TOWARDS CLIMATE RESILIENT PLANNING IN VIENNA
FROM MODELS TO CLIMATE SERVICES

TANJA TÖTZER, WOLFGANG LOIBL,
NIKOLAS NEUBERT, JÜRGEN PREISS

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FIGURE 1: View to Vienna´s most modern urban district, the "Donaucity", close to large recreational areas such as the Danube island and Danube park

RESPONSIVE CITIES

The idea of climate adapted urban planning and design is as old as our cities themselves. The physical pattern of cities frequently reflects, to some degree, their local climate conditions – e.g. narrow, shadowed streets and compact buildings can be found in regions with hot summers and cold winters whereas open designs for optimal air ventilation are typical for damp-warm climate zones. However today, the intersection of rapid urban growth of the last decades and the unprecedented rapidly changing climate conditions, such as increased episodes of heavy rains or longer and hotter heat waves, require that new design solutions have to be added to traditional urban development planning practices. We cannot ignore these new climate and rapid growth events as they increase mortality, cause other public health issues, and can cause large scale economic damage to properties and global value chains. City administrations need to offer their citizens solutions that increase liveability, secure habitats, and provide the assurance of a reliable base for the operation for businesses. Municipalities and their associated public operators also need to secure their investments in public infrastructures, fleets etc.

The city of Vienna, which is famous for its high quality of life and its very comprehensive smart city approach, has become a leader in recognizing the need for, and establishing itself into, a climate resilience urban development. The Austrian Institute of Technology (AIT) has been assisting the city of Vienna and its development process towards climate resilient planning for over a decade. This paper describes this collaboration, which marks a further effort to make Vienna more sustainable.

FIGURE 2: Climate related hazards are getting an urban reality. Flood water in the inner-city of Vienna

WHY CLIMATE RESILIENT PLANNING?

In 2018 Mercer ranked Vienna as the city with the highest worldwide quality of living – this for the 9th year in a row ![1] One of the categories analysed for the Mercer study deals with the natural environment and includes climate aspects and recreation facilities, such as parks and huge green areas.[2]

As a highly attractive place to live and do business, the City of Vienna with its 1.87 million inhabitants (2017) is steadily growing.[3] During the last five years (2013-2017) the Viennese population increased on average by around 30,000 inhabitants each year, creating the annual need for about 10,000 new apartments. This on-going population growth required both the planning of new districts as well as the establishment of new growth policies. However, the policies and plans, which enabled densification, became highly topical.

Beside densification in new settlement areas, the need emerged to get a clear understanding of the current and future microclimatic situation in built areas of the city, especially those with existing compact middle-European urban structures, where green spaces were allocated for representation purposes and a large share of the building stock dates to the 17th to 19th century.

Another issue resulted from an analysis of the city's land use. It found that about half of the Viennese city area can be considered green; meaning that it consists of large green areas such as parks, agricultural lands and urban forests. However, the green areas are not evenly distributed. The green share within the municipal districts varies from 2% to 15% in the inner city and up to 70% in the western districts, due to their hilly topography and forested areas.[4]

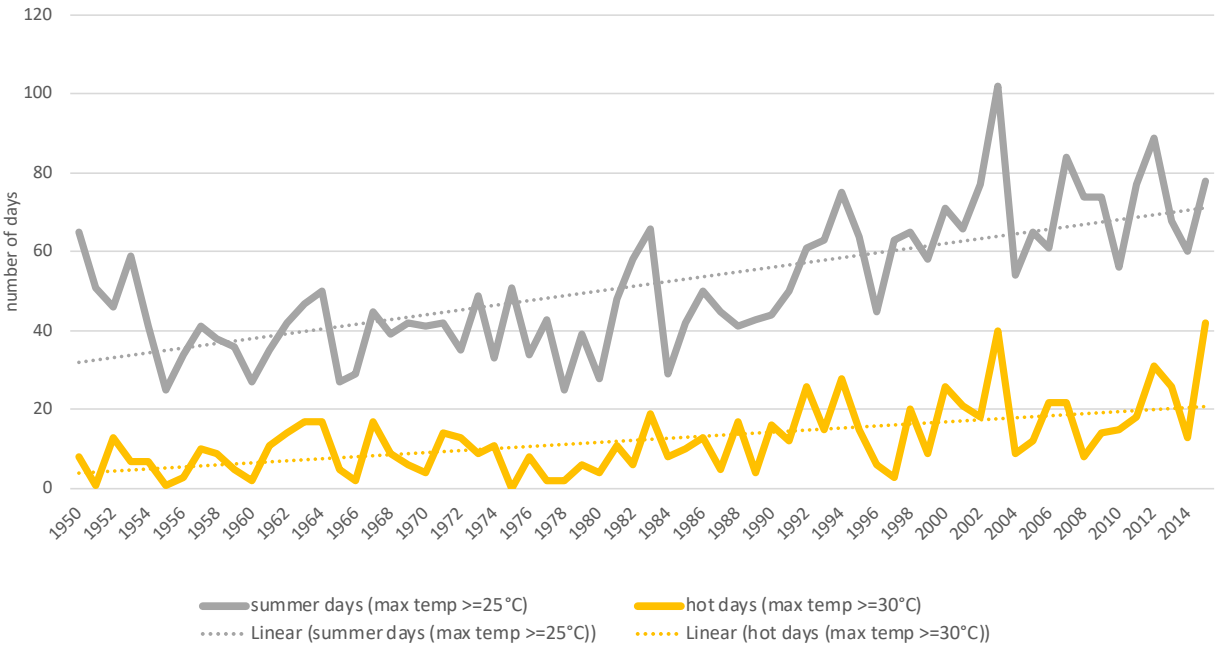
Finally, there was the need to get a clear understanding of the climate performance of the city, which is located in a transition climate zone influenced by oceanic and continental climates. This results in low precipitation totals and longer dry periods during summer and autumn. Particularly in summer, Vienna faces rising temperatures and peak periods of extreme heat. Climate change is already evident. For example, in 2016 Vienna experienced the fourth-warmest year since 1775 when regular temperature records where documented.[5] During the greatest heat period in Austria, in August 2017, the city centre of Vienna observed a daily maximum of up to 38.9°C.[6] Meteorological records since 1950 show a trend towards an increase of summer days (max. > 25°C), hot days (max. > 30°C) and tropical nights (min. > 20°C).[7]

These circumstances, of ongoing urban growth, unevenly distributed green, compact urban shape coupled with a warming and drier climate trend produced the need for Vienna to pioneer climate resilient planning if it was to maintain its high quality of life.

FIGURE 3: One of Vienna´s largest development areas "In der Wiesen" transforming open, agriculturally used areas into residential areas

FIGURE 4: ↑ How to design transformation towards resilience in a compact city like Vienna?

FIGURE 5: ↓ Increasing number of summer days and hot days in Vienna from 1950 to 2013.
SOURCE: ZAMG, own illustration



CLIMATE MODELLING FOR ASSESSING THE IMPACTS ON URBAN CLIMATE

For more than 15 years AIT has been engaged in conducting regional climate simulation modelling of current and future climate conditions. Our first projects focussed on the testing of regional climate and microclimate models and the modelling of current and future climatic patterns. This work helped the city to achieve a better understanding of microclimatic conditions in particular urban structures and of the future effects climate change may have on on the city as a whole.

One big challenge in climate modelling is the numerical downscaling of global scale climate simulations from the General Circulation Models (GCMs) to a regional and urban scale. In the project "reclip.century", AIT and three partner institutions, carried out 21st century climate simulations for the Greater Alpine Region providing hourly data for 10x10 km grids, which have been further downscaled in Austria to 4x4 km grids. Currently AIT is conducting transient urban climate scenarios with 1x1 km grids for the Greater Vienna Region, applying a model version tailored for urban climate simulation involving additional high-resolution data sets. Climate scenarios on an hourly base for a century with 1x1 km resolution can be seen as a milestone for urban climate modelling.

After developing a holistic understanding of the urban climate, the next step was to link our models to on-going urban planning processes. This transition was first realized with the planning of the new "aspern Seestadt" (aspern lakeside), designed to accommodate more than 20,000 inhabitants[8]. The City's goal was to establish a smart and sustainable show case development. In terms of climate, this meant that the urban design master plan had to be climate proofed to provide a sustainable planning framework for the ongoing development of the new urban district.

Several research projects supported this planning process. In the aspern Seestadt climate project ("Open space and Microclimate: Foundations for climate sensitive urban planning in Aspern"), the microclimate simulation was conducted for the entire area to provide microclimate indicators for specific block layouts. Based on this, planning and design guidelines for climate sensitive urban planning were established to improve the design of the new district with respect to block layout, surface properties and green open space share. The projects carried out for aspern Seestadt showed that the original master plan provided a good baseline for climate sensitive planning. Only a few adjustments were necessary and these have been implemented with respect to the orientation of streets, building height distribution and open space design addressing surface layout and vegetation distribution. This made aspern Seestadt a kind of prototype for integrated climate resilient planning in Vienna.[9]

FIGURE 6A+6B: Aspern Seestadt is Vienna´s most known and one of Europe's largest urban development projects. With a lake in the middle, extensive green areas and excellent transport links it is designed to become a show case for a new climate resilient urban district of Vienna

URBAN FABRIC
TYPE 1, 23RD DISTRICT
“urban fringe, industry and urban expansion zone“

URBAN FABRIC
TYPE 2B – 4TH DISTRICT
“inner city: perimeter block structure, late 19th century, close to city center, in slope position”

URBAN FABRIC TYPE
2A – 8/9/16/17TH DISTRICT
“inner city: perimeter block structure, late 19th century, close to city center”

URBAN FABRIC
TYPE 4 –19TH DISTRICT
“suburban area, in slope position”

URBAN FABRIC
TYPE 3B – 21ST DISTRICT
“suburban area, Vienna Basin”

URBAN FABRIC
TYPE 3A – 21ST DISTRICT
“sparsely populated Vienna Basin – mixed structure”

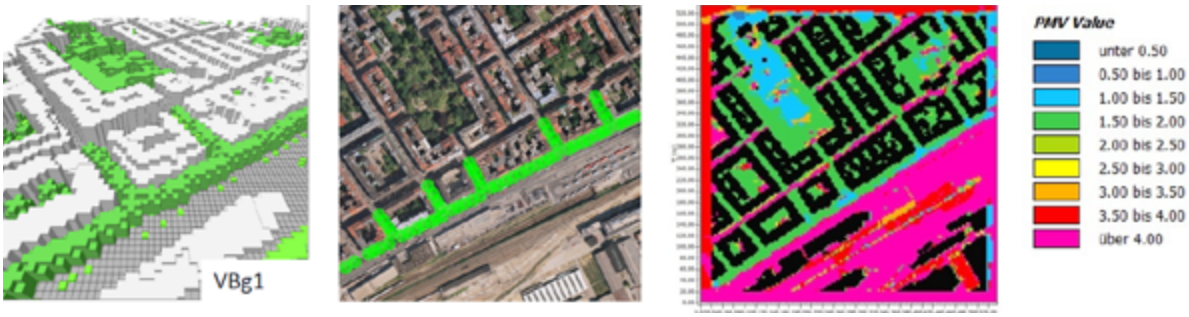


FIGURE 7: Microclimate modelling helps to show the effects of certain design and greening measures. It illustrates that planting tree rows along the south-eastern facades massively improves the microclimatic situation of the street blocks behind

After setting a case for large-scale urban planning and property development, the next challenge was to investigate impact-oriented generic design recommendations which could be applied to existing urban structures. AIT, partnered with national and international partners from Technical University of Vienna and the Technical University of Munich, conducted microclimate modelling for potentially exposed urban fabric types (for more details see [10]). In this project the triggers of local urban heat island effects were explored.

We also examined how open space characteristics, interacted with different surface properties and densities, could lead to negative impacts in urban environments. To achieve this, we modelled the effects of various climate design measures on different open space types located in the most exposed urban areas. Based on the model outcomes, green open space strategies were developed to mitigate negative effects at the local level. This equipped the city with general recommendations for UHI-reducing measures as well as with urban fabric type specific recommendations for guiding tailor-made design measures to counter climate stresses in different urban structures of Vienna.

The climate related projects carried out in cooperation with the city provided a valuable basis to understand how urban form affects urban climate and to understand how counter measures can be set. These advancements towards climate resilient planning increasingly raised our awareness and enabled us to think about acting on a more strategic scale.

FIGURE 8: Green facades to shade and humify the rooms behind instead of air-conditioning on a MA 48 - Waste Management Department building. SOURCE: MA 22

BOX 1: CLIMATE RESILIENCE

IPCC[11] defines Resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organisation, and the capacity to adapt to stress and change". This definition refers strongly to the definition of C.S. Holling (1973) and later Berkes and Folke 1998, Berkes et al. 2003 and Carpenter et al. 2005 on socio-ecological resilience. Applying the IPCC definition to the concrete issues of climate change and cities, climate change will cause disturbances on the city as socio-ecological system; but if the city is (climate-)resilient, it will be able to sustain its basic structure and ways of functioning – this also means its quality of life.

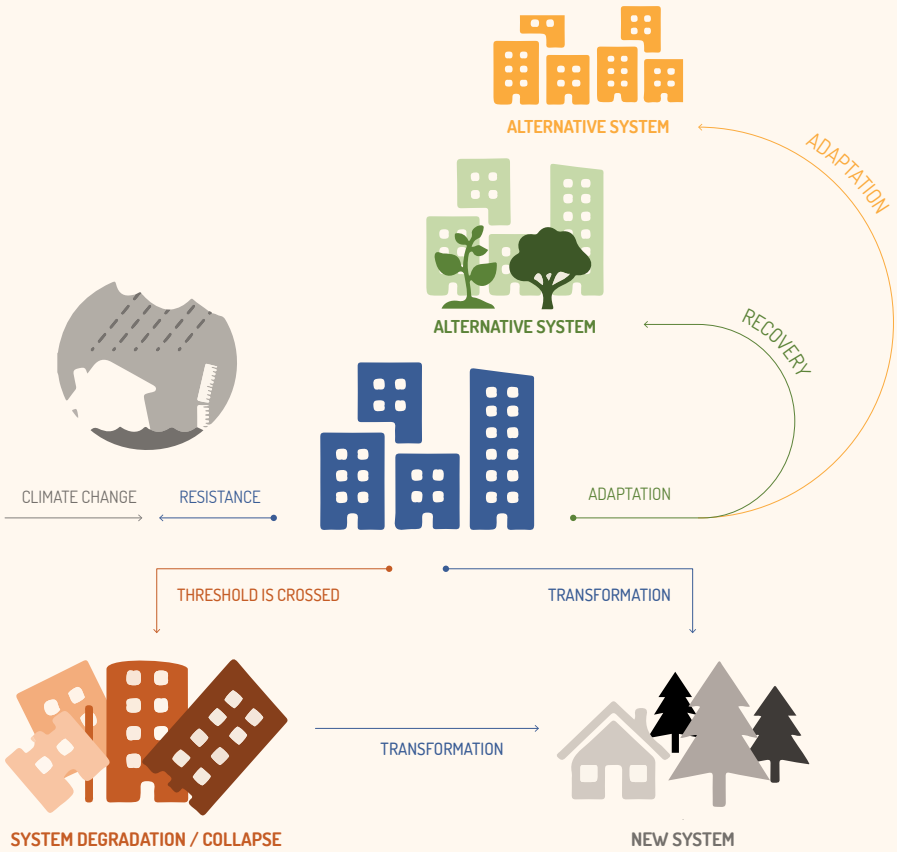


FIGURE 9: Climate resilience – see description in the text. Own illustration based on Fuller and Quine (2016)

The figure illustrates how a system like a city can react or adapt to climate change. It can adapt and recover as it is, or it can adapt to alternative systems e.g. by greening the city or optimizing its building structure and infrastructure. Although the city changes, its basic functions and structures are still sustained. A non-resilient outcome would occur if climate change causes such dramatic damages that it leads to demolished infrastructure and devastated areas, such that the city must transform into a completely new system. Politicians and planners try to prevent such disasters. Applying the concept of resilience can help to precautionary set the right measures.

FROM THEORY TO ACTION

BRINGING CLIMATE RESILIENCE TO THE NEXT LEVEL

Building on accomplishments, Vienna's Environmental Protection Department actively pushed the issue of urban climate change and took a leading role in developing an "Urban Heat Island Strategy Plan" for Vienna (UHI-STRAT). Completed in 2015 and one of the first plans of this kind, the city put itself in the front runner's position towards climate resilient planning.

Its main goal was to show planners, architects, and other relevant stakeholders a series of measures to reduce negative climate effects and to demonstrate appropriate mitigation and adaptation measures. Besides, the process of inter-sectoral discussions was essential for raising awareness on this issue.

To fill the UHI-STRAT with life, it was, and still is, essential to integrate it into the urban development practice of the city as found in both the city's strategic plans as well in local area plans. Current planning experience show that success implementation of UHI measures depends on transdisciplinary and integrative process setup and on stringent consideration over all relevant planning levels.

Since then, the UHI-STRAT has successfully been implemented in several planning documents. Examples for important fields of action include: the City of Vienna's Climate Protection Program; the Urban Development Plan - STEP 2025; the Public Space Concept; and, the management of measures within the framework of the Urban Development Plan and urban planning and building design competition processes.

FIGURE 10: Urban Heat Islands Strategy Plan of Vienna, published in 2015 - one of the first plans of this kind

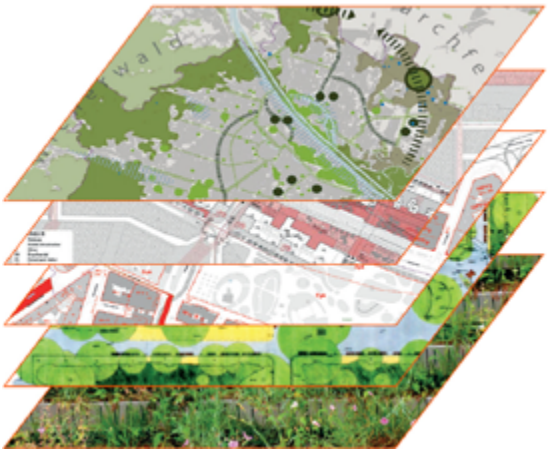


FIGURE 11: Planning levels in the City for the mitigation of the UHI effect.
SOURCE: from top to bottom: Stadtentwicklung Wien, Magistratsabteilung 18 – Stadtentwicklung und Stadtplanung, 2014, STUDIOVLAY; Stadtentwicklung Wien; Büro tilia; Jürgen Preiss, MA 22

NEW AND DEVELOPING CLIMATE RESILIENT TOOLS

Having identified the need to bridge the gap from the strategic side into the development realm, the city of Vienna, together with research partners such as AIT and local initiatives, has begun a series of projects to develop crucial insights into implementation processes and the methods needed to mitigate negative climate impacts. One of the on-going key projects[12] aims to develop a prototype tool set for the regulation, improvement, and evaluation of climate-sensitive urban planning in the city. In other words, the purpose of this project is to deliver scientifically proven findings which document how green infrastructure can contribute to the mitigation of the Urban Heat Island (UHI) effect in existing and planned quarters and to provide information about how to couple different planning tools at various scales. The proposed set of field-tested tools will allow the city to scientifically back planning decisions, allowing full transparency while making the impact of climate resilient planning measurable. Once completed, it will be a prototype multi-scale city planning tool for climate resilient urban planning.

Another important issue, being discussed in many cities, is the impact of urban densification on the urban climate. A recent AIT project named CLUDEX (Climate Change and Urban Densification impact EXploration) adapts the city's 3D model to develop urban densification scenarios for a particular Vienna district. It then assesses the impact of climate change and urban fabric change on indoor climate comfort and outdoor microclimate conditions. Citizens and stakeholders, including property developers, will discuss building-related and street layout adaptation measures to mitigate the densification impact on urban microclimate. Participants can choose from our tool box and select to test various adaptation measures, such as green roofs, green facades, green open spaces which can then be virtually tested to assess their impact under various microclimate and wind conditions caused by densification. The results will facilitate the establishment of climate sensitive densification guidelines.

IMPLEMENTATION WITH LIVING LABS

Besides the application of models and defining guidelines, AIT also has assisted the city to set up implementation test beds. These allow for a certain freedom of design, process and outcome, while testing under real conditions. The objective is to learn (about obstacles and features to be replicated) by actively involving the local population and stakeholders to ensure future acceptance of decided activities. For example, AIT, together with several partners, is setting up a living lab in the project "LiLa4Green" to test how the provision of green-blue infrastructure improves the climate resilience of a city. Another issue, worth being explored, are the

costs to counteract the urban heat island-effects in areas where financial resources are low. This research can provide the justification to accelerate the provision of low cost remedial blue green solutions. However, the implementation of so called Nature Based Solutions (NBS) is facing challenges, such as priority for technical solutions and infrastructural needs (streets, parking lots, city sewer systems, etc.) as well as low acceptance or appreciation from the citizens.

To realize projects that not only strive for climate-friendliness but also consider social aspects (quality of life, health, safety, social equity, etc.), the focus of LiLa4Green is to develop a living lab to facilitate the involvement of users into the implementation process. It aims to bring the benefits of green-blue infrastructure nearer to the people and to raise awareness of the value and positive effects of greening the city. Participation and mutual learning are two crucial elements in the process to become a resilient city as they increase the societal acceptance, knowledge acquisition and thus adaptation capacity. Co-creation and experiments complement this process. By considering social aspects the resilience concept is extended. Besides the exposure of certain urban structures to climate change, the vulnerability of the local people living in the neighbourhood is addressed. This is particularly important in existing built-up and deprived areas. However, while this proposed lab is an important new issue, it has only recently been discussed in the context of climate change in the City of Vienna.

FIGURE 12: As space is scare, Vienna begins to use vertical surfaces for greening. Façade greening of a public building (MA31)

SMART AND RESILIENT VIENNA

Vienna's pioneering climate resilient urban planning can surely be considered a success. The circumstances of increasing urban growth and changing climate conditions provided a clear call for action. In addition to the support from the city government, an atmosphere of cooperation developed between the municipality and its research partners, such as the AIT, that has proven very productive. Jointly we are unlocking the complexity of the topic, developing a blue print for a climate resilient planning approach, and creating capabilities in this new field – all in a relatively brief time. Through the involvement of applied research partners and a scientifically based approach, the concerned stakeholders build confidence in the projects based on trust and professionalism. This confident partnership allowed the topic of climate resilient planning to be ingrained into the city's strategic plans and enables the team to gain experience with cutting-edge planning tools and in the implementation of measures in living labs.

The milestones we have accomplished can be considered a proper foundation and base to guide the next steps towards developing implementation appropriate criteria and related thresholds at planning standards appropriate at all scales. For the years to come, this will be one of the crucial tasks to tackle to establish a truly integrated climate resilient planning practice.

There are also issues which need the city's urgent attention, such as the elaboration of advanced urban climate maps displaying the city's climate functions, or the handling of climate caused cascading effects (e.g. malicious impact of heavy rain on public transport). Another key issue we need to address is the advancement of the governance structures. Current planning processes show that the success of implementing climate resilient measures depends on transdisciplinary and integrative approaches and on stringent consideration over all relevant planning levels. Giving an example for integrated planning, the City of Vienna launched a project in 2016 to promote façade greening. With the assistance of experts from all relevant interdisciplinary disciplines the legal requirements, the framework conditions, ecological, economic and social sustainability, best practices, quality assurance procedures, and implementation instruments are being defined. The issue of relevant fire protection is already finished and the new guideline for facade greening hopefully will be published this year (2018).

Besides the internal coordination within the City administration, a successfully realized resilient city also relates to how other stakeholders are involved in the entire planning process. Experiences in stakeholders´ processes, until now, have proven that balancing interests is not an easy task, since the understanding of, and the approach to the topic can vary widely. While companies want to climate

FIGURE 13: "Alt Erlaa" buildings from architect Harry Glück with generous green areas, spacious terraces and pools on the roof top. Already 40 years old but still popular for their high quality of life

proof their entire business environment, citizens request comfortable interior living environments with sound climate conditions. We are just beginning to develop stakeholders´ participation methods using crowd sourcing in the adaptation scenario assessment process. Further research and experience is required to learn how to involve all social classes, to identify how local requirements can be fulfilled, and to learn how the acceptance of implementation measures can be increased to achieve co-benefits.

Another key issue for the coming years will be the city's long-term commitment to implementation. To make this feasible, the support of concerned ministries to provide aiding policies and funding streams to support the city administration´s efforts is critical.

Climate events already have a direct impact on citizen's life and on businesses operating within cities. We think that being resilient will be a crucial factor if the city is to cope with rapid and unprecedented changes and continue to provide well working infrastructure and high quality of life in the long run. Therefore, a comprehensive approach towards climate resilient planning will play a vital role for the agenda of our cities.

FIGURE 14: Attractive settlement areas, mixed with social housing, along the Old Danube

In Vienna, this can already be observed in the debate on the further development of the smart city framework strategy. The strategy's close link to the urban development practice and its focus on sustainability and life-quality has proven highly successful. With the rising importance of climate resilience, it might turn out that Vienna's smart city strategy might soon become the city's smart and resilient strategy. That would be a major step in the right direction and secure the city's pioneering role.

ENDNOTES

1 The study evaluates local living conditions in more than 450 cities surveyed worldwide according to 39 factors, grouped in 10 categories, such as political, social, economic, and environmental factors. https://www.mercer.com/newsroom/2017-quality-of-living-survey.html

2 https://www.mercer.com/newsroom/2018-quality-of-living-survey.html

3 Vienna City Administration 2017

4 Magistrat der Stadt Wien 2017

5 https://www.zamg.ac.at/cms/de/klima/information-sportal-klimawandel/klimaforschung/klimamessung/messnetze-oesterreich

6 https://www.zamg.ac.at/cms/de/klima/klima-aktuell/jahresrueckblick

7 In 2017 28 tropical nights in the city centre, average (1981-2010): 15,5 tropical nights https://www.zamg.ac.at/cms/de/klima/news/drittwaermster-sommer-der-messgeschichte

8 https://www.aspern-seestadt.at/en

9 aspern Seestadt recently won the "immobilienmanager award 2018", the most prestigious prize of the property developer community in the german-speaking countries! https://www.aspern-seestadt.at/presse/aspern_seestadt_erhaelt_immobilienmanager_award_2018

10 http://info.tuwien.ac.at/urbanfabric/index.php/en/

11 IPCC WG2 2007: 880 (Parry et al. 2007)

12 "Green.resilient.city" https://nachhaltigwirtschaften.at/en/sdz/projects/green-and-resilient-city.php

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