Urban Resilience, Governance and Climate Change.

Coping with the consequences of climate change in Hanover, Germany

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Preface

“Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience” (100 Resilient Cities 2019). Resilient cities are more resistant towards different kinds of risks and hazards (e.g. natural hazards, human-made shocks such as a financial crisis, etc.) and allow for integrated approaches. Resilience as a cross-sectoral topic is based on integrative strategies and overall guidelines, which have to be developed commonly and bring together political, economic and civil stakeholders to increase the adaptive capacity of cities.

In many cities, the question arises how and with which measures the resilience can be increased as well as how strategies for successful sustainable urban development can be implemented. Therefore, we are pleased that the German Academic Exchange Service (Deutsche Akademischer Austauschdienst) and the German Federal Foreign Office (Auswärtiges Amt) grant our joint research project or exchange “Resilience as Challenge for European Cities (HeKriS): Developing urban planning strategies and concrete projects” from 2017 to 2019. The project is based on a partnership between the National Technical University of Athens – NTUA (Faculty of Architecture) and the Leibniz University of Hanover – LUH (Faculty of Architecture and Landscape). The main objective of HeKriS is to qualify Greek and German students as well as young researchers to (1) understand the challenges of a sustainable and resilient urban development, (2) analyse the steering mechanisms and instruments and (3) develop appropriate strategies and measures for resilient cities, including new and robust governance arrangements between public, private and civil stakeholders (governance structures).

This publication is the result of the Hanover Summer School 2019 on resilient European cities and city-regions that took place from 22nd to 26th July 2019. This year’s summer school dealt with the issue of “Governance of Resilience: Environmental Challenges in European Cities”. The participating students were required to holistically analyse and develop planning strategies and concepts concerning vulnerabilities caused by climate change such as urban heat islands and floods in the area of the city of Hanover. This publication firstly presents contributions from scientists and experts involved in the summer school on the issues of local, regional and supra-regional approaches towards coping with internal and external shocks and stresses in the light of urban resilience. Secondly, it outlines the strategies, ideas and conceptual approaches for the local context in the city of Hanover developed by the participants in interdisciplinary groups. With the third publication of the HeKriS project summer school, we hope to contribute to the ongoing discussion on building more resilient and sustainable cities.

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Hanover and Athens
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Part 1

Introduction

Heterogeneous Perspectives of Urban Resilience – Dealing with Flood and Heat Events in European Cities

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Responding to climate change challenges

Numerous threats, stresses and shocks occurring from both natural hazards and human-made events are not only put on our ecosystems but further concern our urban and regional systems. Global warming has reached European cities and city-regions with its alarming impacts such as enduring heat waves and heavy flash floods. To react to these challenges and to reduce vulnerabilities in response to rapidly changing climatic conditions and growing urban complexities, various planning concepts have been introduced to urban and regional development.

This contribution deals with the issue of making our cities and city-regions resilient. The scientist Crawford S. Holling has been shaping the resilience research by having defined resilience as "[…] [determining] the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist." (Holling 1973: 17). Until today, his ecosystem approach has been further developed and translated into the field of urban and regional planning by becoming a holistic approach to problem-solving (Scharte & Thoma 2016: 127ff). Yet, the concepts' multiple facets and characteristics comprising economic, social and ecological aspects, challenge spatial planners and actors to successfully respond to uncertain conditions to serve for equal living conditions of citizens and to create attractive urban agglomerations. Being considered as a crucial step towards achieving sustainability, the notion of developing resilient urban landscapes has been becoming increasingly popular (see Brand et al. 2011; Bürkner 2010; Scharte & Thoma 2016).

European Perspectives for Resilient Cities

This publication offers heterogeneous perspectives and several solutions for tackling the challenges by thematically focusing on urban resilience research towards climate change. The following contributions specifically address threats from flooding events and the occurrence of urban heat islands. Crucial capacity-building actions and measures to cope, adapt and transform are demonstrated in six contributions to give valuable insights for shaping resilient European cities and city-regions.

Dirk Schmidt from the Climate Control Department of the city of Hanover introduces into the climate change adaptation strategy established for the City of Hanover. With his contribution **"The City under Climate Change: The Adaptation Strategy for the City of Hanover"**, he emphasises Hanover's increasing threats and consequences to climate-related stress such as the occurrence of urban heat islands and heavy rainfall events. For Hanover, aspects concerning town planning, water management and landscape planning are taken into consideration for a local climate adaption strategy plan that includes eight further pillars. Dirk Schmidt presents local planning examples focusing on flood protection, rainwater management, de-sealing, preventive soil and ground water protection and further measures. He stresses the importance of public awareness to build resilience within the city.

The following paper **"Urban vulnerability analysis towards heat - based on the example of the city Hanover"** written by Julia Michalczyk well-explains a research method to analyse heat vulnerability for evaluating capacities of heat avoidance and reduction in urban quarters. Affected areas in Hanover city are presented by mapping out areas, finding, that by 2050 the entire Hanover urban area will be vulnerable to heat. Simple measures of improvement dedicated to the functions of respective areas are proposed. Additionally, the role of vulnerability assessments for the maintenance of high quality of life and support decision-making in the context for climate adaption is emphasised.

Prof. Dr. Lutz Katzschner from Kassel university enlightens the topic of **“Urban climate evaluation for urban development and urban design”**. This third contribution gives ample explanation on designing climate-responsive as well as sustainable and energy-efficient inner-city settlement developments in the city of Frankfurt. By using urban climate maps, the case study provides detailed analysis and recommendation maps which are being used to vividly highlight the usage and importance of climate models for resilient urban planning.

The geographic location of the city-region Hanover has always been prone to flooding. Dr. Frank Scholles from the Institute of Environmental Planning approaches this issue for Hanover and its region by pointing out how good governance and urban planning support enabling flood resilience. The paper **“Governance of Flooding Risks in the Region and the City of Hanover”** offers valuable examples for experts and practitioners how successful flood prevention can be established by land-use planning.

The last two contributions are written by the professors Thanos Pagonis and Riva Lava from the National Technical University of Athens, Schools of Architecture who contribute with practical implications from Greek contexts.

Prof. Dr. Thanos Pagonis discusses **“The regeneration of Lycabettus hill as example of resilient planning”** in Athens. He links the resilience concept with an urbanism that he highlights as being a crucial factor for urban resilience. The author presents recent challenges of Athenian urbanism in the city before referring to the Lycabettus programme to explain the regeneration of the hill in relation to urban governance structures. Approaches towards urban resilience are elaborated.

Prof. Dr. Riva Lava’s research is located at the Greek island Santorini in the 21st century by exploring the island’s role in tourism, resilience, identity and the future. Graphically, she outlines Santorini’s natural and societal challenges of dealing with local challenges. In **“21st century Santorini - tourism, resilience, identity and the future. Public awareness as the focus of NTUA pedagogics”** Prof. Dr. Riva Lava exemplary presents ways of resilience-building in Santorini by focusing on the topics of modern heritage, traditional settlements, landform and inhabitation as well as the cultural carrying capacity.

These excellent contributions enrich resilience research by providing theoretical input and practical frameworks, guidelines and examples for expert, scientists and practitioners for coping with climate change and building urban resilience.

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1. The City under Climate Change - The Adaptation Strategy for the City of Hanover

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Abstract
The paper shows the impacts of climate change in the city of Hannover. Problems with heat load and extreme weather events (heavy rain, summer droughts) are already in existence. In the future, these impacts are expected more often und more extreme. Hannover has dealt with the consequences of climate change at an early stage and has already developed a local adaptation strategy in 2012. The strategy comprises of eight fields of action, which were defined as particularly significant. The article describes the adaptation measures which are implemented in the last years and which are necessary in future to maintain the quality of life for the people living in Hannover.

The Complex of Problems Regarding the Urban Climate

The climate of a city differs significantly from that of a widely undeveloped landscape. This is primarily due to the changes caused by human building activity (housing, trade and industry, traffic areas), whereby the soil and surface characteristics, the water balance and the air composition are changed sustainably. The typical urban climate is influenced by the degree of sealing and the proportion of green space, the building structure (height, density, shape and arrangement of the buildings), the heat storage capacity as well as the thermal conductivity of the artificial surfaces and by air pollutants and waste heat.

The larger a city, the more intensive is the formation of a heat island and therefore the temperature difference to the undeveloped surrounding area. This is pronounced distinctively during summer nights, and it amounts to a maximum of seven to eight degrees centigrade in Hannover. This is also illustrated in the climate analysis map of the City of Hannover, that was developed in 2016 (Geo-Net 2016). During a summer night, the warmest sectors are found in the inner city and on the large industry and trade areas, the coolest sectors at the outskirts and in the river meadow.

The city climate is most distinctly formed during so-called autochthonous weather conditions. These are low-wind high-pressure weather conditions with dominating local influences. These weather conditions can appear annually on 15 to 25 per cent of the days in Lower Saxony.

Besides local climatic changes, the high extent of sealing has further consequences for the city. Due to the sustainably changed soil and water balance, heavy rain events can more often lead to flooding and thereby damages to streets and buildings. There are examples of this in many German cities. Severe flooding as a result of heavy rain with corresponding damages occurred in Dortmund and Bad Honnef on 20th June 2013, in several communities in Bavaria and Baden-Württemberg on 29th May 2016 as well as in Hannover on 22nd June 2017.

Intensification of Negative Consequences for the City of Hannover due to the Climate Change

The negative consequences of the dense urban building development will appear more often and more extreme with the continuing climate change. In Hannover, the following changes are to be expected:

1. Increased heat load, heat waves, a significant rise in the number of hot days and tropical nights with negative effects on human health

2. Changes in the distribution of precipitation, an increase in heavy rain and extreme weather events resulting in an increase in the risk of flooding and damages to buildings and associated infrastructure

3. Increase in periods of summer droughts with negative effects on agriculture, forestry and water management.

For the City of Hannover, the summer heat stress, changing under the influence of climate change in the course of this century, was simulated by means of a model calculation. Depending on the building structure (density of construction or proportion of green respectively) the number of days with heat stress varies in parts significantly.

In the inner city of Hannover, the number of very hot days (days with a maximum temperature of more than 30°C) will increase from actually nine to ten very hot days per year to 12 to 13 very hot days until the middle of the century. By the end of the century, there will be 21 to 22 very hot days on average (see Figure 1). As a result, the number of very hot days in the inner-city sector will more than double until the end of the century. Within the green areas, like the Herrenhausen Gardens, the number of very hot days will increase from actually two to three days up to nine to ten days until the end of the century (Geo-Net 2006).

Therefore, it can be concluded that the areas, in which the consequences of the global warming will become particularly evident, are characterised by an urban structure with a high building density, a high building volume and a low level of green facilities.

On top of that, the climate projections show, that the heat periods will last longer and their start will be moved into the springtime, a season, in which the human organism is not yet accustomed to the heat and therefore reacts more sensitive to heat stress. People affected by heat stress will mainly be older and weakened persons but small children, too. Against the background of the demographic change and the observed trend, that older people move from the surrounding regions into the city again (shorter ways, a higher level of service offers) the number of affected (heat sensitive) people will increase even more.

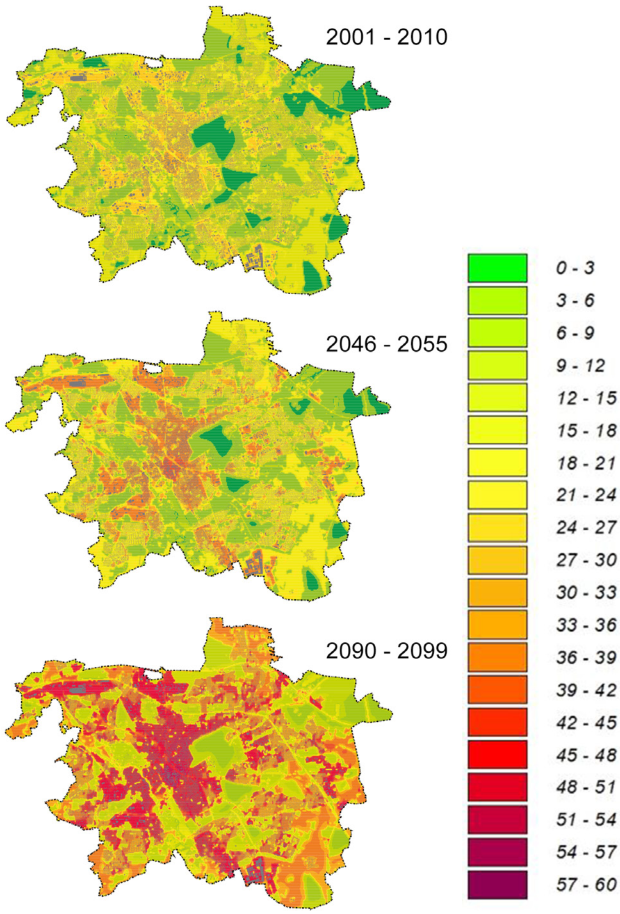

Fig. 1. Summer Heat Stress under the Influence of Climate Change in the State Capital Hannover – Average Number of Days with Strong Heat Stress at the Beginning, the Middle and at the End of this Century. (Geo-Net 2011)

The Adaptation Strategy for the City of Hannover

Although the climate simulations forecast the most serious changes only for the second half of this century, the course has to be set today already for a climate-adapted sustainable development of Hannover. Since 2009, the Division Environmental Protection of the City of Hannover is intensely involved with the subject "Climate Change and Adaptation". The reason was, amongst others, the resolution of the German Adaptation Strategy by the Federal Government in December 2008. What started with a thesis paper "Adaptation Strategies towards Climate Change" led in 2010 into the cross-departmental development of the adaption strategy for Hannover.

With regard to the expected changes caused by climate change (see above), three working groups were established, which developed adaption measures for different subjects. The results of the individual working groups were a central component in the development of the adaption strategy for the City of Hannover.

The "Adaption Strategy to Climate Change for the Capital City Hannover" was made public in April 2012. It comprises of eight fields of action, which were defined as especially important within the framework of the working group phase.

1. Flood Protection
2. Rainwater Management and Handling of Heavy Rain Events
3. Preventive Soil and Groundwater Protection
4. Roof Greening
5. Climate-adapted Vegetation
6. Climate-adapted Urban Planning and Climate-adapted Construction
7. Specific Map Climate Adaptation
8. Public Relations and Educational Activities

For the implementation of the initial adaption measures, the "Programme for the Minimization of the Consequences of the Global Warming" was compiled and provided with funds to a total of 1,050,000 Euros for the period 2012 to 2016. Furthermore, some measures were funded through other programmes (e.g. Flood Protection, Street Restructuring).

Examples from the Action Programme

Action Field 1: Flood Protection

The Action Programme "Flood Protection in Hannover" with an investment volume of about 30 million Euros covers several actions. At first, the outflow width of the river Ihme in the area "Schwarzer Bär" had to be expanded. Therefore, the Benno-Ohnesorg-Bridge had to be reconstructed (see Figure 2). The old bridge formed a bottleneck, which slowed down the floodwater runoff and caused floodings in the south bordering city regions. With the new bridge, the span was significantly increased by 21 metres. As a further measure, the foreland on the east side of the river was dug out by 1.5 to four metres over the length of 1.2 kilometres, and thus the volume for flood retention was increased.

Besides that, the extension of the dyke in the city district Ricklingen was part of the action programme. There had been a gap in the existing protection systems which was closed by means of an earth wall and a protective wall.

In the past, the originally near-natural rivers and brooks were strongly straightened and with the usage of the near-natural meadows flood plains were lost. In the course of flood events, the loss of natural retention areas leads to the increase of the high-water mark, particularly in the lower course of waters (and especially in the Leine river). In 1996 the Hannover Council decided to develop the Hanoverian flowing waters more near-nature and structured again. Integral parts are, amongst others, the creation of high-water profiles with variably designed slope angles and berms in medium water height, the creation of reserve river meadows by the construction of structurally rich riparian strips and the expansion of flow-off profiles. The measures are aiming at slowing down the outflow of the flowing waters and thus moderating the flooding events. Meanwhile, 22 waters have been completely or partially redesigned near to nature since 1996.

Fig. 2. The Reconstruction of the Benno-Ohnesorg-Bridge with the Newly Designed Ihme Embankment. (Department Environment and Urban Greenspace, State Capital Hannover)

Action Field 2: Rainwater Management in the Handling of Heavy Rain Events

An important part of the adaption strategy concerns the rainwater management. The aim is water-sensible urban development. Floodings should be avoided as far as possible and the canalisation relieved through the retention of water on the surface as long as possible (without causing damages). Particular importance in this respect is laid upon the multi-usage of areas. Innovative solutions and new views of “Water in the City” are required. This also includes the acceptance of water at places, where it is usually not found.

The following measures are examined and where possible implemented:

- Identification of city districts/street areas (e.g. sinks), which are especially threatened by floods in case of heavy rain.
- Relief of these areas through suspension of lateral (canalisation) inlets or connection of these areas to less burdened sewers / areas.
- Creation of additional seepage areas (also independent from development planning procedures).
- Targeted control of the runoffs for rainwater including the respective design of these areas (emergency waterways) by the inclusion of heavy rain events into the planning of streets, ways and places; extension of traffic areas as backwater areas.
- Adaptation of the design of street profiles, curbs and house entrances to water drainage necessary in case of heavy rain

events.
- Temporary usage of green areas as emergency overflow areas (multi- and interim usage of areas).
- Retention of rainwater through temporary technical storages (cisterns). Usage of the water for the irrigation of public spaces during dry weather periods.
- Desealing of paved surfaces, especially in highly sealed city districts and permanent greening of these areas. Examples: Desealing of no longer required / over-dimensioned traffic areas; enlargement of tree-grids in the inner city, desealing of inner courtyards, reduction of the traffic area at the “Hohes Ufer” through the construction of a green corridor according to the programme City 2020).

An example of rainwater management in a development area is the “Zero:e park” on the southern periphery of Hannover. 300 private homes were erected here in a passive house method of construction. A trough-trench system manages the drainage of this area. Surplus water is retained in three dry rainwater retention basins and led throttled into the receiving water (Hirtenbach). Despite the sealing, no more water is led into the receiving water as was before the development of the former farmland.

The development area “Herzkamp” in the Bothfeld city district (250 housing units) which is actually under construction, is completely built without a rainwater canalisation. The rainwater is drained away in road-accompanying troughs and troughs within greenspaces. In the case of heavy rain events, emergency waterways and overflows take care of a damage-free discharge into the greenspaces bordering the construction area.

Action Field 3: Preventive Soil and Groundwater Protection

Near-nature soils contribute to the improvement of the city climate. Due to the lower surface heating and the higher evaporation of near-nature soils in comparison to sealed areas, heat extremes can locally be diminished. The water retention function of near-nature soils contributes to the reduction of impacts of heavy rain events and dry summer periods. Therefore, the positive climatic effects of the soil should be maintained as much as possible, and the soils have to be protected in the best possible way against the impacts of climate change.

The adaptive measures contain:

- Maintenance of near-nature soils that are still existing in the city
- The reutilisation of already built-up areas
- Desealing of areas and
- Restoration of natural soil functions.

In 2013, a traffic area of about 4000 m^2 could be unsealed and after that greened. This refers to the bus lane on Friedrichswall, which led past the New Town Hall between Willy-Brandt-Allee and Lavesallee. Further desealing on a smaller scale was carried out since 2012 in connection with the renovation of three locations.

Action Field 4: Roof Greening

The adaption strategy of the City of Hannover also provides for a promotion programme for façade and roof greening. This programme started in 2012 and is offered in cooperation with the non-governmental organisation BUND ("Friends of the Earth Germany") for the Hannover Region. The BUND informs building owners about the advantages of roof and façade greening as well as the funding opportunities that were made available by the City of Hannover. Funded are up to a third of the eligible costs of a measure. In case of roof sizes up to 250 m^2, this amounts to a maximum of 3,000 Euros, with more than 250 m^2 to a maximum of 10,000 Euros. Apart from the roof greening, façade greening is funded up to a third of the costs. This amounts to a maximum of 3,500 Euros with a greening of multi-layer exterior wall structures (thermal insulation system, suspended façades) and a maximum of 500 Euros with all other façade greenings.

Ideally, the greened roof should be combined with a photovoltaic system (see Figure 3). The experiences of recent years have shown that the efficiency of these systems is better than on tarmac or gravel roofs.

The positive effects of a roof greening are:

- Retention of precipitation (up to 70% with extensive and up to 90 per cent with intensive greening)
- Reduction of peak discharges by 50% (remaining runoffs are released time-delayed into the canalisation)

• Cooling of the surroundings by water discharge and evaporation (evapotranspiration)

Furthermore, roof greenings offer a habitat for numerous plants and animals and increase, thereby the biodiversity, especially in densely populated urban quarters.

Fig. 3. On the roof of the maintenance depot Stammestraße a photovoltaic system was installed in addition to the roof greening. (Department Environment and Urban Greenspace, State Capital Hannover)

A mapping of greened roofs in the year 2016 showed that in the City of Hannover 3,131 roofs with a total area of about 836,200 m^2 have been greened. The greened roofs can primarily be found in commercial areas. In residential areas mainly subterranean garages and single garages are greened. Thereby the number and size of greened roofs increase from the inner city to the outskirts. The largest greened roof has a size of 9,645 m^2.

Action Field 5: Climate-adapted Vegetation

Vegetation has a large influence on the urban climate and has a positive effect on its surroundings. A body of air flowing over green areas adapts to their properties. The air is cleaned, the evaporation of plants increases the moisture of the air, and the temperature is lowered. If the body of air changes its position, e.g. resulting from corridor winds into a neighbouring residential area, its positive properties will be carried further, the heat-burdened residential area will be cooled.

Trees with large crowns are climate-effective elements within a city. Especially their cooling effect in summer and their function as providers of shade are of great importance for the reduction of thermal stress.

However, the plants themselves are affected by climate change. Summer heat- and dry periods lead to impairments: they dry out or discard their leaves. Thereby their bioclimatic function (creators of cool air, air moisturizers) is strongly reduced. So, in Hannover, copper beeches had already to be felled, which were damaged by “Climate Stress” over several years.

With all replacement plantings of trees and bushes in the future, the conditions altered by climate change must be taken into consideration. Therefore, the following measures are carried out, especially in the heat burdened, densely populated city quarters:

- Choice of shrub species that are better suited to the future climate situation (choice from the Climate-Species-Matrix; Klima-Arten-Matrix, KLAM)
- Irrigation of the urban green areas. In this context, alternatives to drinking water are preferred (cisterns, rain retention basins)
- Enlargement (desealing) and substrate exchange at tree grates in order to increase the vitality of the trees

A fundamental renewal of the tree population in the southern part of Philipsbornstraße was carried out in 2012/2013. The row of street trees standing there, consisting of Norway maple and Sycamore trees was in a desolate condition. After the removal of the trees, the root areas were restored, the tree grates enlarged by desealing measures and with Ginkgo tree and Honey locust two drought-tolerant species were planted.

In 2014, a total of 14 trees were planted on both sides of the street in an up to then a non-greened section of Sallstraße to shade the pavements and roadways. This will have a positive effect on the temperature field of the street. The shading by the trees can lower the near-ground temperature on a sunny summer day by up to 12°C in comparison to a non-shaded street.

Action Field 6: Climate-adapted Urban Planning and Climate-adapted Construction

The target of a sustainable City planning is the permanent assurance of a good quality of life for the inhabitants in all parts of the city. To this belong healthy living and working, the supply with goods of daily requirement as well as easy accessibility of all necessary resources, leisure and nearby recreation possibilities and a maximum level of security against the impacts of catastrophes and bad weather events.

Sustainable city planning empowers the so much needed consensus for action against climate change worldwide.

The climate changes that have to be expected require a rethinking of the traditional practise for planning and construction of buildings and the layout of open spaces as well as in parts the integration of new building standards, adapted to the changed conditions.

Particularly the spatial interconnectedness of open spaces and built-up areas, hence the city structure as an entity, can buffer negative impacts of climate change. To what extent the existing structures are sufficient and whether additions will be required at certain points, in order to maintain the residential location, Hannover as worth living in has to be carefully assessed in the course of every new planning as well as during the overplanning of the portfolio.

Substantial for climate-adapted urban planning is also the consideration of the requirements and rhythms of life of the population, changed with the climate, as well as the active inclusion of the residents in the development and realisation of climate-adapted behaviour patterns.

With regard to the city structure, it is especially important to continue specifying “The City of Short Ways” in future as an essential target for the city administration. Compact building structures are, in favour of maintaining directly adjacent open spaces, especially suited to develop a climate-adapted urban structure in already densely built-up locations, to point out and to increase the attractiveness of alternatives to the motorized traffic and thereby counteract the heating-up.

Especially important in this context is, of course, the preservation of cold-air productive open spaces, fresh air corridors and the graduated green system of close-to-home, city-district-near and wide-ranging green spaces. A large-scale connection between urban and regional linking of open spaces should be ensured because they represent important cool air delivering areas for the City of Hannover.

Provided an analysis of existing and presumably newly occurring “Hot Spots” has been carried out, the laying out of new green spaces can be necessary to counteract an overheating of the densely built-up city areas. Interlinking of the new green-spaces with existing ones ensures the development of a climate-adapted urban structure in this way.

It makes sense to connect a compact, area-saving development of settlements with an open space structure concept, that limits the residential development in the interior area to an adequate construction density. A redensification should furthermore take priority over an unlimited exterior development.

Further elements / measures for a climate-adapted city are:

- Shade giving greens (deciduous trees with large crowns and pergolas) as well as structural shade creators (arcades, sun sails)

- Fountains (moving water) at places with a high thermal load (see Figure 4)

- Optimising the cooling of buildings (avoiding the usage of air conditioning systems)

- Light-coloured surfaces and façades (usage of the Albedo-effect)

Fig. 4. The Trammplatz in front of the New Town Hall – on hot days, the fountains offer a welcome cooling possibility in the city. (Department Environment and Urban Greenspace, State Capital Hannover)

Action Field 7: Specific Map Climate Adaptation

In order to steer the urban development in the direction of a "climate-adapted" city, the aspects of climate change must already be considered before the planning stage, e.g. of construction planning and urban development planning and be integrated in the plans. Therefore, a "Specific Map Climate Adaptation" at the scale of the Land-use Plan was developed as part of the adaption strategy. It is meant to serve as a decision support tool for the implementation of adaptation measures and as a basis for all climate-relevant planning.

The specific map shows, for example, important cool air delivering areas and bioclimatically higher burdened settlement areas. Climate comfort islands are displayed, smaller cool air delivering areas (less than 2 hectares) like greened inner courtyards and public places with a welfare impact which is in general limited to the area itself and does not unfold a long-distance effect (like larger cool air delivering areas do). The climate comfort islands offer, especially on very hot days, pleasant places of stay for the city residents. Furthermore, the specific map points out areas, in which a significant rise in the heat burden will take place until the middle of the century. Moreover, institutions like day-care centres and hospitals are shown, in which people stay who react more sensitive to heat stress. Additional information of the map relates to the floodplains along the rivers that are defined by law and residential areas with an above-average population density.

It is planned, to include further subjects in the specific map in future.

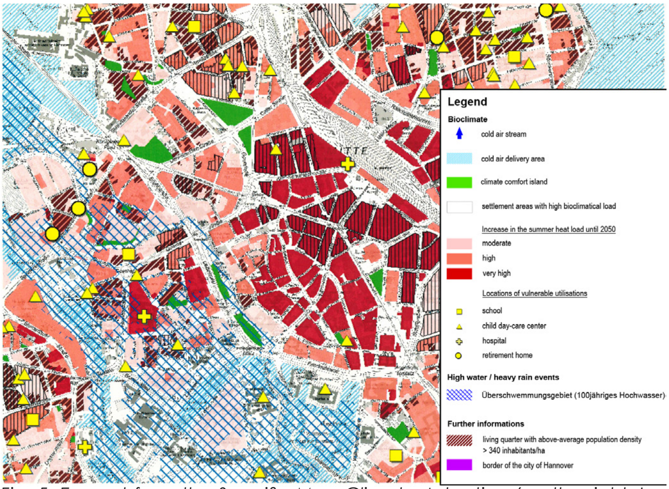

Fig. 5. Excerpt from the Specific Map Climate Adaption (on the right: Legend). (Department Environment and Urban Greenspace, State Capital Hannover)

Action Field 8: Public Relations and Educational Activities

It is very important that the population will be informed about the subject of climate change and the possibilities of adaptation measures. Because the citizens of the city are not only persons affected by the climate change but also actors who themselves are responsible for the implementation of adaption measures, for example through a change in behaviour during heat periods or through taking precautionary measures on their houses to protect them flooding or storms.

The City of Hannover offers material on the subject of climate change for day-care centres and schools. Furthermore, it informs citizens by flyers and brochures (e. g. Tips for behaviour on hot days) but also through public lectures. Between 2013 and 2017 the city organised in cooperation with the Adult Education Centre Hannover a series of events totalling eight lectures on different aspects of the climate change.

Conclusion

Climate change represents great challenges for the cities. Especially larger cities will feel the consequences of the climate change even stronger because their climatic conditions have changed due to strong sealing and dense building as well as through waste heat from factories, air-conditioning and cooling systems, central heating and car exhaust gases. The city is warmer, dryer and less exposed to the wind than the rural surrounding. Climate change will increase this effect even more.
This requires short-term measures, to protect for example the health of citizens but also long-term measures, for example in the urban development planning in order to counteract inner-city heat islands, to minimize the danger of flooding during heavy rain events or to adapt the city trees to the changed climate conditions.

The Capital City Hannover had already published an adaption strategy to the climate change in 2012, that contains eight fields of action with a bundle of measures. In the same year, the "Programme for the Minimization of Impacts of Global Warming" was compiled, and the initial adaption measures were implemented.

The aim of a long-term adaption strategy is, to maintain the quality of life for the people living in Hannover at the present high level and where possible even to increase them through adaption measures to the changed climatic conditions, that are initiated as early as possible. Therefore, it is necessary to think ahead and to act, whereby a climate-adapted urban development is maintained, and the resilience is promoted.

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2. Urban vulnerability analysis towards heat based on the example of the city Hanover

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Abstract

The exposure to heat is currently seen as the most important direct impact of climate change on human health (Menne 2011: 6f). In areas with high levels of sealing and low aeration, the overheating in cities leads to urban heat islands. This results in an acute need for action for urban and environmental planning to optimally exploit the potential of local measures to mitigate this stress situation for urban residents and to be able to localize the adaptation measures to the changing climate. Against this background, planning action is crucial to the reduction of vulnerability as well as the targeted establishment of adaptation capacities against the effects of climate change (BMVBS 2010: 10).

This master-thesis aim to use a GIS-based analysis to accurately identify the vulnerabilities of the city of Hanover against heat (depending on the different adaptive capacities of the room). The work shows that against the background of increasing climate change, the determination of the vulnerability of urban areas plays a central role in maintaining healthy living quality. Furthermore, this work has shown that vulnerability analysis is a central starting point when it comes to identifying vulnerable uses of space against the effects of climate change and making them more adaptable through planning measures.

Introduction

Climate change and fluctuations have already been recorded in the past. However, human activity has never before had such a rapid and significant impact on the climate as it has in recent decades (UBA 2012: www, IPCC 2014: 6f).

According to the Intergovernmental Panel on Climate Change (IPCC) (2007), climate projections assume that the average annual temperature in Germany will warm increase by 1.8 to 4,0 degrees between 2081 and 2100 compared to the reference period 1980-1999 (Federal Government 2008: 8f). Climate change will vary significantly from region to region and season to season.

The frequency and intensity of extreme weather events will increase overall. In the future, there will be fewer cold days, but the number of summer days (daily maximum above 25°C), hot days (daily maximum above 30°C) and tropical nights (daily minimum not below 20°C) will probably increase significantly (SMUL 2005: 9f; Witting & Schuchardt 2013: 43; UBA 2017: www). Due to the rise in temperature and the higher number of heat days, there will also be more frequent heat periods, which may last longer (Witting & Schuchardt 2013: 43).

This range of possible climatic changes influences in particular future-oriented planning projects, so that climate change is becoming increasingly crucial for planning (BMVBS 2009: 5; Rössler et al. 2014: 1). Compared to rural areas, large cities, urban regions and their inhabitants are particularly affected by extreme weather events and face challenges of adequate adaptation to climate change (BMZ o. J.: www; Witting & Schuchardt 2013: 43). Due to large surfaces of sealing, the concentration of the population, the durability of built infrastructure or the excessive input of air pollutant emissions, cities heat up much more than the surrounding countryside, a fact which can be summarised under the terms “urban heat”-problem or “heat island effect” (Steinrücke et al. 2010: 1, Stadt Karlsruhe 2013: 78). Additionally, there are high settlement pressure and still-rising demand for housing, which tends to exacerbate the problem even further (GEWOS 2013: 4; Stadt Karlsruhe 2013: 78).

Consequently, there is an increased need for action in urban areas - in comparison to the surrounding countryside. When developing adaptation measures for the consequences of climate change, it should be noted that each city has its own urban climate as a result of its respective urban structures (so-called urban climate). So that cities, individual districts and even apartment blocks can exhibit different sensitivities and vulnerabilities (LHS Stuttgart 2017: www). The significant impact of climate change, particularly in the case of heat pollution, does not only affect human health in the sense of a healthy life, work and environment. Human health (in terms of healthy living and working conditions) is most affected by the consequences of climate change (Campe et al. 2015: 343f). Especially in inner-city quarters, due to the heat islands, is associated with the heat-induced health burdens for the residents and an impairment of the residence quality (IPCC 2014: 16; Holst & Mayer 2010: 13, Bongardt 2013: 13).

To improve the performance, well-being and health of people, the cities and conurbations will inevitably have to focus more on the future of the adaptation to the consequences of climate change (Steinrücke et al. 2010: 1). In the future, urban development will have a unique role. It should develop solutions, which are optimized for urban climates in order to reduce the thermal stress within the settlement area even under extreme heat conditions (Stadt Karlsruhe 2013: 78).

However, it is not only the warmer urban climate that increases health and physical stress. The sensitivity of human beings to heat also determines the level of stress. Not all people are affected equally: Especially the elderly, sick people or Infants are more sensitive or more susceptible (so-called vulnerable children population groups). However, even healthy people, heat can lead to exhaustion and lead to reduced productivity (BMVBS 2009: 22, Stadt Hannover 2009: 2; IPCC 2014: 16; Rössler et al. 2014: 1, UBA 2015: 606ff). To adapt to the heat islands in urban areas, it is, therefore, necessary to identify the likely effects, to assess them as best as possible and to represent them spatially. Only on this basis, climate-change-adapted structures can be developed in order to reduce the risks for human health and the environment or delete them.

Thus, the urban climate and its effect on humans acts as a decisive factor in urban planning and, against this backdrop, they are also a key factor for the establishment of legal principles (e. g. §1 para. 3 no. 4 BNatSchG or the Federal Immission Control Act) (Reiss-Schmidt & Beckröge 1993: 58f; Matzarakis 2001: 9).

According to recent developments in urban and landscape planning principles (see Federal Nature Conservation Act §1 Para. 3 No. 4 BNatSchG or BauGB 2011 (§1 Para. 3 No. 4 BNatSchG or BauGB 2011). 1 para. 5 BauGB), it becomes clear, that urban climatic issues and their effects are already relevant to planning and will be among the most important tasks of spatial development in the future due to the increasing number of extreme weather events (Spieckermann & Franck 2014: 159). Although climate change and extreme weather events cannot be excluded from planning processes, the vulnerability of the population and cities can be reduced through foresighted action (adaptation).

Therefore, of essential importance are the identification of heat-sensitive as well as affected areas and the derivation of local spatial vulnerabilities within the urban periphery. An urban vulnerability analysis against heat stress using the example of the City of Hanover can record and evaluate affected urban areas, as well as their vulnerability, as determined by compensating adaptation capacities.

Concept and aim

Vulnerability to heat stress results from social aspects demographic sensitivity as well as from use-related sensitivity (degree of sealing) including compensatory reduction and alternative capacities. The work aims to identify vulnerability precisely (depending on the different adaptation capacities of the space) and to determine where adaptation measures are necessary and which areas should be given priority. The results are presented in maps and are intended as a decision-making aid for the implementation of adaptation measures.

Methods

There are hardly any standardized methods in the literature for investigating existing vulnerability (Weis et al. 2011: 12). The methodological steps of vulnerability analysis were mainly oriented to sections of the vulnerability analysis in the Region of West Saxony in May 2011 (Schmidt et al. 2011).

First, the first component of vulnerability, the exposure to heat, is described. In addition to exposure, sensitivity is also considered. Shown are two different sensitivities. The third result is the intersection of the sensitivities and the exposure, this results in **an area that is affected.**

The Exposure describes the heat islands in the city (status 2006). These areas are characterised by dense building development and high degrees of sealing. Due to their greater distance from greened areas, they are no longer sufficiently ventilated during higher temperatures at night (Department of Environment and City Green 2015: 2).

The exhibition shows current heat islands, but also future rooms burdened by heat, in which the summer heat load will increase until 2050. The gradation is carried out in the categories moderate, high and very high Increase of days with heat load during the period 2001-2010 to 2046-2055 (Department of Environment and City Green 2015: 3). In addition to exposure, **sensitivity** is also considered. This reflects the sensitivity of the population (BMVBS 2011: 5) towards the phenomenon.

To determine the sensitivity of the people to heat stress, two aspects should be considered.

A. Sensitivity to use describes exposure to heating effects due to sealing.

B. Demographic sensitivity describes the sensitivity of people to heat stress, depending on their age or condition of health. Another factor of demographic sensitivity is population density per hectare (Schmidt et al. 2011: 48).

The intersection of the sensitivities and the exposure results in **an area that is affected.** This mainly depends on the geographical distribution and the possible overlapping of the sensitive areas in the climate-charged urban space. In addition to the determination of the areas currently affected, the analysis will also be carried out in future identified affected areas. After determining and evaluating the local impact, **the adaptation capacities** are determined. To maintain well-being and quality of life as well as the reduction of climatic stress in urban areas, there are several different adaptation concepts. In the result, there is an **adaptation by reduction** or also an **adaptation by evasion.**

A reduction capacity exists, for example, through the presence of areas producing cold air such as forests, water bodies or agricultural land. Such entities cause a reduction of heat stress of the areas affected within urban space by radiating effects.

In contrast, the avoidance capacity describes the presence of climatically favourable areas that can be visited in the event of increasing heat loads. Due to their small size, these areas have no mitigating effect on the surrounding buildings (Schmidt et al. 2011: 53). In the context of two different adaptive capacities, two different vulnerabilities of space arise accordingly (BBSR 2016: 21).

The assessment of the vulnerability of urban spaces to heat within the framework of their **reduction capacity** results from the combination of demographic sensitivity and exposure as well as the use-related sensitivity (this component based on the degree of sealing, includes compensating reduction capacities). Vulnerability within the framework **of the alternative spaces** results from the combination of the affected areas with the alternative capabilities (alternative spaces within walking distance).

Results

The results of the individual steps of the vulnerability analysis are described below. The data on exposure were given and are, therefore, not described in the results chapter. The first partial result was the spatial determination of the sensitivities. The next step was to determine the affected areas in relation to heat. This result, in combination with the adaptive capacities, finally resulted in the vulnerability of urban spaces.

Sensitivity - The sensitivity is based on two indicators: firstly, the demographic sensitivity, which relies on the proportion of senior citizens in the total population, the population density and the density of socially sensitive facilities, and secondly, on the usage-related sensitivity. The second indicator is the degree of sealing, which, according to Mosimann (et al. 1999) is derived from the land-use mapping (ATKIS Basis DLM).

Results on demographic sensitivity

The map (see Figure 1) depicts the urban areas in which demographic sensitivities overlap and spaces are to be assessed by different sensitivities. The population density, the proportion of senior citizens and the density of sensitive social facilities overlap. The demographically sensitive areas were assigned to a 5-step sensitivity scale. Areas with a very low demographic sensitivity are located outside the city, where the population density is very low, the proportion of senior citizens is deficient, and the density of social facilities is very low. These are, for example, the characteristics of the districts Misburg-Süd, Lahe or Isernhagen-Süd. Due to the concentration of high individual sensitivities, the districts Oststadt, Vahrenwald, List, Südstadt or Linden-Nord and Linden-Mitte are highly demographically sensitive. One striking feature is the concentration of high to very high demographic sensitivities surrounding the medium-sensitive districts of city-centre, Nordstadt and Calenberger-Nordstadt.

Results on use-related sensitivity

The higher the degree of sealing of a surface, the higher is the degree of sensitivity of the surface to heat. Highly sensitive areas include mainly industrial and commercial areas, traffic areas but also areas with restricted development methods. The housing estates with an open construction method and individual buildings as well as railway facilities are less sensitive. Green areas and open spaces that are not sealed, such as forests, water bodies and agricultural areas, are not sensitive to heat loads. These areas are shown in white on the map.

Legend Degree of sealing
Sensitivity due to use shown in five categories

(white)	No sealing (green and open spaces)
(light grey)	Hardly any sealing (< 25% sealing)
(light yellow)	Low degree of sealing (25-50% sealing)
(pink)	Average degree of sealing (50-70% sealing)
(red)	High degree of sealing (> 70% sealing)

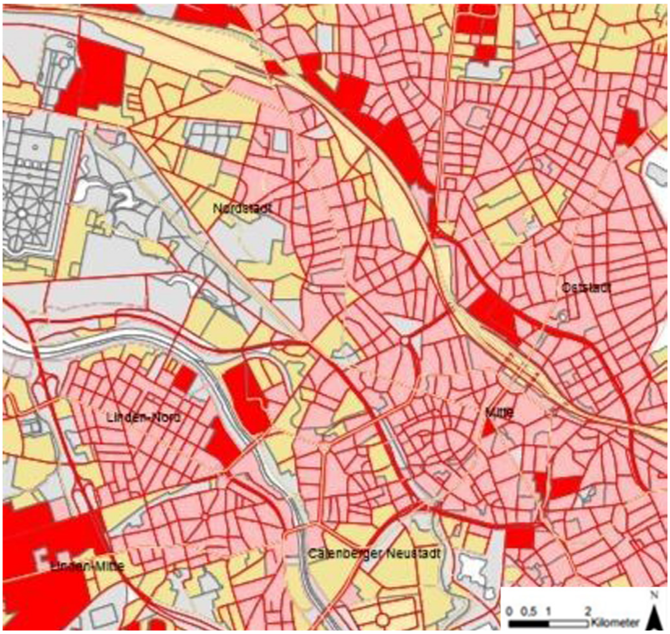


Fig. 1. Degree of sealing – Sensitivity due to use shown in five categories. (Michalczyk 2017)

Results of the affectedness

<u>The Current</u> affectedness is composed of the aggregation of demographically sensitive areas with highly bioclimatic settlement areas. Three levels of concern in the urban area were identified: medium, high and very high. Larger areas with medium levels of exposure to heat are primarily commercial and industrial zones outside the city, in the districts of Stöcken, Brink-Hafen and Mittelfeld. In comparison, very severely affected areas can only be found in smaller parts of the urban area. These areas are located in the districts of Vahrenwald, List, Südstadt and Oststadt.

<u>The Future</u> affectedness is composed of the aggregation of demographically sensitive areas with areas where heat stress will increase by 2050. It is generally noticed that in 2050 significantly more residential areas within the urban area will be affected by heat stress. It is also noticeable that the degree of involvement only increases in small areas (e. g. Linden-Mitte, Vahrenheide). In a few settlements, the degree of concern even decreases (e. g. in Misburg-Süd).

It is expected, that many urban areas will be at least severely affected by heat, unless protective- or adaptation measures are taken.

It should be noted that, especially in the currently highly and very highly affected areas, the degree of affectedness will expand significantly in the future (see Figure 2). A significant spatial expansion of the affected areas can be expected in the districts of the city centre, Vahrenwald, List, Oststadt, Südstadt, Linden-Nord and Calenberger Neustadt. On the other hand, the outskirts of the city are less affected due to a low increase in heat and a low demographic sensitivity.

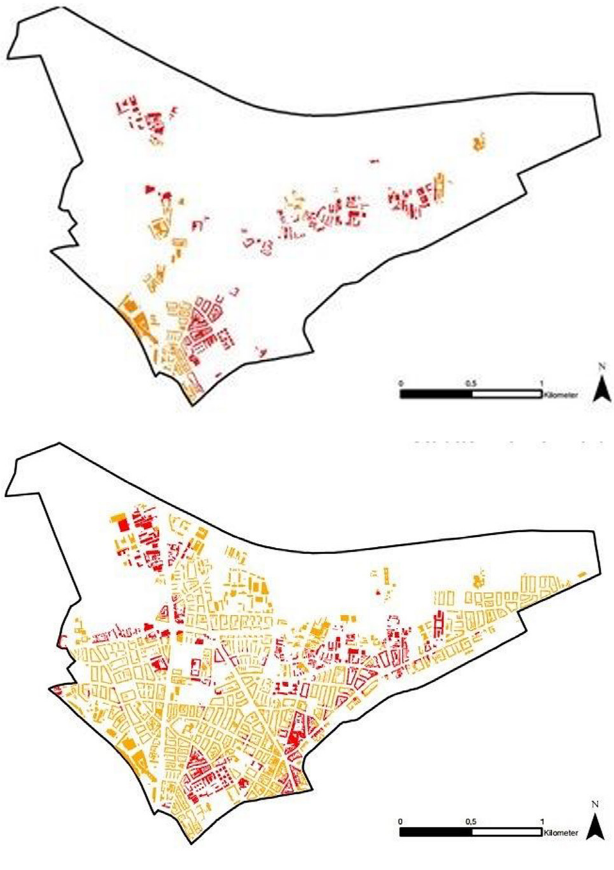


Fig. 2. Excerpt from the district maps Vahrenwald/List. Top: Areas currently affected by heat, bottom: areas with an increase in heat load (scenario 2050) (Michalczyk 2017)

Results on adaptation capacity

From a climate-ecological perspective, the green and open spaces in the city of Hanover provide a dual ecosystem service. On the one hand, heat-stressed city dwellers can use the areas during the day as a recreation area (alternative space including pedestrian accessibility). On the other hand, the areas are above all cold air production and transport areas with radiating effects on surrounding areas, which normalise the urban climate and enable the inhabitants to have a restful sleep. Both maps (see Figure 2) represent almost the same green and open spaces. The map of alternative areas shows large areas such as forests, parks, water bodies and garden colonies, as well as smaller climate comfort islands. The agricultural areas in the urban area are unsuitable as an alternative space and are therefore not shown. It can also be seen that green and open spaces can be reached within a maximum radius of 300 meters (corresponding to 5-10 minutes on foot) in the city area, and that it is ensured that the population can seek recreation in nearby bioclimatic favoured areas on hot days. In addition to the green and open spaces, the map also shows the agricultural spaces, including the radiating effects (up to 100 meters) as areas of climate-ecological importance with heat reduction capacities.

Vulnerability results

Both vulnerable areas identified are made up of
- the walking accessibility of the alternative areas
- vulnerable areas resulting from adaptation capacity.

The results on the vulnerabilities are explained separately below.

Vulnerability resulting from the consideration of alternative spaces

The following figures 3-6 show the current impacts with a focus on demographic sensitivities, the alternative areas suitable for recreation and their pedestrian accessibility (up to a 300 meter radius). Consequently, the areas affected by the heat that is outside the walking distance of the evacuation areas are vulnerable residential areas. The inhabitants of the affected areas lack the possibility to visit recreational areas and climatic comfort islands within walking distance in case of high heat loads.

Fig. 3. Section of the current results map; Linden-Mitte district. Vulnerability under consideration of the alternative spaces (current scenario). (Michalczyk 2017)

Fig. 4. Section of the results map 2050; Linden-Mitte district. Vulnerability under consideration of the alternative spaces (scenario 2050). (Michalczyk 2017)

Fig. 5. Section of the current results map; City Center of Hanover. Vulnerability under consideration of the alternative spaces. (Michalczyk 2017)

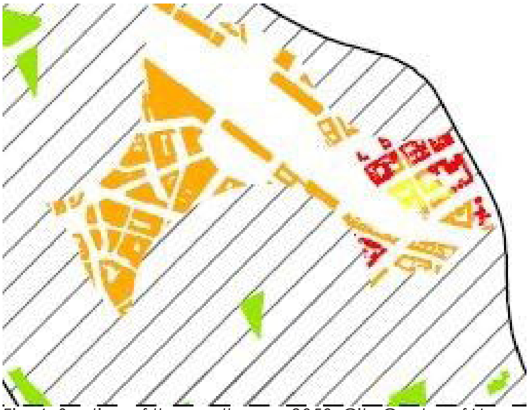


Fig. 6. Section of the results map 2050; City Center of Hanover. Vulnerability under consideration of the alternative spaces (scenario 2050). (Michalczyk 2017)

Legend

Current affectedness

- Medium affectedness
- High affectedness
- Very high affectedness

Within walking distance (up to 300 meters)

- Accessibility

Alternative spaces

- Parks
- cemetery
- Water bodies
- Garden plot

Dense vegetation

- Near-natural surface
- forest

Low-growing and loose vegetation

- Loose vegetation

Climate-comfort islands (< 2 ha)

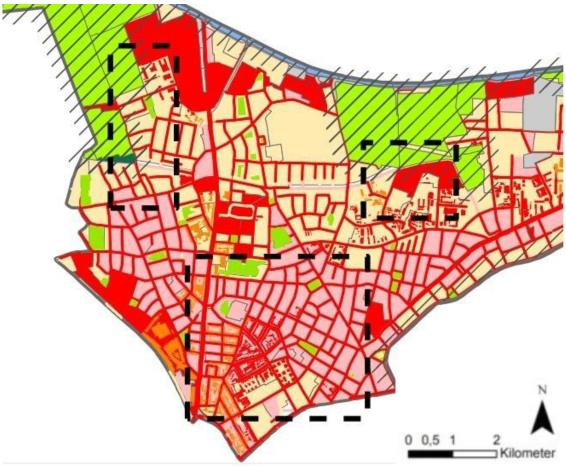
- Climate comfort-islands

All in all, however, there is almost area-wide accessibility of alternative spaces within the city on foot. Only small residential areas are situated beyond a walking distance.

In comparison to future vulnerability, which results from taking the alternative spaces into account, it becomes clear that generally, only a small spatial expansion of the vulnerable areas takes place. The areas that will be vulnerable in the future are more likely to be affected by heat (see Figure 3, Figure 4, Figure 5, Figure 6). This result supports the need for future action.

Vulnerability arising from the reduction capacity

Four factors can explain the spatial pattern shown in the following Figures 7 and 8: Firstly, the areas are climatically highly contaminated settlement areas (as of 2006), which are also sensitive to heat due to their demographic composition. This is the reason why they are affected. This affectedness is the second factor. Thirdly, the sensitivity to use (degree of sealing) contributes to the identification of vulnerable areas, which in turn is reduced by the fourth factor "radiative effects". The interaction and possible superposition of all factors result in low, medium and highly vulnerable settlement areas to heat.



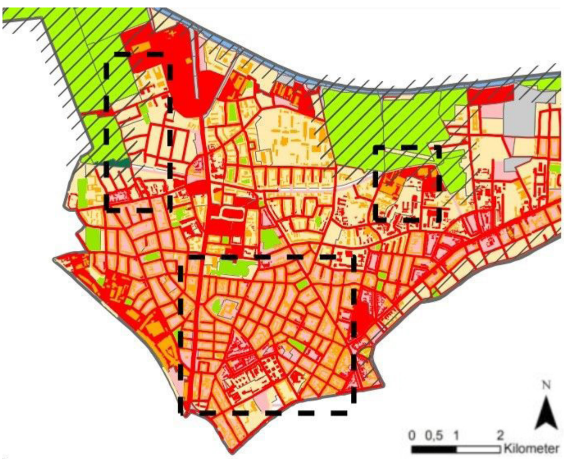
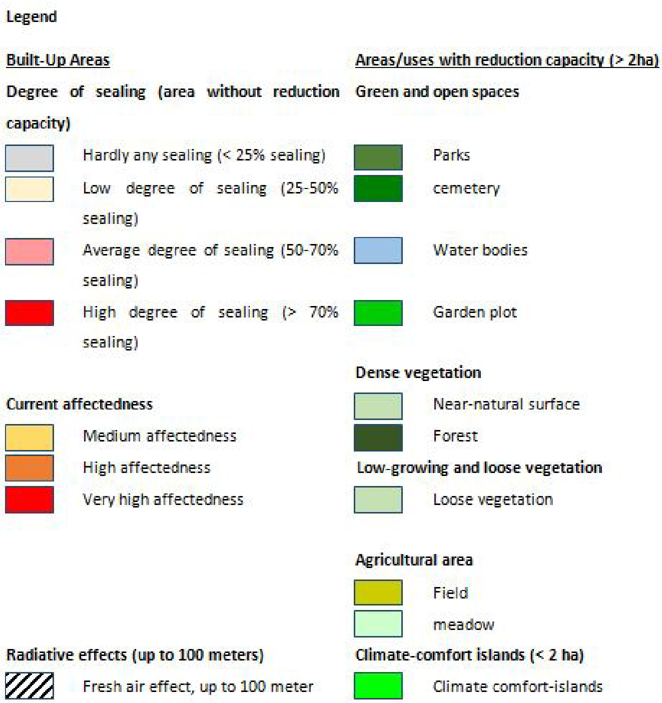


*Fig. 7. and 8. Upper figure shows the section Vahrenwald district; Vulnerability under consideration of the reduction capacity (current scenario). Lower figure shows the same vulnerability in the future scenario. (*MICHALCZYK *2017)*



Currently, vulnerability to heat is most evident in the densely populated area and on the highly sealed industrial and commercial sites. Where high degrees of sealing outside the radiation effects overlap with high levels of contamination, there is the highest degree of vulnerability. This shows the greatest need for action to reduce heat exposure.

The comparison (following Figures 9 and 10) shows that the selected areas will increase only less their level of vulnerability by 2050. It becomes clear that the spatial extent of the vulnerabilities will increase and that in 2050 almost the entire inner city area will be vulnerable to heat.

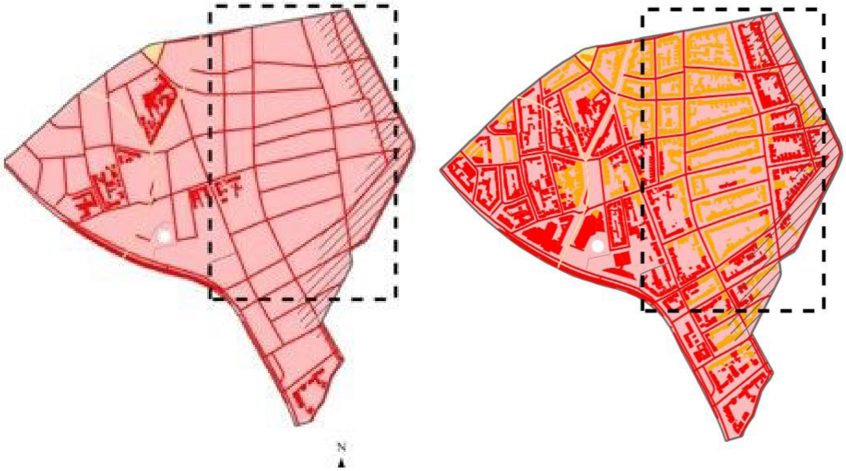
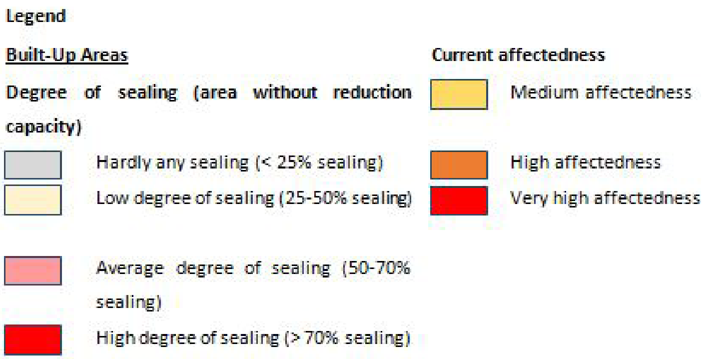


Fig. 9. and 10. Left figure shows the Vulnerability under consideration of reduction capacity (CURRENT scenario) and right: Vulnerability under consideration of reduction capacity (scenario 2050) (Michalczyk 2017)



Where there is currently no overlapping of sensitivities, the settlement areas are only sensitive to heat due to their use or the degree of sealing. In the future, a significant increase of vulnerable settlement areas can be expected. Because of the increasing demographic ageing, the expected migration and the associated growth in development, an increase in the degree of vulnerability is to be expected.

Summary of the results to vulnerabilities

The result is only a small increase in vulnerability over a large area. This means that the settlement areas that are currently vulnerable will also be vulnerable to heat in the future. The future vulnerable areas will tend to be more affected by heat.

Vulnerability in the light of alternative spaces
The result is only a small increase in vulnerability over a large area. This means that the settlement areas that are currently vulnerable will also be vulnerable to heat in the future. The future vulnerable areas will tend to be more affected by heat.

Vulnerability in the light of mitigation capacity
Currently, vulnerable areas will increase less in the degree of their vulnerability. Because of the increasing demographic ageing and the expected migration and the associated increase in development, an increase in the degree of vulnerability can be expected. It is also becoming clear that the spatial extent of the vulnerabilities will increase and that in 2050 almost the entire inner city area will be vulnerable to heat.

Guideline for Urban Development for Maintaining and Improving the Climate Situation in Hanover

Between 1950 and 2005, the proportion of the population living in cities increased globally from 29 per cent to 50 per cent. It can be assumed that this trend will continue so that in 2030, the urban population could account for around 60 per cent of the population (Kropp et al. 2009: 243). The city of Hanover is also expected to grow noticeably, from 524.450 in 2014 to 543.600 inhabitants by 2030 (3,7% growth) (Region Hannover & Landeshauptstadt Hannover 2014: 20f). Against this background, Hanover is one of the growing cities with pressure to move to and settle.

Urban development should be carried out with the aim of maintain or even improve the quality of life in the city despite climate change“ (Landeshauptstadt Hannover 2017: 14). This leads to the underlying idea of inner development, which - if all adaptive capacities are exhausted - is best suited to ensuring a liveable environment in the city even under the conditions of climate change (Brandl et al. 2011: 26). Due to higher energy efficiency, good connections to public transport and a comprehensive local supply network, fewer greenhouse gases are released in the densely populated city than in less densely-populated cities. Interior space development also offers the advantages of free space and soil protection. Against this background, there is the increasing demand for green and open spaces, which significantly improve urban climate and take on numerous climate-relevant functions (e. g. reduction of heat islands, pleasant living environment) (Brandl et al. 2011: 26).The combination and interlocking of open spaces and built-up areas, which can reduce the negative effects of climate change, is therefore essential for urban development in the City of Hanover (Knieling & Müller 2015: 19f; Schmidt et al. 2017: 25).

The aim of urban and environmental planning is, therefore, a sustainable, climate-change-adapted urban development, with a focus on re-compaction on unused, fallow or misused areas in the inner city (Schmidt 2017; Luft 2017). Within this framework, an internal development strategy should be sought which takes into account the city boundaries, preserves diversity in urban space and provides sufficient climate-effective green and open spaces (Luft 2017; Brandl et al. 2011: 67). When adapting to climate change, and especially to heat loads, it is sometimes overlooked that the need for action arises not only from the vulnerability of the urban structure but also from human vulnerability (Schmidt et al. 2017: 25). As a result, future adaptations to climate change should also take into account changes in society. In addition to planning adjustments that can reduce the consequences for the population, independent health care for each citizen is also important.

The two strategies with the concept of “inner development before outer development“ and “compact city“ are to be regarded as trend-setting for successful climate protection. The adaptation to climate change, however, is aimed at keeping areas free, especially in the highly densely populated inner-city areas, and would therefore instead be associated with the model of the “relaxed city“. As has already been shown, adaptation is to be seen as a cross-sectional task for planners, while the success of adaptation depends on integrative processes. To achieve this, the formal planning instruments must be exhausted (Steinrücke et al. 2010: 214f).

Conclusion

This paper explains that in view of increasing climate change, determining the vulnerability of urban areas plays a central role in maintaining a healthy quality of life. Furthermore, this work has shown that vulnerability analysis is a central starting point when it comes to identifying vulnerable land uses and structures to the effects of climate change and making them more adaptable through planning measures.

The analysis has shown that there is almost complete pedestrian accessibility to alternative spaces within the urban area. Only small settlement areas, such as in the city center, the district Vahrenwald, List or Linden-Mitte are beyond walking distance and can be considered vulnerable. In comparison to future vulnerability, only a small spatial expansion of the vulnerable areas takes place. The areas, that will be vulnerable in the future, are more likely to be affected by heat.

Vulnerability, taking into account reduction capacity, is currently most evident in areas where highly sealed surfaces overlap with a lack of radiative effects and high demographic impact. These are mostly in the densely populated part of the city Vahrenwald, List or Oststadt and the City center.

Because of the projected climate change, these problematic areas are likely to worsen and widen, which is why the identified areas should be considered primarily for the development and implementation of measures.

Against this background, climate adaptation measures should be implemented and applied above all in the highly sealed residential areas, which show also demographic sensitivities (e. g. high population densities, a high proportion of older people and low density of social infrastructure such as hospitals) e.g. in Mitte, Vahrenwald, Linden-Nord or Linden-Mitte.
In general and also in comparison with other large cities like Stuttgart, the city of Hanover has relatively only minor climatic problems due to its spatial location and is characterised by a quite good urban climate (Luft 2017; Schmidt 2017). However, the results of the vulnerability analysis also make it clear that the climatic situation will deteriorate by 2050.

Due to the desired re-densification (infill development) and the associated conflicts with the adaptation measures, solutions have to be found, allowing for a flexible adjustment. It is therefore essential for the success of climate-relevant actions that they are communicated and coordinated with the other concerns of urban development in order to create as many synergies as possible in planning and implementation. In the future, it will be increasingly important to test the compatibility of structural post-compaction measures particularly. In the event of priority given to post-compaction in the course of consideration, the following with the introduction of specific requirements for mitigation and compensation.

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3. Urban climate evaluation for city planning

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Abstract

Over the last 40 years, there has been an increasing amount of world interest on urban climatic map (UCMap) Studies. Up to now, there are over 15 countries around the world processing their own Climatic Maps, developing urban climatic guidelines and implementing mitigation measures for local planning practices. Facing the global issue of climate change, it is also necessary to factor the climatic consolidations holistically and strategically into the planning process.
In the literature, the latest concepts are mentioned. Key methodologies, selected parameters, structure and making procedures, mitigation countermeasures and climatic recommendations of urban climatic map studies ware described. More than 30 relevant studies around the world are cited, and both significant developments and remaining problems are discussed. The review noted that the thermal environment and the air ventilation condition within the urban canopy layer play the most important role in the analytical aspects and climatic-environmental evaluation. It is also noted that possible mitigation measures and planned action can include decreasing anthropogenic heat release, improving air ventilation at pedestrian level, providing more shaded areas, increasing greenery, creating air paths, and controlling building construction. Future research should be focused on the spatial analysis of human thermal comfort in urban outdoor areas and climate change impacts and adaptation. It is also important to share the learned lessons and experiences with planners and policymakers in the rapidly expanding cities of the developing countries and regions.

1. Background

Based on the chronology of UCMap studies in the world, it could be observed that more than 15 countries have conducted their own UCMap studies (Ren et al. 2011). Recently, UCMap is of increasing interest in the world. For example, researchers in China, Chile, Singapore, Macau, France and the Netherlands are starting the relevant projects and studies for pursuing good planning and sustainable development.

Urban climate analyses serve as a suitable means of assessing possible climate impacts. Their results are compiled in so-called climate function maps and mapped nationwide. Overheating areas and areas with ventilation deficits, such as densely populated inner cities or commercial / industrial areas with large parking lots and less vegetation are mapped and located just as favour and the potential regions - meadows, forests or other semi-natural areas - which have a positive effect on the urban climate and mitigating the influence on pollution.

A municipal climate adaptation strategy operates in this context with the protection of the climate-ecological potentials and with the rehabilitation of possible deficit areas. This means that e.g. cold air generation areas and outflows with a high climate ecology value are considered particularly worthy of protection. Climate protection in (city) planning, on the other hand, argues for reduction of greenhouse gases savings should be developed to limit the traffic volume or energy expenditure overall. In this interplay, climate adaptation has a passive, sustaining role. The two issues of climate protection and climate adaptation thus appear in the competing competition for the same process of urban planning. Climate change is to reduce greenhouse gases while adaptation looks for ventilation and heat. Wherever there is the possibility to affect the influence of air, these potentials should be used extensively and as efficiently as possible. Planning and development tailored to local climatic conditions serve as a basic prerequisite for well-conceived solutions ranging from building structures to architectural design (including use of living space, building insulation standard, ventilation options within each residential unit, distribution of window openings, passive solar gains, small wind turbines , Building greenery, blue-green infrastructure, targeted colour choice and building technology) are fine-tuned.

An increasing number of people worldwide live in cities. To accommodate urban growth, it is necessary to intensify density in many inner cities. One of the consequences is that already existing urban heat islands (UHI) intensify. Climate change and the predicted increase in the air temperature add to the problem. This means that two of the most serious environmental issues of the 21st century, population growth and climate change, become evident in redensification projects. This case study deals with designing climate-responsive as well as sustainable and energy-efficient development. The aim is to combine high density and high quality.

In order to provide information for the planning institution for the total urban scale and ultimately generate recommendations for urban planning and development under the conditions described above, the urban climate must be observed and evaluated to. To this end, many cities use urban climate maps (Ng & Ren 2015). They are generated using existing international standards in environmental meteorology (f.e. ISO). These describe how urban climate conditions can be cartographically presented, evaluated and used for planning with the help of reference maps. Moreover, urban climate studies can help to increase open space qualities for the improvement of urban live conditions (Lenzholzer 2016).

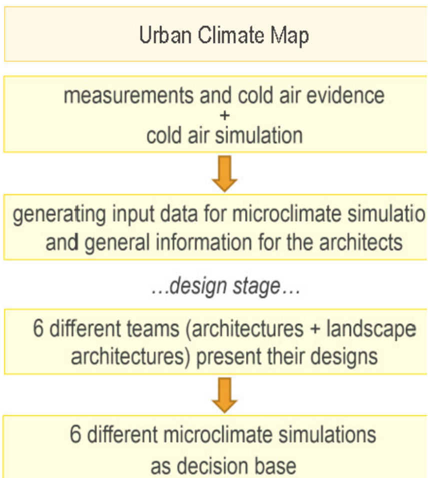

Fig. 1. Example of a flow chart of the procedure urban climatic mapping. for an architectural design competition. Basic line an urban climatic map (Stadt Frankfurt am Main 2016)

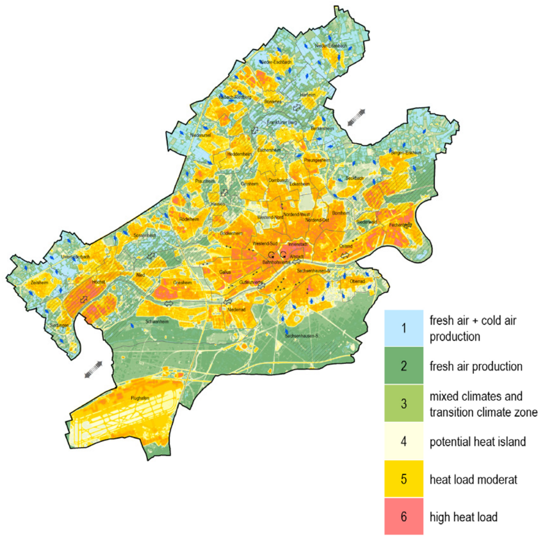

Fig. 2. Urban climatic map of Frankfurt/Main (Stadt Frankfurt am Main 2016)

2. Case Study Frankfurt

The city Frankfurt am Main lies in the centre of Germany in the protected location of the expering northern Oberrheingraben and is the largest city in Hessen and the fifth-largest in Germany. Due to their topographical location on the southern slope of the Taunus and the rivers Main and Nidda, there are still many areas in the city that benefit from the nightly cold air run-off in summer. This outflow is in parts very sensitive and can be blocked by obstacles such as buildings, noise protection or dense tree plantings or at least partially limited in quantity or delayed in time. It is of great importance to maintain the cold air downhill movements as well as the mesoscale ventilation along the rivers.

Other settlements are again surrounded by a cold air system in which several outflows combine locally to form a very powerful outflow stream. In this case too, it is possible to examine whether the urban use and the concomitant reduction of the cold airflow about the overall system are acceptable. The number of possible variables is manageable. The main objective is basically that the current situation should not be significantly worsened. If uses with demand for cold air are within the sphere of influence, structural development should also be avoided.

However, if the analysis reveals that sufficient cold air can escape in a sensitive development or if the outflow is directed in one direction without real needs, then this favourable climatic position can be actively maintained. Structural changes might be possible.

Based on the information retrieved from a mesoscale urban climate map (see Figure 2), it was possible to deduce the conditions for a smaller area of the city. The new development is attached near cold airflow within a climatop (areas of the same climatic characteristics) of importance for the surrounding areas.

The aim in the case of Frankfurt was to create a new inner-city settlement in a climate-sensitive way and to make sure climatic conditions in other parts of the city characterized by higher heat load problems would not deteriorate. Figure 4 shows the planned settlement area. Darker orange to red areas have high heat load conditions with weak ventilation. The area is affected by cold airflow from nearby mountains and can be characterized as a cold air production zone. The urban climate map indicates the thermal conditions using the thermal comfort index. This index called PET is based on the energy balance of a human body and expresses heat or cold stress. This now must be separated to see the effect of ventilation.

After identifying the urban climate functions and interactions, a cold air evaluation was carried out to obtain more detailed information of the fragmented and sensitive cold air situation. The simulation model KLAM_21 was applied to calculate cold airflows in an orographically structured terrain. This is used in urban and regional planning and facility siting. Quantitative statements on the cold air height and the volume flow in two meters above ground in a high spatial resolution were generated (see Figure 2). At the same time, detailed climatic measurements and cold air evidence (tracer gas method, pictures in Figure 3) were carried out in two different spots so that the local conditions could be described quite clearly.

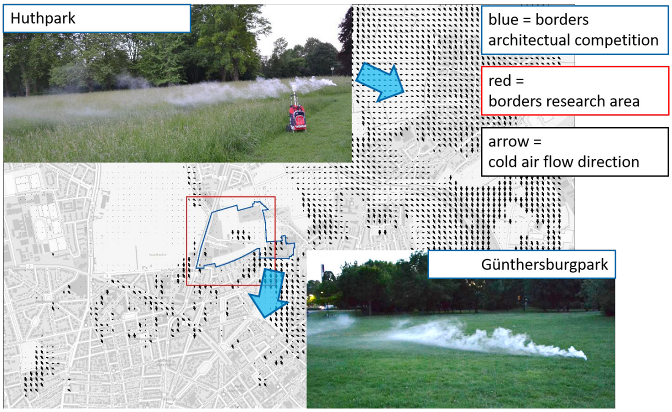

Fig. 3. Cold air calculation, combined with near-surface measurements and cold air evidence by smoke experiment (Katzschner & Kupski 2018)

Figure 3 shows the calculations with the KLAM_21 model and the results of the measurements to ensure these results in the investigation area. The small black vectors show the cold air drain direction in a spatial solution of 40 meters as well as the velocity in three different categories. The large blue arrows represent the direction of the smoke experiment to visualize the atmospheric processes and to validate the calculation at the same time.

The case study was carried out with electronic sensors (Vaisala Weather Transmitter WXT530) and smoke pipes to visualize the nocturnal cold air drainage near the investigation area.
After collecting all this information, a short overview of the most important climatic processes was created and handed over to the planners in order to provide the knowledge needed to prepare the drafts.

The design stage developed next: At the end, six drafts of the new settlement were selected and rated. With regards to the climate criteria, a comparable and transparent calculation of the microclimate was undertaken.

Based on that, an urban climate consideration was carried out with architects and climatologists. Some changes were made, and the reviewed design proposals were simulated. For this task, each draft was calculated by using the three-dimensional microclimate model ENVI-met (pro-version). To predict building design, a numerical simulation was used to understand the climate conditions and the interactions between walls and atmosphere near the ground.

There was a reduction to two relevant parameters in order to not make the decisions more complicated than necessary. These two parameters were the physiological equivalent temperature (PET) value and the wind field two meters above the ground. The focus was on avoiding weak ventilation and allowing wind to penetrate the city pattern. The jury can now easily use the climatic information to come to a decision and choose the winner of the competition (amongst others Figure 4).

3. Results

The result at this stage was a decision, based on many different needs, but also influenced by urban climate information to strengthen the climate-sensitive development of the city. It is obvious that any changes in land use will modify the microclimate. To develop a more satisfactory situation with regards to thermal comfort, it is necessary to manipulate, especially the orientation of buildings, bearing in mind the wind direction and radiation balance.

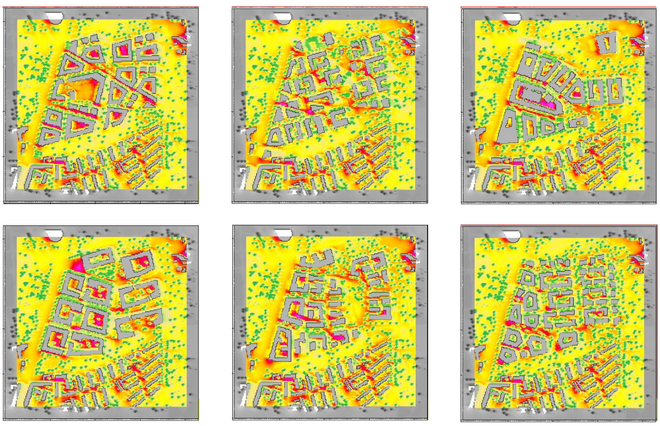

Fig. 4. Finalized studies of the microclimate as decision base (Katzschner & Kupski 2019)

Each architectural team received an objective evaluation of their design based on the microclimate simulation results. It was generally advised to stick to the albedo recommendations on colour sets or natural unsealed surfaces. A precise location of disadvantaged areas and situations with positive effects to the thermal comfort was prepared. In addition to that, the drafts should give an impression of the changes the new area will bring to the urban climate in the surrounding neighbourhoods. To answer this question, the wind field (wind speed and velocity in two-meter height) was simulated. Looking at a heavy traffic road which tangent the development area in the west, e.g. the ventilation is able to reduce the emissions caused by cars. In other areas, the corridors to maintain the city ventilation were checked meticulously. Its mesoscale potential is high; we could, therefore, conclude that one has to prevent the air path from east to south-west direction. This was then incorporated into most proposals. The winning project featured large green areas in the direct neighbourhood which could assist the local ventilation pathways and compensate some of the heat load. Another climate criterion was met by reducing the height of the buildings and planting large trees in order to reduce the heat load in some of the courtyards.

The next steps are already decided: The revised winning draft will be recalculated including the previously prepared climatic information to optimize the simulation base. This calculation can show in much more detail the effects of the new development and is as close to reality as possible.

4. Conclusion

If cities worldwide want to be well prepared for and resilient to climate change and its effects like the rise of air temperature, the increase of heavy precipitation events, the rise of the sea level etc. they need information in the form of the current analysis data to calculate their individual risk level today. After that, each planning or land-use change must be crosschecked to show the local effect so that an adaptation strategy to future requirements can be developed. Planning needs to be aware of urban climate issues. Amelioration can only work if planning is based on a smart platform.

The procedure shows an effective way of proceeding in the process of densification. Urban climate information is needed beforehand, followed by the architecture design proposal, which is again crosschecked with microclimate modelling. This way, redensification in cities can be organized, providing the highest possible thermal comfort. It is also by the current German guidelines VDI 3787 Part 1 and 3787 Part 8 with the title: urban planning and climate change (Verein Deutscher Ingenieure 2015; Verein Deutscher Ingenieure 2017).

This best practice framework should be part of each large inner-city development. The advantage is the objective and transparent approach. So, it is very important to accompany the process with experts from the beginning. Many elementary requirements must be respected in the early process steps like main corridors and building structure. Other issues like local thermal hot-spots or wind discomfort can be solved later.

It is also very important to convince the planners, politicians and decision-makers as well as the population to support the process. They will be rewarded with a liveable city.

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4. Governance of Flooding Risks in the Region and the City of Hanover

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Abstract

The article deals with flood protection and flood prevention as a contribution to a more resilient city region in general and in Hanover. Flood protection of Hanover's city centre has been dealt with since the 15th century. Today, floods are prevented by land-use and sectoral planning of the city region and the municipality. The regional plan has designed binding priority and reserve zones for flood prevention on the basis of flooding areas identified by the water management administration. Urban planning has set up an informal local action programme, but a basic update of formal plans, especially the preparatory land-use plan, is missing.

1. Flooding and Flood Protection in Hanover's History

The city of Hanover has been built on the so-called high banks of the river *Leine*. Later on, lower areas and especially the flood-plain have been used for urban development including housing and administration. This means that the city of Hanover, right from its origin, had to learn how to cope with flooding.

There have always been flooding events in history, as the Leine may seasonally carry an enormous run-off due to melting of snow or heavy rain in its catchment area, especially in the *Harz* mountain.

Therefore, there has been already the idea in the 15th century to protect the city centre against flooding by deviating the *Leine* in the south of the city and by using the brook Ihme for the bulk of the run-off arriving from the South. Thus, the canal *Schneller Graben* has been constructed in the *Leine* and *Ihme* floodplain south of Hanover and the *Ihme* has been broadened to bypass up to 90% of the overall run-off. The project has been built in the 17th century and renewed in the 18th century. The city centre, as well as the *Südstadt* neighbourhoods, could be protected by this first flood protection activity, however at the expense of more flooding events for *Calenberger Neustadt* and *Linden*, the latter being an independent city until the 1920s. In 1922, a hydroelectric power plant was added to the weir, thus utilising the 3.60 m difference in altitude between *Leine* and *Ihme*. The plant is still in operation (Röhrbein 2009; LHH 2019a).

Besides that protection activity, dykes, dams, and walls have been built after the hazardous floods in 1808, 1909 and 1946. During the most hazardous flood in February 1946, 1666 hectares of land have been flooded up to 3 m high. This happened only some months after the end of the Second World War. Only three persons died, but there was enormous damage in the city that was still suffering from having been heavily bombed. Especially the municipal archives were flooded and lost a larger number of valuable documents (LHH 2019a).

2. Flooding and Flood Protection in Hanover's History

"Resilience determines the persistence of relationships within a system and is a measure of the ability of these systems to absorb changes of state variables, driving variables, and parameters, and still persist." (Holling 1973: 17)

What does that mean for a city region? “Urban resilience refers to the ability of an urban system – and all it is constituent socio-ecological and socio-technical networks across temporal and spatial scales – to maintain or rapidly return to desired functions in the face of a disturbance, to adapt to change, and to quickly transform systems that limit current or future adaptive capacity.” (Meerow et al. 2016: 39, 45)

What does this mean for resilience regarding flooding? On the one hand, societies have understood that the traditional water management strategy to get rid as quickly as possible of stormwater and to protect the land against flooding is not feasible any longer because it is expensive and leaves the problem to the downstream municipality, thus creating the need for ever-increasing expenses for protection measures. On the other hand, central European urban planning must react to the fact that heavy rain events will increase while the amount of rainfall per year will not change (Kuttler et al. 2017). Today’s strategy is (1) to retain and if possible drain or evaporate/transpire as much rainwater as possible within the built-up areas (by e.g. green roofs, green open spaces, protecting or reclaiming floodplains), (2) to identify optional areas that may take over or substitute functions at risk in other areas, (3) to identify areas that may be flooded in a controlled way if necessary and (4) include protection of key areas. Resilient cities are, on the one hand, robust against and on the other adaptive to hazards from flooding (Jakubowski et al. 2019). Disturbance or even damage is accepted to the degree that does not compromise desired functions in the long run, thus preventing these functions from disappearing due to hazards from flooding. The disturbance is a part of development rather than an obstacle to it (Folke 2006: 258). “A management approach based on resilience [...] would emphasize the need to keep options open, the need to view events in a regional rather than a local context, and the need to emphasize heterogeneity.” (Holling 1973: 21)

There are three types of hazards from flooding resilient cities should be able to cope with. These include firstly flooding from running waters, secondly flash floods from heavy rain (that are likely to increase due to climate change, s.a.), and thirdly storm floods from the sea. The first two must be dealt with in Hanover, whereas the third is irrelevant as Hanover is not (yet) located at the coastline.

Good governance for resilience, therefore, takes place, especially on the regional level. It focuses on spatial planning, whose task it is to identify optional development opportunities (supported by strategic environmental assessment), negotiate land-uses and moderate processes.

3. Regional Governance in Hannover

In 2001, the Hanover Region was legally founded as a unique new administrative body for better governance by integrating the Hanover County with the Greater Hanover Association (competent for regional planning, economic development and public transport) and competencies from the Capital City of Hanover and the federal state of Lower Saxony. The capital city is now one among the 21 municipalities within the region (Frohner & Priebs 2001). Multilevel governance has been reduced. Thus, all competencies in the regional level are now gathered in one administration, which is responsible e.g. for regional planning, water management, climate protection and adaptation, regional landscape planning. Since a couple of years, a central team for the coordination of climate protection (*Klimaschutzleitstelle*) that reports directly to the head of a department exists within the Department of Environment, Planning and Building. They are responsible for coordinating all-climate protection and adaptation activities within the region, while the original competence for e.g. flooding has remained with the sectoral team within the service environment. Besides, the region founded the Regional Climate Protection Bureau also in 2001, a public enterprise that informs and consults the population, house owners and small and medium-sized enterprises and shows up paths to subsidise appropriate actions.

4. Flood Prevention in the Hanover Regional Plan [1]

Spatial planning is an integrative and independent task and thus must help implement flood prevention. This is a principle according to the Spatial Planning Act (*ROG*) since 1989 and also laid down in the Water Management Act (*WHG*).

Spatial planning and water management must cooperate to guarantee flood management. This includes protection and reclamation of natural flooding areas, prevention in potentially flood-prone areas and retention of water within the land of

[1] The author is grateful to Dr. Wolfgang Jung and Mark Herrmann from the Hanover Region administration for valuable input for this chapter.

the entire river catchment area. Flood prevention by spatial planning especially includes protecting and reclaiming land for floodplains, retention areas and other discharge areas.

Regional plans must designate the intended open space structure, which includes open spaces for flood prevention. Therefore, regional planning in Germany designates priority and reserve zones for flood prevention.

To implement flood prevention in the Hanover Region, natural flooding areas (HQ 100) are identified and protected by sectoral planning of the lower water authority of the Hanover Region and by the Lower Saxon agency for water affairs, coast protection and nature conservation (*NLWKN*). The regional planners have then designated the already decreed flooding areas, in which a flooding event is expected statistically once in 100 years (HQ 100), as “priority zones flood prevention”. Spatially significant proposals and actions within these areas can only be permitted, if they are in line with water retention, especially if flooding retention is not compromised, alternative sites outside flooding areas are not available and the interests of upstream and downstream municipalities are complied with.

The designation as a “priority zone flood prevention” shall protect decreed flooding areas against conflicting proposals and land-uses, especially against further land consumption by development. These open spaces shall be kept free of housing and sealing because natural running waters and their floodplains in these areas have a high capacity to store. stormwater To prevent damage, new building zones in these areas must not be permitted. The lower water authority (not the municipality) may decide upon exemptions.

The boundaries of these priority zones are aligned at those of the already decreed flooding areas that can be affected by a flooding event likely to occur once in 100 years (HQ 100) according to federal and state water management law. The boundaries are generalised because of the different scales of sectoral and spatial planning (1:5,000 vs 1:50,000). More exact sectoral planning data must be, therefore, considered in all permits for spatially significant proposals and actions.

Recent flooding events in Germany show that changes in frequency and intensity must be expected as planning risks. To completely avoid flooding has proven to be both insecure and expensive and is thus neither effective nor sustainable (Grünewald & Schanze 2011: 31). Therefore, the EU Floods Directive has been transposed into national law in the Water Management Act such that risk areas are identified and mapped in flood hazard maps. These classify risk areas according to flooding events with high, intermediate or low probability and the vulnerability of the land-use.

Decreed flooding areas shall guarantee stormwater run-off without damage and protect the required retention areas for an intermediate flooding event. In case of extreme flooding events (flash floods), areas beyond this may be flooded. For an effective flood risk management and climate change adaptation, areas that can be flooded at lower risk shall be designated as "reserve zones flood prevention" to prevent risks from potentially occurring extreme flooding events. This is a designation to protect the public welfare and, therefore, it has a higher weight in decision-making in case of conflicting land-use. The boundaries of the "reserve zones flood prevention" are aligned at the flooding event likely to occur once in 200 years (HQ 200). This is again for sectoral water management, since the latter may only designate binding protection areas in case of HQ 100 (cf. Schanze & Greiving 2011: 95).

Figure 1 shows maps of HQ 100 and 200 in the southern Leine floodplain. The map in figure 2 shows the priority and reserve zones for flood prevention in the regional plan (Region Hannover 2016). The provision of objectives and intentions under the heading open spaces, water management, in the text statement includes (Region Hannover 2016, ch. 3.2.4[1]):

- 06 Stormwater sewers shall be separated from foul water sewers. Rainwater shall be drained with priority if groundwater protection does not contradict. [intention]
- 07 Flood prevention actions shall be foreseen to prevent flooding damage. A natural development of surface waters and floodplains shall be pursued. Retention shall be improved by targeted action like backward relocation of dykes, disman-

1 Translation by the author

tling of river training or construction of retention areas. Reclamation of natural retention areas shall have priority over the construction of retention areas. Land-use planning shall especially consider keeping free of retention areas that can be reclaimed. [intention]

- 08 Decreed flooding areas must be kept and protected with their function as natural retention areas. “Priority zones flood protection” are designated in the map statement to guarantee flood prevention. Within these areas, all spatially significant proposals and actions must be compatible with the purpose of flood prevention. [objective]
- 09 To prevent risks, areas less probably to be flooded (at a statistical interval of 200 years) are designated in the map statement as “reserve zone”. [intention]

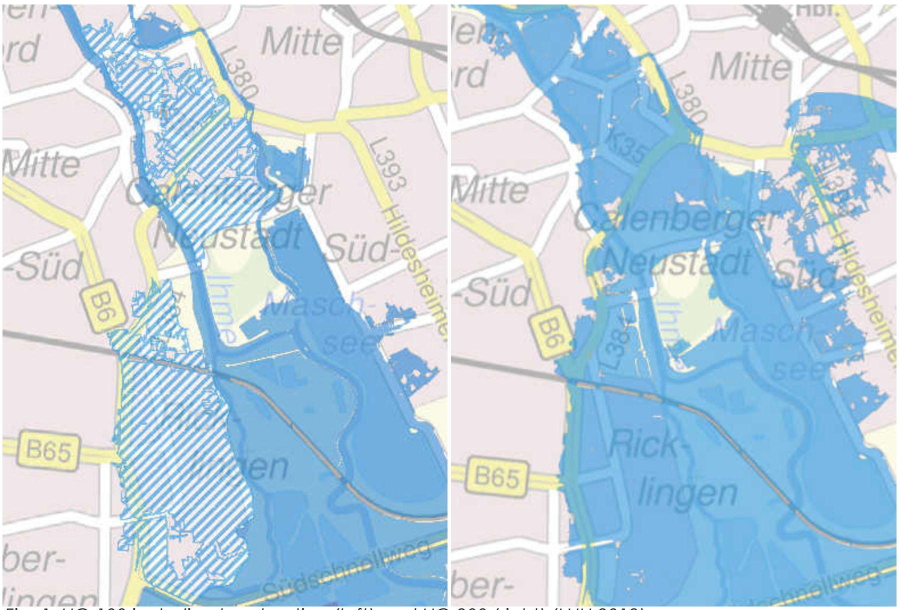

Fig. 1. HQ 100 including local action (left) and HQ 200 (right) (LHH 2018)

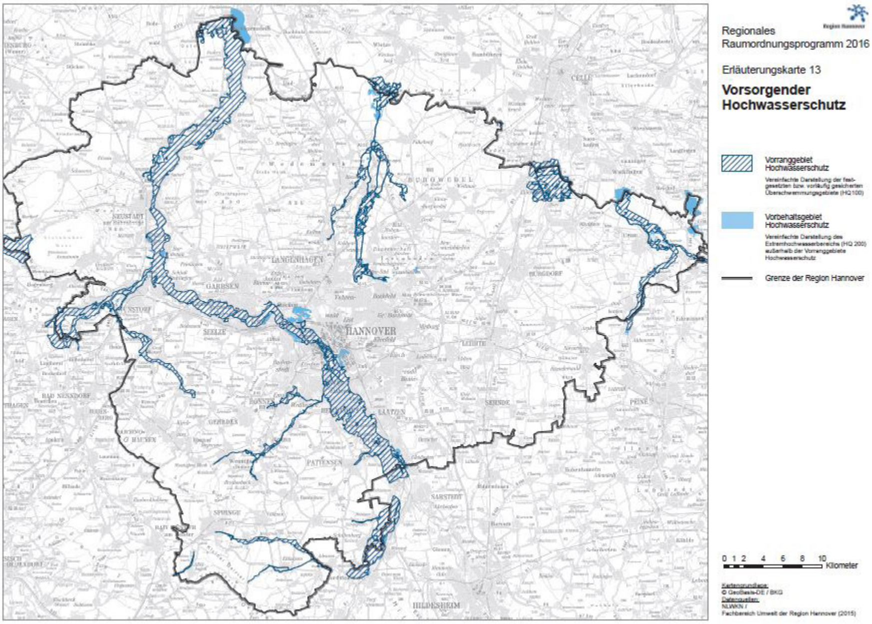

Fig. 2. By map flood prevention of the regional plan with priority and reserve zones (Region Hannover 2016)

This means that priority zones constitute planning objectives that must be complied with in sectoral and local land-use planning, whereas reserve zones are planning intentions that must be taken into account only. But water management authorities may invest in preventive action in these areas, whereas spatial planners may support and moderate the process (cf. Schanze & Greiving 2011: 95).

The implementation of spatial planning objectives and intentions into action is the task of municipalities and sectoral planning. Therefore, it would be logical for the Capital City of Hanover to set up a new preparatory land-use plan or basically update the existing one. However, this happened in 1975 for the last time and since then there have only been a large number of amendments to the plan regarding small areas. The stock taking data and the predictions on which the plan is based are completely outdated.

5. Flood Prevention by Urban Planning in Hanover

The Capital City of Hanover has set up a number of informal development strategies instead, among which there is a Local Action Programme 2017 on flood prevention, adopted in 2006. The programme focuses on three fields of action, which meanwhile have been implemented (LHH 2019b):

1. Excavation of the Ihme floodplain between *Spinnereistraße* and *Lavesallee* to enlarge the water profile and retain runoff. There has been a landscape architecture competition to find a flood-resistant multifunctional design and to use flood resilient tree and shrub species. The population first protested against cutting of a large number of trees, but has now accepted the area and is happily using it for daily recreation.
2. Widening of the *Benno Ohnesorg* Bridge to eliminate an existing bottleneck. The old bridge had not been wide enough to let HQ 200 pass completely. Additionally, there had been an accommodation berth for a passenger ship next to the bridge that might have led to the ship blocking the water passage in case of a flood. The berth has been dislocated and the bride replaced by a larger one that is also capable of accommodatin a barrier-free tram stop.
3. Closing of a gap in the dyke in *Ricklingen* to protect the neighbourhood.

The city has created a central coordination unit for flooding protection in 2015. Their tasks include the analysis of recent flooding events, the analysis of weaknesses, the optimisation of the system of flooding protection, and the information of the population. Other competent local authorities that are cooperating with the coordination unit include: the fire brigade, the service civil and underground engineering, the urban service drainage, the service environment and urban green, and the service urban development and planning (LHH 2019c). The city has also set up an adaptation strategy to climate change (LHH 2017, cf. Schmidt in this book). This strategy includes eight fields of action, three of which are relevant here, including flood protection, rainwater management and handling of heavy rain events, and roof greening.

6. Conclusion

Due to using a geographical and hydrological opportunity, the city centre of Hanover could be protected from flooding very early. Having protected flooding areas on the regional level and implemented a local action programme, relatively few built-up areas a still flood-prone at HQ 100. At HQ 200, however, and also taking into account the probable increase of flash floods, a number of neighbourhoods must be better prepared and should become more resilient against flooding.

A general update of the preparatory land-use plan accompanied by a strategic environmental assessment that will include natural risks could constitute an element of good governance for a more resilient city. The existing preparatory land-use plan is based on social, economic and environmental data and predictions from the 1970ies. It has been incrementally changed more than 200 times without questioning the basic conception. To cope with HQ 200 events within the built-up areas, it may be necessary to change existing binding land-use plans in the affected areas. Suitable prescriptions for dealing with flash flood within building stock include roof greening, canal network adaptation, retention basins, temporary retention, e.g. on sports grounds and reconstruction of streets to serve as emergency waterways (Kuttler et al. 2017). However, prescribing most of these within existing building stock will require public financing or subsidising private owners. This needs to be funded by climate adaptation programmes on the national and state levels.

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5. The regeneration of Lycabettus Hill

An example of resilience planning

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Abstract

Urban areas increasingly have to deal with systemic transitions in response to climate change, such as adaptation for extreme precipitation and heat, which require interventions to mitigate and adapt. In the case of Athens, since 2010, these challenges have been dealt with in a context of urban crisis and austerity governance, which exacerbated available resources for the management of public spaces and green areas. In response to these challenges, the municipal administration of Athens of 2010-2018 has engaged in innovative urban initiatives and formulated strategies for promoting urban resilience (City of Athens 2017; City of Athens 2018). A key component of these initiatives was creating synergies with social stakeholders and promoting participation and collaborative action. The Program for the Regeneration and Activation of Lycabettus Hill initiated by the Municipality in 2018 assumes all the above characteristics since it involved the collaboration of two universities, the Municipality as well as numerous local and international experts and engaged more than 200 stakeholders with support from the 100Resilient Cities network that Athens forms part of. The program focused on issues of adaptation to climate change, mobility, sustainable environmental management and ecological design for Athens' major touristic landmark and urban forest. The text presents the rationale of the strategy developed by the National Technical University of Athens.

Setting the problematic of resilience planning in the case of Lycabettus Hill

The hills of Athens form an integral part of the identity of the urban landscape. Lycabettus, as the largest and most central hill, is the rival of the Acropolis, an emblematic touristic landmark and vital urban forest at the heart of the city. Over the last 15 years, the hill has been facing complex problems such as dealing with soil erosion due to increased intensity of precipitation, the decay of infrastructure and general abandonment. The call for a comprehensive strategy to revitalize and activate such an important urban resource is a unique opportunity for visionary and strategic planning. Rarely do we have the opportunity to touch upon the 'sacred' objects of the city that played a constitutional role in the formation of its particular identity. And such a venture inevitably involves dealing with important legacies, such as the city's history, collective memory and environmental capital, especially at a time of systemic transitions.

Fig. 1. View over Athens from the top of Lycabettus Hill (Church of Saint George) (own photo)

The public policy applied so far in Lycabettus has used almost exclusively the instrument of regulatory planning. The hill is thus covered by a framework of legal protection that prohibits virtually any action or intervention with potentially negative content. As designated green space in the statutory city plan, Lycabettus is also protected by forestry legislation that significantly restricts any alteration of the balance between hardscapes and softscapes in great detail that extends to the use of materials. The same protection status also applies for the built structures, the most celebrated example being the open-air theatre that is a listed monument of recent architectural heritage with the Ministry of Culture. There is no doubt that the hill needs to be protected. However, trying to fix things as they are and preventing change is not sufficient to promote resilience. Firstly, an ecosystem that is in constant metabolism needs constant corrective interventions to keep it in balance. This applies both to natural processes, such as renewal of vegetation and dealing with the effects of soil erosion, as well as to anthropogenic related to maintenance of infrastructure, ensuring safety and providing services to visitors. Secondly, such an emblematic landmark in a touristic city like Athens demands innovative thinking. The renegotiation of a city's relationship with its past and future and the consequent redefinition of its identity happens at specific moments in its history as a result of a combination of specific political conditions and circumstances. Such a process cannot be designed and implemented within the narrow constraints of the regulatory framework. It is, in fact, a 'violent' change that puts things on a new trajectory that, once installed, becomes the new normality.

The image of well-known European cities that no one would dare to alter today has, in fact, resulted from successive such structural changes in the urban landscape that took place in different historical periods in response to specific demands as they arose at the time. Interventions such as the construction of the Gürtel Ring in Vienna, or the embankment of the Seine in 19th-century Paris, embody the element of visionary thinking and violent redefinition of the state of things in response to a new ideal (Choay 1969). This brought obviously irrevocable changes in the identity of the city. The experience of the practice of landscape architecture in countries where this is well-established, such as Spain, teaches us that landscape is not something "sacred" that we do not touch, but it is an essential object of design, often with the aim of restoring the past damages with today's better understanding of ecological processes and the value of cultural landscapes (Goula et al. 2012). Lycabettus is, after all, a typical example of a 'man-made' landscape.

Taking a brief look at the past, one can distinguish three characteristic episodes of strategic visioning and change, where the identity of Lycabettus and its relationship with the city have been redefined. The first is the period of Neoclassical Athens until early 20th century, in which Lycabettus was transformed from a pasture and a quarry used for the growing needs of construction into an urban forest (an "airy healing clinic" to use the words of Bavarian architect Ernest Ziller) and beloved promenade destination for the emerging bourgeois population seeking to escape the dusty streets of Athens (Kardamitsi-Adami 2006). The experience of the newly created urban forest was enjoyed mainly by the privileged residents of the city center and distinguished guests who accessed the hill by foot. The designation of the hill as green area whose ownership was taken over by the Municipality was anything but smooth with intense clashes with a multitude of private interests, such as the shepherds who wished to continue using the hill as grazing land, the owners of the quarry and the landowners in the periphery of the hill who wished to construct parts of it.

The second episode when the identity of Lycabettus is being redefined takes place in the post-War period with modernism, the cosmopolitan atmosphere of 1960s Athens and the promotion of tourism through the newly founded National Tourism Organization and the Athens Festival (Aisopos 2015). During this period, Lycabettus is transformed from a promenade destination of the bourgeoisie to a recognizable landmark of metropolitan importance. The changes on the hill are fueled by the enthusiasm and perseverance of charismatic public figures like actor Anna Synodinou and architect Takis Zenetos. This is the period that leaves a legacy to the hill its tourist infrastructure, namely the underground funicular that leads to the belvedere restaurant of St. George, the open-air theatre and the large outdoor parking that was created at the site of the former quarry, a symbol of the dominance of the private car, typical for the period. The first tourists arrive at Lycabettus to enjoy the view and the evening performances in the theatre begin, attracting a large number of visitors.

Fig. 2. View of the created forest of Lycabettus and the open-air theatre at the site of the former quarry (own photo)

The third episode refers to the present period with the explosion of tourist arrivals marking the exit from the crisis, the widespread of Airbnb rentals (Balampanidis et al. 2019) and the establishment of Athens as a year-round city-break destination that will be further enhanced by cruise boat tourism in the near future with the prospect of Piraeus becoming a home port. During this period, Athens' tourism product is being redefined through the various technological applications that promote personalized city discovery experiences, such as 'cultural walks', in ways that blur more than ever the boundaries between the experience of visitors and everyday life of regular residents (Urry & Larsen 2011). These challenges are addressed in the frame of urban resilience, understood as a way of responding to increased natural threats and socio-economic pressures under conditions of limited available resources which call for mobilization of collaborative processes.

The research program undertaken by the National Technical University of Athens (2018) attempts to set up a strategic framework for short-term interventions as well as long-term planning goals embarking upon current conditions. The purpose is not so much to invent new elements, nor the holistic redesign of the hill on the basis of a 'masterplan', but rather highlighting

Lycabettus' essential features that have 'lost their edge' and repositioning them in the contemporary urban context through existing or newly created linkages. The proposed strategy is organized in 29 thematic fields that are presented in a series of diagrams. This text summarizes the main points in three sections. The first reexamine the relationship of the hill with the city of Athens and enhances the transitions from the city to the hill. The second explores the internal properties and potentials of the hill as revealed by site analysis by use of various techniques and mappings. The third engages in constructing a new narrative for Lycabettus in response to present conditions and challenges.

1. Evaluating the importance of the hill for the city of Athens (land use, accessibility and integration in the urban context)

The starting point of any attempt to formulate a strategic vision for Lycabettus embarks upon understanding its importance for the city of Athens. Lycabettus is what it is, primarily due to its location and its organic integration to the life of central Athens, which is structured through multi-layered physical, functional and mental connections.

The topographic feature of Lycabettus, due to its significant height and size, has played a decisive role in the urban structure of central Athens, both in terms of defining the urban grid and in influencing the socioeconomic character of the surrounding neighbourhoods. Hence, the presence of the hill has determined the layout of central arteries which also form the backbone of the public transport network. The regulation of traffic obviously affects the structure of land use due to the important metropolitan functions that are located along the main axes. These are not evenly distributed around the hill but rather are concentrated south-west along the Vassilisis Sofias and Panepistimiou avenues with Syntagma being the epicenter. From this point of view, it can be said that the hill is characterized by a "front" side that includes Kolonaki and Syntagma and a "rear" side which is formed by the neighbourhoods towards Alexandras Avenue.

Looking at the land use structure at a macro level, it is noted that the urban fabric around the hill presents a tripartite structure associated with the terrain. The flat parts along the big arteries, where most of the important city-level functions are located, have the character of Central Business District As we move towards the direction of the hill, where the slope of the terrain increases, the typology of mixed-use, typical for Greek condominiums (polykatoikia), takes over with commercial uses in the ground floor, offices in the lower floors and housing in the upper floors. Finally, as we approach towards the hill perimeter, where the terrain becomes steeper, commercial uses are gradually diminishing and the character becomes purely residential. The zones in direct proximity to the hill, which have an excellent view, are typically occupied by higher income groups particularly towards the districts of Kolonaki. This spatial structure defines in general lines as well the differentiation of the social character of the neighbourhoods that surround the hill.

Fig. 3. Lycabettus connection to major urban landmarks and metro system (NTUA 2018)

A primary concern of the revitalization and activation strategy is identifying and reinforcing the hill's linkages to the surrounding urban context. This is attempted at two levels. At the macro level are identified the linkages of Lycabettus to key landmarks of Athens city center. At the micro-level, the interweavement of Lycabettus with the daily practices of the local population is enhanced by increasing the interface between the hill and adjacent residential zones. At the perimeter of Lycabettus, there are twenty-one entrance points linked to the network of paths. Two of them serve the vehicular traffic, one is the existing funicular and the remaining eighteen are reserved for pedestrians. The proposals for improving connectivity focused on changing the character of the existing perimeter belt into a one-way road, thus freeing space for creating a walking and cycling corridor. The aim of the interventions is for the ring road to cease being a hard boundary, and becoming a promenade for the daily needs of locals, workers and visitors offering easy access to the hill at selected points (urban thresholds) (see Figure 4).

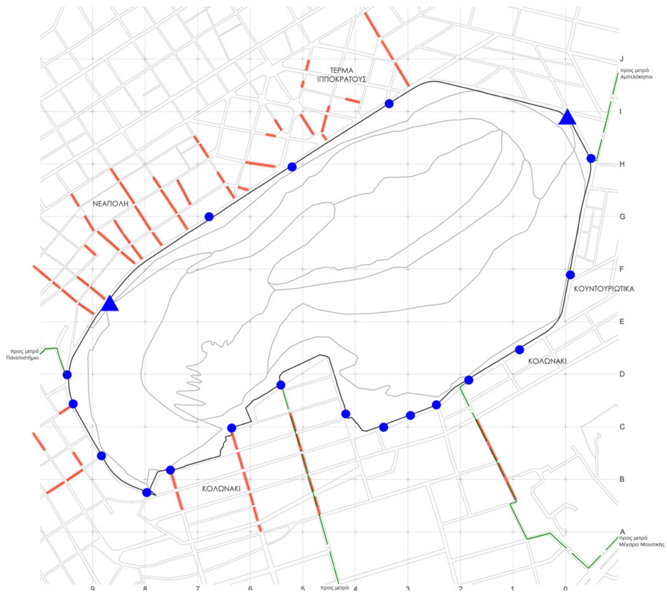


Fig. 4. Lycabettus entrances and pedestrian accessibility (NTUA 2018)

Besides local connectivity, the improvement of supra-local accessibility is also an important priority especially with regard to aspects of sustainability and resilience, as it is a determining factor for the type of activities that can be developed on the hill (from hiking to concerts), the potential users (locals or tourists) but also their expected numbers (from few visitors to large groups). It is also directly related to the question of redefining

Fig. 5. Proposed interventions along the ring road of Lycabettus (NTUA 2018)

the identity of the hill, given that accessibility is not just an operative means but an essential part of the overall visitor experience. Upon reconceiving the way of approaching the hill, the main goal is to promote multimodal accessibility given that Lycabettus does not have a single destination point, where visitors are heading to, but three. These points are accessible in different ways from different areas. The funicular, for example, serves well the peak of St. George from Kolonaki, but it is not convenient for accessing the theatre even less if one is coming from the metro network. In addition, the prospect of the open-air theatre becoming again operational after many years of abandonment creates new travel needs which affect the image and the function of the site in a variety of ways.

In the first phase of the research, the conditions of accessibility by means of public transport have been analyzed. Following from there, alternative scenarios were explored, taking into account functional parameters related to changes in vehicular circulation as well as qualitative ones related to the visitor experience. Specifically, two innovative design interventions have been proposed with regards to adaptation to climate change. The first one involves unsealing the asphalted surfaces of the parking at the top and converting the internal asphalted route into a pedestrian promenade, organically integrated with the natural landscape. The second proposal introduces a new cable car connection that would provide access to the open-air theatre directly from the metro system (station Evangelismos), thus providing an eco-friendly alternative to car travel.

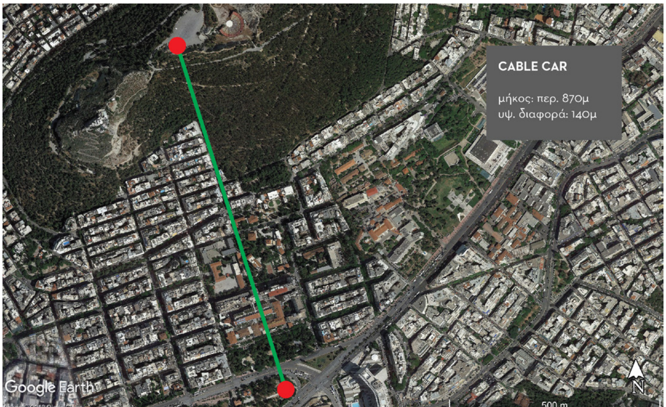


Fig. 6. Proposed cable-car connection to the open-air theatre from Evangelismos metro station (NTUA 2018)

2. Revealing territorial potentialities (topography, views, linkages, suitabilities)

An important parameter for the activation of Lycabettus is its capacity to host a variety of uses and activities. In the first phase of the research, investigations were carried out by means of field survey and web research that revealed through mappings the existence of a wide range of uses, as well as unexploited potential still. Activities fall in two categories, those that exhibit stable and organized operation linked to existing hard infrastructures and those that are spread across the hill for which no special infrastructure is required. The first category is concentrated mainly in the southwestern part of the hill, particularly at the peak of the church of Saint George and the open-air theatre where the highest number of tourists is noted.

The second category is scattered uses, spatially and temporally, with varying frequency and periodicity. The most widely spread activities, which refer almost exclusively to the residents of neighbouring areas, are jogging and walking (with or without pets). At the same time many other formal and informal activities are recorded, such as gymnastics, cycling, skateboard and roller-skating, amateur modelling, demonstration of motor skills (cars, motorcycles), picnic, parties and many more.

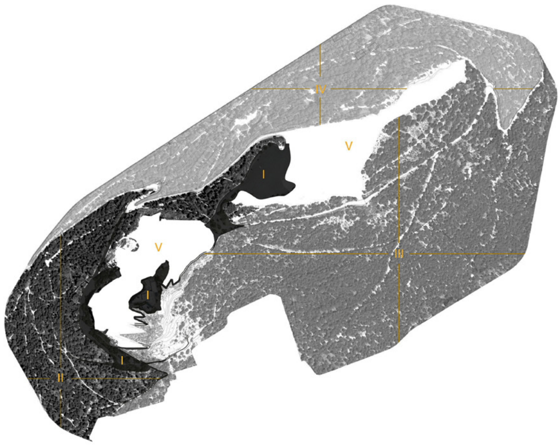


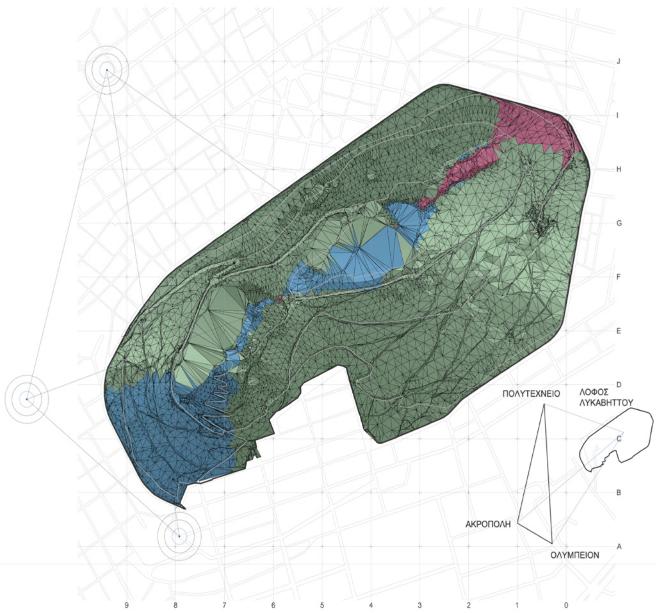
Fig. 7.Lycabettus User Zone Analysis (NTUA 2018)

On the hill take place also seasonal activities, such as annual ceremonies for national holidays and religious functions, sporting events (running, biking), but also unique events, such as outdoor artistic performances and caving. In the second phase of the research, a more systematic investigation of the spatial and temporal pattern of activities was carried out which revealed the way that the hill is used during different parts of the day and by whom. The main findings are summarized below:

- Some age and social groups are excluded (namely children and the elderly population as well as persons with mobility constraints).
- The two main user profiles (local residents and tourists) coexist in harmony and without conflicts.
- Most uses are low intensity referring to individuals or small groups. There is no infrastructure for large groups, such as concerts and events.
- Most uses present a spatial pattern of low complexity associated with single points.
- Most activities are related to recreation and nature-loving.
- The most frequent and widespread activities are: enjoyment of the view, running, walking pets, hiking, dining and organized tourist sightseeing.

– The hill is used almost exclusively during the day.
– The main parameter constraining the spatial distribution of activities is the topography.
– The element that affects most activities directly or indirectly are the panoramic views.

Along with the mapping of activities, analyses of the hill morphology were carried out in order to identify the qualities that the topography itself provides. The results were used to explore emerging forms of spatial organization with the aim to tackle unexploited territorial potential. The following types of mappings were carried out:
Slope analysis through algorithmic calculations has led to the identification of areas that are suitable for different types of activities.
Views analysis through isovists has made it possible to examine the hill as an active field of views, both externally and internally, and to classify the different views according to their formal characteristics.
Path analysis through space syntax revealed the level of integration and interconnection of the hill with the urban fabric enabling the forecasting of expected visitor traffic and recognition of spots that could be programmatically enhanced.



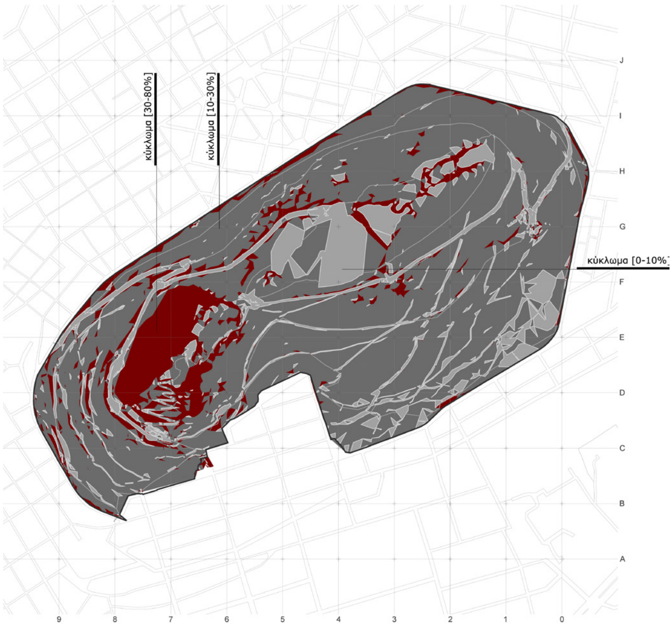


Fig. 8. Lycabettus slope and visibility analysis (NTUA 2018)

The findings of spatial and visibility analysis were used to formulate the proposal of spatial organization, which is structured upon a network of main routes (trails) and poles of activity. The network of main trails aims to improve the visitor experience and orientation as well as safety. The activity areas enable the reprogramming of space and organization of services and amenities with the aim to make their operation more sustainable. Three main service areas are planned linked with the presence of existing infrastructures, namely the restaurant and viewing platform at the peak of St. George, the new recreational pole of the theatre combined with a large belvedere park at the site of the former parking (so-called Athens Plaza) and a third linear zone situated on a natural balcony above the historical square of Dexameni which comprises the popular church of Ag. Isidoroi, the ex-military shelter proposed to be converted into an art venue and the reconstructed café of the Green Tent. Besides the main poles, a system of secondary ones referring to spontaneous and organized activities are organized as points (nodes), pocket activity areas (platforms) and larger zones (activity areas).

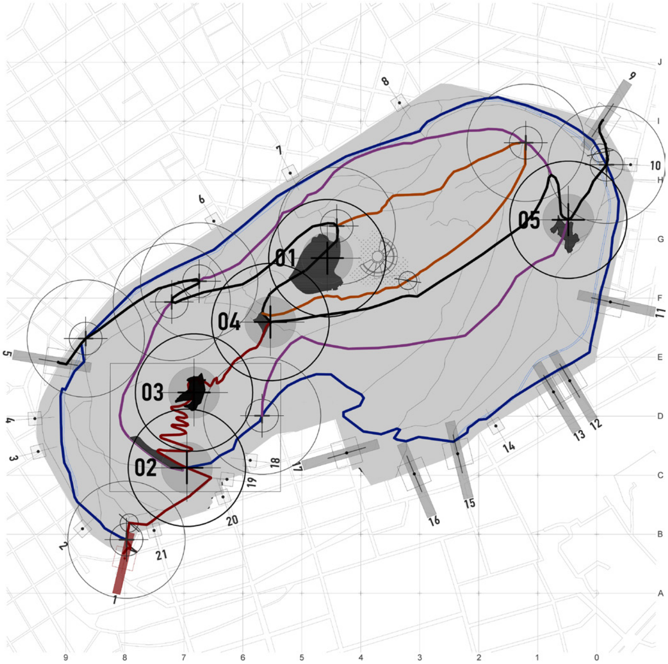


Fig. 9. Lycabettus proposed network of main promenades and poles of activity (NTUA 2018)

3. Constructing a new narrative about Lycabettus Hill: The Athens Eye [1]

[1]This section is based on the chapter „The Athens Eye: Reflection on the myth of Lycabettus" written by Myrto Kiourti (NTUA 2018)

According to the Common Modern Greek Dictionary, visioning means "creating an idealized goal upon which hopes are focused or actions are pursued". Throughout the long duration of History (Braudel 1969), the rhetoric about visioning remains intense. From the pre-modernist visionaries, which the literature today re-examines as early social reformers in the sense of the Renaissance ideal, to the great Utopias of the Enlightenment, the pioneers of Modernism and the post-Modernist critiques and narratives, we reach the contemporary significations of the term. In the present conditions of sudden intercultural proximity, the discourse about cities and their visions articulates around the concept of identity. Realizing the term in the post-industrial environment of international trade, we can talk about branding. At the same time, the discussion focuses on the so-called iconic architecture, that is, the ability of architectural and urban design to produce not only narratives but also intelligible and understandable forms by all representations. In this context, the search for a new vision for Lycabettus is not only timely but imperative, and its construction presupposes an appropriate narrative and then its smart representation.

With this in mind, we compiled a narrative that could help to create a new vision for the hill. As is well known, one of the few planning regulations Greeks collectively complied with is the prohibition on building higher than the Acropolis. While the Acropolis rises about 70 meters above the city level, the height of Lycabettus is 110m. It is therefore fair to assume that as long as the international community conceives the Acropolis as the supreme icon of the values of Western civilization, namely Humanity and Democracy, Athens will never get in its centre any skyscrapers higher than Lycabettus. In this sense, Lycabettus can be conceived as the natural Alter Ego of the Eiffel Tower, the Empire State Building or the London Eye. Just as every big metropolis holds its own iconic buildings that offer spectacular views from up high, so does Athens, only here this takes the form of a hill.

The narrative that intends to re-introduce Lycabettus to the international community as the natural analogue of a skyscraper contains elements of visioning, since, as will be shown below, such an ideology responds in a visionary way to three fundamental problematics about the city, namely the negotiation of the city's relationship with history, politics and nature.

The first refers to the genesis of Lycabettus, which according to the ancient Greek legend resulted from Athena's love affair with Hephaestus. Reconceiving Lycabettus as a construction of the goddess of wisdom in the context of her unorthodox and conflicting love affair with the deformed god of technology is coordinated with modern anthropological and psychoanalytical interpretations of the ancient Greek world regarding the symbols of the technique, the intellect and creation and the role that Man regards them. At the same time, such a narrative proposes to a wider audience, a graceful yet subconsciously relieving resolution of one of the most powerful latent phobias that intensify in modern societies, namely the anxiety and ambiguity

towards a dynamic, yet uncontrolled technology. Lycabettus' narrative offers thus a comforting version of the future: wisdom and technology together can regenerate the City of Humanity.
The debate over the intertwining of a city's identity with so-called iconic buildings has a strong political tone today. In the quest for various cities to gain a place on the global map of tourism and cultural industry by buying buildings with high cultural value, such as Bilbao with Gehry's Guggenheim, Dubai with Burj Khalifa of Skidmore, Owings & Merrill or Beijing with the stadium of Herzog and De Meuron, criticism today focuses not so much on the form but also on the ownership status (Kaika 2010). In the case of Lycabettus, it can be argued that the hill-skyscraper, both as a reality and as an ideology, does not belong to a giant corporation or a tycoon but to the municipality (demos), that is, to all.

At the same time, Lycabettus, as an oversized collective property, highlights a politically interesting interpretation of the constitution of Athenian Urbanism! (Pagonis 2018). The base of the hill is in fact colonized by buildings, the typical self-financed model of Greek polykatoikia (antiparochi). This idiosyncratic urban development condition that is based on the dispersal of land rent and subsequent fragmentation of land tenure establishes early massive democratization. Lycabettus as an emblem of the 'cumulative' mode of urban development (Mantouvalou 1995) offers thus, in tune with the voices of criticism, a democratic alternative to the privately owned iconic symbols of corporate identity and the skyscrapers of a contemporary monarchy.

In-between the built base of the hill and the peak observatory interferes the natural part of the Lycabettus. It is, in fact, a man-made nature, the result of a century-long struggle that Greek society has fought with itself. Green Lycabettus is thus a cultural conquest of modern Greece and could serve as an example and at the same time as motivation in the constant effort of self-discipline in order to establish a relationship with nature that is not hostile, competitive or destructive. In contemporary debates about sustainability and resilience which are dominated by ecological practices of unsealing paved surfaces or planting

roofs and facades with use of sophisticated technology aiming to reduce the effect of overheating, the Green Lycabettus articulates its own radical narrative of green architecture.
Combining the above, we resume that Athens acquires its own iconic skyscraper, which is ultra-modern because it was built by a woman, an ancient goddess, is entirely democratic, green and, against the symbols of contemporary oligarchy, it responds with a form of satirical criticism.

In 1336, Petrarch decided to climb Mount Ventoux. Upon descending, he wrote one of the constitutional texts of Modernity, where for the first time in the history of Western civilization, the experience of climbing a mountain was regarded as an opportunity for introspection (Cassirer et al. 1948). Today a new vision for Lycabettus is constructed by tracing a trail on its "body" that is both material and mental. Along with the interventions aiming at the revitalization and reactivation of the hill, there is also the need to adopt a new narrative capable of inspiring Athenians and the 'Friends of Athens' to reflect critically regarding the collective condition upon which the city was built and take action about the challenges of resilience and systemic adaptation that it faces.

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6. 21st century Santorini - tourism, resilience, identity

Public awareness as the focus of the National Technical University of Athens pedagogics

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Abstract

The School of Architecture of the National Technical University of Athens (NTUA) has over the past four years and within its academic discipline developed educational programs in order to raise awareness on the challenges jeopardizing the future of the island of Santorini. The much-advertised island is presently being overloaded by tourism and lacks a comprehensive plan for the sustainable management of its resources. Among the main risks and hazards threatening Santorini are natural causes (volcanic activity, earthquakes), ecological causes (toxic materials, waste management) as well as the overuse of its natural and cultural resources. The island's resilience is closely linked to the preservation of its natural uniqueness and the sustainability of its cultural landscape.

1. Challenges, Risks and Hazards

In recent years numerous reports in the media feature the Aegean island of Thera or Santorini as “drowning” because of extremely heavy touristic flows to this top destination (Kolodny 1974: 425; Bellos 2019: www); the Greek Organization for Tourism (EOT), even, has recognized the fact[1] that despite the high profits and revenues, Santorini has already entered the cycle of decay and decline. The island’s resources - both natural and cultural - are being depleted beyond recovery, while the existing infrastructure is being severely challenged by touristic overuse (see Figure 1).

Fig. 1. The famous view of the Santorini ‘caldera’ (own photo)

Looking to the future, Santorini’s resilience -the capacity to assume the former shape after a force has been applied on a system- is being questioned and discussed by a number of experts within the scientific community. A study conducted by the Department for Sustainable Development of the University of Cincinnati in 2004 was one of the first to bring Santorini’s challenges into public and scientific discourse (see Reilly 2004: www).

Yet, one must note that in more than one ways Santorini epitomizes the capacity of being resilient throughout its history as

[1] As stated by ex-president of GNTO Betty Hatzinikolaou during a panel for the future of Santorini (Res 2018: www).

it is a place made of extreme natural outbursts, maintaining to this day unique geomorphology and many active volcanoes (Korakakis 2014: www). The cycle of death and rebirth is an integral part of Santorini's identity. From prehistoric ages to today, the isle of Santorini has weathered acute transformations only to emerge with an exquisite beauty to be preserved. (Danezis 2001).

The sustainability triangle model applied for Santorini's development would require all three facets, society, ecology and economy to work together in a balanced way. Yet, at this point, the economy heavily relies on touristic revenue, destabilizing the other two edges of the triangle– social cohesion and ecological equilibrium.

Furthermore, culture alone permeates all three dimensions – social, economic and external – according to the freshly released New European Agenda for Culture (European Commission n.d.: www).

While Santorini enjoys a thriving economy based on touristic revenue, the production of homegrown products does not employ its people as it did before the 1960ies. In recent years, the Therean vineyard was listed as part of the island's intangible heritage on the Greek national inventory, yet the protection of its vineyards requires an enforced regulatory frame.

Most important, heavy touristic overflows affect social cohesion, with temporary stays outnumbering permanent inhabitants. Traditional professions, mores and habits are on their way to extinction, while the scarcity of affordable housing is the reason why teachers, doctors and officers do not opt for living and working in Santorini, a fact that leads to critical shortages in staff.

The heavy air and boat traffic affects the ecological equilibrium, while the recent tragedy of the cruise boat "Sea Diamond" wreck[2] – a toxic bomb at sea bottom – presents a serious threat to the island's waters.

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[2] https://safety4sea.com/cm-sea-diamond-a-pollution-bomb-at-the-bottom-of-aegean-sea/

The abovementioned subjects consist of considerable challenges, risks and hazards. They are bound to Santorini's earth, waters and its subterranean layers: today's risks spring mainly from the volcanic and seismic activity in the area, while historically the extended quarry exploitation of the Therean earth during the 19th and 20th century has left its irreversible marks on the island's strata (see Figure 2).

Fig. 2. Layers of many different geological periods can be seen on the cliffs of Santorini (K.Konstantinidis)

Close-to-saturated landfills progress without a comprehensive plan for waste management, while the Sea Diamond shipwreck at the depths of the islands waters poses a significant toxic hazard.

The cardinal challenge for the island's future lays in the progressive consumption of its natural and cultural resources. At the dawn of the 21st century, after having survived deadly volcano eruptions and earthquakes, tourism now threatens Santorini's very existence. Due to a lack of a comprehensive preservation framework, Santorini's unique natural environment and traditional habitat fall prey to the human disturbance of heavy touristic inflows that threaten to eat up its core natural and cultural values (Lava 2017).

Santorini epitomizes a merging, mutually inclusive world of natural and manmade homescapes, where time and place melt into an etched, onto its soil, history. The island's history is recorded in the formations and layers of its earth, while its traditional architecture –which very much influenced leading modernist architect Le Corbusier - is an inventory of ways man improvises home while balancing between a shortage of building materials and the resilience of Santorini's volcanic soil.

For architects, planners and artists, Santorini has been a source of knowledge and inspiration, especially during the 20th century, when its architecture was proclaimed as archaic by the masters of the Modern movement. Furthermore, Santorini presents a school for architects per se, as it offers a unique paradigm for the study of both, modern and traditional heritage, as well as landforms and cultural landscapes (Frampton 1985).

The overuse of Santorini's resources led to the consumption of its culture, in both territories, society and landscape (Lava & Inetzi 2019) (see Figure 3 and 4).

Fig. 3. Large numbers of tourists meet every year in Santorini (own photo)

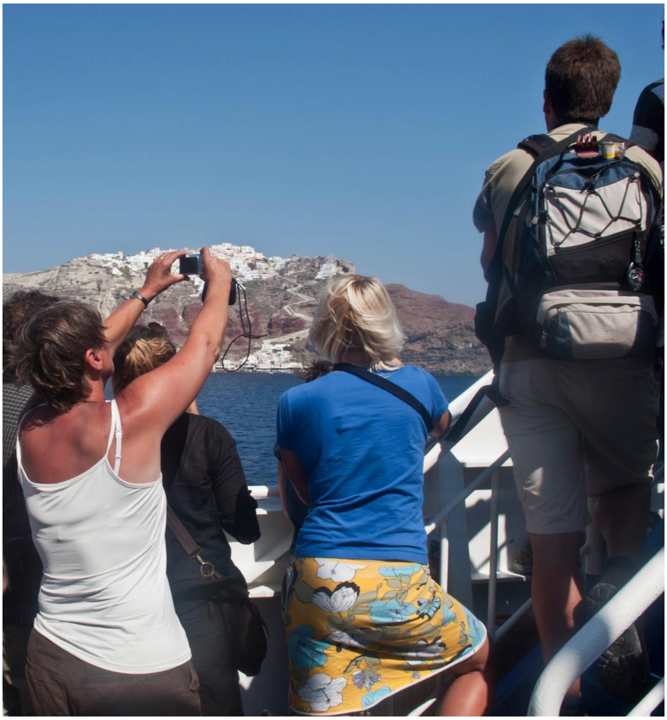


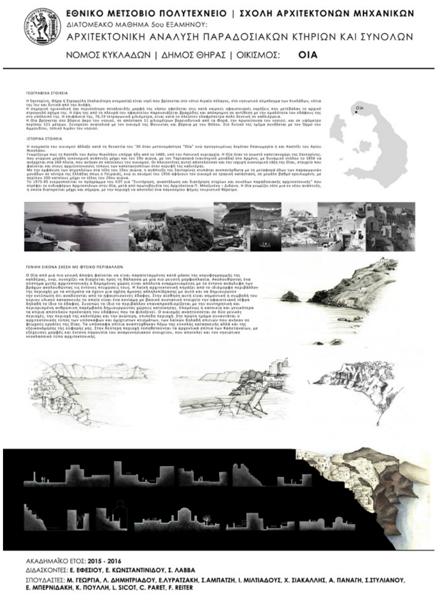
Fig. 4. Large numbers of tourists meet every year in Santorini (own photo)

2. Governance, Pedagogies and Public Awareness

In 2015 the NTUA School of Architecture set out to raise awareness about the challenges Santorini is faced with for the 21st century, addressing many members and stakeholders from the local authorities, as well as members from the national and international scene, among them academics, scientists, artists, writers, students, journalists, entrepreneurs and politicians. A number of educational programs and activities, coupled with numerous mainstream activities such as exhibitions, films and literary publications, have placed Santorini in the limelight of public attention and discourse.

In particular:

During the fall semester of the academic year 2015-16 NTUA students of architecture visited the island of Santorini in order to study the traditional architecture there within the framework of the course "Architectural Analysis of Traditional Buildings and Settlements" (see Figure 5,6 & 7).



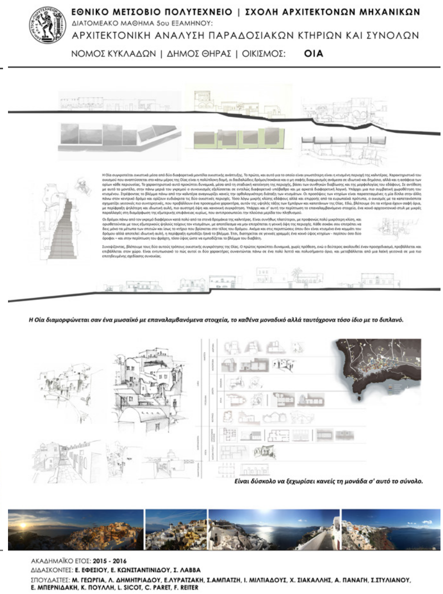


Fig. 5, 6, 7. Student projects from the course "Architectural Analysis of Traditional Buildings and Ensembles", 2015-16 (NTUA photo archive)

The course resulted in a conference and exhibition in the capital of Santorini, Fira, the following spring 2016. With the participation of the mayor Nikolaos Zorzos together with local architects and artists, the issues endangering Santorini's contemporary identity were discussed in length (see Figure 8 & 9).

Fig. 8. Conference and exhibition on the future of Santorini, May 7, 2016 (own photo)

Fig. 9. Mayor N. Zorzos at the podium of the conference (own photo)

In early spring 2016, a workshop for students of architecture at NTUA was conducted as part of the events staged for the 50-year-commemoration of Le Corbusier's death (see Figure 10).

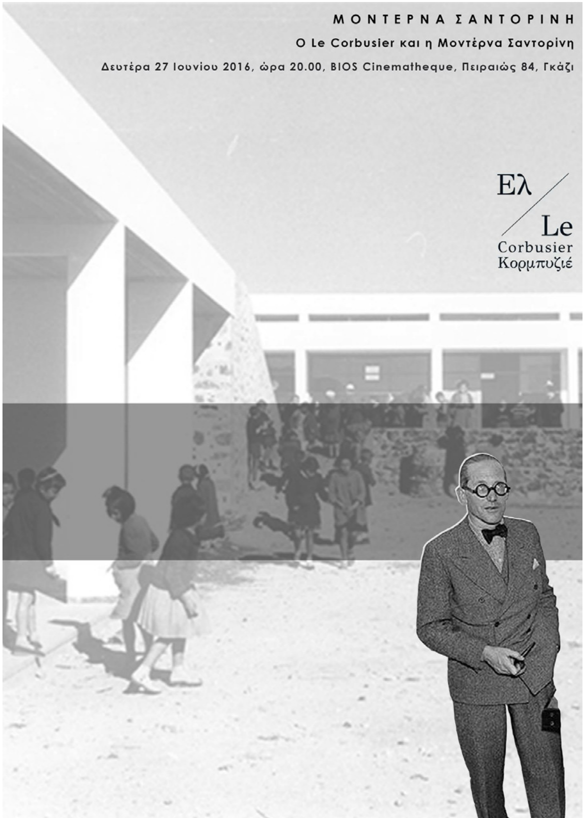


Fig. 10. Poster from the screening of the short film "Modern Santorini (own photo)

As Le Corbusier was inspired by the architecture of Santorini when he visited the place during the 4th CIAM in 1933, students traced the origins of that encounter based on bibliography and the footage that Moholy Nagy had compiled during this visit. The work was edited in the form of a short film entitled "Modern Santorini", which was launched in June 2016 at the BIOS theatre in Athens (see Figure11).

Fig. 11. Screening of the short film "Modern Santorini", BIOS, Athens, June 27, 2016 (own photo)

The film was featured that same year at the Athens Documenta - an international art show usually staged in Kassel, Germany - and was uploaded on the internet. The project received further publicity from the media[3].

The academic year 2017-18, an elective course for architecture students got introduced to the curriculum of the NTUA School of Architecture. The course, established by Dr. Riva Lava, was entitled "Form (Morphe) vs Inhabitation: The case of Santorini " and its scope was to foster research by design.

The course examined the natural and manmade environment of Santorini, focusing on the morphology born out of the volcanic and seismic underground laboratory of the insular complex, as well as the condition for the inhabitation of the cliffs and the valleys with the use of local materials. The topomorphy of Santorini and the forms of inhabitation it implies, consisted the thematic for the study of the Therean cultural continuum from the prehistoric house of Akrotiri, the traditional and modern heritage, up to the contemporary condition, in order to interpret the local architectural idiomatic expression during the 20th and 21st centuries.

[3] A number of Greek news websites, such as LIFO, featured the film "Modern Santorini" within the framework of the events commemorating Le Corbusier's death.

Its pedagogic frame encourages students to develop interpretations of the Therean cultural landscape and transcribe their work into proposals for a better future on the island. At the same time, the projects aimed at raising awareness on the current conditions shaping life in Santorini among inhabitants and visitors.

The first 18 students who participated spent four days on the island conducting in situ research and developing 18 different approaches on the future of Santorini. Each project was based on a working hypothesis which brought together landforms and new possibilities of inhabitation by employing concepts such as the outline and contour of place, the transformation of geomorphological substrata, structural minima of inhabitation on the Therean ground, inhabitation in transformation, traces, trajectories and 3D grids. Other working schemas employed were: the meeting of time and moment, the deciphering of the lands shape, allegories, the sound of poetry, the porous quality of land as a tactile experience, pareidolia and parallax, as well as the narrative as a way to construct space. The last assignment of the course pertained to the design and materialization of the exhibition of the works with the hope of establishing dialogue and exchange with the local people, as well as the visitors of Santorini.

The projects urged local agents and municipal authorities of Santorini to empower educational institutions and to take action in order to balance the heavy tourist activities with heritage and cultural networks.

The course resulted in an exhibition hosted by the Therean municipality of Pyrgos, and it lasted from May until June 2017 (see Figure 12,13 &14).

Fig. 12. *The group of NTUA architecture students at the gallery in Pyrgos, Santorini, May 25,2017 (own photo)*

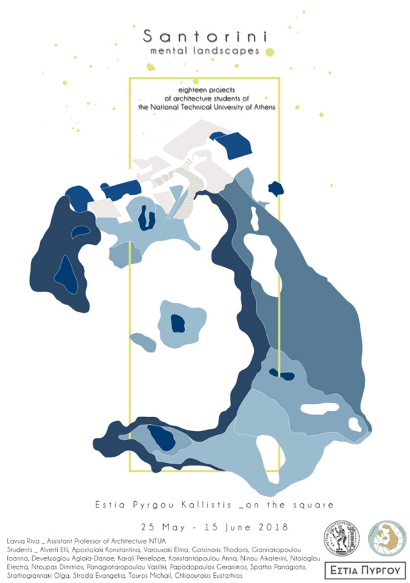


Fig. 13. Poster of the exhibition "Santorini Mindscapes" (own photo)

Fig. 14. The exhibition "Santorini Mindscapes" (own photo)

The compilation of its pedagogics and projects in a textbook for academic use entitled ‘Santorini Mindscapes’ which is currently under publication by the NTUA publishing house (see Figure 15).

Fig. 15. Cover of the educational text book “Santorini Mindscapes” (upcoming)
The exhibition was enthusiastically received, while it stirred public discussion about the potential of the island and its future. (NTUA photo archive)

The second year of the elective course in 2018 was dedicated to the newly coined term ‘cultural carrying capacity’[4] , an expanded term describing the capacity of Santorini to adopt global travellers’ cultures without losing its own physiognomy. A consumers’ culture of ‘things made easy’ establishes populations of visitors who will move in a coordinated fashion via shuttles, taxis, cars and limos to reach their hotels. Such crowds will use pools for swimming and capturing the sea from afar. Place breaks up into a network of advertised spots and photogenic corners serving as sunset decks. A process of cultural territorialization begins (Hatziyiannaki 2011).

Students visited pre-elected sites on the island and developed their research by design with a focus on cultural carrying capacity. After the completion of the course, a number of students presented their findings in the form of academic papers and

[4] The carrying capacity of Santorini has been subject of a collaboration of an expert team from the “Elliniki Etairia – Society for the Environment and Cultural Heritage” and the Municipality of Santorini, 2018-19 with the participation of NTUA Architecture professors K.Serraos and R.Lava

disseminated the research during a special session dedicated to Santorini at the International Congress “Changing Cities IV” which was staged in Chania, Crete, in June 2019 (Lava 2019: www).

In the same year, 2019, the 58th volume of the Greek literary periodical “de_kata” was dedicated to the contemporary culture of Santorini (see Figure 16).

Fig. 16. Cover of the literary magazine “de_kata” dedicated to the contemporary culture of Santorini (de_kata magazine photo archive)

The issue aimed at bringing to the present-day front authors, poets, photographers, architects, painters, historians, archaeologists, geologists, as well as ordinary people who are part of the islands cultural continuum in order to highlight the production of contemporary Therean culture. Numerous NTUA architecture students and graduates participated in texts and project presentations.

3. Conclusions

Assessed against the sustainability triangle model, Santorini's resilience and sustainable development is strongly linked to its cultural cohesion, the framework which holds together the place's character and uniqueness. Regarding its social tissue, travellers and visitors outweigh the indigenous people on the island today; as a result, mores and rituals may become extinct, while traditional art and architecture suffer the mega-invasion of a 'room to rent' culture.

Santorini's natural landscape, because of its uniqueness and beauty, carries the heritage value of a cultural landscape; ecological imbalance and toxic debris today pose the very body of Santorini under threat. As far as the island's economy is concerned, tourism overwhelms traditional production of homegrown goods and thus depletes the natural habitat of the Therean insular complex.

Culture – the way people live and do things – is strongly affected by the imbalanced growth of global tourism in Santorini. The NTUA educational initiatives aimed at bringing the cultural potential of Santorini's place and people to the forefront and harness its power for social cohesion and well- being, as well as for the enhancement of the quality of the touristic experience.

Although some habitually argue that the academia does not change things fast enough by effectively steering politics, we would like to state that we disagree and express our firm belief that through education and pedagogy we see the only true way to redefine the issues of humanity in their totality and radicality. In other words, by delving into the deep structures of each cause, we may be able to reframe politics and create consensus for communities to see and share. The utopias of fresh student projects, can -surprisingly enough- create new mental or imaginary entities (Harari 2016), new narratives about place and culture and cater the 'glue' for a sustainable community of deed and thought.

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Part 2

Introduction

Coping with Flooding and Urban Heat Islands: Resilience Strategies for the City of Hanover developed during the Summer School

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Global climate change, as well as economic and social changes, pose new challenges to urban and regional development worldwide. Rapidly changing climate, economic and social trends require adaptation and address several uncertainties and complexities to enable proactive action. Therefore, cities and regions around the world face the challenge of exploring flexible and innovative forms of governance that address specific local vulnerabilities and commit to development of capacity for future change - the resilient city as a planning goal.

From the 22nd to the 26th of July 2019, the summer school within the research project "HeKriS – Challenges of resilience in European Cities" took place in Hanover, Germany. It discussed the topic "Governance of Resilience: Environmental Challenges in European Cities" within the greater urban complex of Hanover. The emphasis was set on the risk of the occurrence of extreme events in the urban area of the Hanover Region, especially urban heat islands and seasonal flooding and their consequences for humans, the built environment as well as all kinds of infrastructures and services within the city and the region. Dealing with such shocks and events enhances crucial characteristics from architects and urban planners to develop resilient cities and city-regions – now and in the future. The germinal question to be examined during the Summer School was how to deal with climate change induced extreme events, in terms of governance, as planners or architects to aim at resilient, liveable cities for future generations. This summer school aimed at encouraging the participating students to get an integrated perspective on the phenomena of urban heat islands and flooding in specific areas of Hanover. This includes not only aspects about the built environment (like the location of buildings, density of housing, fresh air corridors, etc.), but also raises questions about planning processes and creation of awareness on the local level, as well as about dealing with uncertainty and complexity and reflecting on the roles of different stakeholders. The participants were asked to analyse given neighbourhoods and develop strategies for resilient urban areas in the city of Hanover by identifying, understanding and applying crucial elements and factors to create sustainable urban environments. The results are five strategies providing solutions for reduced vulnerabilities occurring from urban heat islands and flooding in respective areas.

The scope of work of the Summer School

Urban heat islands and flooding are one of the challenges that might become a real threat in the future for the city of Hannover due to continuously rising temperatures and prevailing weather unpredictability induced by climate change. Hence, five groups of German and Greek students, together in interdisciplinary and international groups, were required to carry out and conduct research activities on the aforementioned topics located in an urban area of Hanover city. The participants were introduced to the issues by valuable keynotes of local and foreign experts and practitioners on urban resilience. Additionally, information material such as maps and literature were provided, and the organisation team offered scientific support during the analysis and strategy-making development processes. During the summer school, the groups analysed their specific neighbourhoods according to urban heat islands or flooding risks and answered the questions: Where could you potentially find them? What characterises the local context (built environment, societal dimension, and environmental aspects)? How are the surroundings affected by heat islands/risk of flooding? Accordingly, after the detailed analysis, the groups presented their ideas and approaches to dealing with the respective challenges and eventually introduced their innovative, sustainable and resilient solutions to the organisers and other participants.

Five concepts of the Summer School

The five developed resilience concepts were presented and discussed on the last day of the summer school. The students combined governance approaches as well as practical solutions; they experimented in particular with design concepts such as the planting of trees, unsealing of paved surfaces, introducing green canopies, green roofs and facades as well as creating planned flooding zones. Importantly, the groups did not only focus on their single tasks but also came out with excellent, innovative ideas and concepts on how to cope with flooding and urban heat islands in different resilience strategies for the city of Hanover. The final ideas of each group on how to deal with given topics are presented in the five following articles:

The concept **Tr-Island - Combating Urban Heat Islands in the City Centre in Hanover** presents a proposal for dealing with the issue of urban heat islands in the city centre of Hanover. By utilising the old tram infrastructures in the area, the proposal unifies the area and creates a more attractive public realm network. In the urban areas, water elements and vegetation were introduced to reduce the heat island effect significantly. The paper further emphasises the importance of a comprehensive urban governance implementation process and recommends the introduction of a resilience action programme to achieve sustainable urban development in Hanover.

HannOVER heat - Steintor's heat islands focuses on the north-western parts of the city centre of Hanover, which are profoundly affected by higher temperatures compared to less-urbanised and less-densely built areas. The paper promotes different level solutions in order to defuse the challenge of heat islands. The suggested ideas include proposals of governance as well as more operative solutions, like the expansion of the existing vegetation, the creation of shading and the unsealing of pavements.

The concept **Coping with the heat island of Raschplatz and surroundings in Hanover** analyses the challenges in Raschplatz area in terms of heat islands. With the help of a site observation physical and socio-ecological urban contexts as heat affecters were explored. In order to improve the current heat island situation of the Raschplatz area, the concept suggests creating green spaces, roof greening, the greening of vertical structures as well as heat isolation of buildings and creation of water surfaces.

In **Double Trouble**, the authors focus on flood risks in a specific neighbourhood in the city of Hannover. The concept discusses historical events and actions implemented by the municipality, as well as the study of data provided by it. With the help of research and discussion, the paper aims to develop guidelines and propose design strategies to address flood threats on the study case site.

Resi^2 Rick: Flood Resistance and Resilience in Ricklingen, Hanover explores how factors of flood resistance and resilience are addressed within the development of an area in Ricklingen, a hydro-geologically vulnerable district in the south-west of Hanover. The already existing dyke as a flood control and resistance measure offers protection against fluvial floods but does not offer protection from pluvial or flash floods and further intensification of extreme weather events. To adapt to climate change, the concept proposes the establishment of ditches that relieve stress from the drainage system and ponds and green roofs to evacuate intense rainfalls. In addition, the proposal foresees awareness-raising campaigns, resilience meetings and supplemental incentive schemes to encourage civil initiatives and actions such as the instalment of ponds on private property.

1. Tr-Island - Combating Urban Heat Islands in the City Centre in Hanover

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Abstract

As part of the HeKris research and exchange, this paper presents a creative proposal in dealing with the issue of urban heat islands in the city centre of Hannover. The area in question is essentially fragmented due to heat island effects making some streets and connecting roads unbearable to walk through. By utilising the old tram infrastructure on Prinzenstraße and Schiffgraben, the project unifies the area and creates a more attractive public realm network. The introduction of vegetation and water elements in urban areas was found beneficial to reduce the heat island effect significantly. The paper further emphasises the importance of a comprehensive urban governance-oriented implementation process and recommends the introduction of a resilience-focused action programme to achieving sustainable urban development in and around Hanover.

Introduction

European countries need to react to incoming crises caused by the phenomenon of climate change to ensure sustainable urban and regional development. The increasing number of heat waves puts pressure on social and ecological systems and functions (Kershaw 2017: 5-1f). In this context, the concept of urban resilience refers to withstanding threats and stresses. It describes an urban system's ability to act as an intermediate approach by developing proactive adaptation strategies to reduce the levels of vulnerability of cities and regions. (Leichenko 2011: 164)

The city of Hanover faces worsening heat stress and has the potential to develop urban heat islands (UHIs) (Schmidt 2019: oral). UHIs are defined as a phenomenon in which "the urban air temperature is higher than that of the surrounding rural environment" (Kleerekoper et al. 2012: 30). Depending on the time, place and urban characteristics, differences of temperature can vary (ibid.).

The resilience of the city with regard to heat will be the subject to this paper. This research paper outlines a strategy of a triangle-shaped urban network of green infrastructures, enhancing the city centre's urban micro-climate, reducing the occurrence of UHIs. The paper begins with a brief description of the research methodology. Then, the study area is shortly described, and findings are explained in context to the main concept for the area. The urban governance characteristics for implementing the strategy are shortly pointed out before the authors give a short recommendation for implementation. Lastly, the conclusion is drawn.

Methodology

The mental map approach is a method that outlines personal representations of people's internal perceptions with the external world in terms of experiences, values and goals. The construction of individual perceptions and understandings of the world supports an urban planning process strategically by fostering planners and decision-makers understanding and planning for a variety of concerned user groups and stakeholders. (Jones et al. 2011: 46) Hence, the main approach for the design of the research proposal has been to observe what already existed in the area, what could be adapted and what could be where improved to prevent heat islands from occurring. In turn, by working with the existing city fabric and by constructing a new one, this project carefully deals with the historic buildings and streets prevalent to the area.

In addition to the mental map approach, a review of statistical data, context-related literature and strategic documents of the city of Hanover was carried out to further support the identification of potential UHIs in the study area. An indicator system was developed to evaluate the level of exposure to heat, as depicted in table 1.

Structural Components	Social Components	Green Infrastructures
• Density of buildings • Heights of buildings • Main road network for pedestrians, bicycles and motorised traffic • Building materials • Surface structures and materials, evaporation rate • Functional integration of area with bordering areas • Land use • Wind corridors • Perceived air temperature • Albedo	• Share of residents in the area • Number of visitors • Share of employees • Age structure: Share of people aged >65 years • Sensitive infrastructures: hospitals, kindergartens, schools • Exposure to noise pollution • Exposure to air pollution	• Share of green spaces (in-street, facades, rooftops) • Functional integrity of green spaces in the urban space • Share of shade on the streets and pavements

Tab. 1. Indicator System for the Evaluation of Heat Exposure (own depiction)

This case study area is located in the central city of Hanover, as depicted in figure 1.

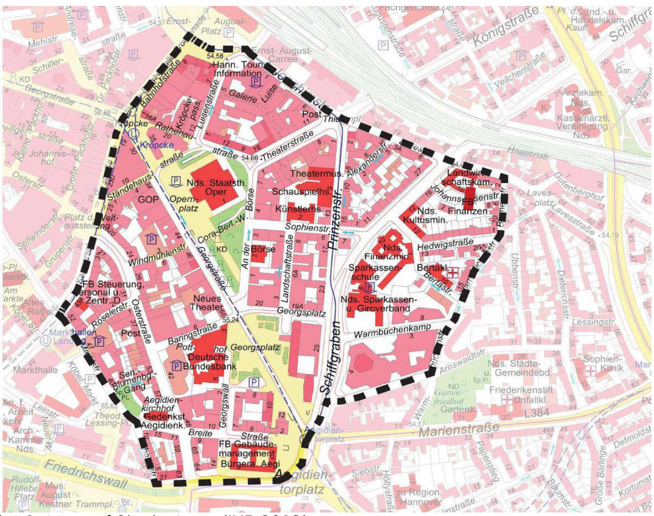

Fig. 1. Map of Study Area (IUP 2019)

In the following section, the analysis results about the location's exposure to heat are presented. Then, the conceptual approach to combat UHIs is explained using a master plan and detail plans of the area. The scientific justification of chosen measures follows before the urban planning process is reflected regarding urban governance.

Analysis results

In the following, analysis results are outlined.

Exposure to Heat

Based on the indicator system and with respect to the three components in table 1, three categories of heat exposure were developed to categorise the analysed area as depicted in table 2.

Level of Exposure	Description
High	Indication of high pressure on the street. The streets are not or hardly equipped with green infrastructures, cooling materials and infrastructures for buildings, facades and surfaces. A high volume of car traffic leads to significant exposures in terms of air and noise pollution. Heat islands are likely to develop.
Intermediate	Indication of a medium level of pressure on the street. The streets are partly equipped with green infrastructures, cooling materials and infrastructures for buildings, facades and surfaces. Constant car traffic leads to partial exposures in terms of air and noise pollution. Heat island may occur.
Low	Indication of a low level of pressure on the street. The streets are mostly well-equipped with green infrastructures, cooling materials and infrastructures for buildings, facades and surfaces. Low car traffic hardly leads to exposures in terms of air and noise pollution. Heat islands are unlikely to occur.

Tab. 2. Levels of Exposure to Heat (own depiction)

Figure 2 shows the results of the analysis. The red-highlighted streets are perceived as being highly vulnerable to heat stress, whereas the green-coloured ones show hardly exposure. Intermediate pressure is revealed by orange-coloured streets.

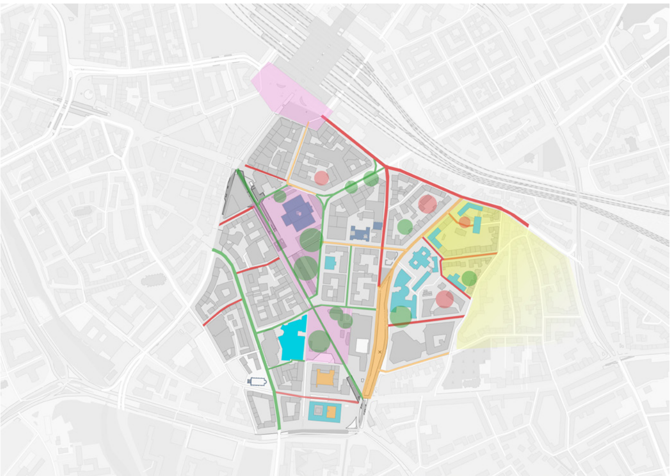

Fig. 2. Analysis Results (own depiction)

Fig. 3. Georgsplatz: Low Exposure to Heat (own depiction)

Fig. 4. Analysis Results (own depiction)

The western area, including the Opernplatz, the Georgsplatz and Theaterstraße, represents well-functioning climate-friendly adaptation measures to heat vulnerability (see Figures 3 and 4). High trees and closely-connected green areas along the alley Georgstraße offer good access to shaded locations. Water elements on Georgsplatz further support a balanced micro-climate and a partly opened surface structure offers possibilities for evaporation. Despite the high density of buildings, the materials are identified as being hardly susceptible to radiation. Nevertheless, the dense concentration of buildings was found to limit air circulation. Only one wind corridor was identified in the Sophienstraße. Despite the wind, a high amount of asphalt, the street's east-west orientation and the lack of greenery were found as strong exposures to sunlight that reflects without hindrance.

Contrastingly, it was found that the eastern part of the study area is mostly affected by exposure to heat. A lack of greening on street, such as trees, and a high density of high-rise buildings with reflective facades, partly of glass, were revealed. This finding is accompanied by the low quality of stay due to the lack of a dedicated public gathering area equipped with shade and seating furniture. The majority of streets is asphalted, which further reflects heat and leaves hardly any possibility for evaporation. Additionally, the area is disconnected to the functional integrity of the main city centre. This separation is enforced by the streets Schiffgraben and Prinzenstraße that prioritise car traffic on multiple lanes. Especially on Schiffgraben, high motorised traffic volumes are recognised. Further, disused tram tracks lower the urban design along Prinzenstraße and Schiffgraben.

Fig. 5. Prinzenstraße with disused tram tracks (highlighted in green) (own depiction)

Fig. 6. Asphalted street highly exposed to heat (own depiction)

Based on these findings, the clear divide within the study area is revealed as depicted in Figure 2. Despite a lack of qualitative and quantitative research methods, it could be proven that the occurrence of UHI varies regarding the urban structure. Micro-urban heat islands were identified in a few streets, public parking lots and public inner courtyards based on perceived changes of local temperatures occurring from a lack of wind and vegetation elements.

Use of Area

The whole area is characterised by three main types of usage that are mixed areas, green areas and residential areas (Landeshauptstadt Hannover 2019: www) as outlined in Figure 7. These usages were further analysed and divided by their functionality. The western part of the area is the dedicated core shopping area. It is interrupted by two green areas at Georgsplatz and Opernplatz that provide healthy gathering places. A small part of the area with high importance in the urban context is dedicated to cultural usage at Opernplatz and partly Prinzenstraße: Key cultural points of attraction, i.e. the Hanover state opera and the state theatre. Furthermore, the functionalities in the centre and centre-east are identified as the financial and administration district. A small part in the east is dedicated to residential use which enhances the possibility to expand over the study area's border. According to the land-use plan of Hanover, one hospice was identified as being located in the eastern area. (Landeshauptstadt Hannover 2019: www) However, it could not be clearly identified whether the institution is vacant. Therefore, this kind of usage is not considered in the following.

User Groups

Based on the zoning and the functional analysis of the study area, three main user groups were identified as being exposed to urban heat stress.

- Visitors to the city of Hanover for the purpose of tourism and shopping
- Employees from surrounding shops, financial businesses, insurance companies, banks and administrations
- Residents living in the north-east of the study area

It is clearly discernible that these user groups follow differing interests with respect to them staying and spending time at locations in the area. While visitors are expected to remain outdoors for longer intervals, employees are likely to gather at these places for shorter intervals, e.g. during their daily lunch break. Moreover, the periods of usage differ significantly from each other. While residents are expected to mainly visit these areas in the late afternoon and evening hours during the week, visitors would rather use the place during the daytime. Employees, however, are expected to use the place during for lunchtime activities around noon. The diversity of user groups points out several demands on public spaces. This makes it clear that new adaptation measures for climate resilience must show beneficial cooling effects on both the inside and outside of buildings.

Figure 7 summarises the findings concerning the functional separation of the area and the main types of land use. The arrows show potential flows of pedestrian ways to reach the closest green public places of stay. The distance to green areas and streets can reach up to 600 metres which emphasises the urgent need for action.

Conceptual design

The following concept consists of a master plan that is followed by a three-stage detailed plan.

Masterplan

The masterplan outlines the core strategy of developing a heat-resilient area in a central part of the city of Hanover. The plan focuses on the more vulnerable eastern area as identified in the analysis; adequately described by the name of the proposal, Tr-Islands referring to the train-tracks and the triangle-shaped as the main unifying component in the design of the masterplan. Three core priorities in three-time frames of implementation are set:

TIME FRAME	PRIORITY
Long-term	Enhancing urban resilience towards adapting to heat stress by the creation of a green network system.
Medium-term	Increasing the urban quality of stay regarding the user groups differing demand by re-using abandoned tram tracks as a complementing network axis.
Short-term	Creation of an expanded pedestrian network to central places of stay from the Eastern part of the planning area by implementing heat-avoiding and resisting guiding elements.

Tab. 3. Core strategy (own depiction)

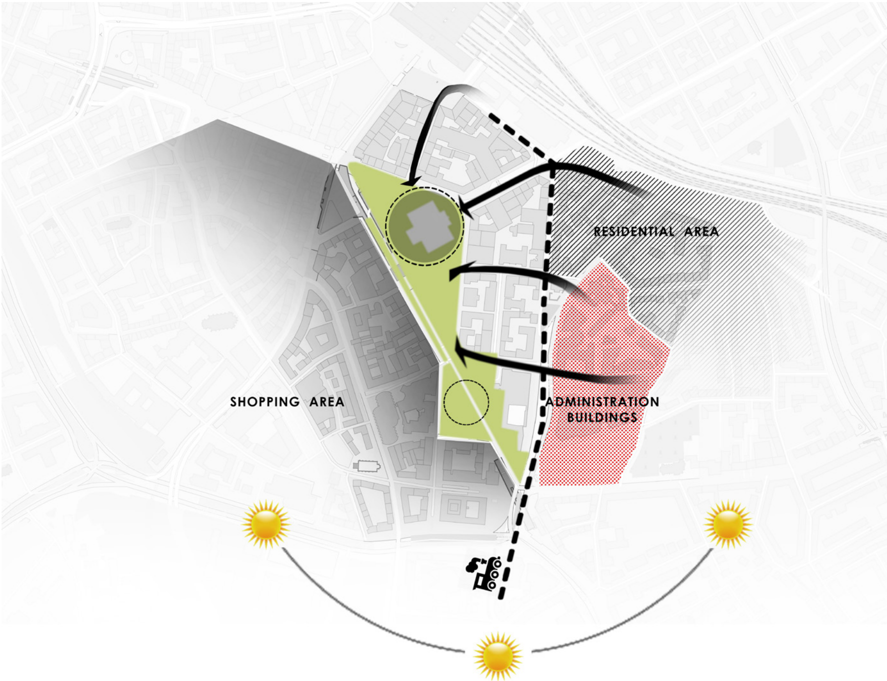

Fig. 7. Brief summary of findings (own depiction)

Figure 8 portrays the masterplan[1].

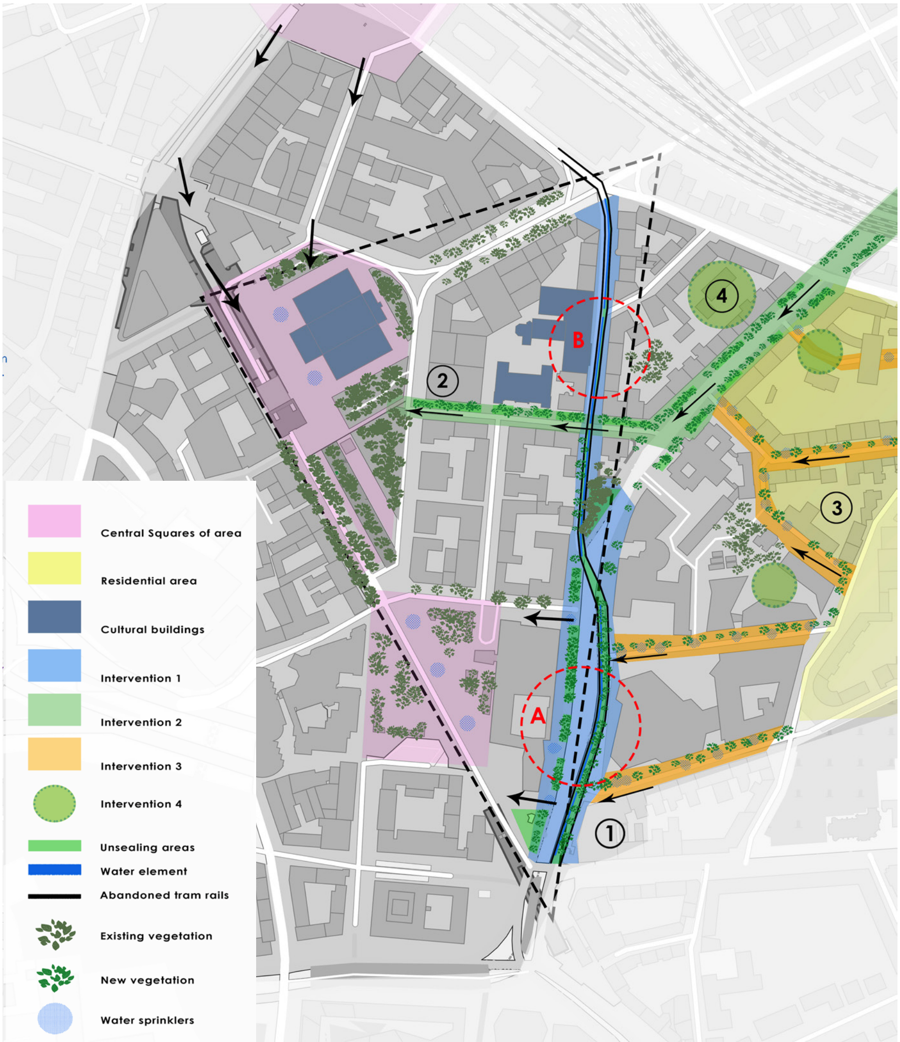

Fig. 8. Tri-Island Masterplan (own depiction)

[1] It should be noted that the paper does not explicitly refer to all measures outlined in the masterplan

Detailed Investigations
Three detail plans point out potential measures for climate resilience adaptation. For each focus area, the precondition is shortly given before the respective approach is explained.

Focus area 1: Schiffgraben south
Preconditions: The regarded section of the street Schiffgraben is characterised by a large cross-section. The road currently includes disused tram tracks with an abandoned tram terminal point Aegidientorplatz. A lack of high trees and greening elements can be identified, leading to a low quality of stay and high levels of potential heat exposure. Similarly, high numbers of passing by cars lead to noise and air pollution.

Approach: While the tram station will be removed, the tram tracks are kept in order to retain the place's former identity. Greening measures are going to be taken for the middle verge on-top and around the tracks. Measures include the planting of high trees for the provision of shade, the planting of grass and seasonal flowers. (see Figures 9 and 10) Additionally, these actions increase the up-take of rainwater and the absorption of CO_2 for counteracting pollutions from e.g. cars. Furthermore, noise emissions can be lowered by the reduction of sealed surface. An additional implementation element is a narrow watercourse along the track, contributing to cooling the area through water evaporation. Plants and tall trees will be planted to the sidewalks and cycle paths along the street, with a steady line of small water fountains, resulting in more favourable heat conditions for pedestrians.

Fig. 9. Installation of Heat Prevention Measures on Schiffgraben (own depiction)

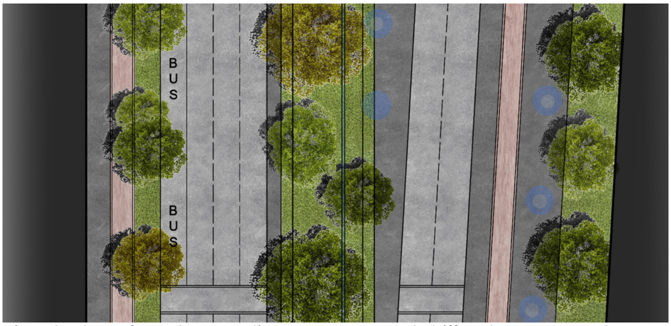

Fig. 10. Plan of Heat Prevention measures on Schiffgraben, Area B (Masterplan) (own depiction)

Focus area 2: Prinzenstraße

Preconditions: Prinzenstraße connects Sophienstraße and Theaterstraße. It is a narrow one-way street, by the northern part of the disused tram tracks in northern and southern direction. The street's importance is highlighted by the presence of the local theatre. Greening elements are missing in the urban structure; hence, the street is perceived as highly vulnerable to heat stress.

Approach: It is proposed to implement greening elements between the buildings. A green canopy is suspended above the street level, with vines and climbing plants creating adequate shading without the use of trees. This measure is implemented to address the narrowness of urban space. Furthermore, the space of the tram tracks is used to extend the water element from Schiffgraben, for further cooling. Additionally, the street


Fig. 11. Installation of Heat Prevention Measures on Prinzenstraße (own depiction)

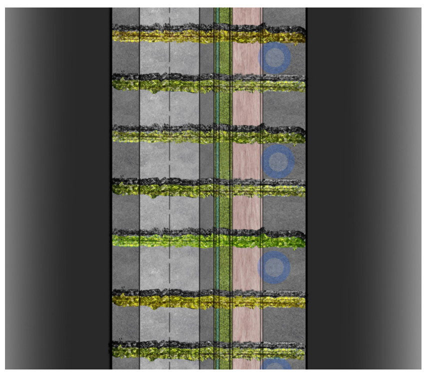
Fig. 12. Plan of the Heat Prevention Measures on Prinzenstraße, Area A (Masterplan) (own depiction)

will be equipped with street furniture to increase the quality of stay for users. The furniture supports spaces dedicated to pubic usage and not for commercial purposes.

Focus Area 3: Streets to the east of Schiffgraben - Creating a Network

Preconditions: See Focus Area 1.

Approach: Along the Schiffgraben road link to Sophienstraße, a combination of tree planting and unsealing surfacing measures should be implemented. This will create more adequate walking conditions for pedestrians and cyclists with reduced street-level temperatures. People are encouraged to actively move westwards the city centre area to benefit from high-quality green spaces of stay. Secondly, the connection between the city centre and the residential area is enhanced by adding more trees for shading. Additionally, spatial markers will guide residents as they move further into the city centre with green sculptures becoming more frequently placed as moving closer. Finally, the creation of additional green pocket spaces, within accessible building courtyards, will improve the spatial quality and the users' values, especially for employees working in the large office buildings.

Justification for chosen measures

Measures to be implemented are chosen based on their scientifically proven capability to provide for environmental and social resilient capacities needed in response to the former analysis. Additionally, the presented approach aligns with the urban development strategy Hannover City 2020+ (Landeshauptstadt Hannover 2011: www).

Whereas the urban built form and the materials are hardly subject to change, water and vegetation were mainly chosen as interventions for reducing the UHI effect (cf. Kleerekoper et al. 2012: 32). According to Kershaw (2017: 4-29), blue and green infrastructure are well suitable for mitigating UHIs.

Vegetation measures can have an average cooling effect up to 4.7°C in urban areas. An environment can be actively cooled by transpiration and evaporation. Additionally, planting high trees with dense treetops provides for shading surfaces and lowers the absorption of radiation. Vegetation in terms of green public spaces further benefits citizens acceptance and can be implemented at a low cost. (Kleerekoper et al. 2012: 32) Moreover, vegetation serves for potential flood relief by being an ecological, natural and therefore sustainable drainage system. Apart from the “hard” facet of built resilience, “soft” social factors are enhanced by the improved health and well-being of users due to the environmental improvements by aestheticised urban structures. (Kershaw 2017: 4-20)

Street trees

Trees can absorb up to 90% of solar radiation and thus have a positive effect on urban micro-climate. The temperatures under trees reach a cooling effect of up to 15°C compared to the temperature of the environment (Tonneijck et al. n.d.: 13ff). The larger the treetops, the stronger the measurable temperature difference in the built environment. (Kleerekoper et al. 2012: 32; Tonneijck et al. n.d.: 16)

Green spaces

Greened areas generate cooling as they are suitable for rainwater retention, which then evaporates again (Kershaw 2017: 4-20; Kleerekoper et al. 2012: 32; Tonneijck et al. n.d.: 16). Green street spaces further provide for multifunctional use. Ecosystem services bind air emissions such as CO_2. Equally, social cohesion is strengthened as the quality of stay at public spaces is enhanced by their regulative impact (BFN 2017: 17). The authors emphasise the importance of social capital in the context of a resilient urban environment. The usage of wildflowers or other plants similarly enhances the quality of the urban environment (Tonneijck et al. n.d.: 24).

Water elements

Water functions as a heat buffer by its heat absorption capacity. Especially flowing waters, such as streams, are most suitable for transporting the heat out of the area (Kleerekoper et al. 2012: 33). The biggest cooling effect comes from dispersed waters such as fountains (ibid.).

Non-consumption areas / Street furniture

Non-consumption areas can animate people to socially interact (Tonneijck et al. n.d.: 28). This contributes to building social capital and thus social resilience as they provide inclusive areas. Likewise, street furniture in various spaces offers the possibility to participate in public life. Especially elderly and weaker people benefit from such infrastructures as these offer rest places and public realm. Therefore, sufficient and well-designed infrastructures in urban places can help people to build social capacities and to encourage social exchange.

Green Network

Apart from urban heat prevention and adaptation measures, the creation of a green network shall provide for enhanced levels of social resilience. On the one hand, a network of green infrastructures enables balancing and synergising heterogeneous user demands by providing for multifunctionalities of space (BFN 2017: 14). The incorporation of the crucial resilience elements, diversity and redundancy, is supported as the urban land-use patterns serve for various social, ecological, economic functions (Sharifi & Yamagata 2018: 19). On the other hand, a network consisting of greened pathways offers a basis for sustainable mobility, as movements of people are facilitated by well-designed pedestrian paths and areas (Olazabal et al. 2018: 200; BFN 2017: 13). Eventually, mixed-use neighbourhoods and walkability “provide more opportunities for strengthening social networks and enhancing social interactions among neighbours, thereby enhancing social capital and sense of attachment to the community” (Carpenter 2015 in Sharifi & Yamagata 2018: 18). (BFN 2017: 13; Sharifi & Yamagata 2018: 18f). “The creation of an urban green network benefits that urban heat island effects as it accumulates from the sum effect of all development [so that] great variations may be evident in small areas and these have immediate impacts on residents’ health and energy demands.” (Stangl 2018: 186) Eventually, linking residential and business is essential for enhancing urban resilience (BFN 2017: 13).

The notion of urban governance

The consideration of urban governance in the context of urban planning plays a major role in resilient urban development. Urban governance "refers to how government (local, regional and national) and stakeholders decide how to plan, finance and manage urban areas" (Avis 2016: 4). As it is profoundly politically informed, a process for decision-making should be strategically determined by a variety of institutions and actors (ibid.). Strong structures of cooperation can build up a local or regional system of action (Plöger & Lang 2013: 334; Lukesch et al. 2010: 47). According to the UN-Habitat (2015: 1), urban governance is understood as "the software that enables the urban hardware to function [...]" by making "local institutions able to respond to the citizen's needs" (ibid.). That indicates the need for multi-level governance in order to make decisions on vertical and horizontal levels (UN-Habitat 2015: 1).

The urban development process for implementing heat-resilient urban areas needs to be shaped by these characteristics. To include various competencies which strengthen redundancy (Kühnel 2014: 181; Lukesch 2010: 50f), stakeholders of the private, public and non-governmental sector will have to be included.

The public sector, represented by the City of Hanover, acts as the executive and legislative power. The city's government, but also the regional and state government indicate key roles in terms of political decision-making and establishing legal frameworks. The multi-level approach is highly important as, in the case of heat islands, not only the urban micro-climate needs to be regarded, but further the meso-climate of the Hanover region. Additionally, an integrated approach towards urban planning should take place. It could be beneficial to create a municipal working group with representatives of the city's' different departments and institutions to foster collaboration, knowledge transfer and the effectiveness of urban planning (BFN 2017: 24).

The inclusion of the private sector is particularly important due to various reasons. First, the outlined concept concerns numerous private businesses and companies that are in the area. Owners and users of the buildings, especially in Prinzenstraße, need to be informed and convinced about the importance and effectiveness of the planned measures as these directly affect the usage of building structures and facades. Them being highly aware of the vulnerability to heat stress can increase their openness and willingness to participation and collaboration.

A further important stakeholder is the ÜSTRA traffic company due to it being responsible for the disused tram tracks that are subject to the re-design of the urban space. Moreover, collaboration with experts from private urban planning companies is useful for a strategic, independent planning process, knowledge transfer between different stakeholders and for quality guarantee (BFN 2017: 24). Public-private partnerships could be a good means for financing construction and maintaining the new functions.

The non-governmental sector is embodied by residents of the city of Hanover, citizen organisations and other action groups. Their early inclusion not only in the decision-making process but also in the urban design process is crucial to balance their demands and interests by dialogue mechanisms (BFN 2017: 14; UN-Habitat 2015: 1). Local knowledge is necessarily offering the intermediary between stakeholders to plan for uncertainties (Kim & Lim 2016: 6; Klein et al. 2017: 35). Additionally, the involvement of citizens at different planning stages fosters public acceptance for interventions (Greenspace 2005 in Kleerekoper et al. 2012: 32). Moreover, the authors expect that the integration of residents increases the participants' internal capacities to act, understand and be responsible for their environment and its vulnerabilities. Such a process equally supports the creation of social capital by interacting with a variety of stakeholders in an integrated way. Eventually, the first step towards social resilience can be taken by broad participatory measures in a bottom-up approach. The actual urban planning process should go beyond formal instruments to achieve common targets (BFN 2017: 24).

Apart from the urban planning process, the latter maintenance of the implemented green infrastructures should be considered as a mutual task between various actors. Here again, a strong collaboration between the responsible departments such as urban planning, environmental and landscape departments can facilitate these tasks. A successful planning process may also encourage other actors such as citizens or private companies to take responsibility for the implemented measures. Urban gardening in public space could indicate one solution, supported by companies' activities for corporate social responsibility. The development of social capital by such offers must neither be underestimated nor be undermined.

Recommendation

The above-presented concept already indicates that urban resilience can only be implemented using an integrated development approach. However, the authors found that the city of Hanover does not yet provide an optimal-sized strategy for managing climate resilience in an urban context. As there is not a one-size model of implementation, the authors recommend the introduction of a resilience concept into the city and regional policies and guidelines for promoting coping with transformation proactively. The necessity for a comprehensive resilience strategy is emphasised in the light that the recognition of resilience contributes to long-term urban sustainability. Despite the current incentives for green roofs (Landeshauptstadt Hannover 2019: www), it is recommended to foster the implementation of greening measures on facades. Stronger limitations for the use of radiating building materials on facades are needed regarding the decrease of urban air temperatures. Enhancing urban resilience in terms of upgrading the urban structure may be one step. Nevertheless, the social component must not be forgotten as outlining policy proposals only may be too weak. Therefore, it is recommended to also focus on enabling locals' social capacities of coping and adapting. It is highly important to foster the creation of social capital by providing opportunities for the inhabitants of the city to gather and exchange. By doing so, awareness for urban stress rises and responsibility for transformation towards urban resilience. Innovative changes towards resiliency can only arise from local governments ability to design comprehensive resilience policies with the influence of numerous stakeholders.

Moreover, a quantitative and qualitative monitoring system is needed for measuring the effectiveness of the proposed measures. As part of that, the authors propose the development of a smartphone application for informing people about stresses and risks and offering a possibility to a reliable exchange with public authorities. By that, useful information can be collected contributing to an efficient information base - for actors and concerned citizens or visitors. The limiting accessibility of a smartphone app could possibly be overcome by installing information and interaction monitors at public spaces. Despite high costs for implementation and maintenance, the authors stress the importance of such a system.

Conclusion

This research paper presents itself as a pro-active approach to making a district more resilient against the coming challenges of heat islands. As with the main issue of dealing with the specific area of Opernplatz and the surrounding streets and quarters, the results of climate change will make this well-built city area less and less productive.
Within the analysis, the area is shown to be distinct for the emergence of urban heat islands which requires a scaled approach to addressing these issues. The masterplan proposal outlines a direct result of the analysis, connecting the main travel hubs, i.e. Kröpcke, Hauptbahnhof and Aegidientorplatz, to the eastern areas of the study site, reducing the need for car travel and greatly improving the quality of street spaces in and around the study area.

Flexibility always characterises an important element of urban resilience. This is put into practice as the areas referred to in the masterplan proposal reflect multifunctional spaces, directly and indirectly, effecting users of the areas. As usability of the spaces is maintained and improved, the areas become valuable to the public and other user groups, greatly improving the social resilience of people.
Moreover, a holistic urban governance process was outlined as key for successful implementations. Lastly, the authors formulated a brief recommendation for the municipality of Hanover, including the need for a monitoring system to measure effectiveness as well as a possible information system for citizens.

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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.).

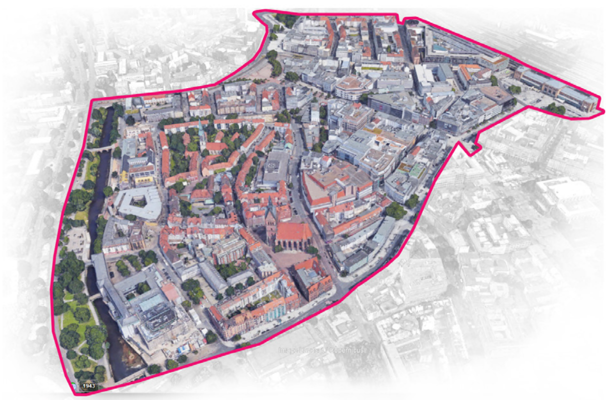

Fig. 1. Depiction of Steintor and the main areas (own depiction (Data Source: Google Earth 2019: www))

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).

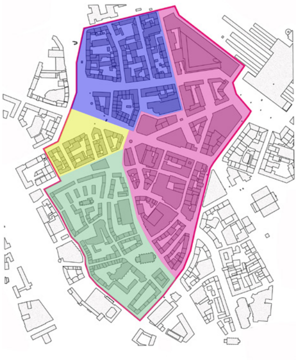

Fig. 2. Depiction of the sub-areas of Steintor (own depiction (Data Source: Cadmapper 2019: www))

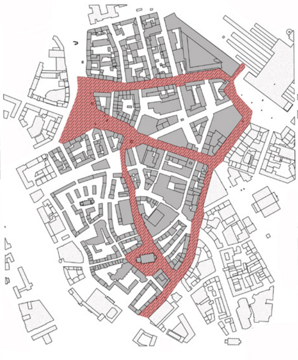

Fig. 3. Illustration of the most vulnerable areas of Steintor (own depiction (Data Source: Cadmapper 2019: www))

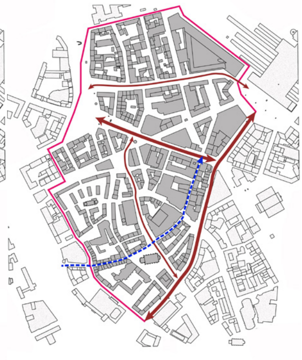

Fig. 4.Illustration of the pedestrian flow in the district of Steintor (own depiction (Data Source: Cadmapper 2019: www)

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 heat-waves. 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.

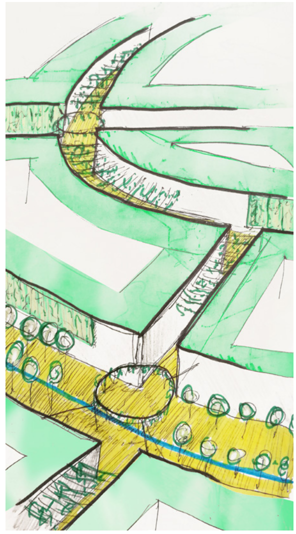

Fig. 6. Illustration of an extemporary paradigm of the concept (own depiction)

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)

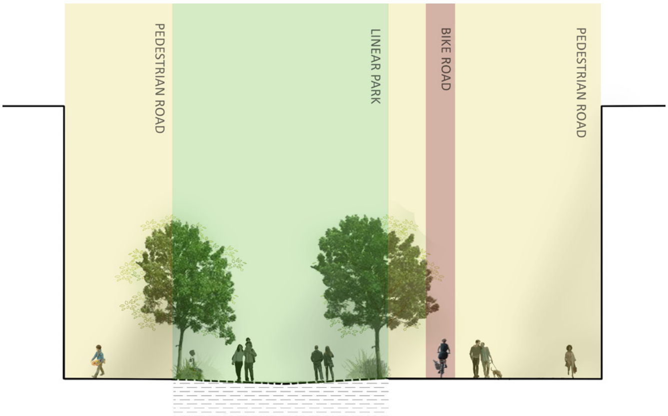

Fig. 8. Illustration of the new Georgstreet - sectional view (own depiction)

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.

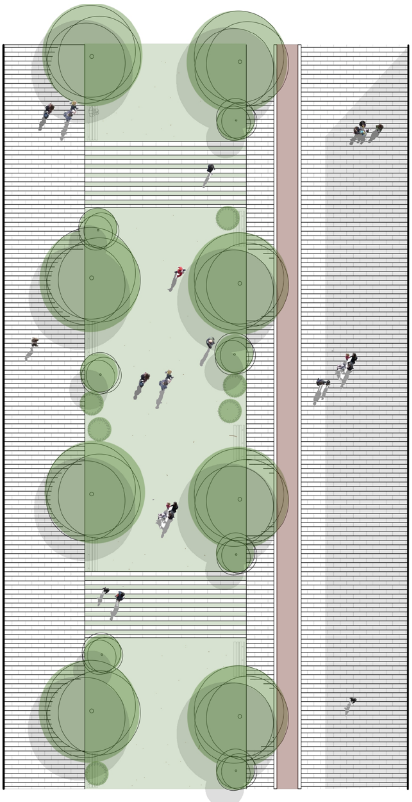

Fig. 9. Illustration of the new Georgstreet - floor plan (own depiction)

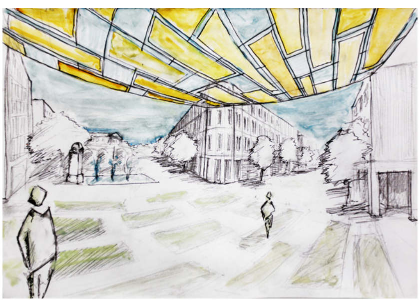

Fig. 10. Depiction of the planned construction for the Kröpcke square (own depiction)

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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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.

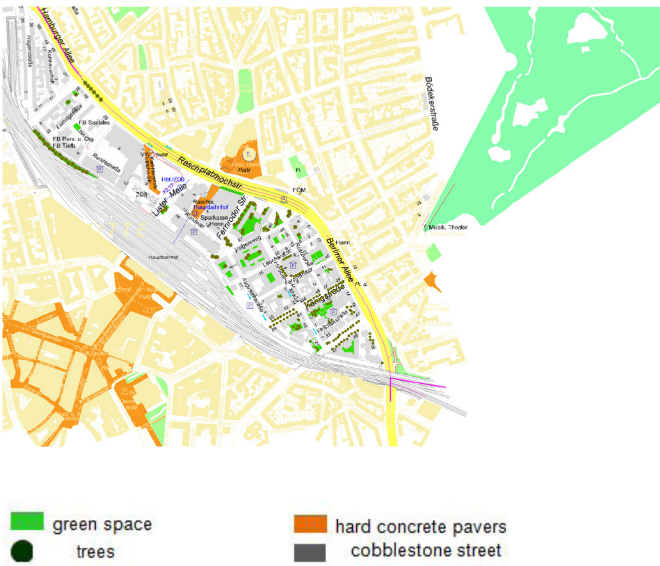

Fig. 3. study area map: green landscape, trees, hard paves and cobblestone streets identified source (own depiction)

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)

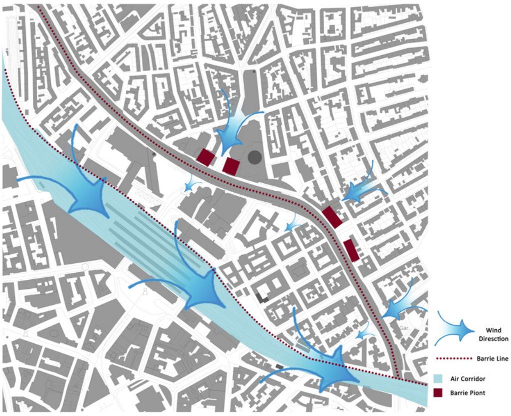

Fig. 5. Study area map of airflow and air corridor (own work)

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.

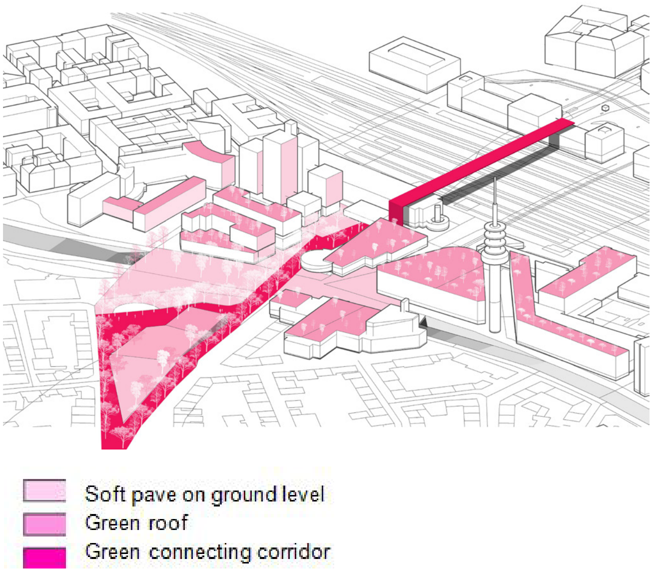

Fig. 6. Conceptual proposal in isometric view of the study area (own work)

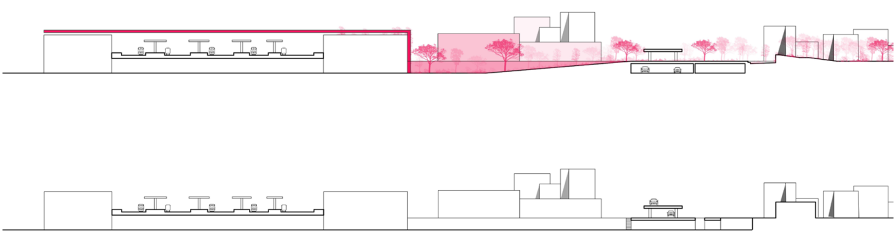

Fig. 7. Comparative conceptual proposal in section view of the study area (top-proposed, bottom-existing) (own depiction)

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. Air-flowing 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 tree-tops 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 micro-climate 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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4. Double Trouble

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Abstract

Maintaining the function of the systems and recovering from shocks or chronic stresses is what, nowadays, refers to Urban Resilience. Resilience is a term derived from the Latin verb resilire, which means bounce. It was used as a synonym of resistance in different contexts such as medical, psychological, among others. However, since the 1980s, the concept of resilience was mostly associated with the ecological field and referred to as the capability of dealing with catastrophes (Fooken 2016: 13ff; Voss & Dittmer 2016: 179ff; Wink 2016: 1ff). Currently, it is a topic frequently discussed worldwide due to the Anthropocene, which is aggravating climate change at an accelerated pace. In this context, the term is used to emphasize the constant symbiosis between humans and nature (Prominski 2014: 6ff). The approach of this paper tackles flood risks in a specific neighborhood in the city of Hannover. For that matter, historic events and actions implemented by the municipality, as well as the study of data provided, will be mentioned in this document. After going through a research and discussion phase, the intention is to develop guidelines and propose design strategies to address flood threats at the study case site.

Flooding events and future threats

Nowadays, about half of the world population inhabit urban areas. By 2030, the projection rises this number close to 70% (United Nations 2018: www), representing a threat to natural ecosystems and the damage of natural terrains because of construction. Thus, topics such as Urban Resilience and Adaptive Cycle have become more critical issues to address worldwide, mainly due to climate change. These concepts deal precisely with that process of “bouncing back” of a city in different contexts such as economic, social, environmental, among others (Meerow et al. 2015: 38ff). As mentioned before, climate change -natural shocks and stresses- is one of the risks a city has to cope with. Particularly in this case study, the approach focused on a flood risk area of a neighborhood in Hannover called Südstadt.

The city of Hannover is the capital of the federal state of Lower Saxony, and it is home for approximately half a million citizens (Hannover.de 2019b: www). Its morphology is shaped by two rivers that run through its extension: Leine and Ihme. Leine has around 281 kilometers long and flows across the whole region passing through two big cities, Hannover and Göttingen, and also through several towns. On the other hand, Ihme is relatively small, around 6 kilometers long, and flows into the Leine river in the center of Hannover. As for Südstadt, it is located in the southwest of the city center (see Figure 1), reachable in a short time -5 to 15 minutes- by any public transportation or by foot. Its western limit is the Masch lake, which is an artificial lake built from 1934 to 1936 (Hannover.de 2019c: www). Moreover, the Leine river shapes its western border, and they have a connection between each other. Worth to mention is also that this neighborhood houses around 24 000 residences, making it the second-largest residential area in the city. Furthermore, around 40% of these buildings were built before 1950 and less than 3% since 1990 (Landeshauptstadt Hannover 2015: www).

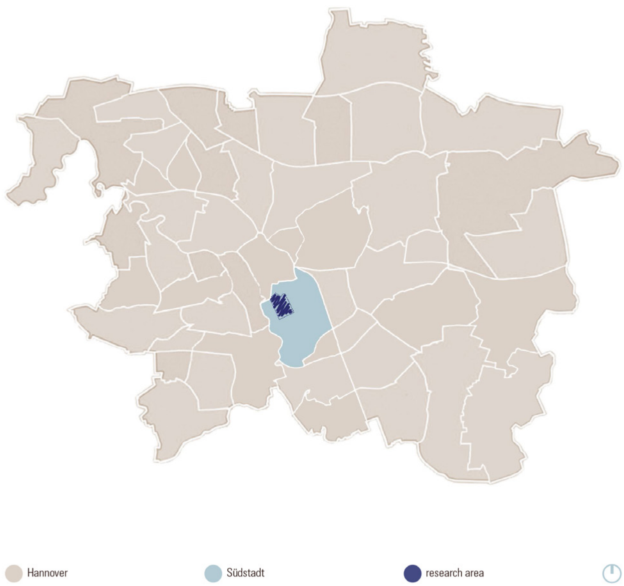

Fig. 1. Location of Südstadt (STS Hannover, 2017)

Flooding events have already occurred for a long time in Hannover; however, in February 1946 the worst of them was registered, turning into an unforgettable catastrophe in the history of the city. On the one hand, there was a major rainfall, and on the other, melted snow from the Harz National Park reached the inner city. Both rivers and the lake were overflooded blocking a large area of the city and 4,69 meters more than the average height of the water level was registered on this event. One of the collateral damages was the destruction of historical documents stored within the building of the state capital archive (Mlynek 2009: 301). In 1981 and 2003, other major flooding events took place in Hannover, reaching again more than a 4-meter high water level in both of them. In 2003, another catastrophe occurred across Europe and the most severe damages registered were in the south center of Germany. On the other side, there were still vestiges from the major rainfall in Hannover flooding event, partly in the north of the city. After that, the City Hall council agreed in 2006 to develop a prevention and contingency plan for flood areas protected by regional planning. The potentially vulnerable areas are evaluated by the rate of flooding events based on historical statistics. Furthermore, they are divided into four categories: high (HQ25), medium (HQ100) and low probability (HQ200), and extreme event (HQ extreme). The numbers next to the acronyms represent how often an area could be flooded. Consequently, the risk talks about events happening once every 25, 100 or 200 years. The areas that fall into any of the categories are registered as protected priority zones in the Regional Planning Department. Moreover, there are other prevention plans including the excavation of Ihme's ridge and the expansion of the Benno-Ohnesorg Bridge at the Linden district. There are also combined strategies that connect built protective measures, for example, from 2013 to 2014, a levee was constructed in Ricklingen connecting it with the protection walls nearby the district (Hannover.de 2019a: www). Nonetheless, even after the construction of the measures mentioned above, there is still a probability that some protected areas overflood under major rainfalls, especially the south side of the lake. However, it is worth to mention that the water level has not reached 4-meter height again.

Residences, open spaces and the lake

The goal of this case study is to develop strategies to address flooding threats in Südstadt, as mentioned above. The assigned area has around 45 hectares, and before thinking about designing, it was necessary to follow some processes to understand the background, function, and constraints of the site. An essential factor to consider for this analysis was the morphology of the zone. In the same way, land use and connectivity were important factors to be taken into consideration. The first step of the analysis was a short field survey through the streets of the area to build an opinion about it. Afterwards, that information was complemented with data -mapping and statistics- collected from different sources, e.g., regional city planning, official web pages and records from the previous flood events in Hannover. Furthermore, there was information provided by university researchers and representatives of entities, who are either involved or working with floods (prevention, theory, planning, etc.). Subsequently, it was possible to have a general understanding and criterion of the analyzed zone. As a final phase, there were debates and discussions to propose guidelines for the design of a Master Plan.

The visit through this neighborhood was on Monday afternoon, therefore, the expectation of movement on the streets or inside the houses was low. Mainly, the research area is divided into two uses: public buildings (red shades) and housing (grey shades). Moreover, the residential use covers the majority of the area of this site (see Figure 2). Buildings of private residences with garages below the street level were found as a common denominator. The western border of the area faces the eastern bank of the Masch lake and is configured by the Sprengel Museum (1) and the NDR broadcast (2). Next to it, there is the lake's parking lot (3). Following the path, directly in front of the sidewalk is an open space - sort of a playground - and another building of NDR broadcast (4) just behind it. Closing the corner, there are offices of a children psycho-analysis facility (5) to be found. In general, this border could be categorized as cultural giving that also the lake promenade has a constant movement of people in and around it. Besides that, every year it hosts a summer festival (Maschseefest), which brings not only the attention of Hannover inhabitants but also foreigners and visitors.

Fig. 2. Land use (Base map source: Hannover.de, Open Geodata, 2019: www)

Both lateral limits of the studied area are shaped by two two-way avenues of significant importance in the city (see Figure 3): Rudolf von Bennigsen Ufer (1) and Hildesheimer Street (2). Both streets have a four-lane avenue with a bus line, bike lane on both sidewalks, and on Rudolf von Bennigsen Ufer there is the lake promenade as mentioned before. The subway lines one, two and eight travel through Hildesheimer Street and they transport a large number of people. There is high traffic of vehicles, and it is possible to find all sorts of commercial locals on both sides of this avenue. On the other hand, the rest of the streets within the site can be categorized as secondary and even tertiary. Among them, parallel to Hildesheimer Street, there is the Meter Street (3). Before the major flooding events already mentioned, a tram line circulated through it and, for that reason, it had to be moved to the avenue underground, and the street prioritizes bikers now. Due to this change in the character of the street, it was decided to close the north extreme of it. When flooding happens, the first thing to consider would be the reduction of traffic impact on the streets. Hildesheimer Street would be on the priority to be protected and then the bank of the lake, and the third protected area would be Meter Street.

Fig. 3. Mobility (Base map source: Hannover.de, Open Geodata, 2019: www)

Generally, the area is situated at a range between 48-63 meters above sea level. The site nearby the bank is lower than the inland of the research area, and also there are two lower spots on the Meter street. Looking at Figure 4, it can be noticed that most of the potential flooding areas are naturally the ones almost at the same height as the lake. This indication helps to recognize the vulnerabilities in the morphology and, therefore, possible intervention spaces.

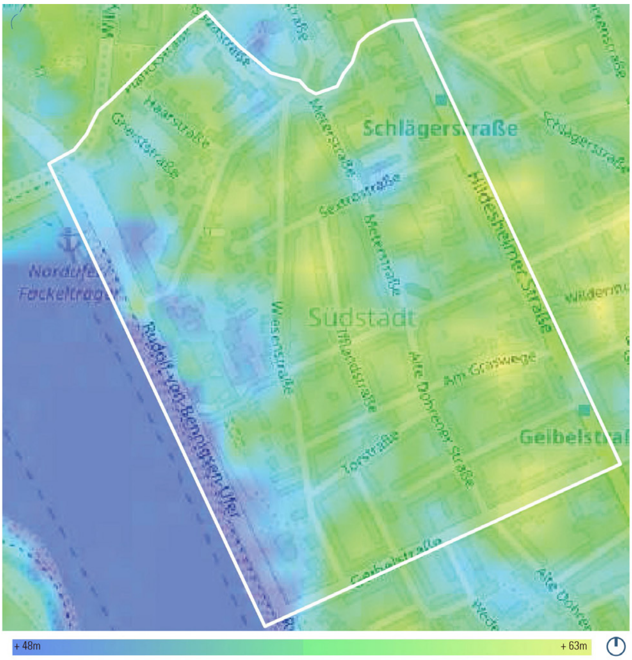

Fig. 4. Topography (Topographic-Map, n.d.: www)

The material of the pavements is also an essential factor that increases flood risks. Inside the sites in the research area, the ground would be separated into two types: permeable and non- permeable pavements (see Figure 5). As a result of the investigation, it has been noticed that most of the residential areas are covered by a high percentage of green surfaces, which have quite a high ability to absorb water in case of sudden rainfall. On the other hand, those non-permeable pavements are sealed by concrete, for example, streets, the base structures of buildings or parking spaces.

Fig. 5. Soil typology (Base map source: Hannover.de, Open GeoData, 2019: www)

The flooding risk map, published by the Hannover government, shows the regular and under extreme events flooding areas (see Figure 6). The red contours represent a medium flood risk (HQ100), which means the areas could be overflooded once every 100 years, as mentioned before. On the other side, the blue contours show the flood-prone area under extreme events and the flooding depth can also be seen on the map. Generally, the areas at risk can be found in two specific zones of the site: the first one along the banks of the Maschsee Lake, with an average flooding depth between 0.75 to 1 meter, and only partly could reach 2 meters. The second one is located between Wiesen Street and Meter Street, and there the average flooding depth is relatively shallow, from 0.5 to 1 meter.

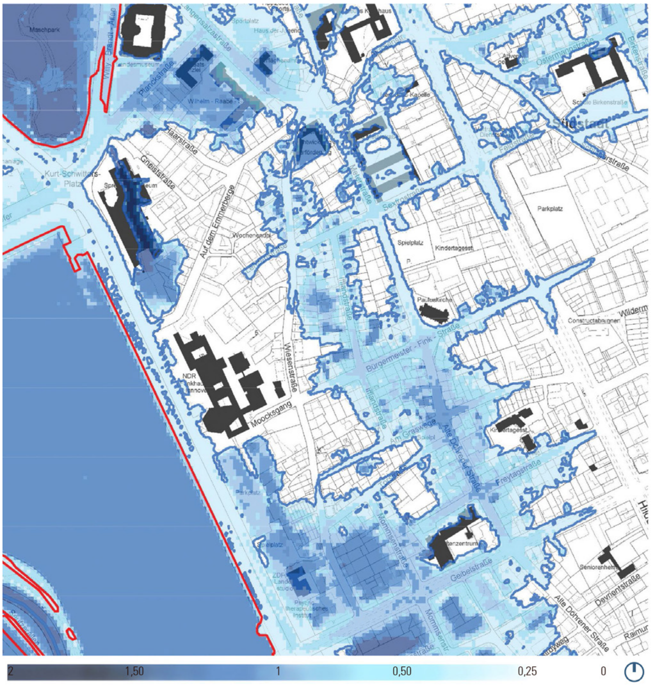

Fig. 6. Flooding risk areas (Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz, n.y.: www)

Configurating axes as shields

After collecting all the information necessary, at this point, it is possible to establish guidelines that will constitute the base for the Master Plan. It will compose the last section of the case study and contains design strategies and measurements dealing with flood risks. This plan will consider all the factors and characteristics that configured the research area.

After the prior processes, it was clear that the area could be facing a double menace: heavy rainfall and overflood of the lake. Giving that the site is designated as HQ100, the potential intervention structuring should be capable of facing this long term risk. On the other hand, short term measures should withstand heavy rainfalls due to the higher probability of this occurrence. With these premises, it was possible to identify two main axes (see Figure 7) capable of facing flooding in case of an extreme event. On one side, the coastal avenue (green shade) that forms the division between the lake's western border and the city. Thus, it plays a vital role because it can delay the water entering the residence zone in case the lake overfloods. As a second axis, Meter Street (mustard shade) can function as a collector of water in case of major rainfalls. Moreover, in case the first axis can not hold the flood any longer, it becomes a second layer delaying the water entering further into the city.

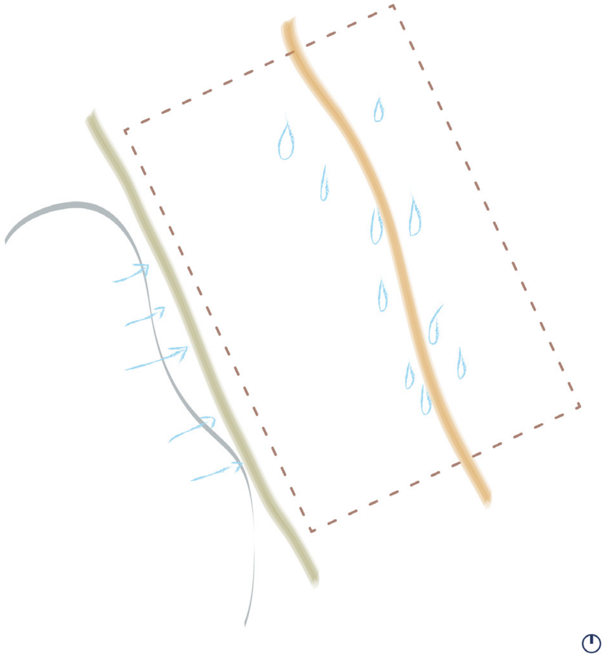

Fig. 7. Two axes (Own depiction)

As mentioned before, the decision was to create these two fronts, which will shape the Master plan in this case study. They have different characters, on the one hand, the coastal avenue (green shade) comprises public buildings and open spaces. Additionally, the closeness to the lake and its frequented promenade turn this axis to a future cultural waterfront. On the other hand, Meter Street, mostly surrounded by private properties and some public spaces, turns to the inland axis in the Master plan (see Figure 8). In both axes, it is proposed to configure a two-layer drainage concept. That first one is a pipeline that will be in charge of collecting water, but most of all, to channel it through the canalization pipes. On the cultural axis -the Waterfront- that line will travel along the lake promenade. On the other side, the pipeline in the residential axis -the Inland- will have the same function, but the street soil will absorb the water and drain it later through the sewage system. Secondly, it was decided to propose a more organic strategy, which can also improve the landscape of the zone. Both axes use open and green spaces to create that second layer drainage through natural reservoirs. This strategy has an extra feature on the Inland, to connect the open spaces across the axis.

Fig. 8. Master Plan (Own depiction)

The short term measure: Inland

The residential area of the Meter street is located 500 meters away from the border of the lake and, as referred to in the analysis section, it does not belong to the high-risk flood areas. That means flooding events do not exceed 1 meter higher than the average levels, and they could take place due to sudden and intense rainfalls. As a circumstance, the roads can be blocked, as well as pavements and public open spaces, not only because unsealed surfaces can not absorb surface water, but also because drains are sometimes not for evacuating the excess of water. Therefore, as a complementary measure of the city drainage system, water is driven to sealed ground,

which should have adequate capacity for absorption and then its drainage through a sewage system. It is no coincidence then, that the lowest parts of the area function as squares to-day. Nevertheless, these spaces have not enough capability of absorption, and this lends a substantial functional burden onto them. For that reason, the design proposal is to implement anti-flooding strategies to increase the resilience of the area, towards the climate change that sooner or later will affect the inhabited zones.
As it has already been mentioned, to avoid smaller floods, which have to be quickly and silently stopped, the so-called short term measures will be in charge of evacuating the over-flooded areas.

Looking closer, the connection of the green spaces and the public buildings of the old tram route, as it has been proposed before in the Master plan, will have a meaningful impact on the urban character of the area. For that matter, the proposal is to establish a small cultural and public core that can simul-taneously be a historic reminder - of the street as the primary connection to the South - and bring a new character to this axis within the residential district.
Specifically, the measures are going to be applied by the fol-lowing actions:

As a main conceptual urban axis, the Meter street should be unsealed and the material installed on that surface must be permeable, which allows water to be absorbed by it and, si-multaneously, be evacuated through the sewage system. At the same time, this highlights the public character of the axis.
Moreover, the street becomes a low-velocity one, maintains the current lane priority for bikes and hosts a broader path for pedestrians. Additionally, there is the possibility that this axis becomes the host for different types of public and collective activities (flea markets, street concerts, cultural events, among others). Besides the spatial connection, the intervention could unify, promote interaction and interest of the residents and not just of possible visitors.

As for the elements that shape this public lane, it is proposed the re-design of the two playgrounds and the area in front of the

Paulus church (see Figure 9), with the main purpose of giving them a versatile function. The main idea for this measure will be to save rainwater more than avoiding flooding, an inspiration that relies on the concept described in the Water Square Benthemplein, designed by De Urbanisten in Rotterdam, Netherlands (De Urbanisten n.d.: www)

Fig. 9. Plan Inland (Own depiction)

For that matter, it is proposed the configuration of slopes in the open spaces already mentioned before so that they can be used with a double purpose.When the surface is dry, they function as public spaces (stages, playgrounds, skate areas, etc.). On the other hand, if a sudden rainfall occurs, they will immediately become retention basins, containing and absorbing surface water. Furthermore, when the rain stops, a drainage system drives the water away from the basins at a controlled pace to avoid overflooding the canalization, and the primary function will be restored (see Figure 10). Finally, the material to be used in these spaces will be the same as the one on Meter Street to present them as an extension of the road.

These urban interventions will have an enormous impact on the area, which is why it is extremely important to take into consideration all the factors that could be affected by them and, most importantly, how they could adapt through time.

From this point of view, strategies used in this case study should deal, not only with the resilience of the city towards climate change but also with the character of the surroundings to prevent other kinds of problems such as functional, cultural, issues of heritage, among others.

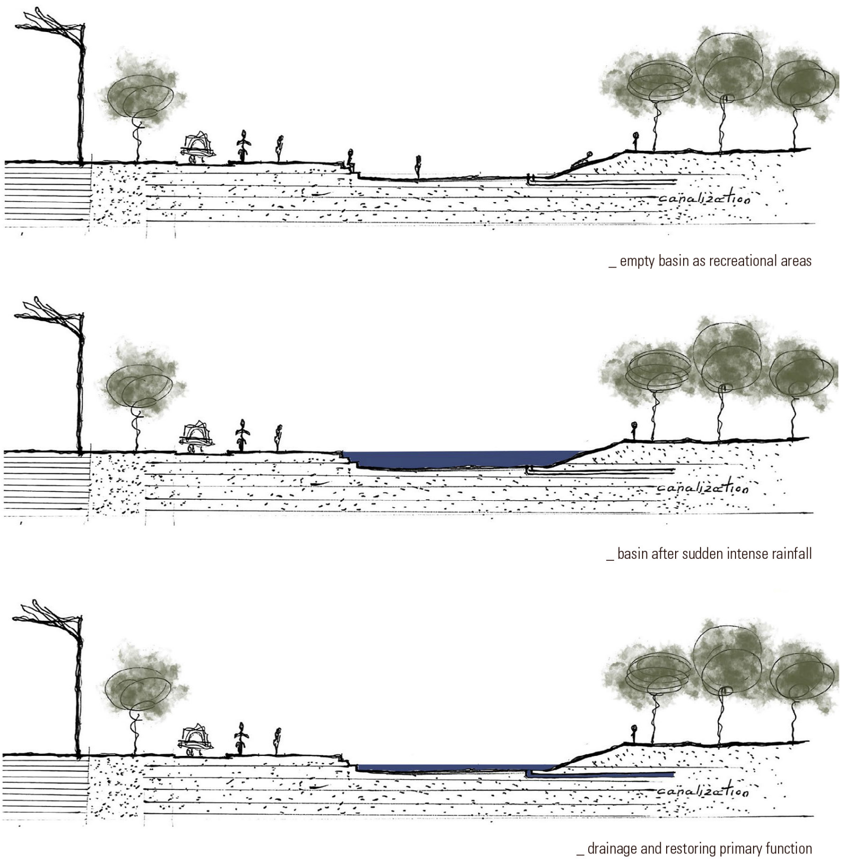

Fig. 10. Sections Inland (Own depiction)

The long term measure: Waterfront

The aim of the long term measure is not only to deal with the flood but to strengthen the natural and cultural dynamics of the area. Spatially, the core idea is to divide the axis into three anti-flooding zones. The Maschsee lake represents the first buffer zone, in the case of the overflood of the Leine river. However, if besides the lake's overflood there is an extreme weather event (strong precipitation), probably, the lake would not be able to contain the excess of water.

For that reason, to cope with this type of condition, it is proposed the construction of a 0,5 meter- high natural slope, which will surround the lake's bank like a ring. In case those measures are still not enough to prevent the water from coming into the residence area, the proposal is to create two anti-flooding zones close to the Rudolf von Bennigsen-Ufer street (see Figure 11).

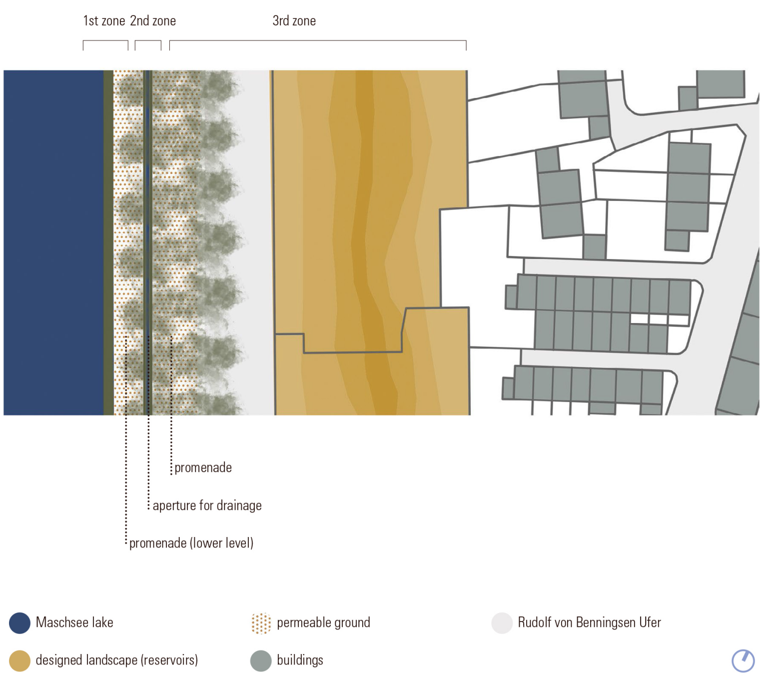

Fig. 11. Plan Waterfront (Own depiction)

The interventions in the first and second zone are slightly connected, so it makes sense to present them together. The one in the first zone aims to transform the existing conditions, from a natural permeable border to a new strong wall of 0,4 meter-high. The objective of this strategy is to stop water without destroying the lake banks during a flood event. Moreover, during the drying period, it will be like a bend that frames the promenade and embellishes the site. Finally, the remaining water in the first zone will run off naturally due to the permeability of the ground.

The second zone will be an open gutter driving the overflooding water to an underground tank (see Figure 12). The opening of the gutter will be on the first zone wall, shaped by a double wall aperture. The underground tank is circular with a 2-meter diameter. Furthermore, the function that serves the second zone has a double benefit. The first one is to trap the water in the tank if

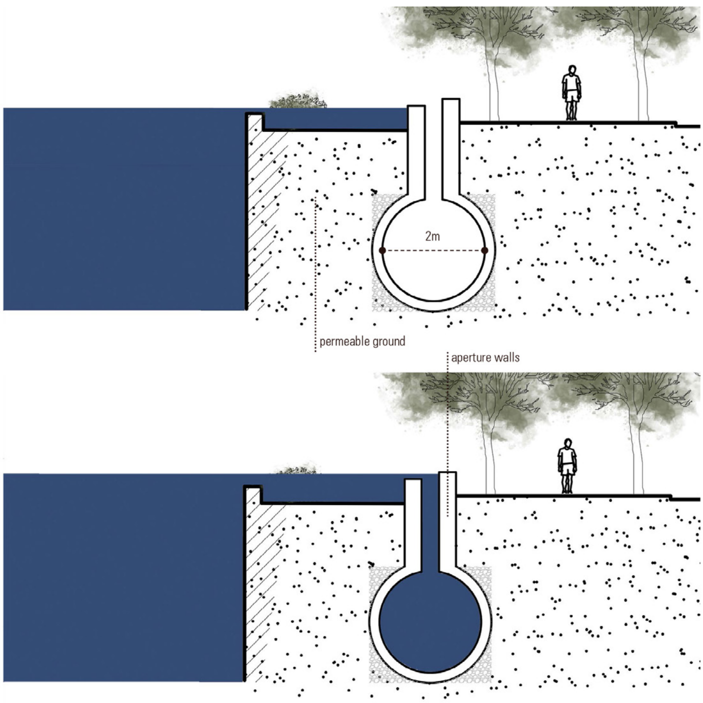

Fig. 12. Gutter and underground tank (Own depiction)

the first zone overflows. It will be driven away through the sewage system avoiding the flooding of the area, as it could happen without the tank. The second one is that, even in case of a huge overflow, when both zones are not enough to bear it, then it will reduce the amount and speed of the water flowing into the city, providing a time advantage to evacuate the area. Moreover, the walls of the gutter separate the two anti-flooding zones and can feature both of the promenades as recreational spaces, which can also safely host cultural events, as it is already happening every year in August with the summer festival Maschseefest.

For the last zone, the proposal, as mentioned in the Master plan, is the formation of reservoirs across the Rudolf von Bennigsen Ufer. After analyzing the land use in this area, it was noticeable that there is enough free space, such as parking or open spaces, to set these retention basins, which can retain water in case of an extreme flooding event. The morphology of this zone is the main advantage for the design measure giving that it is at the lowest topographic level of the research area. For that reason, water could naturally be driven there. Moreo-

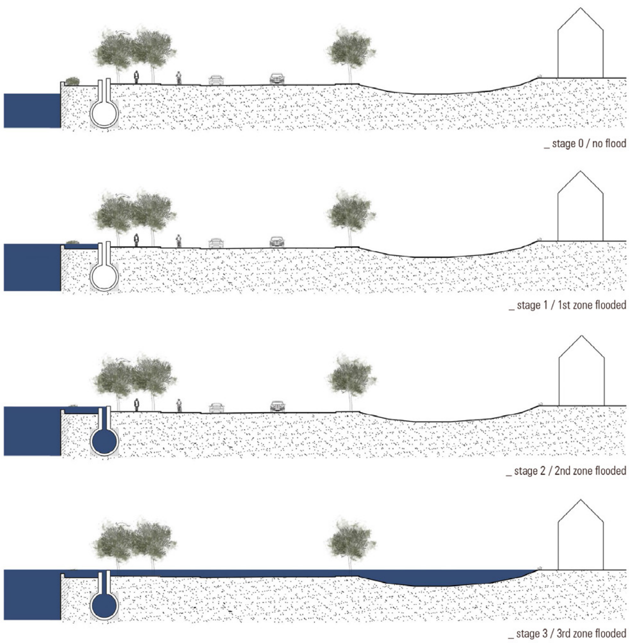

Fig. 13. Sections Waterfront (Own depiction)

ver, the avenue separates the third zone from the first two. Thus it is possible to use also that surface to collect water in case of an extreme flood event. The assemblage of the Waterfront zones creates an extension of the lake's promenade, which inhabitants and visitors can use as open spaces. The idea beyond the design is to create natural reservoirs with the same function of the retention basins in the Inland axis. Their purpose is to collect and absorb the rainwater and, when they are empty, transform into recreational areas. Besides, they will be hosts of a variety of flora and fauna enhancing the landscape of the neighborhood.

Conclusion

As an overview, this case study focused on adjusting present conditions to future circumstances and coping with possible natural disasters. Moreover, the proposal of organic strategies will face not only flooding events, but also transform the character of the neighborhood landscape. On the other hand, to increase the resilience of an area, the design strategies encompass the determinants from the previous analysis of the site. Giving that the plan depicted in this document benefits inhabitants and the city, it possible to think that the government can look at this as an investment. Hence, the interventions could become pilot projects or urban tools, which could be replicated in different areas of the city with similar conditions or circumstances. Some questionings emerge during the design phase of this research, for example, while thinking about the conception of a cultural axis as an extension of the lake's promenade. How is the lake border going to interact with the sidewalk across the street? Will inhabitants use these public spaces, or will it become a residual area? And, on a bigger scale, by implementing new land uses in the site, would it affect its residential character? Everything was taken into account while designing, and it was important to collect diverse information from different profession fields to acknowledge the urban structure of the research area and develop the most pragmatic interventions. In other words, resilience considers not only the climate but also the general transitions of the urban structure and human life. Climate change is a reality that will gradually be experienced in all cities worldwide and will affect the urban structure, urban habits and, of course, the way of living of the inhabitants. Sudden rainfalls, extreme amounts of water falling from the sky to the sealed surfaces and overflow of the water bodies are probably going to influence everyday life as we currently know it. Both natural phenomena may seem like a threat today for the existing situation. Nevertheless, by applying the strategies that have been proposed in this case study and changing some of the standards, it is possible to cope with the difficulties as a society and teach ourselves how to treat better the source of life called Earth.

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5. Resi² Rick: Flood Resistance and Resilience in Ricklingen, Hanover (Germany)

A proposal for future development potentials

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Abstract

This paper explores how factors of flood resistance and resilience are addressed within the development of an area in Ricklingen, a hydro-geologically vulnerable district in the southwest of Hanover. The already existing dyke as a flood control and resistance measure offers protection against fluvial floods but does not offer protection for pluvial or flash floods and further intensification of extreme weather events. In order to adapt to climate change, this paper proposes the establishment of ditches that relieve stress from the drainage system and ponds and green roofs to evacuate intense rainfalls. The City of Hanover has already established a transparent information base on flood precaution, response and recovery and initiated a funding programme for roof and facade greening and land reclamation. In addition to these measures, this proposal foresees awareness-raising campaigns, resilience meetings and supplemental incentive schemes to encourage civil initiatives and actions such as small retention basins on private property. Besides, the high recreational value of the landscape should be further strengthened to support a close connection between people and nature.

1. Introduction

Since time immemorial, access to water supply, water-related transport services, fertile soils and the charm of living near rivers and coastal areas have led to extensive development in regions at risk of flooding (OECD 2016: 12). In 2016, 50% of natural catastrophes had been hydrological events (Munich Re 2017: 54), and progressive climate change is expected to generate a further increase in the level of flood risk brought about through rising sea levels, torrential rainfalls, storms and storm surges (OECD 2016: 12). Using the example of a small area in the German city of Hanover, this research explores the critical factors of flood resistance and resilience and expands on the question, how concrete protection and adaptation measures can be adopted in urban landscapes and practical processes.
The area under investigation is situated in the district of Ricklingen in the southwest of Hanover (see Figure 1). Besides its incorporation in 1920, the district has preserved some of its rural village character and rustic settlement structure. The river Ihme, the nearby lakes, and the attractive landscape conservation area surrounding it provide great potential for recreation but can also pose flood risks to the local population (Fidele Dörp 2005: www).

In addition to the Ihme, the river Leine is crossing the city of Hanover and flooding is a problem that has been around for a considerable time. The importance of addressing this phenomenon has been recognized early on and already in 1449, a ditch as a measure against the floods was mentioned in historic documents (Region und Landeshauptstadt Hannover 2019c: www). With progressive urban development and the attendant loss of natural floodplains, the need for further protection measures became inevitable which led to the establishment of special precautions in forms of dykes and dams as well as a contingency plan by the fire department and the municipal drainage operation. Furthermore, the necessity for flood protection has been incorporated on the administrative level and is being considered in urban land use planning of the city (ibid.). This paper develops a number of additional measures in order to build a solid foundation for continued protection and resilience in the future.

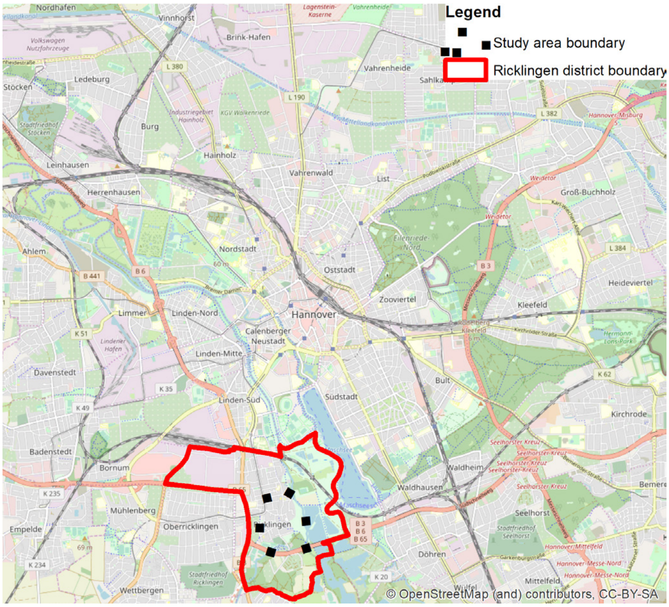

Fig. 1. The district Ricklingen in the southwest of Hanover (own depiction based on Landeshauptstadt Hannover *2019: www;* Openstreetmap.org *2019: www)*

In the following chapter 2, the topic will be introduced in more detail by outlining the concept and methodology on which this research developed. Subsequently, chapter 3 provides insights into the area under investigation situated in the district Ricklingen, introduces flood risks and already existing protection measures. Based on the outcome of this analysis and based on the findings of previous research and projects as provided in chapter 2, a design proposal for flood resilience measures will be presented (chapter 4) as well as governance mechanisms that can be introduced into the political process to increase private action and initiatives and can be promoted through incentives such as tax breaks (chapter 4.3). Finally, in chapter 5, the design and results of this research will be reflected, and some concluding remarks will be given.

2. Contextualisation

Amongst others, the British Natural Environment Research Council proposes five types of flooding, i.e., coastal/ tidal, river/ fluvial, groundwater, surface water/ pluvial and flash floods (Nerc & Gilliland 2017: www). Thereby, coastal/ tidal floods are associated with heavy storms and high tides that inundate coastal areas and protective levees and dykes, whereas rises in the level of groundwater specifically endanger underground infrastructure such as cellars and tunnels (ibid.). A fluvial flood is caused by a river overflowing its banks due to heavy rainfall or a thawing period, spreading large quantities of water over its floodplain and especially in urban areas, the resulting damage can be correspondingly extensive (ibid.). Surface water or pluvial floods are associated with heavy rainfall resulting in an overload of the drainage system. The problem is further intensified by the predominance of impermeable grounds in cities, which also offers optimum preconditions for flash floods that can develop very rapidly and refers to a downflow of water and respectively an inundation of subjacent areas (ibid.).

According to the Urban Flood Community of Practice, strategies to address the challenges of flood risk should include regulatory, financial, economic and behavioural implementation tools (UFCOP 2017: 9). On a regulatory level, building, zoning and emergency plans can bring clarity and may be consulted by the population in case of new construction or rebuilding of houses. Appropriate insurance for (private) buildings and ground in flood-prone areas is an essential factor for livelihood security and should be supplemented by the provision of public funding sources (ibid.). Awareness-raising and capacity building initiatives serve the purpose of establishing solid knowledge and information and change public awareness and behaviour in the long term - a process that can be accelerated significantly utilising economic implementation tools such as tax incentives (ibid.).

Within flood risk management, a distinction is being made between flood resistance and resilience. The latter can be measured by the 'flood ability' of a city, i.e., the capacity of a city to maintain its overall functions (e.g., secure human subsistence, economic performance and transport network) despite flooding and, in case of damage, the speed of reconstruction and rehabilitation of the city (Kuei-Hsien 2012). The focus of resilient flood management strategies is on impact reduction utilising prevention and preparation measures, whereas flood resistance focuses in particular on the development of precautionary measures to decrease the risk and danger of flooding

(Gersonius et al. 2016). Thereby, measures that primarily serve to control or resist floods, such as levees, dykes and dams, are considered to only partially address the increased severity and frequency of hydrological weather events (Kuei-Hsien 2012).

Methodology

The contextualisation of flooding and the associated risks, concepts and strategies as outlined above, forms the theoretical basis for the scope of this research. A thorough investigation of the territory is essential to ensure appropriate outcomes. In this sense, literature such as reports and articles, as well as statistical data on the population, building structure and nature of the terrain, were harnessed to portray the local conditions. A GIS-based spatial analysis was compiled to provide an in-depth overview of the territory and visualise different flood scenarios and display the already existing flood control measures. In the context of this research project, several maps of the area were made using the GIS-software ArcGIS 10.6.1 (chapter 3). Furthermore, an urban stroll has been conducted by members of the research team in July 2019 to gain a good overview of the local opportunities and challenges. Following an explorative approach and based on these findings and experiences, a design proposal for flood resilience on the survey site has been developed and will be presented in chapter 4.

3. The Study Area in Ricklingen

The study area is located in the urban district Ricklingen. It does not cover all territory of urban district and has the size of 0,80 km^2 while the area of the whole urban district is 4,78 km^2 (Landeshauptstadt Hannover: 102). The part of Ricklingen where the survey took place is situated to the south of the center of Hanover, close enough to the city border.

The river Ihme flows through the study area. It discharges into the river Leine in the north-west of Hanover center. Leine runs in the distance of no more than 1 km from the eastern boundary of Ricklingen. To the west from the investigated territory, the pond Großer Ricklinger Teich lies between riverbed of Ihme and Leine. It is one of gravel ponds Ricklinger Kiesteiche. They were established in the place of gravel carriers. The study area consists of a connectedly built-up zone and territory dominated by woodland and grassland with few detached houses. Undeveloped part lies within the floodplain of rivers Leine and Ihme (Region und Landeshauptstadt Hannover 2019b: www).

The most common building type in the investigated territory is dwelling house. Apartment buildings differ from each other by size and number of floors. In the western part of the built-up zone within the study area, there are a lot of multi-apartment houses mostly of three to five storeys. In the eastern part multi-storey brick houses with attics and few apartments are prevalent. Area without dwelling houses that is located close to river Ihme is generally covered by forest or meadows. Few buildings, such as swimming pool with café and little outbuildings ("Ricklinger Bad") and the group of summer houses that are not suitable for year-round residence, were constructed there. Allotment garden houses are located between the river Ihme and highway B65 which is the southern border of the study area. In the opposite bank of the river from summer houses, adjacent to the built-up zone, the cemetery Michaelis-Friedhof is situated.

Within the built-up zone, some houses that are higher than surroundings on average are observed. The multi-apartment building in the corner of streets Kneippweg (house numbers 1-7) and An der Bauerwiese (house numbers 11-17) has total length of more than 300 meters, and some its sections have a height of 12 storeys. Another example is multi-apartment building Stammestrasse 16 in the eastern part of the built-up zone. This house of six storeys is surrounded mostly by buildings of two to three storeys. In general, the building Kneippweg 1-7/An der Bauerweise 11-17 is the only house that really stands out of other constructions by size.

The part of Ricklingen described above faces the risk of flooding due to the overflow of rivers Leine and Ihme. The headwater of Leine is located in southern Harz mountains in Thuringia and the source of Ihme is situated in Deister chain of hills in Lower Saxony to the west of Hanover. In springtime because of snowmelt and increased precipitation, the water level of these rivers grows significantly. That can lead to flooding.

After the end of World War II, Hanover faced with several floodings. The most destructive one occurred in 1946 when the whole investigated territory was flooded (Neue Presse 2012: www). In 1954 the first dyke in Ricklingen was constructed (Region und Landeshauptstadt Hannover 2019c: www). Less damaging floodings were observed in 1981, 2003, 2007, 2013 and 2017 years (Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz 2013: www; Hannoversche Allgemeine Zeitung 2017: www).

In Lower Saxony, three scenarios of flooding around the riverbed of Leine were predicted. These scenarios are based either on forecast or on statistics of the previous flooding. The scenario HQ100 displays the freshet that occurs once in 100 years statistically. HQ200 is the scenario of extremal flooding. HQ25 as the scenario of high probability displays the average level of flood that occurs once in 25 years (see Figure 2). Map of HQ100 displays approximate flood lines in 1946 (see Figure 3), while overflows of HQ200 (see Figure 4) level never happened

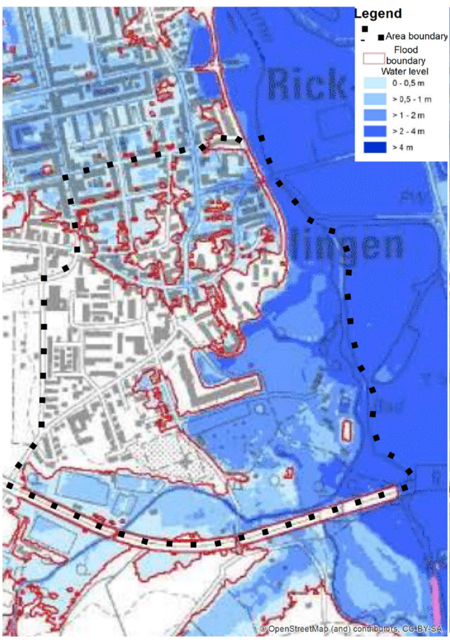

Fig. 2. Study area in Ricklingen within the zone of HQ25 flooding (own depiction based on Openstreetmap.org 2019: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019b: www)

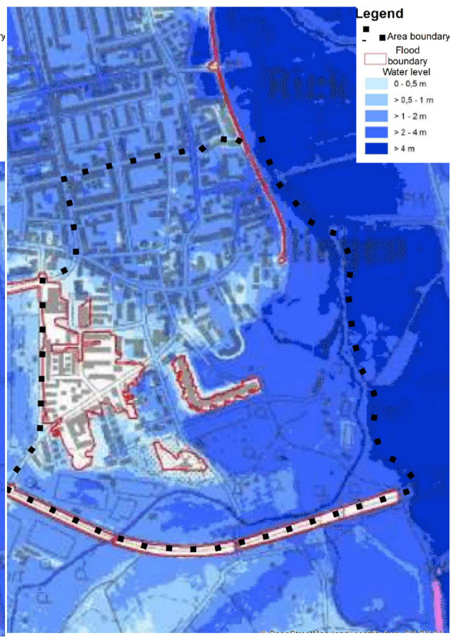

Fig. 3. Study area in Ricklingen within the zone of HQ100 flooding (own depiction based on Openstreetmap.org 2019: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019b: www)

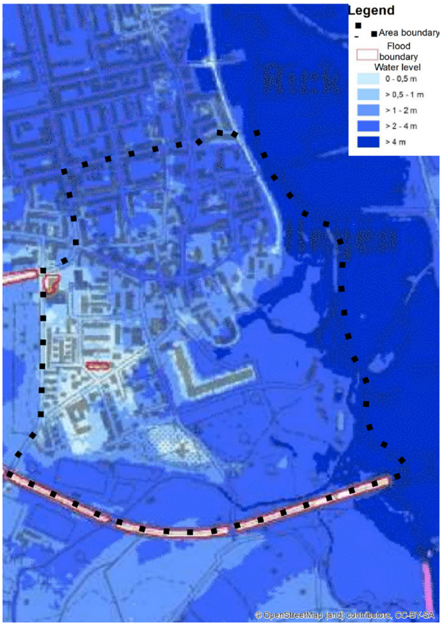

Fig. 4. Study area in Ricklingen within the zone of HQ200 flooding (own depiction based on Openstreetmap.org 2019: www; Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019b: www)

during the history of monitoring (Niedersächsisches Ministerium für Umwelt, Energie, Bauen und Klimaschutz 2019a: www). As can be concluded from the maps below, according to HQ25 scenario only the northern part of the built-up zone within the study area will be flooded while following HQ100 scenario only its south-western part will not be covered by water.

The dyke between the built-up zone and meadows is the main object that protects Ricklingen from flooding. It firstly appeared in 1954. During the last decade, it was reconstructed. The renewed dyke Ricklinger Deich was inaugurated in 2018. Ricklinger Deich is a fortified embankment with several gates between its parts. Within the investigated territory, it lies in immediate proximity from dwelling houses (see Figure 5). It has three gates that can be closed before heavy flooding. In the south of the study area, part of Ricklinger Deich is the wall of the cemetery simultaneously. Objects that need strengthened protection of flooding are: 1) the chapel Edelhofkapelle, the oldest church in Hannover which was built XIV century (Michaeliskirchengemeinde Hannover-Ricklingen 2015: www); 2) half-timbered houses that are more vulnerable to the influence of water due to features of their construction material; 3) cemetery where the ptomaine may come up in case of strong overflow.

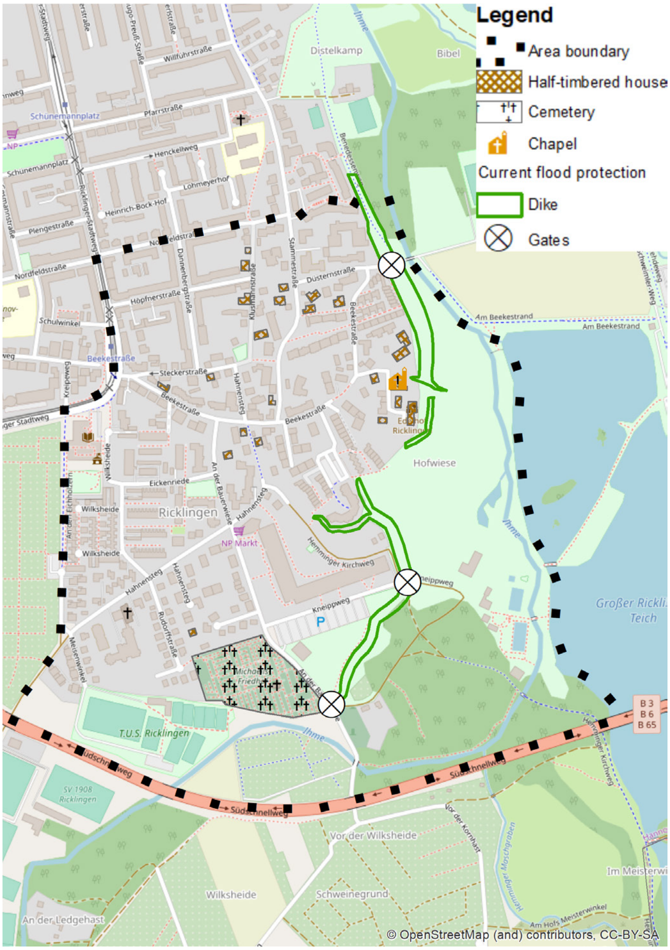

Fig. 5. Current flood protection and objects especially vulnerable to flooding (own depiction based on OpenStreetMap.org 2019: www)

4. Design Proposal for Flood Resilience in Ricklingen

For the future of Ricklingen, a proposal was formed through the following process. First, it was established as a vision through a status survey for the flood resistance, which Ricklingen aims to achieve in the long-term. A total of four principles were conceived to apply the vision to the target area as follows:

1. Water storage space to accommodate sudden events with heavy rainfall
2. The system that connects the flow of water from inside and outside areas of the survey site

3. Strategy applicable to individual buildings in the area
4. Application of multi-purpose recreation by an understanding of the natural context

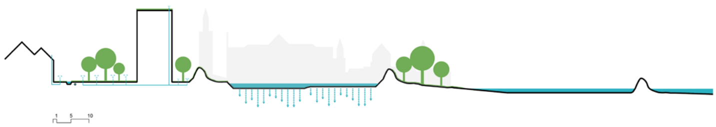

Fig. 6. Design and topography of the target area (own depiction)

Based on the direction of each principle, the measures suitable for the target area are planned with specific action plans (see Figure 6). The existing dyke in Ricklingen as flood control and resistance measure offers protection against fluvial floods but does not provide for flash floods and further intensification of extreme weather events. For adapting to climate change, the proposed measures include ponds at the inside and outside areas, as well as, ditches that relieve stress from the drainage system in the area. Besides, as individual strategies for private and public perspectives, it can be considered planting works on each building with a flat roof to evacuate intense rainfalls, and the high recreational value of the landscape will be further strengthened to support a close relationship between people and nature in Ricklingen (see Figure 7).

Fig. 7. Proposed measures and their location (own depiction)

Temporary Water Storage Space

Ricklingen's contour level of the land is not much different from the nearby lakes. For this reason, torrential rain could indeed cause flooding problems in the investigated area. According to the physical situation, the priority should be considered how to cope with temporary events with torrential rain. Although there are flood problems to consider in Ricklingen, drainage facilities have been identified in the field survey to a general level that is not as special as in any other region. Thus, plans are presented to supplement existing facilities. One measure is to install several ponds with basins inside and outside of the area. Each pond temporarily stores rainwater during torrential rains and splits it away after the rain stops or allows the water to be utilised for such as cleaning and landscaping. Besides, rainwater that suddenly swelled due to torrential rains is stored at various locations at the same time, so that it is adequate to supplement the drainage capacity to prevent flooding in the survey site. Especially since Ricklingen has a variety of allotment gardens, it may be possible to consider using rainwater in conjunction with the gardens.

Fig. 8. Multipurpose playground and rainwater storage (own depiction)

The location to install these ponds which are developed to retention basins can be divided into the inside and outside area of Ricklingen. First of all, it is possible to utilise the playground spaces in the case of the inside area. Under general weather conditions, playgrounds that are environmentally friendly as children's activity areas can be changed to open spaces for effectively storing rainwater in urgent situations such as torrential rain (see Figure 8). Through the field survey, a total of 6 playground spaces could be identified within the area, and if the direction to be shared for the local residents' private spaces is given, more space of possibility will be expected in the future. In the case of the outside area of the territory, the large-scale landscape area, which has been neglected, could be used temporarily as a facility for the low-lying area. Above all, this landscape area is located between the inside area and the lakes nearby so that it is suitable as a buffer zone to control the mutual effects of flooding.

Water Network System

As described before, Ricklingen's drainage facilities are at a general level. The rainwater is possible to be pumped directly into the soil in the outside areas of the dyke. But in the case of inside areas, there is a large amount of drained surface which has been covered by asphalt and blocks with development of residential district. In this situation, the water moves to the nearby river basin while the water drifts to the ground impermeable surface during heavy rainfall. However, the gates are closed at urgent events such as torrential rain, and the flood risk of the inside area is increased. Therefore, a well-planned water network system should be designed and be related to the temporary water storage spaces which are proposed before.

Fig. 9. Proposal for ditches (own depiction)

The proposal for the water network system is to make ditches in the entire area of the site (see Figure 9). It is not a function for the movement of rainwater but also a linear system that allows self-absorption to proceed smoothly from the ground surface to the soil. In some cases, it connects the water drainage inside and outside of the territory and controls the flow rate itself. Moreover, Ricklingen can be expected to have a positive effect in terms of complementing the general functions of existing drainage facilities.

Individual Strategy

The appropriate strategies are suggested together at the individual level for the flood resilience in Ricklingen. First, the strategy of greening on roofs and walls of individual houses and public buildings expected to perform as an effective function of quantity control of rainwater. Above all, a green roof system can temporarily store water like the pond, which was proposed, so that has the advantage of no leaking copious amounts of water in a short time. Therefore, it is possible to devise an environmental strategy in which individual members of society can participate by actively linking the green space of individual buildings with the ponds in the area. Also, each resident can independently make a temporary water storage space for the public benefit if there is an open space. Such individual efforts for the public may be compensated by municipalities on private real estate through incentive policy. The virtuous cycle structure of the area can be expected to get positive effects not only on the flood resilience strategy but also on the development of Ricklingen itself.

Under the name "Begrüntes Hannover", the City of Hanover has already launched a funding programme for the greening of roofs and facades and de-paving of urban areas (Region und Landeshauptstadt Hannover 2019a: www). This incentive scheme could be expanded so that the ponds are eligible for funding as well. Furthermore, awareness-raising campaigns and resilience meetings can enhance the civil preparedness for hydrological events and create the basis for environmental literacy. Like the construction of new buildings, house rebuilding should be coupled to specific structural and ecological requirements to progressively increase the system robustness of the area at all levels.

The existing dyke and outside area of Ricklingen were understood as a landscape with abundant recreational value through the field survey. Some areas have been used as a function of a seasonal outdoor swimming pool by the city of Hanover, but the green areas which occupy a large proportion that are preserved without any special functions. If the high potential areas can be utilised as a park, cycling routes, and external community spaces, it will be possible to induce the active participation of residents for public development.

Conclusion

In conclusion, floods, resulting in life loss and huge damages, have always occurred and will continue to do so. Consequently, there is an urgent demand for reaction, especially while taking into consideration the further increase of flooding due to the serious climate change the planet is facing. However, despite the inevitable character of the problem, appropriate planning and adoption of efficient measures may still have the power to influence the extent of the phenomenon, and, most certainly, their impact on society, in response to the greater need for resilience in our surroundings.

Resilience, defined by Bruneau et al. (2003), as “the ability of social units (e.g., organizations, communities) to mitigate hazards”, is considered to be a powerful tool, as “it contains the effects of disasters when they occur, and carries out recovery activities in ways that minimise social disruption, and mitigate the effects of future disasters” (Bruneau et al. 2003). Living with water requires innovative architectural and planning solutions. Success can only be reached if an interdisciplinary approach is adopted in the development of an integrated strategy towards flooding mitigation. In integrated approach for resilience consists, therefore, of processes and strategies that engage design, planning and engineering, along with social and political solutions to proactively adapt to and live with nature. The best strategy for a particular area, needs always to take into account technical feasibility, financial constraints and environmental considerations, as well as political and societal acceptability.

In the present paper, the development of the proposed strategy started with a proper understanding of the flood risk in the given study area and its surroundings, based on a GIS-based spatial analysis for the visualisation of possible flood scenarios and the investigation of the existing flood control measures. In accordance with the concept of integrated planning, the practices proposed, aim mostly at the retention of excess water amounts caused by pluvial flooding, as well as fluvial and flash floods, rather than at the implementation of further structural protection measures. As a result, a proposed network of waterways running through the intervention area guides the water towards and into small ponds, spread throughout the neighbourhood, which serve as water storage spaces. Adapted to certain particularities, some individual action plans were considered, in a number of buildings that could accommodate green roofs, contributing further to water retention.

At the same time, the ultimate aim of the resilient strategy was to raise awareness of the issue and ensure public participation. Therefore, in accordance with the natural context, multi-purpose recreational activities and spaces are proposed, as an addition to the technical part of water guidance and retention measures, in order to invite, not only the local, but also the surrounding community and engage their interest in protecting the place.

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Conclusion

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In the current fast-paced and technologically-oriented world, the issue of climate change – after years of negation – has been gaining importance in urban development agendas and city-related research. Simultaneously, it has been one of the crucial aspects to consider in the strategy creation processes to secure a better future for cities; and in order to do so, conscientious and well thought through governance actions are required.

In the first part of the book, the theoretical and empirical approaches of practitioners and scientists are presented, in order to develop a more detailed understanding of resilience and governance; especially in climate-related aspects. These served as a holistic basis for the developed proposals which are subsequently presented. The proposals were developed in interdisciplinary and multinational groups of promising students, who were obliged to scrutinise given areas, define occurring problems and specify the actions to eventually create a comprehensive resilience strategy. This publication, being the outcome of the Summer School on Resilient Cities in Hannover, does not only aim at the presentation of the final results of the event but also at further fruitful discussions on the stated topics and encouragement of young researchers and practitioners to develop their skills and enrich their experiences. The authors and editors of this book genuinely believe that the published papers and development proposals will significantly contribute to strengthening awareness of resilience discourses in urban-related research agendas.

Moreover, as this book is the last published edition within the HeKriS project, the authors would like to thank all the scientists, professionals and students involved in the work in the past years for their valuable contribution and commitment. Together, this group has undoubtedly contributed to promoting and enriching the resilience-oriented research, as well as theoretically and practically dedicated their work to create a better future, which aims at developing more liveable, sustainable and inclusive cities.

Additionally, the support of the German Academic Exchange Service (DAAD) has been of great significance throughout the whole three years of the duration of the project. In the course of the DAAD University Partnership between the Leibniz University Hanover (Institute of Environmental Planning) and the National Technical University Athens (School of Architecture) various complementing measures and formats were put into practice to foster the exchange of research and practice in strategies for sustainable urban development. The formats include summer schools, excursions and involve different target group of different constellations (Bachelor and Master students, PhD candidates, Post-docs and Professors). The main objective was to train

Greek and German students as well as young researchers to develop integrative strategies of crisis resistant cities as well as new and resilient types of cooperation between public, private and civil stakeholders (governance structures). The joint research and teaching activities aimed at (1) understanding the challenges of a sustainable and resilient urban development, (2) analysing the steering mechanisms and instruments and (3) developing appropriate strategies and measures. The intensive knowledge and experience transfer offered the possibility to the partners as well as the involved students and young researchers to learn from each and to acquire new competencies in developing sustainable and resilient cities.

The networks and cooperations that have emerged will be continued in the future. On behalf of the involved actors, we would like to thank all the participants and the DAAD for their support again.

Challenges of resilience in European cities

The development of resilient cities is a crucial factor for sustainable development. In the events of crises or hazards (e.g. natural hazards such as climate change), cities should be able to fulfil their societal and economic duties in the long term. In many cities, the question arises how and with which measures resilience can be increased and how strategies for successful sustainable urban development can be implemented.

The publication summarises the contributions of the Summer School 2019 in Hanover that focused on the development and discussion of approaches and strategies coping with governance of resilience, in particular, the two challenges, namely phenomena of „heat islands" and „flooding", within the greater urban complex of Hanover. The Summer School is a central cornerstone of the University partnership for joint educational and research activities at the Leibniz University of Hannover (Faculty of Architecture and Landscape) and the National Technical University Athens (School of Architecture). It is funded by the German Academic Exchange Service (DAAD) as part of the project "Resilience as Challenge for European Cities (HeKriS): Developing urban planning strategies and concrete projects".

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