Fostering the implementation of green solutions through a Living Lab approach – experiences from the LiLa4Green project

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Fostering the implementation of green solutions through a Living Lab approach – experiences from the LiLa4Green project

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Abstract. For dealing with participatory aspects in urban planning, the method of Living Labs (LL) currently turns out to be a most popular and promising approach. In our project LiLa4Green we apply such a Living Lab in the City of Vienna for implementing green solutions in densely built settlement areas characterised by heterogenous ownership and building structures, few public open space and green areas and the dominance of car traffic. In the first year, the potential analysis of the status-quo situation was completed, and the Living Lab had been established. First lessons from the now successfully running LL process can be drawn. The analysis and the initiated process revealed deficits, but also clear potentials for the implementation of green measures which could significantly improve the current situation. So far, the Living Lab process made clear that the people are generally affected and therefore interested in the topic of heat stress and greening the city, but it does not seem to have top priority for them. Although many people could be addressed and involved in discussions, only a small group of people were willing to take part in the first workshop. Confronted with such challenges the strategy for the next stage was to bring the LL process closer to the people's everyday life context and to extend the participatory methods. Innovative ICT-solutions which help to intuitively visualize and understand green solutions and their effects were tested, as well as a co-decision process for the realization of a first intervention was offered. The higher participation rate in the second green lab indicates that this is a promising approach which will be continued in the further LL process.

1. Introduction

In order to sustain the livability of a historically grown city such as Vienna, adaptation measures to climate change must already be considered and implemented today to proactively counteract negative developments in the future. Climate models predict a clear upward trend of heat waves and tropical nights [1] which will affect an increasing number of people in future decades, not only in Vienna, but worldwide as urbanization as well as climate change is expected to continue through the 21st century [2] [3].

Consequently, many cities start to strategically plan and adapt the urban environment to the changing framework conditions. The building structure (height, orientation, density, facades/roof color, texture, etc.) plays an essential role for the urban microclimate. Equally decisive are type, shape and extent of the greening as well as a corresponding rainwater management [4] [5] [6].

The Urban Heat Island (UHI) effects in cities are intensified by solar radiation which is absorbed by buildings during the day and emitted during the night in form of sensible heat as well as by anthropogenic heat emissions, which are among others produced by traffic, households and industry and increasingly through air conditioning systems [7]. Due to this, the air temperature in the city and in the countryside can differ by 1 to 3 degrees in annual average during the day and up to 12 degrees during the night [8]. Buildings and green influence each other via light reflection, shadow, radiation, etc. A comprehensive implementation of green-blue infrastructure measures represents a possibility to significantly reduce the extent of UHI [9] [10]. Although strategies for counteracting the UHI in the city of Vienna already exist (e.g. UHI STRAT [9]), the realization of green-blue infrastructure measures is challenging as it addresses various urban issues (green&open space, traffic&pipeline infrastructure, water&sewage infrastructure, etc.) and stakeholders.

The Smart Cities demonstration project "LiLa4Green"[1] presented in this paper aims to support the realization of green-blue infrastructure projects (urban green and urban water areas) in densely built areas of the City of Vienna. It is carried out by an interdisciplinary project consortium consisting of the Austrian Institute of Technology, Technical University of Vienna, Weatherpark, PlanSinn, the green innovation laboratory GRÜNSTATTGRAU and GREX IT. In order to realize measures that not only consider climate-resilient aspects, but also social aspects such as quality of life, health, safety and usability, a Living Lab is set up that involves citizens, stakeholders and decision makers in the implementation process (co-creation). The Living Lab aims to raise the awareness for the positive effects of green-blue infrastructure measures as well as strives for increasing the acceptance and willingness to implement and invest. LiLa4Green started in March 2018 and has now run for one year. First findings on the potentials for greening densely built urban areas and the added value of applying a Living Lab approach are presented in the following.

2. Need for greening the City of Vienna?

Vienna is, like many other European cities, particularly affected by the impacts of climate change. Analysis of climate data clearly demonstrates the already pressing need for action as regional impacts of the global climate change for the city of Vienna are already apparent. Increasing temperature during the summer months is the most significant impact in terms of visibility in meteorological data and negative consequences for the inhabitants.

2.1. Heat waves and tropical nights in Vienna on the rise

For the climate analysis conducted within LiLa4Green hourly data of air temperature for the time period from 1984 to 2017 were purchased from the national weather service ZAMG (Zentralanstalt für Meteorologie und Geodynamik) for the climate station "Wien Innere Stadt" and "Wien Hohe Warte". The climatic analysis focused on two parameters that clearly show how quickly the character of summers in Vienna has changed during the last 30 years: the frequency of so called “Kysely-days” (i.e. heat wave days) and of hot nights with minimum temperatures above 20°C (“tropical nights”). A day is defined as a heat wave day, if there are three or more consecutive days with 30°C maximum temperature or more. The mean number of heat wave days per year in the city center of Vienna was 8.4 in 1984 and increased to 18.9 in 2017. The temperature data show a clear upward trend over the whole period, with maximum values reaching more than 30 days per year in the second half of the period (after the year 2000). The number of hot nights also rose significantly over the last 30 years. In 2018 there were 41 “tropical

[1] LiLa4Green is funded by the Climate and Energy Fund and implemented under the "SMART CITIES - FIT for SET" program.

nights", which is the highest number ever recorded in the city center. The mean value over the whole period was 13,8 tropical nights per year.

Especially the longer lasting heat waves and tropical nights pose an additional stress to the body and lessen the quality of life. Respiratory and cardiovascular diseases, impacts on mental health and, as a consequence, reduced work performance and productivity are just some of the proven implications of heat waves [11]. Particularly affected are elderly and sick people as well as children.

The temporal development of these and other parameters clearly show that the intensity and duration of hot periods during the summer months are rising dramatically. As a consequence, the city and its inhabitants have to adapt to new characteristics of summer, including extreme events becoming more frequent. Facing such changes, greening and proper rainwater management can have an essentially positive influence on the microclimate in densely built city structures. Green within the city not only creates a valuable recreational space while reducing CO_2, it also reduces the noise and pollutant exposure, decreases the radiation temperature through shadowing and cools down the adjacent air due to the evaporation of plants. Thus, vegetation should not only be limited to parks and dedicated green areas but integrated into the entire urban fabric for realizing its full micro climatically positive potential.

2.2. Microclimatic situation in the test area "Quellenstraße Ost"

The LiLa4Green test area "Quellenstraße Ost" illustrates the dilemma that is fairly common in densely built urban areas: the amount of green, unsealed areas is quite high with 33 %. However, the densest area - the Wilhelminian style block development area "Kreta" existing of 6 blocks crossed by 3 streets - shows no greening at all and is characterized by sealed surface and stationary traffic. Predominantly in such areas, green infrastructure measures are of utmost importance for the city´s climate and social cohesion.

The microclimatic analyses reflect the dense urban structure. During hot summer days the air temperature and the human comfort measure "PET" (Physiological Equivalent Temperature) rise in the mainly north-south and east-west orientated street canyons. While the distribution of the air temperature is quite even, the PET values vary strongly. Around noon the maximum values in the north-south-street canyons rise up to 50 degrees, which means that people experience strong heat stress in these areas. Minimum values are around 26 degrees, which is felt as slightly warm by humans. Areas with these moderate values are shady spots along north- or east-facades or under trees. The high values can be explained by a lack of vegetation and shade and the corresponding high radiation input, both short wave radiation from the sun and long wave radiation (i.e. sensible heat) from the blacktop and the building facades. During heat waves air temperature stays high also in the night.

Putting this characterization in context with the climate of the whole city, the test area "Quellenstraße Ost" can be described as a residential area with high bioclimatic stress. The area is vulnerable with respect to densification. Common recommendations for such areas are ameliorating the fresh air supply, increasing the green infrastructure and unsealing the ground.

3. Greening Potentials

In addition to the (micro-)climatic analysis, the potentials for implementing green-blue infrastructure measures within the test area have been analyzed. The aim was to highlight links to existing green networks and to general strategies of Vienna and to point out areas of especially high need for action. The analysis included the open space structure in regard to its private, semi-public and public character and especially the characterization of the streetscape concerning e.g. existing greening, division and public usability, parking situation and the quality of stay.

With respect to urban climate and social aspects the Wilhelminian style block development area "Kreta" has been identified as the area with the highest need for taking measures. Apart from that this area is surrounded by current urban development that will change the context and role of this city area in the near future. With the opening of two new bridges and a new connection to public transport in the north it will form an important link between the future development site and the currently temporary used area of the Kempelenpark and to the recreational area of Laaer Berg in the south-east. The potential

map (see **Figure 1**) illustrates the important superordinate (green arrows) and internal district connections (orange arrows), adequate streetscape sections for restructuring (violet areas) and the location for especially important areas for quality of stay e.g. in front of educational buildings (dark violet hatch).

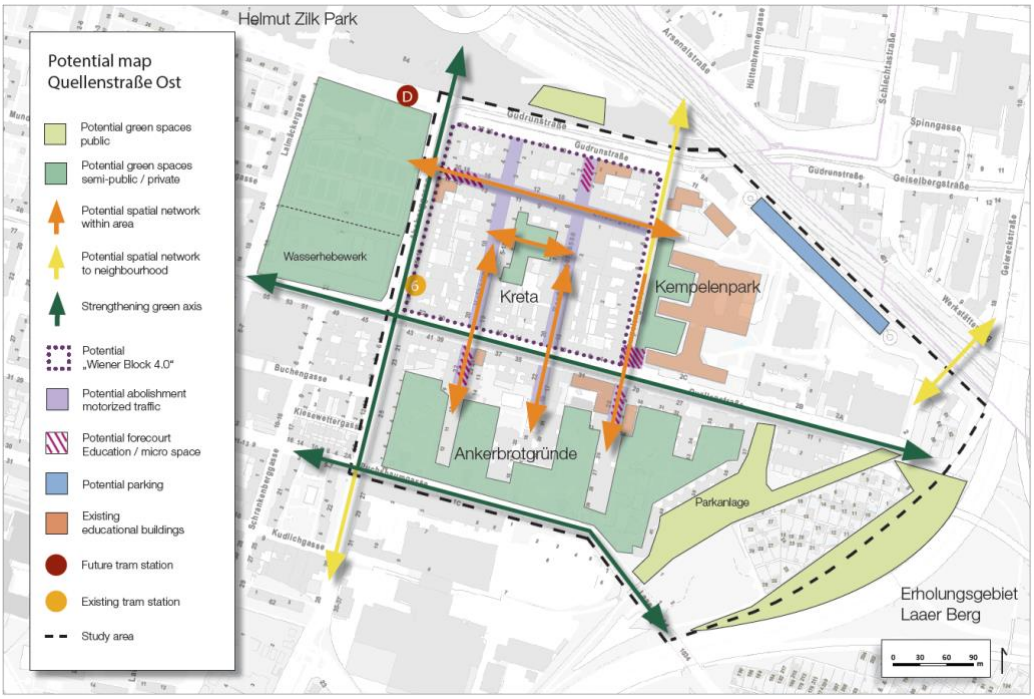

Figure 1. Potentials for improving the green space in the test area Quellenstraße Ost in the 10th district of Vienna.

4. The Living Lab in LiLa4Green

Parallel to the scientific analysis of the potentials, a participatory process in form of a Living Lab has been started. There is no unique definition of Living Labs (LLs), but commonly cited characteristics of Living Labs are openness, realism, empowerment, spontaneity, sustainability and value [12] [13] [14] [15]. One of the key criteria of urban LLs is the geographical embeddedness [16]. Urban LLs represent ecosystems of open 'urban' or 'civic' innovation and are situated in a real urban context where the process in focus is taking place. In our Living Lab for more urban green ("LiLa" for Green) we discussed its meaning in the specific project context and formulated the following definition: Our LL aims to find solutions to urban issues such as the effects of climate change, resilience and sustainability and focusses on citizens and stakeholders as core elements of an urban LL from a holistic view (ecological, economic, social, technical, spatial).

During this LL process it is examined how a smart user participation can be organized and designed in order to raise awareness within the public regarding mitigation and adaption measures to climate change. By combining innovative methods of social science with the latest digital technology an ideal dissemination of information with regard to the diverse functionalities of green and free spaces is to be facilitated. Therefore, also new methods of assessment (e.g. crowdsourcing) and visualization (Augmented Reality) will be tested. These new forms of smart user participation and the visual depiction of measures and their effects aim to ensure a broad acceptance within the public for green-blue infrastructure. The Living Lab in Lila4Green is constituted by a range of different activities that open the research project to stakeholders and citizens.

The LiLa4Green-LL started with a design process including a screening of suitable participatory methods and strategies and a workshop during which the research team collectively developed a shared practical understanding of our LL, clarifying the context, goals, key questions and initial design of the LL-process. The first step of the Living Lab was taken by hosting a "Start-Workshop". Within this meeting we gathered knowledge, constraints and needs together with relevant stakeholders (representatives of municipal agencies and local institutions) and collected information on spatial and social potentials within the project area. Furthermore, it was discussed what the participating stakeholders can "give and take" to/from LiLa4Green, emphasizing the importance of mutual benefits. The participating stakeholders made their commitment to take part in the upcoming process including the "Green-Workshops" and to support the project with their knowledge.

Figure 2. On-the-street activation for participation in the Living Lab.

Figure 3. Mapping of hot spots and cool spots in the case study area Quellenstraße Ost.

The corner stones of the LL are four major events called "Green Workshop". These will take place roughly every 6 months, bringing together the research team, stakeholders and citizens. Leading up to our first "Green Workshop" in October 2018, we conducted several on-the-street "activation" activities: we visited the project district with our cargo bike, built up a temporary space for conversations using pictures, signs with questions and a deck-chair (see **Figure 2**) and approached people walking by. To initiate conversations we used small, game-like activities like a "bean-poll" about people's perception of heat waves or a mapping of hot and cool spots in the area (see **Figure 3**). These conversations aimed at mobilizing people for the "Green Workshop" and to gain a better understanding of the area and its inhabitants.

The first "Green Workshop" (see **Figure 4**) was designed to kick off the LL-process and focused on sharing information, building mutual understanding and establishing social connections. At the beginning of the event all participants were asked to answer a brief survey about their perception of urban heat and potential solutions. At the end of the project, this survey will be repeated in order to detect changes in their perception. We then conducted a few simple exercises to allow people to get to know each other briefly. The first half of the workshop was set up as a "Knowledge Bazar", with the research team offering information to stakeholders and citizens about the topic of urban heat effects and sharing first insights from the so far conducted research. Posters, a memory set and a flyer have been prepared as playful and easily understandable starting point for the discussions. In the second half of the workshop we conducted a "World Café" and swapped tasks: now the stakeholders and

Figure 4. Participants of the first "Green Workshop" in October 2018.

citizens offered their local knowledge and ideas about the spatial and social environment of the project as well as ideas for potential solutions.

In May 2019, the second "Green Workshop" took place. As the first workshop revealed the desire of the citizens for action, the research team decided for a first intervention on-site by designing and implementing a green parklet in the streets. In the design studio project "Green up - Cool down" at the Landscape Department of the Technical University of Vienna students developed seven different design concepts for parklets which were presented at the second green workshop (see **Figure 5)**. After the presentations and a timeslot for discussions, all workshop participants formed a jury and voted for their preferred parklet design by awarding points to their favourite concept. In this way a co-decision process was established defining which design will effectively be implemented by the students in summer 2019. Further, local initiatives such as the Materialnomaden (re-use of building material), the local carpentry, kindergardens and the Stadtraum Kempelenpark are involved in consultation, maintenance and supporting the acceptance of and identification with the parklet.

Figure 5. Different design concepts for parklets presented in the jury process of the second "Green Workshop".

In the second part of the workshop, a first application of a smart interaction tool was set up and tested with the workshop participants (see **Figure 6**). The chosen tool was a lightweight Augmented Reality (AR) tool that visualizes a greening project as it will look like after its realization. Users can view the AR model of the greening project superimposed on the real physical location on their smartphone. To lower the barrier to use, no installation and registration is required. Users can express their opinions about the project, and the tool stores user opinions and interactions in an existing civic participation tool (www.smarticipate.eu). In the sense of co-creation, the users where asked for feedback on applicability, user-friendliness and added value of the tool. Generally, the tool was well received and attracted a lot of interest. A quick survey revealed that it helps people to imaging how greening measures could look like. For some of the participants, the handling of the tool was still too complicated, which was a valuable input and will be incorporated in the further development of the tool.

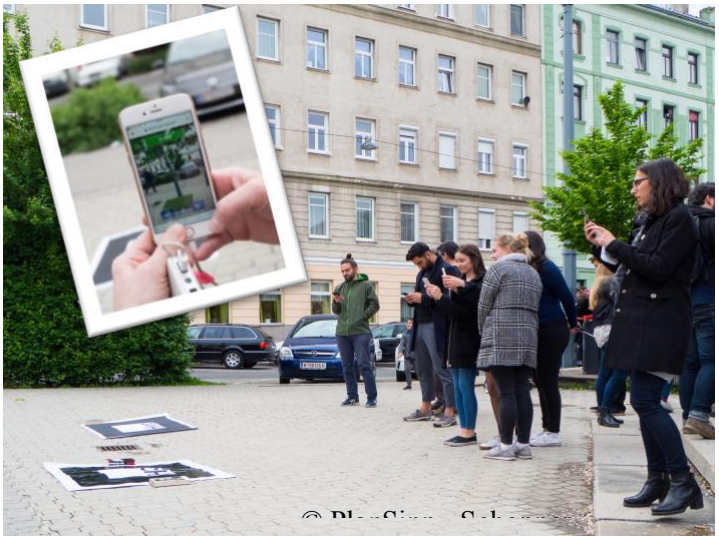

Figure 6. Participants of the second "Green Workshop" testing the AR application in the street.

5. Discussion and lessons learned

Four major insights from the LL process in LiLa4Green could be gathered so far:

1) **Continuity, co-decision-making and setting concrete actions** is essential for successful participation. During the mobilization process in the streets many people could be encountered who were interested in the subject. Yet it was hard to gain their commitment for joining the "Green Workshop". While they verbally supported the idea of greening their neighborhood, their interest did not translate into willingness/ability to participate in the "Green Workshop". Participants of the first "Green Workshop" were mainly acquired through tapping into local networks. The willingness to participate appeared to be much higher in the second "Green Workshop". One reason was that the LL process was already well established and continuously promoted through various channels. A second reason was the real opportunity given to the citizens to decide and co-create, which attracted additional participants. The participants in the LL had the chance to discuss the design solutions and be part of the decision which design will be implemented on-site. Through close collaboration with the residents the willingness to adopt – that means care for – the built design object in front of their building could be enhanced and enabled an emotional binding to "their" green island. The green parklet will work as a pilot project for later implementation activities of LiLa4Green and will help to foster the awareness and acceptance for such green-blue infrastructure measures in the close neighbourhood.
2) Participation needs a **professional accompanying process**. As a key component of LLs is experimentation and co-creation, the process has to be kept flexible. Nevertheless or exactly for that reason, such a process needs a guiding structure and profession management. In LiLa4Green, one partner is exclusively responsible for the LL process, which requires knowledge and resources. The first "Green Workshop" aimed at establishing a core group for the LL-process, including locals, decision makers, regional agents and scientists for gaining a better understanding on the context of microclimate, green and urban spatial planning. A shared idea of this Living Lab was developed. Between the workshops info-mails kept the participants updated and networking activities took place. The results and aims verbalized by the citizens in the first workshop were taken up and built the base for the second workshop. This approach appeared to be successful as the members of the core group also participated in the second "Green Workshop". This highlights the importance of aligning the "what, why and how" of participatory research activities carefully. Besides, a professional process management guarantees, that the results of these activities will be transferred into the documentation of the LL as a complementing source of learning. In that way lessons learned in the LL process is gathered and will not be lost.
3) It is crucial to create a **low-threshold level** for participating in a Living Lab process. The second green workshop proved that the participation process benefited from further on-the-street-activities, as well as from the mobilizing effect of local participants and stakeholders. Furthermore, the offering of co-creation (ICT-solution testing) and co-deciding (jury for the parklet) integrated into the workshop set-up built a pull-factor for the participants. As a result, 55 people showed up for the second "Green Workshop". The design offered a combination of low threshold activities and options to more deeply discuss and create solutions together.
4) For mobilizing and obtaining the local knowledge of the heterogeneous population in the test area **different approaches and sources** are needed. So far, the LL process made clear that it is rather difficult to reach all those residents that normally do not participate in a planning process. It requires perseverance, networking and visible activities for attracting attention. Thus, raising awareness for green-blue infrastructure projects and increasing stakeholder acceptance demands a wide range of communication and interaction measures. In Living Labs, face-to-face communication, supported by information material, is the dominant channel for information exchange and interaction. The low threshold activities on the street are a valuable methodology for gaining insights into people's perceptions and collecting local knowledge. However, this form of event requires potential stakeholders to actually come to a specific location at a specific time. The project team discussed and evaluated alternative ideas for intelligent information and interaction and decided to embed the

information dissemination and interactions in the physical space of concern in order to be closer to the everyday´s life and daily routes of people. As it is very time-consuming to be on site and directly address people, the project team decided for additionally applying a "smart" way of user participation and integrated a smart interaction tool by using Augmented Reality, which was well received by the participants of the second workshop.

6. Conclusions

Two well known facts could be verified for the City of Vienna by analyzing meteorological measurements and applying microclimatic simulations: first the frequency of urban heat waves and tropical nights are dramatically rising, and second densely populated areas are particularly affected by climate change. However, it could also be demonstrated that even in most densely built urban structures potentials for new green infrastructures can be found. Particularly the streetscapes as well as facades and rooftops offer a variety of possibilities for greening measures. However, for realizing those potentials, existing legal, technical and administrative barriers have to be overcome. Though the streetscapes are mainly public in character, they are currently dominated by the moving and stationary traffic. Moreover, a range of built-in installations under the sidewalks as well as, particularly in existing building structures, heterogeneous property relations often hinder the implementation of greening measures. In this regard, be it buildings or streetscapes as potential settings for measures, it is essential to bring decision makers and citizens on board. Without the integration of users within the process, the realization of urban green networks in built-in structures is not expedient and might not prove long lasting.

Therefore, the first step on the way to a greener city that is less affected by heat is to raise awareness of the manifold functionalities of green infrastructure in the city especially with regard to the streetscape. Secondly, solutions have to be developed, implemented and monitored together with local stakeholders that fit the specific framework conditions.

To this effect, a Living Lab proved to be a very appropriate approach to support the overall process and to combine classical participation methods as well as new, smart ICT-tools in an experimentally way. The process thereby facilitated the inclusion of a broad range of users (residents, users of buildings, architects and planners, housing subsidies, neighbours/social environment and politics and administration, etc.) with new and smart methods of participation to enhance the possibilities for the realization of green city infrastructures also in existing urban structures. So far, the experiences made during the Living Lab proved that it does not only serve as exhibition space for various measures to adapt to climate change, but also poses a networking opportunity. For the project LiLa4Green the Living Lab includes competence networking, dissemination and citizen cooperation in the form of integration of future users into new and old technologies and projects. Interaction with public stakeholders and involving local residents in open innovation processes (co-creation) leads to shortened iteration processes of technology developments and applications with a high level of acceptance. The Living Lab helps to bring information face2face to people and to gain acceptance for technologies and solutions.

The ongoing LL process already showed positive effects regarding the visibility of the issue (UHI, greening the city) within the area and the networking between single activities and actors. The biggest challenge appeared to be to reach those citizens who are not yet interested in the topic and to motivate them to participate in an organized workshop. It got clear, that it is crucial to meet the people on the level of their needs and in their everyday life context – "in the street". It is a long-term process, continuity is needed, various efforts for mobilization have to be made, new ICT-tools are helpful for reaching additional population groups directly on the street and action in form of physical interventions designed in a co-creative way are essential. All these crucial components have been considered and applied in LiLa4Green. So far, the Living Lab established proved to be successful and will be continued in the next two years.

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