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Making Green Real – How to Promote Greenery in Real Estate Development

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1 ABSTRACT

Climate change and rising temperatures particularly affect the built environment and intensify the Urban Heat Island (UHI) effect in cities. Nature-based solutions can have a balancing function and reduce overheating. However, greenery still receives too little attention in architecture and is added as an additional element at the end of the planning phase or even after the building has been constructed.

For a climate resilient urban development in the future, in addition to a change in processes, a change in real estate development and in the project management is necessary.

At least, three preconditions must be met for this to happen:

- Sound knowledge base: Many studies already exist proving the positive effects of nature-based solutions for densely built cities. However, the knowledge transfer to real estate companies is still insufficient as they require precise and site-specific information showing effectiveness of greenery on microclimate, building envelope and indoor temperature. At best, analyses apply a system view and consider interrelations with water and energy.
- Greenery-friendly planning framework: Real estate development takes place in compliance with local planning standards and procedures. Planning strategies and regulations, standards, urban development contracts and funding programmes strongly influence urban design and development and hereby have great potential to promote greening.
- Integrated mindset: In architecture and real estate development, it is still not standard to include greenery and nature-based solutions in design, planning and construction. Building optimization also includes greening. Thus, it needs an integrated mindset regarding greenery as natural part of architecture. This requires more awareness and knowledge about climate change and the benefits of nature-based solutions on quality of life and value of real estates in the long run.

The paper summarizes the experience of an interdisciplinary cooperation in the research project GreenDeal4Real and addresses all three aspects in detail. Analyses of the planning framework in Vienna and impacts of greening measures on the microclimate are described and general conclusions for more green in real estate development are drawn.

Keywords: microclimate simulation, real estate development, nature-based solutions, planning framework, climate resilience

2 INTRODUCTION

The latest IPCC report confirms that worldwide cities are already affected by climate change with negative effects on human health, livelihood and key infrastructure (IPCC 2023). Thus, in order to sustain the liveability in cities, adaptation measures to climate change must be implemented today to proactively counteract negative developments in the future as climate change and its effects on cities in particular is expected to continue through the 21st century (Goodess 2012, Christidis et al. 2015, Qiu and Yan 2020).

Main issues in cities are the above-average warming known as Urban Heat Island (UHI) effect and the increase of heavy precipitation and its resulting runoff intensity (IPCC 2023). Causes are to be found in the typcial urban structures with sealed surfaces and construction materials with different heat storage capacities than natural ones (Sharifi and Lehmann 2014, Singh et al. 2020), absorbing solar radiation during the day and releasing the energy surplus in the form of sensible heat flux and longwave radiation during the night. The UHI effect is further intensified by anthropogenic heat emissions, which are among others produced by traffic, households, industry and increasingly through air conditioning systems (Sham and Memon 2012).

Climate scenarios and projections show that the climatic situation in cities will even worsen in the future. Brown (2020) researched the present and future heatwave hazard for cities worldwide and found that temperatures are expected to rise during heatwaves by between 3.4 to 6.6 ◦C until 2099 (basis 2006). Although it is proved that more intense and frequent heatwaves result in excess deaths, this is still an "invisible risk" that is not given sufficient attention in policy and planning (Brimicombe et al. 2021).

Thus, it is high time that cities seriously address their vulnerability to climate change and start to transform towards climate resilient urban structures. More and more cities are becoming aware of the impending effects of rising temperature and extreme weather events and strategically plan and start to adapt the urban environment to the upcoming changing framework conditions. Green and blue infrastructure, i.e., a network of green spaces and water permeable surfaces as well as individual plants, green facades or green roofs, and corresponding rainwater management play an essential role for the urban microclimate and represent a possibility to significantly reduce the extent of the UHI effect (MA22 2015, Roehr and Laurenz 2008, Kleerekoper et al. 2012; Norton et al. 2015). Integrating nature-based solutions into urban structures helps to mitigate negative climate change impacts such as heat stress and flooding through natural cooling (evapotranspiration) and water absorption, storage and infiltration (Carter 2018; Everett et al. 2018; Li et al. 2019). Nevertheless, it is not even a matter of course for new buildings that optimal and most effective greening is implemented.

Exactly this issue is addressed in the research project "GreenDeal4Real - Improving the thermal comfort in mixed-use areas through cost-effective green infrastructure", which is funded by the BMK (Austrian Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology) and implemented under the "City of Tomorrow" program. The project researches how positive effects of greening measures can be assessed, quantified, optimised and integrated into planning and construction processes. An actual real estate development project in the 22nd district of Vienna is taken as case study and demonstration site for testing the optimal integration of green measures into the design and construction process. The research project contributes to the construction process in an early planning stage when it is still possible to adapt static and design and to integrate greening into archtitecture. A systemic, integrative approach is pursued, which is also reflected in the composition of the interdisciplinary project consortium consisting of the AIT Austrian Institute of Technology GmbH, 6B47 Real Estate Investors AG, the landscape planning companies grünplan gmbh and Lindle+Bukor, the City of Vienna represented by the MA 18 - Stadtentwicklung und Stadtplanung, the greening company 90deGreen GmbH and the green innovation laboratory GRÜNSTATTGRAU. The exchange in the interdisplinary team allowed mutual learning and revealed regulatory barriers at the interface of private and public sectors that were discussed with city administration. Findings from the analysis for an efficient implementation of urban greening technologies, the microclimate simulations and the planning lab are presented in the following.

3 BENEFITS OF MICROCLIMATE SIMULATIONS IN THE EARLY PLANNING STAGE

In the last decades, microclimate simulation models became an important tool for the assessment of microclimatic performance of urban planning and building projects. While some models support the analysis of selected parameters (e.g. solar radiation, wind comfort), others aim at a holistic representation of physical processes in complex urban environments. In the project "GreenDeal4Real", two different microclimate simulation models were applied. While the Ladybug tool suite (module of the Grasshopper Plug-in of Rhino 3D) was used for evaluating radiation parameters (shading functions, mean radiant temperature in front of facades), ENVI-met as an example for a holistic microclimate model served to quantify the effects of greenery in an early planning stage of the real estate development project. ENVI-met is a three-dimensional model, locating buildings, vegetation and surfaces on a rectangular grid structure and simulating physical processes and interactions, such as radiation, wind dynamics, atmosphere-surface interactions, evapotranspiration and others. It is thus suitable to demonstrate the effects of greenery within this project.

While the entire real estate development project is divided into seven construction sites, two of them have been used in the microclimate studies. The 3D model of the buildings and vegetation were designed in Rhino 3D based on the current planning status and directly exported to ENVI-met to guarantee a consistent simulation process in both models. For meteorological boundary conditions, June 10th 2010 was selected as a representative hot summer day from a typical meteorological year (data source: EnergyPlus Weather File).

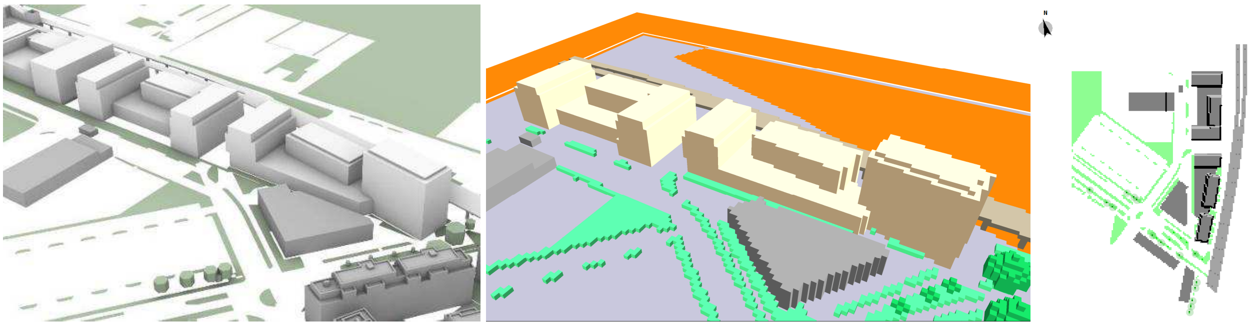

Figure 1: left: Model domain designed in Rhino 3D, middle: Model domain imported to ENVI-Met, right Orientation of domain

Based on the simulation results of a draft version without greenery, the interdisciplinary project team discussed options for façade greening, green roofs (including water management and retention) as well as the economic viability and developed realistic versions of applicable NbS for the site. The close cooperation between real estate developers, landscape architects, greening experts, microclimate experts and local authorities in the project provided the possibility to highlight important aspects from different perspectives in an early planning stage, allowing for consideration of statics, architecture, rainwater management and for relevant adaptations. The consideration of microclimate simulations in an early planning stage proved to be essential for facilitating fruitful discussions about greening measures and adaptations to conventional building design. Such changes towards microclimatic effective NbS have to be taken in an early planning stage when costs of design changes are still low and the ability to impact design is high.

First conducted simulation results focused on the analysis of solar radiation with the Ladybug tool suite. It revealed the shading function of balconies on Southern oriented façades (Figure 2) and suggested to focus façade greening options on west- or east-facing façades. Besides, the roofs were identified as most exposed areas to solar radiation. To provide the necessary thermal comfort and make use of the roof areas at one high-rise and both low-rise parts of the buildings as gardens and recreational zones, NbS were required fulfilling the necessary shading function. Following this recommendation, intensive roof greening including trees and pergolas was included in subsequent simulations with ENVI-met. On the remaining roofs, extensive roof greening was applied (Figure 3).

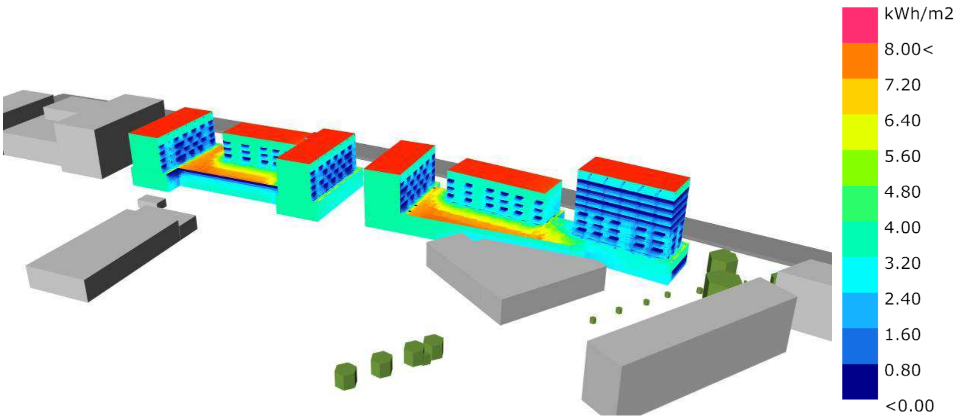

Figure 2: Solar radiation analysis of June 10th, 2010.

With regards to façade greening, various types have been discussed in focus groups:

- Wall-mounted green façade with substrate layer (full and partial coverage)
- Ground-based green façade without substrate layer (full and partial coverage)

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- Trough-based façade greening without substrate layer (full and partial coverage)
- Climber systems in front of balconies

In accordance with experts for façade greening, economic viability and fire protection considerations, partially covered wall-mounted and trough-based façade greenings were selected for further microclimate simulations. Sensitivity results focusing on the effects of façade greening on Western and Eastern oriented walls, showed the expected results of strongest effects for Eastern oriented facades during the morning hours and Western oriented facades during the afternoon and evening hours. Due to increased microclimatic effects during the times where cooling effects are desired by residents of the building (afternoon and evening hours), façade greening was focused on west-facing façade areas between balconies on the high-rise buildings in the middle of each construction site. For simulation purpose, each selected type of façade greening (wall-mounted, trough-based) was applied to one building (Figure 3).

To evaluate the effects of both types of façade greening on the outside and inside wall surface temperature, one grid point with applied greening was selected at each building and compared to the draft version without greening (Figure 4). The trough-based version only led to a reduction of the outside surface temperature during sun exposition of max. 2.2 °C. After sunset the surface temperature adjusted to the non-green draft example. However, the effect on the inside surface temperature remained throughout the day without any significant peaks, but an increasing difference to the non-green version during the simulation period. As the same is true for the wall-mounted type, it can be concluded, that the effect of façade greening on inside surface temperature and consequently inside air temperature (not shown) increases during heat wave periods. In contrast to the trough-based façade greening, the wall-mounted type led to reductions of outside façade temperature during the entire day with maximum differences during sun exposition of 17 °C. The larger differences can be explained by the substrate layer, acting as additional insulation layer in the wall construction. The experiments were calculated with a leaf area index (LAI) of 1 (wall-mounted) and 1.5 (trough-based) as they are the default values in ENVI-met. Further sensitivity experiments with higher LAI values suggested even stronger temperature reducing effects for the trough-based type, but similar results for the wall-mounted type of façade greening.

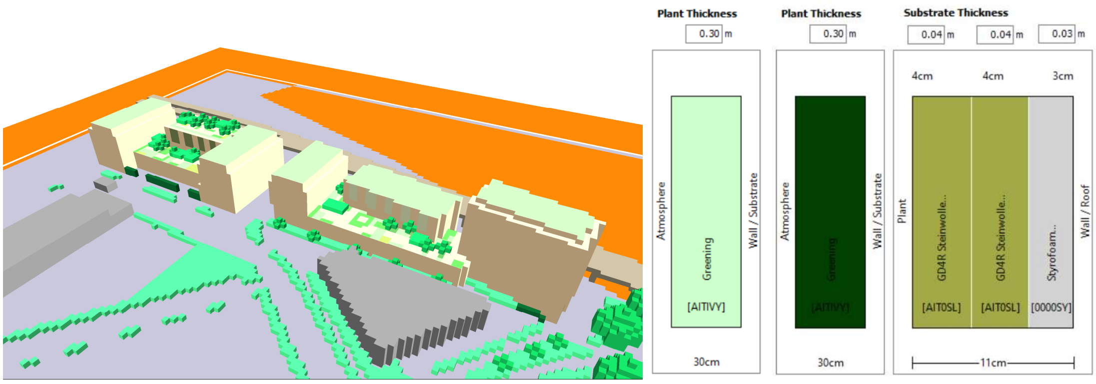

Figure 3: left: ENVI-Met model domain with applied NbS: extensive and intensive roof greening, wall-mounted (left building) and trough-based (right building) façade greening, trees in front of buildings; middle: trough-based greening implemented in ENVI-Met; right: wall-mounted greening implemented in ENVI-Met.

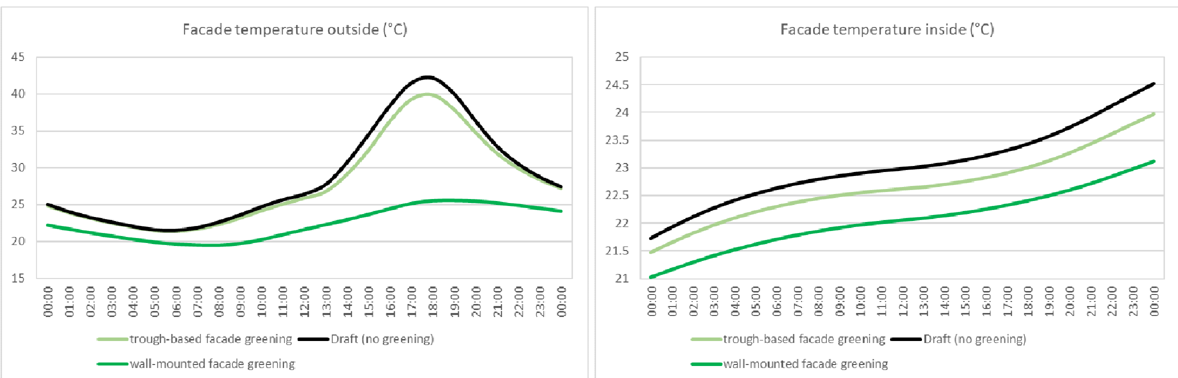

Figure 4: Comparison of façade temperature outside (left) and inside (right) with/without façade greening during one day

Evaluation results of different types, locations and intensities of NbS in the vicinity and directly at the buildings provided profound and decision-relevant information to the real estate developer of the building project. Especially in early planning stages, where significant changes can be realised at low cost, compared to later planning stages, microclimate simulations provided an important source of information.

4 RELEVANCE OF THE PLANNING FRAMEWORK

Although microclimate simulations allow for assessing the effectiveness of different greening scenarios and for identifying optimal solutions from a microclimatic point of view, the actual implementation depends on additional framework conditions such as the planning framework. This is also the reason why a standard has been published in Austria in 2021, ÖNORM L1136, which includes the consideration of site conditions. Furthermore, the latest draft of the revision of the Energy performance of buildings directive (EPBD) already integrates green infrastructure. Member States must ensure that "new buildings…adapt to climate change through, inter alia, green infrastructure…" (Article 7 Paragraph 4). However, due to progressing climate change, further adaptations in the planning framework are needed to foster a transformation of cities towards more climate resilience. However, many existing regulations still act as a barrier for an easy and efficient implementation of nature-based solutions. For identifying the best greening solutions for the selected building project, the regulatory planning framework in the City of Vienna was evaluated. In a "planning lab" the project team exchanged with relevant stakeholders from city administration such as urban development, planning neighbourhoods and building inspection on potentials of guidelines, regulations, and urban development contracts.

In the City of Vienna, several guidelines for green roofs and green façades exist and since the amendment of the building code 2018 it is mandatory for new buildings that 20% of the façade oriented towards the street must be greened. However, the stakeholder interviews conducted during the project GreenDeal4Real showed that there are still several challenges in practice and potentials for further improving the planning framework to promote greenery.

In Vienna, the general definition of a mandatory 20% street-side façade greening in new buildings contributes to the promotion of green infrastructure and represents an essential step for greening in the city. However, in the case of street-facing façades that are exposed to the north, it is to be expected that the growth of plants will be impeded, and the microclimatic effect will be rather low. As a further development of the regulation, compliance with a green and open space factor in the construction of new buildings, which is planned to be implemented in the City of Salzburg (Stadt-Salzburg.at 2021) and combines built-up area, building volume, façade and roof greening, would be conceivable. It offers a system of parameters with a clear target but which can be achieved with several "levers" and takes the whole plot into account, which is more relevant for the microclimate than the single building, thus increases the positive effect on the microclimate and gives more flexibility to the design and planning processes.

Even though correct maintenance measures are essential for a well-functioning growth of green roofs and façades, controlling the compliance with required maintenance measures is a complex issue. At present, the current legal situation only requires a civil engineer to confirm the (correct) installation of greening measures. Although in the Austrian standard L1136 a care concept is integrated, a regular listing of maintenance checks in the building logbook could be a way to guarantee a continuous evaluation of the state of greening measures. Furthermore, the controlling bodies need relevant professional knowledge in landscape planning and greening as well as additional human resources.

Climate analyses are useful to assess the effects of building structure and greening measures on the microclimate. In the context of climate change and the resulting consequences for cities, it becomes more and more relevant to gain a deeper understanding of the effects of building projects on the microclimate. Conducting microclimate analyses can help to plan building projects in such a way that the climate resilience of new buildings is as high as possible. Particularly for large construction projects that not only affect the local microclimate but also the neighbouring urban areas and perhaps even wind circulation patterns for the entire city, mandatory microclimate analysis should be taken into consideration to identify the need for optimisation regarding building orientation and height and for greenery to maintain a microclimate at bearable level.

A rather specific but important topic is the fire protection. In the case of the GreenDeal4Real project, several challenges arose in order to comply with the newly issued requirements for fire protection of the City of Vienna. The building is located in a zone for mixed industrial-residential use and apartments are situated above the ground storeys reserved for light industry and commerce. Thus, they fall into a higher building class which implied restrictions, especially on cost-efficient greening measures.

After several discussions in various committees with the City of Vienna, other consultants and representatives for the OIB 2 guideline (OIB = Austrian Institute of Construction Engineering), it became clear that a better consensus between greening and fire protection technology had to be found. The building inspection MA 39 from Vienna therefore carried out further fire tests with plants (meanwhile more than 90) and was able to revise the regulations. Since May 2023, a new requirement has been published and some of the examples mentioned in GreenDeal4Real have been included.

Now expanded greening options are given (see Figure 5), so that cost-effective ground-based systems can be used over several storeys for greening purposes. Through intensive exchanges with stakeholders misunderstandings and ambiguities could be eliminated and a compromise between safety and climate-resilient planning could be reached.

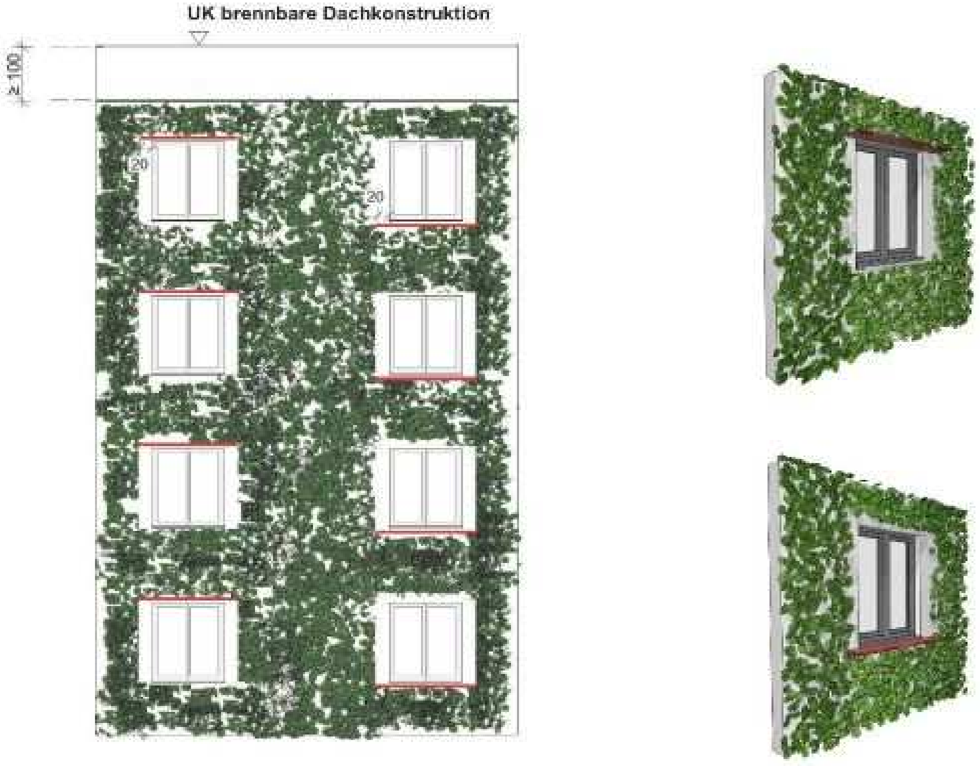

Figure 5: Expanded greening options in the new requirements for fire protection since February 2023; Source: Eder 2023, p.8 Chapter 2.2.6.

5 DISCUSSIONS AND LESSONS LEARNED

Many studies already exist proving the positive effects of nature-based solutions for densely built cities. However, the knowledge transfer to real estate companies is still insufficient as they require precise and site-specific information showing effectiveness of greenery on microclimate, building envelope and indoor temperature. Awareness of the interlinked parameters between built-up area and greening is often lacking, and additionally to the focus on the building itself, the effects on the neighbourhood I increasingly being taken into account. Thus, in the last years, microclimate analyses became an important tool for the assessment of different scenarios of urban planning projects on the local site and its neighbourhood. Even though the broader application of microclimate analysis is important and necessary, the simulation studies conducted in GreenDeal4Real have shown that there are still pitfalls and challenges which have to be considered.

Microclimate analyses are recommended to take place in an early planning stage and proved to be a good means to quantify the microclimatic effects of greening, raise awareness for the positive effects of vegetation for indoor, surface and outdoor temperature and foster a discussion among different disciplines of landscape planners, architects, greening experts, city administratives and microclimate experts. Roof greening and wall-mounted green façade with substrate layer were identified as most effective greening measures regarding cooling effects on the building surface. As such greening measures are not yet a natural part of architecture and can not simply be added to the existing planning design but have to be incorporated into the architecture and static of a building, it is crucial to consider them in an early planning stage. Only then, the potential for impacting the building design ist still high and the costs of design changes are reasonably low.

As the microclimate results from a complex interrelation of multiple parameters such as building height and structure, type of vegetation, water saturation of the soil, surface materials, etc., simplified averaged results are often misleading. Simple spatial and temporal averaging involves the risk to neglect important results and lose meaningful outcome of a study or project. At best, microclimate analyses can be an appropriate approach to apply a systemic view and reveal interrelations between buildings, vegetation, water and energy as well as bring together experts from multiple disciplines (urban, planning, meteorology, physics, statistics). Expertise from different fields is needed to holistically approach the improvement of the local microclimate and to allow suitable and feasible additional climate adaption measures to be recommended, added, and finally realized.

While this process led to several positive developments and best practice examples, the impact of a project on the microclimate of the surrounding areas or even the entire city is still neglected. Climate analyses are useful to assess the effects of building structure and greening measures on the microclimate. In the context of climate change and the resulting consequences for cities, it becomes more and more relevant to learn more about the effects of building projects on the urban climate. Conducting microclimate analyses can help to plan building projects in such a way that the climate resilience of new buildings is as high as possible. Particularly for large construction projects that not only affect the microclimate on-site but also the neighbouring urban areas and perhaps even wind circulation patterns for the entire city, mandatory microclimate analysis would be conceivable to identify the need for optimisation regarding building orientation, height and greenery to maintain a microclimate at bearable level. Depending on the size, location, extension, and execution of the project, it can negatively or positively affect its surroundings. Even positively assessed microclimate simulations on-site can have a negative effect on the urban climate of the surroundings, especially if formerly green areas are sealed, existing buildings are extended in height, cold-air production areas are sealed, or cold-air corridors are blocked. In this case, it is recommended to investigate and quantify the potential impact of construction projects on its surroundings. Further research is needed for identifying a suitable set of criteria that allows cities to decide whether an extended microclimate analysis is required.

Beside a sound knowledge base on the positive effects of green measures on the microclimate, a greenery-friendly planning framework is essential for promoting greenery in building projects. Real estate development is a highly regulated market based on local planning standards and procedures. From a business perspective it involves high initial investments with the potential of reasonable monetary returns. As nature-based solutions in their different forms are not per se cost-neutral, they need to be enhanced and demanded by authorities and regulations to come into effect on a large scale.

When it comes to nature-based solutions in real estate development, not only the initial construction, but also maintenance responsibility, costs and control measures need to be considered. While real estate developers may be held responsible for the proper implementation of greening measures, vegetation can only unfold its full positive microclimatic effects if properly cared for and maintained. Specifications on care and maintenance in the construction instructions ("Baubuch") or even a subsequent assessment of state and growth of plants could help to improve the long-term quality and actual effectiveness of greening measures.

Basically, taking into account the whole life-cycle of a building and the operating costs for heating and cooling as well as the increase in value, would be a significant motivation for real estate developers to implement more green. Our studies showed (see Chapter 3) that wall-mounted green façades lead to the biggest reduction on the wall surface temperature outside as well as inside. This is particularly true for glass façades. Experiments proved that double-glazed facades combined with modular vertical greening significantly reduce indoor temperature and energy consumption in summer (Bao et al. 2022).

Besides life-cycle and maintenance, also vegetation types are a relevant issue for climate resilient greening. With respect to predicted changes in temperature and water availability, plants with high cooling performance nowadays may not survive future climate conditions without extensive maintenance and irrigation. Nevertheless, with regards to current strategies of biodiversity enhancement, it is also important not to limit greening to a small number of "high-performance plants". In contrast, replacement planting in case of cutting down trees or even deforestation for construction purpose needs strict and quantitative regulations. Large, long grown and climatically effective trees are often required to be compensated. However, small and young replacement trees need decades to reach the performance of the cut down tree. This vegetation performance gap is often neglected in current regulatory frameworks by only requiring a 1:1 replacement. To close this gap, an equivalent number of young trees with the same estimated performance could be enforced as replacement planting. This would not only account for the preservation of the current status, but also for an improvement in the future.

A greenery-friendly planning framework needs to be established to push nature-based solutions on the one side and still provide a flexible framework for real estate developers and architects to develop efficient and effective solutions embedded into the architectural design. Although strict specifications such as mandatory 20% façade greening are needed for monitoring and for implementation to take place, flexibility in the specific design or even additional microclimatic analysis help to find the most effective individual solution. As climate change is proceeding and hence the Urban Heat Island effect in cities, the cooling effect of greenery can be seen as necessary social measure for maintaining the quality of life. That is why greening is also being discussed to be included in urban development contracts. However, the legal basis asks for justifying the requirements in the contract by urban development reasons. Urban planning contracts have so far not been used as a control instrument for promoting greening. If uniform criteria existed that clearly give reasons for greening requirements under specific project conditions, this could change in the future and allow for an implementation in urban development contracts.

Furthermore, an integrated mindset in architecture and real estate development is needed. It is still not self-evident to include greenery and nature-based solutions in design, planning and construction, although there exists the L1131 standard for green roofs since more than 10 years and the ÖNORM L1136 for green walls since 2021. With regard to a transformation towards climate resilient urban patterns, building optimization has to include greening as well. Thus, it needs a new approach to perceive greenery as natural part of architecture. This requires more awareness and knowledge about climate change and the benefits of nature-based solutions on quality of life and value of real estates in the long run and under consideration of a changing climate. Applying microclimate simulations in an early planning stage helps investors, real estate developers and architects to quantify the effects of greenery on the surface temperature outdoor and indoor, as well as on the thermal comfort and air temperature. These aspects are becoming more and more important in the light of climate change and relevant regulations by the European Union such as its EU taxonomy, where climate adaptation is one out of 6 environmental objectives, which have to be met for green, sustainable investments. Consequently, nature-based solutions as effective measures for balancing the Urban Heat Island effect and the increase of heavy precipitation will find their way into architecture and real estate development.

6 CONCLUSION

The project GreenDeal4Real addressed the research question how greenery can be promoted in real estate development for realising climate resilient urban structures. An interdisciplinary team analysed the planning framework in Vienna and described the impacts of greening measures on the microclimate.

Findings from the research project show that although strategies, standards, guidelines and regulations are already in place to promote greenery in real estate development, there is still room for improvement regarding awareness and knowledge about the added value of green, the microclimatic effects, the benefits for outdoor and indoor temperature and for preserving the long-term quality of the property. The interdisciplinary cooperation between researchers, real estate developers, landscape planners, green planners and city authorities led to joint learning and a common understanding of microclimatic effects of greening.

Furthermore, it was key that the research project contributed to planning at an early stage, so that adaptations in design, static and materials were still possible.

The research project made it possible to look more closely at microclimate simulations, carry out sensitivity analyses and thus created trust in the quality and reliability of the modelling results. At the same time, the effect of different greening measures for the outdoor and indoor space could be examined and proven based on the microclimate simulations. This allowed to identify the most effective greening measures considering multiple parameters such as building orientation, sun exposure, material, architectural design, type of greening system, leaf area index and fire protection regulations. The cooling effects calculated by the microclimate simulations and the proven effectiveness of green convinced the property developer to plan further measures in addition to the subsidised façade greening. Thus, research projects like GreenDeal4Real can give important impulses for changing the mindset in the building industry and prepare real estate developers to comply with new regulations like the EU taxonomy.

The planning framework appeared to be another important driver for promoting greenery. The parallel planning laboratory allowed for an intensive exchange with stakeholders from the city administration. This also turned out to be very fruitful, as it made it possible to identify opportunities and hurdles in the planning framework. For example, severe constraints imposed by the fire safety regulation were uncovered and discussed constructively. This provided the impetus for further fire experiments to be conducted and the restrictions in the regulation to be withdrawn. The project helped to find a compromise between safety and climate-resilient planning and the new fire protection requirements will foster greening also in mixed industrial-residential areas.

In sum, the project underlines the relevance of interdisciplinary work. The exchange of knowledge between research, real estate developer and city administration is key for urban transformation directing to optimized climate protection and adaptation. Understanding both, the respective point of views and hurdles of each stakeholder is the starting point for essentials dialogues leading to the inevitable transformation.

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