different surface materials for roads and pavements.

The study area is mostly used as a commercial district with the main function business and transport. ***Green spaces*** are very scarce, absence of green is more prominent in the west part of the study area rather big parking lots and hard pave concrete plazas can be found. The east part has a comparatively older plan, where green can be found to some extent in building plazas and courtyards, alongside streets and pedestrians. In the analysis of the project ratio, the green and hard area ratio has been calculated. The whole study area measures 25164.8 m^2, and total green covering area is 1973.6 m^2; which is only 7.8% of the total area. The scarcity of proper green space contributes to increasing urban heat islands effect, as green surface does not absorb heat from sunlight, rather holds water and keeps premises cool. In the older part of the area, there are some big trees alongside the streets providing shadow. These streets are self evidently cooler and more comfortable than the neighboring ones.

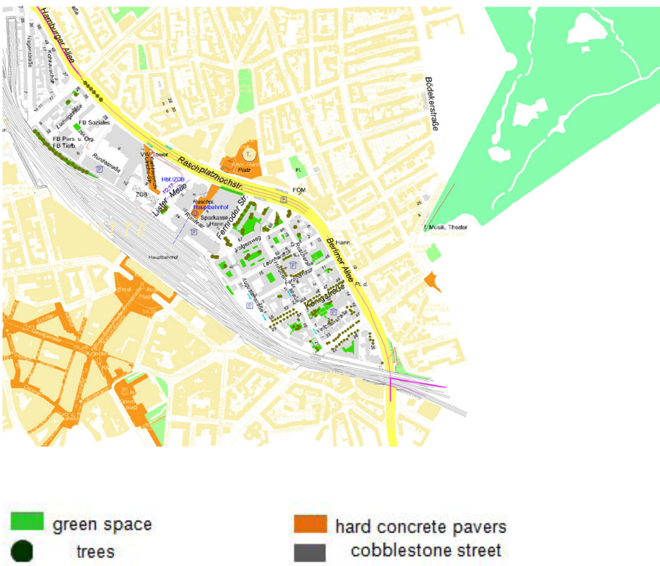

Fig. 3. study area map: green landscape, trees, hard paves and cobblestone streets identified source (own depiction)

According to the master plan of the city of Hanover, the railway space in the hauptbahnhof (central train station) is used as a main ***air-corridor*** for the neighboring area (Landeshauptstadt Hannover 2017). Nonetheless, the wall besides the railway acts as a barrier of the airflow. There is no obvious planned corridor in the western part of the area, on the contrary the old style grid pattern planning on the eastern part using the streets as air-corridors. The wind going through the streets brings fresh and cooling air in the area, and makes the block friendly to walkers. The other edge of the area is a highway with a bridge, and the high buildings standing by the edge cut the planned airflow down. On the contrary, instead of possessing qualities of air corridor by a street, at some point, erection of tall buildings at the edge interrupts the flow and ventilation, and the street becomes stagnant pit, only consuming heat from top.

The study area includes the main public ***traffic infrastructure*** of the city, as the main train station, main bus terminal, bus and tram stations. The big parking lots in the area causes more frequent and increased car use here, making it unfriendly for pedestrians to walk. Also, in north-east side, parallel to the central station and alongside the study area, there is one of the main vehicular roads, having heavy vehicular load all day long. Moreover, it contains an elevated fly-over road. As a result, the traffic situation and function are very complex here being one of the busiest node and commuting points in the city. Higher concentration of different modes of traffic in this area contributes to heat emission. This may remain trapped in poorly ventilated roadways and spaces with interrupted airflows, therefore it turns to heat pools. Consequently, it will result in urban smog on heat island (Louiza et al. 2015: 252ff).

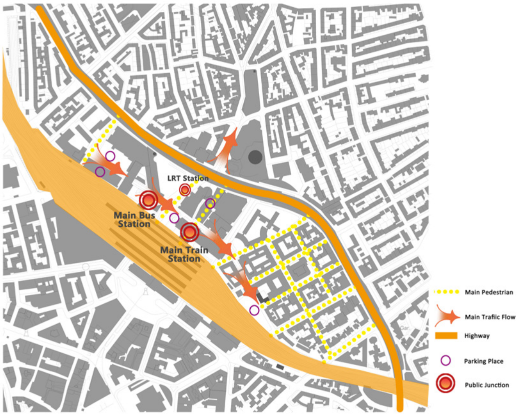

Fig. 4. Study area map of traffic infrastructure (own work)

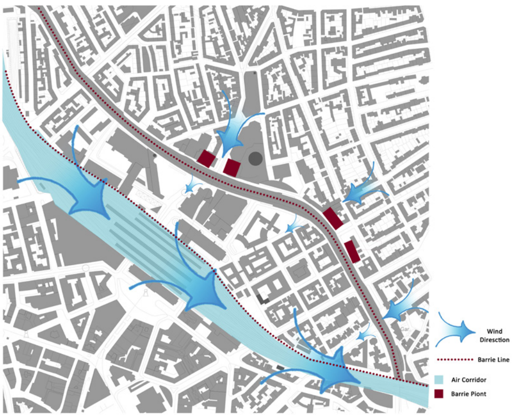

Fig. 5. Study area map of airflow and air corridor (own work)

4.1.2 Socio-ecological factors related to heat island

i) Land use plans

The main functions of the area are offices, hotels, supermarkets, housing and public transportation. Based on the functions lead to the attribute of this area as high-density, fast-speed and super-mixture, the heat island effect is caused by the buildings as well as people. More commercial land-use means more use of air-conditioning and heavy machineries. It causes more energy consumption and more waste heat emission (Nogrady 2017: www). Around the study area, there are city parks, community center and shopping center.

However, the railway and highway act as barriers at the edge of the area, and lead the area to a missing link behind the main train station.

ii) User behaviours

The study area plays a role of a link between the area behind the train station and the city centre. It is a corridor of transportation for both tourists and residents. The use rate of this area is high and its attractiveness results in commercial infrastructure. The Raschplatz is more used by homeless people as temporary shelter against the city regulations, which makes the conflicts of different social groups more complex.

The ***mobility behaviour*** of the user group in the study area is also very impactful on the environment. The big parking lots and underground parking space supply more opportunities for car-users in the area. The public transportation of trains, buses and trams would be the heat spots. Because of the complex traffic situation, the area is not very friendly to the eco-transportation, like biking, though having provisions for bike routes and pedestrians. A big chunk of the area is office buildings, that makes it busier during the peak office hours, especially in the inner roads. The vicious cycle of heating from traffic pollutants and emissions increasing the use of air conditioning, resultantly emitting yet more heat and pollutants, eventually lead to urban heat islands.

5. Design Concept

Analyzing and processing the most important aspects of the effect of heat islands in the area, major design problems arose. The urban tissue of the area, in the most part, was found contributing and worsening the phenomenon of heat islands. Thus, in order to face the problem, apart from environmentally wise solutions - such as enhancement of green, creation of green roofs and facades, etc. - changes in the design of the area seemed necessary in the process of minimizing the heat island effect.

More specifically, the whole area was intuitively separated into three different sub-areas along the railway. Each of these areas was handled differently and different strategies were developed for each one, with greater attention paid to the central one, meaning Raschplatz. However, on the whole area, an enhancement of vegetation and the creation of new green spaces is necessary, as the existing ones were found inadequate. For the other two sub-areas, proposed measures are less drastic. In the north-east area, where most of the higher buildings with flat roofs are located, a lot of them are selected as potential spots of green roofs. Where it is possible, the creation of green facades is also suggested, as far as the orientation, the height and the use of the building allow it. In the south-west area, although the urban fabric is dense, the height of buildings does not exceed the six floors.

Furthermore, most of them do not have a flat roof. As a consequence, the flat-roof buildings are detected, in order to bear a green roof and create a network of flat roofs.
On that part, there is also a great urban forest, in a very short distance to the area of interest, that is, however, not really affecting the microclimate as far as the heating problem is concerned. In order to enhance this relationship, the creation of multiple green corridors in strategic points is proposed, so that the connection between the area and the nearby city park is restored. This gesture is strengthened by the addition of some green facades along the green corridors on buildings that can support them.

However, the most important change that is proposed is on the central point of the area, namely on Raschplatz, as well as on Hauptbahnhof and Andreas-Hermes-Platz. In other words, at the same time of configuring a strategy in order to face the problem of heat islands, an upgrading of the junk space behind Hauptbahnhof (central station) is attempted. This aim is achieved through unification of this area with the commercial street of Lister Meile. The elevated road is removed, so it ceases to be a wind barrier, as well as a social limit. The pedestrian movement is established on the ground level and it is facilitated through a continuous route/square which unites the two „islands“. At the same time, green roofs, green facades, trees and vegetation on the square contribute to the problem of the heat island, on that spot. The building at the north part of the square becomes a landscape structure with a green roof. It constitutes an infrastructure for cultural uses, taking, also, up the square for outdoor activities and events, giving life to the area. In this way, the limit created by the elevated road, which had a part in the problem of the heat island of the area, as well as the isolation of the station, is removed, contributing finally in the revalorisation of the space.

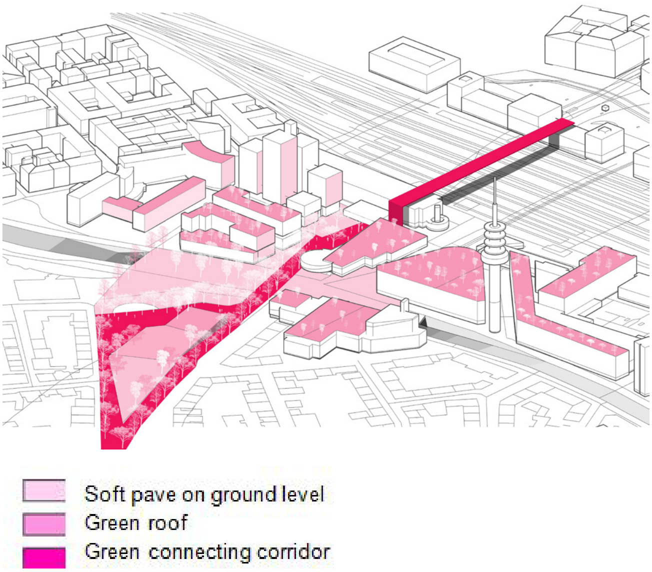

Fig. 6. Conceptual proposal in isometric view of the study area (own work)

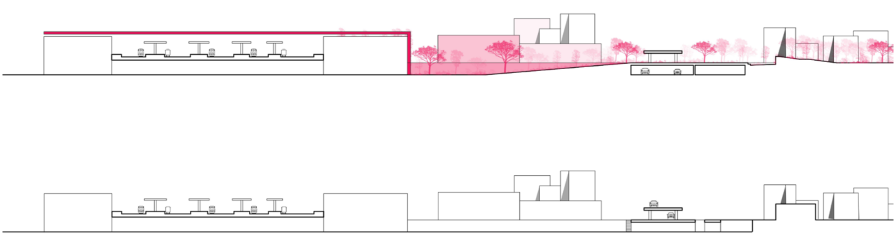

Fig. 7. Comparative conceptual proposal in section view of the study area (top-proposed, bottom-existing) (own depiction)

6. Recommendations

In order to improve the current heat island situation of the Raschplatz area, the following suggestions are made and described in detail below:

Creation of green spaces

Vegetation has a positive impact on the climate of the city. Airflowing over green spaces adopts the characteristics of these green spaces. The air gets purified, the humidity of the air increases due to the evaporation of plants and the temperature sinks. If the wind flow continues to move, heat affected sealed areas will be cooled accordingly (Landeshauptstadt Hannover 2016: 23). Increasing of green spaces in cities contributes to decrease in the urban surface and ambient temperatures and mitigates the heat island effect (Santamouris 2014: 684). A near-natural soil with an organic layer improves the city climate due to its water retention function. The lower surface heating of organic layers compared to sealed floors can reduce local heat islands (Landeshauptstadt Hannover 2016: 20). It is thus recommended to replace sealed areas with near-natural soil wherever possible. In case the sealing cannot be removed, a light-coloured sealing can reduce the heating-up of the floor (albedo effect). However, a possible dazzling effect must be considered (Landeshauptstadt Hannover 2016: 29). Large treetops also influence the city climate. They have a cooling and shade-providing function (Landeshauptstadt Hannover 2016: 23). Trees evaporate water through their leaves that keeps the temperature cooler around the trees. Already six trees within a 500 meter long and 10 meter large street canyon cause a cooling of the air of 5°C in case of a hot summer day with 35°C (Landeshauptstadt Hannover 2016: 24).

Roof greening

In densely populated and sealed areas, where there is limited space for trees in the street, roofs are often the only area to develop vegetation (Landeshauptstadt Hannover 2016: 21). Roofs provide an excellent space to apply mitigation techniques, given that the cost is relatively low, while the corresponding techniques are associated to important energy savings for the buildings. Green or living roofs are partially or fully covered by vegetation and a growing medium over a waterproofing membrane. There are two main types of green roofs: Extensive roofs which are light and are covered by a thin layer of vegetation and intensive roofs which are heavier and can support small trees and shrubs (Santamouris 2014: 683f). Usual pebble roofs and black roof fabric will raise the temperature to 50°C up to 80°C. The maximum temperature on green roofs is only between 20°C and 25°C (Landeshauptstadt Hannover 2016: 15). The greening of roofs reduces the heating-up of the building in case of intensive insolation during summer and serves the humidification of the surrounding air which leads to cooling of the air in sealed city quarters and balances extreme temperatures in the course of the year. In wintertime, it reduces the heat loss of the building and thus the need to heat and thus CO_2 emissions are reduced (Landeshauptstadt Hannover 2016: 21). Additionally, it presents a habitat for insects and other animals and raises the lifespan of the roof (Landeshauptstadt Hannover 2016: 13). It is recommended to do greening on roofs which have a slope between 1 – 5 ° as this is the easiest and cheapest option (Bauder 2019: www). The City of Hanover takes over of up to 1/3 of the costs for green roofs according to their existing Promotional Programme of Façade and Roof Greening.

Greening of vertical structures

The greening of facades has similar effects as the greening of roofs: The greening has a positive influence on the thermic, air hygienic and energy-saving potential of a building. The microclimate conditions of the building are improved, and extreme temperature differences are balanced through the course of the year. Also, the air quality will be improved because the plants bundle dust and air pollutants. They provide habitats for urban fauna and reduce noise pollution (Landeshauptstadt Hannover 2016: 28). Green facades reduce the local air temperature about 0.8 – 1.3°C - depending on the kind of greening - compared to usual non-green facades. 40-80% of the sunlight is reflected - depending on the thickness of the vegetation (TU Darmstadt 2016: 15). Again, the City of Hanover would take over of up to 1/3 of the costs for facade greening according to their Promotional Programme for Façade and Roof Greening.

If a facade greening is not possible or not desired, the changing of the facade colour might be an alternative: light colours of facades lead to a lower heating-up of single buildings itself and the city as a whole through to the albedo effect. Due to the reflection of the light, the energy will not be absorbed by the buildings. Dark material instead absorbs a lot of energy and emit it successively to the close environment. The combination of absorption, cold due to evaporation and reflection of insolation reduces the thermal load on the building and thus the need to cool down the building during summer (TU Darmstadt 2016: 12).

Another suggestion is the greening of the concrete pillars of the elevated highway. This measure too will balance temperature extremes throughout the year. Plants which survive the German winter are preferred. The plants should not be self-climbing as an uncontrolled expansion is not desired (Hannoversche Allgemeine Zeitung 2018: www).

Heat isolation of buildings

Apart from greening measures, a lot can be reached through an improved heat isolation of buildings: first of all, the availability of shade in and around the building should be considered. Thus, a heating-up of the interior rooms can be reduced. Insolation can be minimised through integrated shade dispensers such as arcades, solar panel, pergolas and access balconies or physical structures on facades and windows. A south orientation of the main window front is preferred towards an east or west orientation because the vertical shining south sun implicates a lower shading effort. Shade providing deciduous trees in front of the buildings will provide shade in the summer and still enough light during winter time due to their transparency (Landeshauptstadt Hannover 2016: 26). Extensive glass architecture should be avoided due to its energy inefficiency and heating-up during summer. Apart from that, classical air conditioning with active cooling should also be avoided due to the undesired side effect of an additional heating-up of the city area. Instead, passive measures such as a better heat isolation of the building, especially the roof and the reducing of inner heat sources such as artificial lighting during the day, technical equipment, and stand-by modus should be considered. This should be combined with a night cooling in an optimal way (free ventilation during the night) and shade-providing elements outside the building (Landeshauptstadt Hannover 2016: 27).

Creation of water surfaces

As a final recommendation, it is suggested to create water surfaces. In case of intervention in complex design or space scarcity, even artificial fountains contribute to some extent. Water fountains and moving water in general can contribute to local cooling and humidification of the air, despite their high costs. A cooling effect appears through evaporation of water. Stagnant water should be avoided because of the negative side effects such as mosquitoes and the risk of infections as well as the process of rottenness on a sinking water level (Landeshauptstadt Hannover 2016: 29).

Figure 8 shows how a part of the Raschplatz area looks today and how it would look like if all recommended measures were implemented:

Fig. 8. comparative visualisation of a part of the Raschplatz (existing vs. after implementation of recommended measures) (own depiction)

7. Conclusion

Urban planning, as well as urban design and other types of construction have extensive influence on the thermal behavior of a city. The heat island problems result from the physical form of the urban fabric but also from the planning processes. Like in the researched case study, some of the core conflicts of the area is traffic and infrastructure. The road network pattern, the proportion of streets and open area in relation to its surroundings, but mostly the roads act as a source of pollution and heat emission, has also impact on the thermal behavior of urban areas. This eventually leads to urban heat island phenomenon.

Dealing with the heat islands problem should be considered from the beginning of the planning process, because the renewal strategies are usually hard to implement according to the financial and social situation. Urban and construction policies need to be revised with preference of white or light-colored surfaces, heat reflective materials, reforesting cities, developing transport, and real changes in the behavior of future users of transportation which will not be achieved without an approach to promote the use of active and collective transportation. The city should consider urban remodelling through masterplanning combined with regulatory measures to make sure that cooling strategies like air-corridors are working well. For instance, the subject area has failed to establish any proper environmentally sustainable cooling strategy for not including this in the initial planning process, resulting in high buildings and walls at the edge, functioning as blockages. In the analysis and discussion, it is evident that random unplanned areas significantly affect the temperature. The accumulation of such type of growth and increased urban density over the years contribute to worsen the condition with further increase of temperature in the micro-climate. Urban heat island mitigation in the planning level reduces the demand for artificial air conditioning as well as cooling energy use. For sustainable heat island prevention, it is particularly important to characterise the urban surface according to its material properties and vegetation potentials. The effect of light-colored surfaces in roofs, walls and pavements and urban greens from grassland to tall trees on the micro-climate and air quality of the area needs to be estimated beforehand the planning process. Accurate estimation of surface properties will allow calculating the effect of the material's albedo in potential increase of temperature. Besides, in the case of urban vegetation, the impact can be measured on heat island reduction by ambient cooling. In the analysis of the site area, the role of green areas is self-evident for keeping a cooler micro-climate. This accentuates the importance of green and open areas in urban context in order to alleviate the heat island phenomenon. Besides more greens and water-face, the strategies like eco-building material and eco-lifestyle need more empirical studies. Thus, there is a need to combine all sectoral plans together to ensure the comprehensive benefits by making an environmentally friendly area and making an urban environment resilient to climate change in the city center.

Finally, it is also discussed that the absence of necessary urban management laws and reluctance to maintain building regulations for organizing urban areas have adverse effect in the thermal properties and thermal performance of the area. Consequently, poor urban design and management eventually lead to urban heat island phenomenon, which does not only affect human thermal comfort, but in a bigger picture contribute to global warming.

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