

 reviewed paper

## Urban Heat Islands – Strategy Plan Vienna

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### 1 BACKGROUND

“Heat all over Austria” – “Dog days of summer in Vienna” – “Survival tips for the heat wave” – “This week is getting hot” – “Cooling in the city”. These have been the headlines in the Austrian but also European media in the past few years accompanying the summer in Vienna (Alex et al., 2011). Many studies already refer to the increase of heat days (daily maximum temperatures of at least 30° C) and heat periods in cities with dense building and few green spaces (Formayer et al., 2008). Kysely et al. (2000) define heat periods as a minimum of three consecutive days with a maximum temperature of at least 30° C. The period is considered to be continuous if the maximum temperature of each succeeding day is not less than 25° C, and the average maximum temperature during the entire period does not fall below 30° C (Kysely et al., 2000). The increasing of the daily maximum temperatures also leads to an increase of very warm nights (tropical nights).<sup>1</sup> This is important, because the minimum night temperature has more impact on the wellbeing of the people as well as the increase in mortality than the daily maximum temperature (StartClim, 2006). As shown in figure 1, in August 2001 the evening temperatures of Vienna were already around 20° C or even higher, especially near and in the city centre.

A comparison of the number of hot days in the period 1961-2010 showed an increase for Vienna by an average of 9.6 to 15.2 days. Also for the number of summer days (25° C or more) in Vienna climate models calculated a 30 to 50 percent increase of summer days for the period 2071 to 2100 (ZAMG, 2012) which can result in a rise of the Urban Heat Island phenomenon.

Vienna is a dynamic and growing city. Forecasts expect an increase in population to over 2 million by 2030. Urban expansion and re-use of large brownfield sites will be particularly relevant in this respect (MA 18, 2012). Densification of the urban structures without additional measures, however, increases the UHI effect.

Urban Heat Islands concern both urban residents and tourists. Persons who have to spend much time in open space as well as health-impaired and elderly people are, however, particularly affected by the impacts. This becomes manifest, for example, in a reduction of activity due to heat (Dune et al., 2013). According to a study by Robine et al., the 2003 heat wave caused around 70,000 deaths across Europe (Robine et al., 2008).

In relation to these developments and trends, the city of Vienna has early and strategic decided to elaborate options for mitigating or preventing these effects and to take part in an international research project.

<sup>1</sup> Nights with a minimum air temperature higher than 20°C are regarded as tropical nights (ZAMG, 2011).

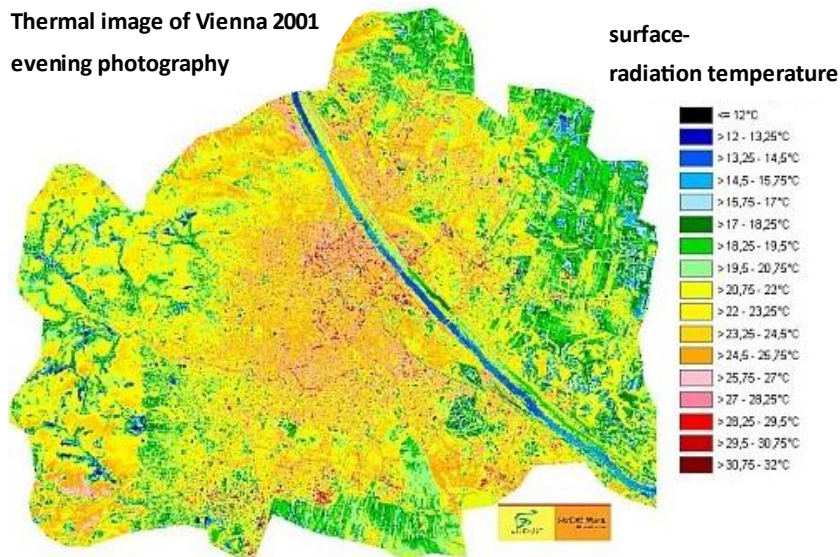


Fig. 1: Thermal image of Vienna, August 15th 2001, 20 – 22 h (City of Vienna)

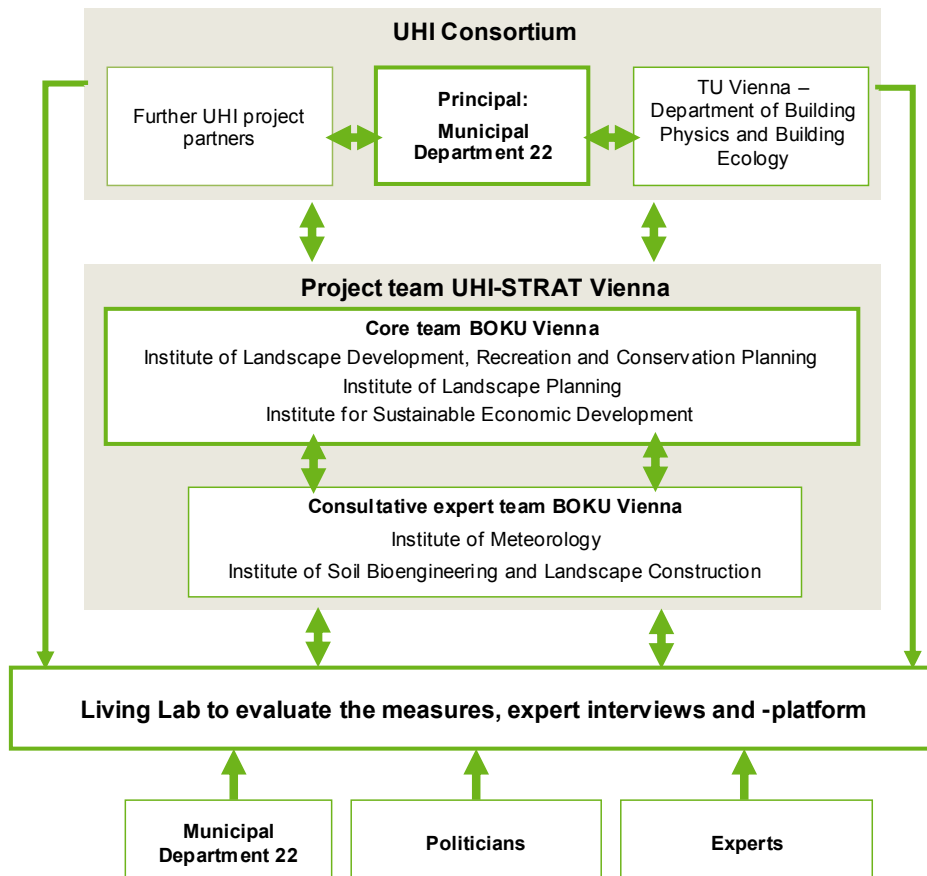


Fig. 2: Organisation of collaboration and networking

## 2 AIMS OF THE PROJECT

The project “Urban Heat Islands – Strategy Plan Vienna” is part of the international CE (Central Europe) project “Urban Heat Islands – Development and application of mitigation and adaptation strategies and measures for counteracting the global Urban Heat Islands phenomenon” (duration 2011-2014). Within the framework of the international project eight metropolises are examined. Along with Bologna/Modena, Venezia/Padova, Stuttgart, Lodz/Warsaw, Prague, Budapest and Ljubljana, Vienna is one of the study areas.

The aim of the project “Urban Heat Islands – Strategy Plan Vienna” is the identification of measures and adaptations to reduce the negative aspects of urban warming. The intention is to develop a strategic plan for the City of Vienna to implement urban and open space planning measures as well as urban ecology measures

that reduce the negative aspects of urban warming. Based on planning tools and instruments of the different control levels of urban planning and development, possibilities of action for the City of Vienna and in addition, opportunities to raise awareness and promote acceptance of measures that reduce urban heat effects will be identified.

The scientific approach is based on inter- and transdisciplinary cooperation. Figure 2 gives an overview of the collaboration and networking in the project. On the one hand, the core team of the UHI-STRAT project is integrated in the overall CE-UHI project, and on the other hand, the UHI-STRAT team cooperates closely with the relevant departments of the City of Vienna and scientific experts. The findings obtained during the project work are reviewed in expert workshops for their relevance and applicability in the everyday management of the City of Vienna.

### 3 WORKFLOW AND METHODS

In methodological terms, the project includes a mixture of planning, urban ecological, socio-scientific and economic methods. The applied research project is carried out in close cooperation with the responsible municipal departments of the City of Vienna and consists of six main work packages (WP). Figure 3 provides an overview of the UHI-STRAT workflow. First results of WP 2 (Identification and evaluation of relevant measures) and WP 3 (Verification of the control levels and their tools & drafting of proposals for urban planning tools) are described in this paper. The additional work packages have not processed yet.

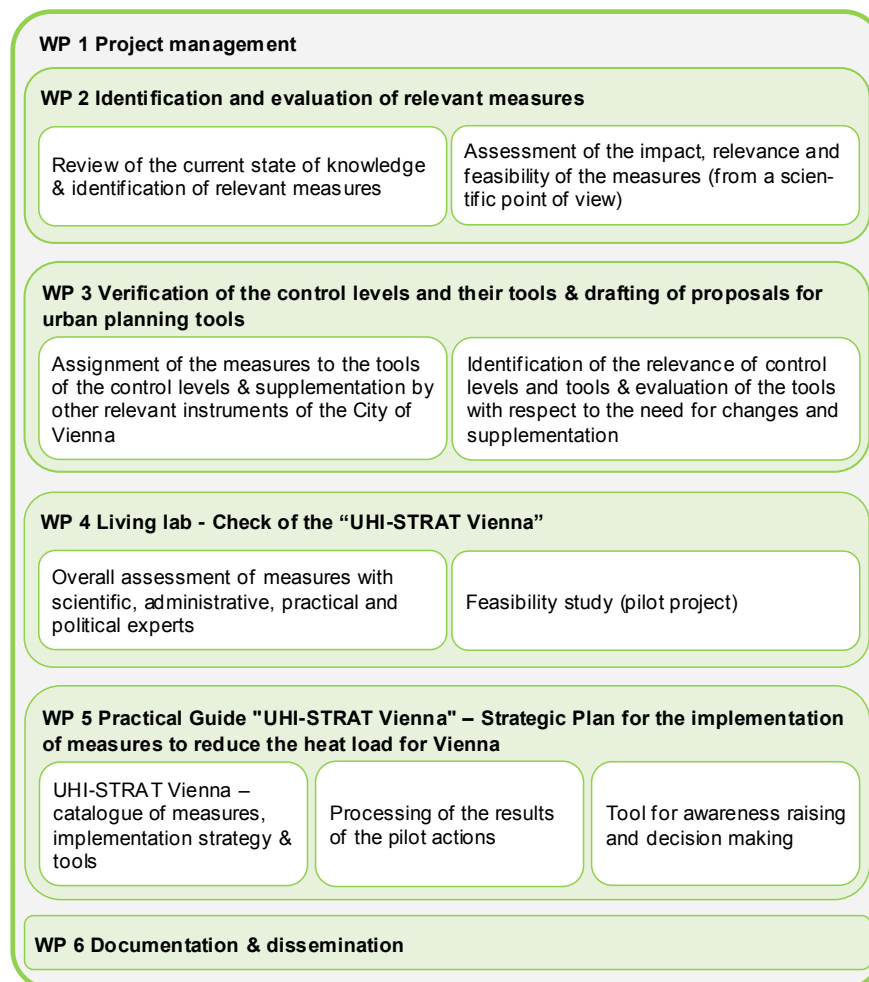


Fig. 3: Workflow “UHI-STRAT Vienna”

### 4 IDENTIFICATION OF RELEVANT MEASURES

The elaborated measures are of different temporal relevance. In the short term, preventive measures such as heat warning systems can be established or the individual behaviour of people can be changed by providing information. Other approaches such as the increased consideration of UHI effects in urban planning or an

adaptation of the building technology have a long preliminary lead time, i.e. in many cases they cannot be implemented that fast, but are characterized by a long-term impact.

In the project, measures are defined which refer to information and public relations or which can be implemented either by planning tools (e.g. overall concepts of urban planning, zoning and development planning) or by technical or structural means.

**Technical measures to reduce UHI effects**

Based on the previous knowledge and preliminary studies of the project consortium UHI (including the measures identified by the Environmental Protection Department Vienna, Municipal Department 22) and the project team UHI-STRAT Vienna, measures for the City of Vienna were identified, using a simplified SWOT (Strengths, Weaknesses, Opportunities and Threats) analysis (e.g. Terrados et al., 2005). These have been supplemented by relevant measures that have been investigated in a comprehensive literature search of scientific papers. The catalogue of measures thus compiled serves as a basis for further work steps.



Fig. 4: Possible measures to reduce UHI effects (Allex, Damyanovic, Reinwald)

A total of about 370 possible measures have been identified so far by the UHI-STRAT Vienna team. Some examples are shown in figure 4. The measures can be roughly classified into technical and non-technical measures and categorized by subject area. The identified technical measures, for example, were summarized into the following categories (figure 5). The summarization of the non-technical measures information and public relations as well as control levels and instruments is currently in process.

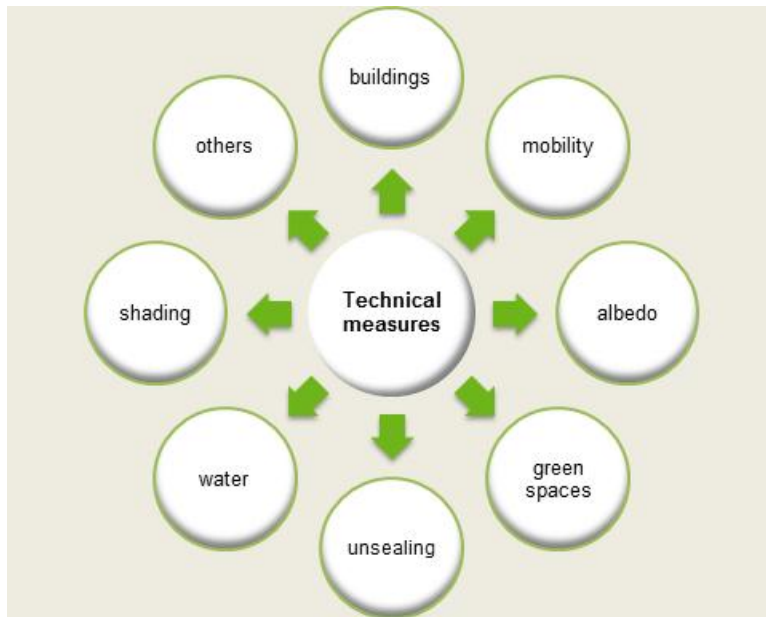


Fig. 5: Categories of technical measures

To each category, measures as well as associated explanations and instructions were assigned. Table 1 shows an example of the catalogue of measures concerning the category “buildings”.

category	UHI-STRAT – technical measures	Nr.	measures – explanations & instructions
buildings	active/passive cooling of buildings (e.g. ventilation, long-distance cooling, component activation, insulation, ...), (temporary) use of brownfield sites as green and open spaces	1	comfort ventilation (system, providing a constant supply of fresh filtered air)
		2	cross ventilation
		3	night ventilation
		4	solar cooling
		5	ventilation systems – cooling of the incoming air by low ground temperatures
		6	geothermal cooling technologies
		7	thermal component activation / concrete core cooling
		8	reduction of the percentage of glass facade
		9	thermal insulation, thermal renovation
	shading devices on buildings (e.g. blinds, sliding shutters, photovoltaic systems, ...)	10	shading devices on buildings (e.g. blinds, sliding shutters, ...)
		11	shading roofs (e.g. by photovoltaic systems)
	water cooling of buildings	12	roofs with water cooling / Blue Roofs
		13	vertical cooling surfaces on buildings

Table 1: Excerpt from UHI-STRAT catalogue of measures – technical measures

The categorized and summarized measures will be evaluated with regard to their impact, relevance and implementation according to the categories: climate (micro-/mesoclimate), urban ecology (biodiversity/quality of life), feasibility (e.g. in the control of the City Council of Vienna, private/public, new/old stock, long-term realisability > 5 years/ short-term realisability: within 5 years) and acceptance (politicians, builders, residents) during the next work steps of the project. The assessment will be based on scientific evidence and will lead to a categorized ranking, so that both quantitative and qualitative results can be incorporated in the assessment.

Subsequently, the identified relevant measures will be analysed and evaluated under consideration of their efficiency in terms of urban planning, open space planning, urban ecology and economy. This assessment is essentially based on scientific knowledge from literature research. In addition, the evaluation results will be cleared with representatives from the fields of landscape ecology as well as urban and landscape design. The impact on the physical and mental quality of life of the people will be assessed by expert interviews. Aspects of ecosystem services, such as the habitat function, will likewise flow into the urban ecological assessment. The measures will thus also be evaluated in close relation to the conservation and enhancement of biodiversity.

The variety of possible options for action of all stakeholders and actors will be further structured and analyzed by economic criteria. Through the systematic environmental-economic approach of view, an involvement of perspective of the users can be achieved. In this context, interviews will be conducted to determine the acceptance of measures and the amount of the hypothetical individual willingness to take action themselves. This allows a qualitative assessment of costs and benefits of the elaborated measures.

The review of selected relevant measures takes place in an iterative process. Depending on the topic, experts of the project team with expertise in the relevant subject areas (e.g. planning, economics, meteorology...) will be consulted for the development of criteria for each measure or category.

Furthermore, expert interviews with people outside the project team will be conducted.

## 5 ASSESSMENT OF (EXISTING) REGULATIONS, TOOLS AND INSTRUMENTS

In the first step, all relevant legally binding and non-binding levels of control and tools for implementing the various measures to reduce heat effects have been identified and analysed.

Moreover, the relevance of the control levels and the individual instruments identified before will be evaluated under the aspect of urban planning, open space planning and urban ecology based on the effectiveness and importance in the implementation of the measures. In order to ensure sustained implementation of the “UHI-STRAT Vienna”, experts from responsible Municipal Departments are involved in the process for information and expert interviews.

On the basis of this, suggestions will be made for modifications and extensions of the instruments and tools for implementation.

### **The City of Vienna’s relevant tools to reduce UHI effects**

The possibilities and instruments to implement UHI measures are manifold. They range from a legal basis to strategic programmes and approaches, different planning processes and procedures all the way to direct granting of subsidies or regulation by standards. Furthermore, they may be differentiated by the level of regulation. There are already approaches and tools on EU<sup>2</sup>, Austrian<sup>3</sup> and Viennese<sup>4</sup> level dealing with climate change – especially the increase of temperatures – or UHI phenomena directly.

Considering the importance of superior strategic approaches such as the urban development plan or the climate protection programme and the requirement of legal implementation, planning processes which lead to the development of overall concepts of urban planning or master plans, zoning and development planning, developer competitions as well as granting of subsidies have turned out to be essential points of reference and tools.

The level of urban master plans in particular has major influence on further planning and project development steps. In the City of Vienna this planning level has successfully established itself as (informal) planning tool. At this level different public and private interests can be coordinated – especially also in view of a market-driven urban development (MA 21B, 2010). In master plans and urban planning concepts the prerequisites for further planning steps are created (MA 18, 2013). The consideration of UHI matters at this level is important in order to have a basis for further implementation (especially as regards zoning planning).

The zoning and development plan is an essential tool in the City of Vienna, serving to establish a legally binding framework for development. In this planning document all future uses and the type of development of urban areas are bindingly codified. Analyses of this tool show that already with the possibilities in existence urban heat effects can be reduced. Also the realisation of zoning so far shows that climate relevant aspects have already been partly considered or used as justification for planning decisions. Apart from orientation, height and dimension of buildings, legal provisions regarding e.g. tree planting, the degree of soil sealing and development as well as green roofs can be implemented mandatorily.

Another essential level at which the City of Vienna can exert influence on the quality of development structure represents the so-called developer competitions. These have been carried out in Vienna already since 1995. From 200-300 accommodation units onwards, public invitations to tender are issued in subsidised housing for reasons of quality control (Liske, 2008). Apart from architectural and planning qualities also economic and ecological aspects have to be considered. Moreover, these competitions are partly carried out with reference to specific thematic focuses – social topics such as multi-generational or integrative housing as well as constructive topics such as passive house or multi-storey timber construction. In the case of publicly funded projects, the City of Vienna has major influence on the built quality.

It is also by granting subsidies that the City of Vienna has the possibility to control quality in terms of reducing UHI effects. In doing so, two major approaches are being pursued: the support of courtyard and vertical greening as well as the greening of roofs. These have among others micro-climatic impacts and facilitate the implementation of UHI-relevant measures (MA 22, 2013).

## **6 DISCUSSION OF FIRST RESULTS**

In the course of research for the UHI-STRAT catalogue of measures a variety of different measures (~ 370) has been identified. On the one hand, these concern different scales (city-wide to single objects) and disciplines (e.g. engineering biology, architecture, materials research, public relations), on the other hand, different time frames will become effective in the implementation of short-, medium- and long-term

<sup>2</sup> E.g. Directive 2001/42/EC on the assessment of the effects of certain plans and programmes on the environment, Directive 2002/91/EC on the energy performance of buildings, Thematic Strategy on the Urban Environment, 2nd European Climate Change Programme ...

<sup>3</sup> E.g. Federal Law on the presentation of an Energy Performance Certificate (BGBl. I Nr. 137/2006), Austrian federal climate strategy, klima:aktiv – the Austrian climate protection initiative ...

<sup>4</sup> E.g. Vienna residential construction and renovation act, Strategy Plan for Vienna, The City of Vienna’s climate protection programme ...

measures. Thus, in order to coordinate the various measures, detailed knowledge about their effects, impacts and corresponding action is needed.

Due to the different levels at which the measures are to be classified, a variety of actors and sectors are affected. An important issue in the realisation of the measures, therefore, is the inclusion of the different perspectives of the actors involved in the implementation, who come from the public, the semi-public and the private sectors. A huge difference in acceptance regarding the implementation of the measures is to be expected from the departments responsible for the implementation as well as from policy makers and citizens. For example, the introduction of a driving ban in the settlement area would indeed be a very effective measure for the motorised private transport, which due to the expected low acceptance, however, is not feasible. The assessment of the impact, relevance and feasibility of the measures must therefore be carried out from the perspective of all stakeholders.

For a better understanding a cost-benefit analysis is helpful, which makes it easier for stakeholders to assess the direct monetary benefits of the measures and the willingness of the population to accept or pay for additional measures.

In order to develop and implement the UHI strategy plan an environmental analysis of the Vienna City Administration has been carried out. The outcome was that a total of 4 administrative groups, 13 municipal departments, 5 superior units and institutions related to the City as well as the 23 districts were affected in their scope of operation or should take part in developing the UHI strategy plan. In addition, an analysis has been conducted of the different planning levels and tools that could be useful for the implementation of the elaborated measures. It turned out that all kinds of different legal regulations, strategic programmes and projects, spatial concepts, master plans as well as planning processes and procedures, granting of subsidies or standards have an influence on the development and implementation of measures to reduce UHI effects. Numerous planning levels and (legal) matters are affected.

The reduction of UHI effects is a “longitudinal and cross-sectional matter”. The chronological sequence of a planning process has to be taken into account and the different levels of decision making and tools have to be adjusted and implemented in a coordinated way in order to reduce UHI effects successfully.

Furthermore, planning which is partly carried out separately (regarding e.g. nature conservation, zoning, public space, streets) and the individual steps of a planning process – from the creation of a master plan to zoning and development planning as well as project development all the way to the concrete construction – lead to intersections. These have to be transformed into junctions in order to consider necessary qualities in planning and design that contribute to the reduction of UHI effects – from the first strategic planning to the concrete implementation. An intensified cooperation and coordination therefore is of major importance.

There are also partly conflicts between the different strategic aims of the City of Vienna regarding urban planning and development and the approaches to reduce UHI effects. Competing interests have to be balanced – between measures to adapt to climate change such as fresh air corridors or larger green spaces in cities, and other political and planning aims such as densities suitable for the location or city of short distances.

Yet there are synergies as well between measures to adapt to climate change and other strategic aims of the City of Vienna. Planting activities, for example, create cooling effects but also support improved rain water storage or an increase in biodiversity.

An important aspect of the discussion is the evaluation and development of effective measures such as information and involvement of the residents as well as the establishment of information and early warning systems. It is assumed that the political commitment and the acceptance by the population will support a sustainable implementation of the defined measures. Therefore the cooperation with scientific, administrative, practical and political experts is given high priority in the whole project.

The results will be processed in a practical and hands-on guidance thread. The guide will consist of the following three modules

- (1) Summary of policies and measures and the results of the evaluation
- (2) Representation and processing of the two pilot actions
- (3) Creation of a tool for awareness raising and decision making

and will address the scientific society, politicians, decision-makers, the administration as well as the general public.

The reduction of UHI effects on the inhabitants of the City of Vienna is challenging regarding the manifold driving forces causing UHI effects as well as the broad spectrum of mitigation and adaptation measures. To develop a balanced set of effective measures, which meet the needs of the City of Vienna, a multilevel and multidisciplinary approach is needed.

But before concrete measures are developed and implemented a mainstreaming of the topic is necessary. Awareness rising is required to show which effects and impacts climatic changes and increasing densification of the city have on the entire population and the quality of life of the citizens of Vienna. It is also important to show that with existing instruments and measures steps against UHI effects can be set effectively.

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