Report on potentialities of urban interventions and action plans

D3.9

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List of abbreviations

D	Deliverable
ENoLL	European Network of Living Labs
LL	Living Lab
SWOT	Strengths-weaknesses-opportunities-threats
UHI	Urban Heat Island
ULIs	Urban Level Interventions
WP	Work Package

1 Executive Summary

The effects of air pollution and the urban heat island are found significant on especially vulnerable population groups such as children and older people in urban areas. To tackle these effects, adequate interventions at the urban level are required. This report details the functionality and effectiveness of urban level interventions (ULIs) and sums up the implementation action taken in those Living Lab (LL) cities (Bottrop, Hasselt) that focus on this kind of interventions.

The report presents an interdisciplinary approach to develop action plans on a city-wide scale to tackle the problem of mitigating air pollution and reducing urban heat. It functions as a methodical manual by pointing out possibilities for drafting an action plan and interventions on the urban tissue. This includes the derivation of objectives interlinked with strategy development as well as methods for a comprehensive weighing and prioritising of alternative measures.

A collection of interventions of mitigation solutions for both air quality and urban heat islands contains effective activities within three fields of action: '**settlement development**', '**green infrastructures and green elements**', '**eco-friendly transport and mobility**'. Comprehensive portfolios of ULIs contribute to a more informed decision-making on interventions and make the urban level interventions ready for implementation. In the context of an action plan, field trials took place in those Living Labs (Bottrop and Hasselt) whose stakeholders' interests focused on urban level interventions. By doing so, the applicability of the various identified interventions was proved which helped to identify opportunity areas, barriers and transferable lessons-learned.

Based on the academic analysis/perspective, the expertise of city representatives and the experiences from the realm of praxis recommendations are generated along the components of action plans being understood as implementation strategy. Among others, links to (formal/informal) planning instruments for realisation are presented and modes of participation are suggested.

2 Introduction to the Report

This report is based on the scientifically proven connections between urban design and settlement-related burdens such as air pollution and the urban heat island effect described in *Report on solutions at urban level* (Deliverable (D) 3.4; Mägdefrau et al. 2018). In addition, it builds on urban development strategies presented in D3.4 which were derived from a strengths-weaknesses-opportunities-threats (SWOT) analysis to cope with these problems.

2.1 Aims and Objectives

This report completes Task 3.6 of the third work package (WP) of the iSCAPE project. Below you can find a description of the aims for the WP in general and the objectives of Task 3.6 taken from the project proposal.

The proposal defines the aims of WP3 (planning and evaluation of PCS solutions) as follows:

- *"To optimise and deploy high-end air quality and meteorological stations at the Living Labs locations to monitor the improvements in terms of air quality;*
- *To optimise and deploy low-cost air quality monitoring kits for citizen science initiatives at the Living Labs;*
- *To improve the performances of photocatalytic coatings used on building facades in urban environments;*
- *To develop, model and deploy a range of infrastructural solutions identified in WP1 ad-hoc for each city location to improve the air quality in current climate conditions and reduce climate change adverse effects at neighbourhood and urban levels, with particular focus on areas where vulnerable population groups are;*
- *To capitalize on the technological innovation and smart citizen approach through the Living Labs to strengthen scientific knowledge on the use of low cost sensors."*

Task 3.6 works towards the aim "to prepare actions plans for urban level interventions" that "make the interventions ready for a real implementation". Therefore, this report will contain fact sheets to inform decision makers about the interventions. In this context, the proposal defines the objective of Task 3.6 (action plans for urban level interventions) through the following actions:

- Discussion of draft plans at a workshop with local stakeholders as part of the Living Lab activities (originally part of Task 3.3);
- Ex-ante analysis of the effectiveness of interventions through an iterative process;
- Derivation of quantitative information on their effectiveness;
- Qualitative weighing in regard to given synergies and conflicts with other interests (such as noise reduction in inner cities or their cost-efficiency);
- Development of action plans which includes selected interventions.

Due to the common information basis and many interrelations, the *Report on potentialities of urban interventions* (D3.9), the *Report on action plans* (D3.10) and the *Report of climate effectiveness of urban interventions* (D3.11) are summarised by this report. The required contents of the different deliverables can be found within this report as following: The potentialities of urban level interventions (D3.9) will be considered by fact sheets that contain detailed information on the potential functionality and effectiveness of urban level interventions and inform decision makers about the features of the intervention (e.g., effectiveness, costs for implementation and maintenance, time-horizon of the implementation) (see chapter 5.2). Detailed documentation on the climate effectiveness of infrastructural solutions on urban level will be forwarded in the *Detailed report based on numerical simulations of the effects of PCSs at the urban level* (D6.3). Another focus of the deliverable is to sum up the implementation action taken in the different cities with interventions on urban level, as requested for D3.10. The practical experiences of implementing different urban level interventions are provided as well as reflected and form the basis for the derivation of recommendations for an integrated action plan (see chapter 6).

2.2 Introduction to Urban Level Interventions and Action Plans

A city is a dynamic system with complex conditions. The dynamic processes of urban social life mean that neighbourhoods should not be viewed in isolation, but be managed on a city-wide basis. *Urban development planning* represents the connecting element. It is defined as all activities aimed at creating, sustainably securing and continuously improving the material and immaterial conditions for the well-being of the population and the functioning of urban community (Lenort 1960). It is the epitome of all activities to consciously control the development and expansion of the dynamic community (Lenort 1960). In this context, urban development takes a structural and spatial perspective and differentiates between five dimensions: **demographic**, **economic**, **social**, **political** and **fiscal** (Friedrichs 2005). Urban development and planning [1] are asked to define development goals for the people of a city by taking into account these five dimensions. For this purpose, urban planners need to develop, weigh up, manage and take appropriate interventions at urban level. In order to coordinate these interventions appropriately, action plans must be developed that fit the needs of the respective city.

2.2.1 Urban Level Interventions

As diverse as urban planning tasks are, as diverse can urban level interventions be. An intervention[2] or measure[3] is an action with the purpose of achieving a clearly defined objective. In many cases, several measures are bundled to achieve one goal.

The success of an intervention can be measured by its effectiveness and efficiency, depending on the spatial and temporal scale (Neil Adger et al. 2005). In addition, the criteria of equity and legitimacy are also crucial in terms of governance and wider effectiveness (Neil Adger et al. 2005).[4]

In the context of urban development planning, interventions or measures are diverse. In this report, we divide them in organisational and technical measures (see Figure 1). Apart from that, interventions also differ according to their objectives, effectiveness, cost-efficiency, time-horizon of implementation, and time-horizon of target achievement. Measures can be compared and ranked regarding these characteristics. We define organisational measures as interventions that are implemented by information, instructions, procedures and policies. Examples are working instructions, planning designations, implementation processes etc. By technical measures we mean

[1] Urban planning is the forward-looking activity of the municipality for the planned order and control of spatial and structural development within its territory (Borchard 2005).
[2] "The action or process of intervening." (Oxford Dictionaries 2019a)
[3] "A plan or course of action taken to achieve a particular purpose." (Oxford Dictionaries 2019b)
[4] These criteria (efficiency, effectiveness, equity and legitimacy) are contentious issues since they are context-specific and formed of a variety of (competing) values (Neil Adger et al. 2005). The weighting and the selection of the individual criteria is different for each country or sector. Moreover, they can change over time due to changing attitudes and expectations (Neil Adger et al. 2005). The importance of these values is highly subjective, in particular dependent on one's world view and responsibilities and thus varies between the stakeholders engaged (Neil Adger et al. 2005).

interventions that can be physically implemented in the broadest sense, or measures that are implemented in hardware and software.

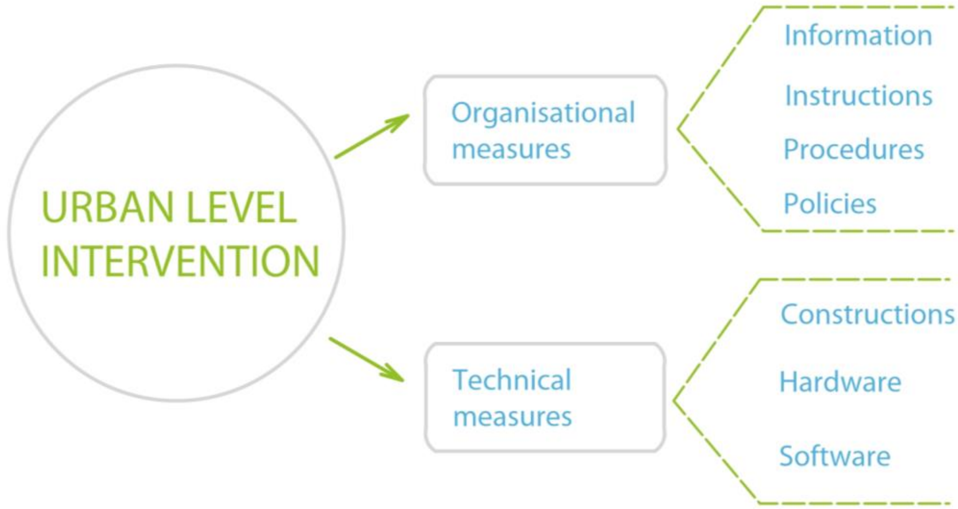

Figure 1: Categories of urban level interventions (own figure)

There are often dependencies between measures. This means that technical interventions can require organisational measures beforehand. In the planning context, this can be illustrated by the example that – at least in some member states – the legitimacy of constructing buildings and developing urban green spaces (= technical interventions) depends on designations in legally binding planning documents (= organisational interventions).

The example also shows that measures are addressed to different groups of stakeholders. Organisational measures relating to formal planning documents are addressed to administrations and decision-makers. Technical measures as well as organisational measures that refer to informal planning concepts address a larger target group, including administrations, politicians, economic actors, and civil society while technical measures are often to be implemented by private households or commercial enterprises. However, it should also be stressed that measures, which differ in their characteristics, may nevertheless pursue the same objective.

2.2.2 Action Plans

Action plans can be adapted to the needs and goals of the respective city. In principle, it lists the individual steps that are required to achieve objectives (Tang et al. 2010). As a government policy instrument, it provides a clear and systematic framework and offers planners but also other local decision-makers an orientation for the complex and demanding task of developing, implementing and reviewing strategies for dealing with the consequences of climate and environmental impacts. This instrument describes the problem and the need for action, defines the goals to be achieved, sets priorities, and bundles existing or new interventions to achieve these goals (Tang et al. 2010). At the same time, it contains the elements monitoring, evaluation and communication. An action plan is developed in a participatory manner and by involving various experts and non-state stakeholders (Tang et al. 2010). With the adoption of an action plan, the stakeholders publicly express their political will to implement the adopted interventions within a certain period of time.

Action plans can be found in all policy areas and at international, European, national and local levels, for example:

- National Energy Efficiency Action Plan of the Federal Republic of Germany, 2011
- Action Plan on Adaptation of the German Adaptation Strategy, 2011
- Safe Biking Action Plan 2007-2012, Copenhagen

Action plans can be of an informal nature, but can also be made binding by law. In the environmental context and pursuant to § 47 (2) of the *Bundes-Immissionsschutzgesetz* (German ‘Federal Immission Control Act’), an action plan consists of measures designed to counteract predicted or existing exceedances of emission limits or thresholds. In the course of amending the German ‘Federal Immission Control Act’, however, the term ‘noise action plan’ was retained on the basis of the Directive 2002/49/EC of the European Parliament and of the Council and made binding in 2005 and 2006 with §§ 47 a-f of the German ‘Federal Immission Control Act’.

Within iSCAPE and this deliverable, the term action plan stands for a rather informal approach. An action plan is understood as a guidance document for planning and implementing addressing urban planners and other employees of the respective city administration. It shows future steps for further development and serves as a decision-making aid for urban level interventions as wells as for the therein incorporated participation processes. The design of the action plan is oriented towards an integrated strategy for air pollution control in European cities and gives an overview of tools or rather possible activities the Living Lab Cities are meant to follow in order to address air quality and climate change concerns in the next years.

In order to develop and implement action plans effectively, a number of conditions need to be met. These conditions are addressed to different stakeholder groups, which play an essential role in the development and implementation processes. On one hand, it requires good cooperation and networking between different specialist promoters (e.g., the various departments of an administration) to ensure the exchange of disciplinary information. Networking can be fostered by network/exchange formats. Unless that the responsible specialist promoters are well coordinated, the support of the power promoters in the form of political decision-makers is also of great importance. The agreement of political decision-makers is the linchpin to implement an action plan. In addition, the acceptance by the citizens concerning the objectives and measures integrated in the plan is required.

Strong action plans result from planning processes involving a wide range of stakeholders, and this is necessary to promote a significant impact on the actions of local governments (Burby 2003). Stakeholder involvement can ensure that local knowledge is integrated into plans and therefore contributes to learning and better plans (Burby 2003). At the same time, public participation promotes acceptance of the contents of the respective action plan and enhances its acceptability and consequently implementability as several measures are up to private households. Public participation helps planners and politicians to broaden their problem understanding and develop stronger guidelines for handling them (Burby 2003). In a number of case studies, Innes et al. (1994) and Innes (1996) argued that the involvement of stakeholders contributed to the creation of political capital that enabled the formation of new alliances that helped to adopt and implement laws (Burby 2003). Creighton (1992) pointed out that stakeholder participation "build solid, long-term agreement and commitment between otherwise divergent parties" (Creighton 1992, p. 14) that minimises controversy and helps to implement plans.

However, obstacles often arise during the preparation and/or implementation of action plans:

- Prioritisation of the action plan's objective in the current urban policy. In some cases, other urban problems are seen as more urgent by local politicians, so that lower priority is given to environmental problems,
- Lack of resources in financial, temporal or personnel terms in city administrations. Some of the employees in the city administration of Bottrop reported that there is not a lack of conceptual basis, but of appropriate implementation structures and lack of responsibilities (iSCAPE Workshop 2018a),
- Consideration of everyday conditions. It is somehow impossible to factor in everyday conditions and reactions of individual citizens.

2.2.3 Integrated Urban Development Planning Approach

The complexity of a city's system calls for an integrated urban development planning approach to deliver sustainable outcomes for the cities (Yigitcanlar and Teriman 2014; Walsh et al. 2011). This integrated approach contributes to avoiding conflicts of objectives regarding the reduction of air pollution and the urban heat island effect, as well as other urban topics such as economic growth or long-term changes of demography, technology and social behaviour (Walsh et al. 2011). Urban functions and objectives interact both on different spatial and temporal levels. With regard to the spatial scope, the scale ranges from buildings or building blocks to cities or regions. A further issue to consider is the temporal dimension (Walsh et al. 2011). To some degree, Figure 2 describes this complex construct of interacting and often emitting urban functions, considering dynamic developments such as climate and socio-economic changes (Walsh et al. 2011).

In order to make this complex construct of a city more tangible a decomposition must be carried out on the basis of spatial and temporal scales (Walsh et al. 2011). Nevertheless, these insights have to be regarded in an integrated way when it comes to decision making. The figure gives an impression of possible impact chains of decisions by mapping direct and indirect interdependencies between various urban functions. Whenever one challenge is addressed through an intervention/measure, the relevant interdependencies need to be taken into account in order to identify, at best, synergies and to tackle challenges simultaneously (Walsh et al. 2011).

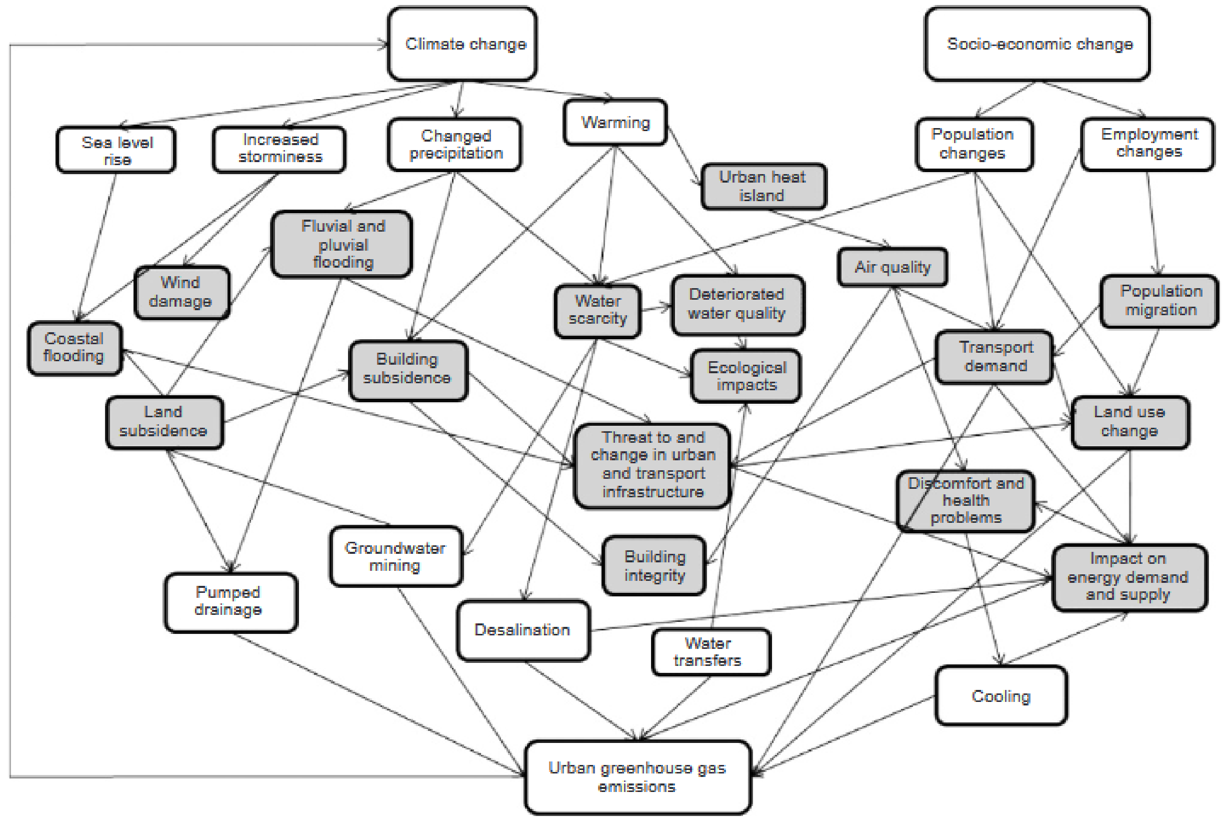

Figure 2: A sample of the many complex interactions and interdependencies between climate change, adaptation and mitigation in cities (Walsh et al. 2011, p. 79)

Urban planners see themselves confronted with the challenge to steer the future spatial development in a sustainable manner through drawing-up/establishing multi-faceted formal and informal plans and programmes. These are designed to help reduce air pollution and develop/adjust existing urban structures in order to promote low-emission urban lifestyles and be less vulnerable to other harmful environmental problems such as the urban heat island effect (Walsh et al. 2011). For developing an integrated action plan and portfolio of effective ULI options, a better understanding of synergies, conflicts and side effects between ULIs is crucial.

In general, there is a need for integrated responses to urban challenges as some are outlined above. Due to the complexity of this task general effective decision-making remains challenging and can be restricted if it is attempted to consider and weigh all alternatives at the same time. That can be amended by an appropriate methodical procedure. Methods and tools that facilitate integrated consideration or assessment help to meet this challenge (Walsh et al. 2011).

The following chapter describes our approach to deal with the complexity issue. It illustrates how we develop integrated responses through measure portfolios to tackle the challenge of urban air pollution and the appearance of ULIs in the iSCAPE Cities.

3 Our Approach

Our approach is based on a collaborative approach with urban stakeholders that have been built in the context of the iSCAPE Living Labs. Living labs strengthen the relationships between different actors or groups of actors (e.g., research, politics, administration, and citizenship) within a city. By doing so, it seeks to close the so called science-policy gap (Bulkeley et. al 2016). The knowledge gained at city level in Bottrop and Hasselt LL work out an application-oriented scientific contribution to the development of tailored action plans.

The relationships in Bottrop LL with relevant administrative stakeholders are used to create a mutual understanding on objectives, methods and content of an action plan in an iterative process.[5] This process included two workshops and two additional feedback loops that aimed at an evaluation of an integrated portfolio of ULIs reducing air pollution and the urban heat island effect. Moreover, the various ULIs were qualitatively weighed with regard to synergies, conflicts, and positive side effects.

The Bottrop LL as well as the Hasselt LL are also used to test two of the ULIs previously discussed during the stakeholder workshops.[6] In Bottrop, we tested the effects and benefits of mobile green elements in the form of Wandering Trees, while in Hasselt environmental effects of changes in travel behaviour using smartphone-based customised coaching were examined.

In the following subchapters, the individual elements of our approach are described in more detail.

Side Note: Living Lab Approach

The Living Lab approach, which emerged in the 1990s gained in importance since the mid-2000s and is nowadays, in various forms, integrated in recent research projects in diverse scientific disciplines following distinctive traditions and concepts. Thus, it is no wonder that a commonly accepted definition of the term is still missing. Nevertheless, most of the definitions agree on a living lab as human centred innovation approach that manifests itself through experimenting in a real life environment (Ballon and Schuurman 2015). This understanding is also supported by the European Network of Living Labs (ENoLL) that grasps living labs "as user-centred, open innovation ecosystems based on a systematic user co-creation approach integrating research and innovation processes in real life communities and settings" (ENoLL 2019).

Basically, the iSCAPE project follows this aforementioned general understanding and stresses three normative principles of a living lab. The following basic elements of activity are required to run a living lab:

[5] "A process for arriving at a decision or a desired result by repeating rounds of analysis or a cycle of operations. The objective is to bring the desired decision or result closer to discovery with each repetition (iteration)." (WebFinance Inc. 2019)

[6] see *Community feedback reports* (D2.5) for more information about the LL activities in Bottrop and Hasselt

- integrate end users in the innovation process within every stage (iterative and adaptable approach) and consider their needs and behaviour by using user-centric methods (ideation, testing, evaluation, feedback),
- ensure the real-life context by understanding cities settings of experimentation and oppose the everyday environment to the sterile laboratory,
- follow the multi-stakeholder idea and build collaborations between researchers, civil society and other stakeholders from the realm of praxis; end-users are no longer observed subjects testing new technologies but rather active subjects taking part in the development process: A source of creation, designing and experiencing the future and addressing urban problems.

The graph below illustrates the iSCAPE Living Lab understanding and depicts its three indispensable components (see Figure 3).

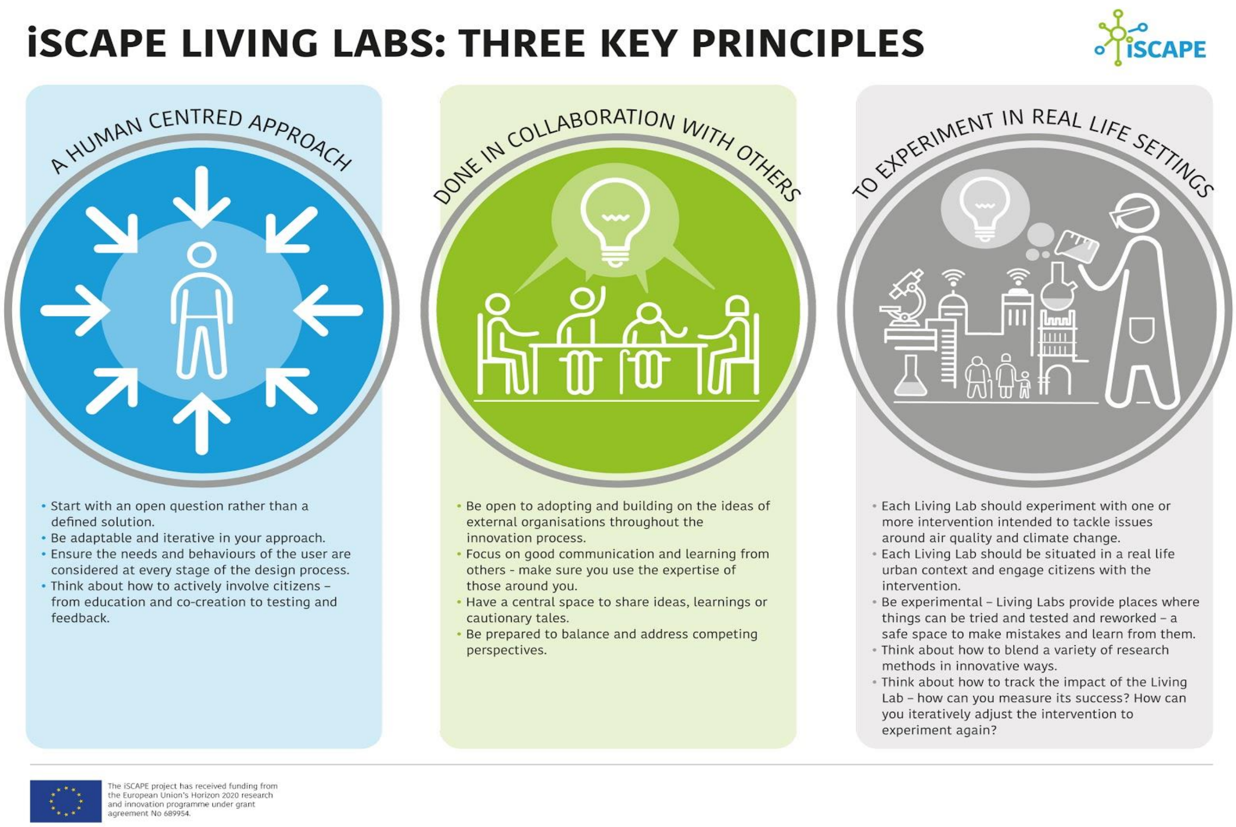

Figure 3: Living Lab Approach

Besides sustainable passive control systems and behavioural change initiatives, the living lab approach and its implementation is the central pillar in achieving the objectives of the iSCAPE project. The iSCAPE Living Labs tackle air pollution from different perspectives and assess the effectiveness of the tested urban level interventions.

3.1 The Process of Drafting an Action Plan

Several methodological approaches are used to develop an implementation strategy in the form of an action plan. The procedure which is described in the following is illustrated by the example of the City of Bottrop, but is in principle commonly applicable.

As previously figured out, drafting an action plan requires cooperation with interdisciplinary experts from a city administration and transdisciplinary cooperation with citizens. In the context of a jointly implemented workshop with the city administration of Bottrop, we carried out a criteria analysis (see chapter 3.1.1) of various criteria for the assessment of ULIs to reduce air pollution and the urban heat island effect. These ULIs were collected from planning documents such as the *Luftreinhalteplan Ruhrgebiet* (2011, 'Clean Air Plan Ruhr Area'), *Integriertes Klimaschutzkonzept der Stadt Bottrop* (2011, 'Integrated Climate Mitigation Concept Bottrop') and *Machbarkeitsstudie Klimaanpassung Innenstadt Bottrop* (2014, 'Feasibility Study on Climate Adaptation in Bottrop City Centre') added by further appropriate measures. The detected measures are not fundamentally new but innovative in their combination. The increasingly urgent challenges of air pollution and urban heat in the urban fabric will provide them with an additional weight in upcoming decision-making processes.

In a second workshop, the interdisciplinary team discussed those measures that were best rated on average in the criteria analysis. As preparation for the discussion, which focused in particular on synergies, conflicts and side effects with other interests, we prepared fact sheets with further information on each intervention. A qualitative weighing was then carried out with regard to the aforementioned three priorities (see chapter 3.1.3). This information was used to develop an informative catalogue of ULIs as part of an exemplary action plan. The methodological procedure used in Bottrop is illustrated by the following figure (see Figure 4). The catalogue of ULIs was developed through an iterative process.

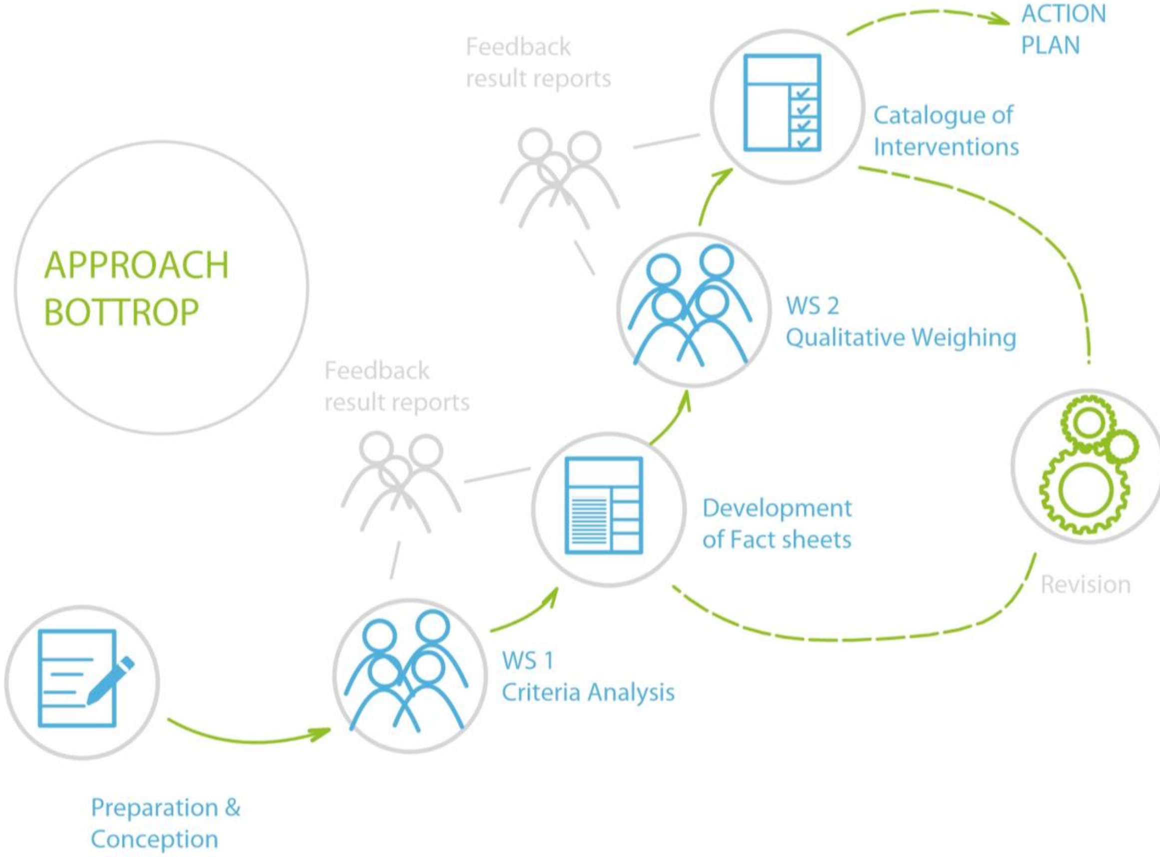

Figure 4: Iterative process in Bottrop (own figure based on e-pixler NEW MEDIA GmbH 2019)

3.1.1 Criteria Analysis of ULIs

Together with a group of interdisciplinary participants, a criteria analysis of ULIs was carried out during a workshop (10 July 2018). Stakeholders, who were not available during the workshop, were later on involved in the criteria analysis through a further feedback loop. The interdisciplinary group of stakeholders consisted of the following specialist areas: urban planning, integrated urban development, environmental planning, civil engineering and economic development.

The criteria analysis focused on four criteria:

(1) effectiveness regarding avoiding and reducing air pollution,
(2) effectiveness regarding mitigating and adapting to urban heat islands,
(3) costs for implementation and maintenance, and
(4) necessary time-horizon of the implementation.

These criteria, which are described in the following subchapters, enable to derive more information on the cost-efficiency of various alternative measures. Within the discursive process all relevant criteria were considered one after the other and weighed according to their significance. An important part of the criteria analysis is the joint assignment of evaluation categories. For this purpose, the group of participants first discussed the four criteria for each ULI regarding the evaluation categories shown in Table 1 and Table 2 and then agreed on a common assignment. Based on the respective evaluation categories, the workshop participants ranked the most effective, cost-effective and promptly implementable urban level interventions on an ordinal scale. By using the ordinal form (e.g., ‘very effective’, ‘less effective’, …) the estimations of the involved stakeholders were documented and jointly merged. An overall value was assigned to the interventions with the aid of standardised scales and a comprehensive ranking was guaranteed.

(1) effectiveness regarding avoiding and reducing air pollution			
very effective	effective	less effective	hardly or not effective
(2) effectiveness regarding mitigating and adapting to urban heat islands			
very effective	effective	less effective	hardly or not effective
(3) costs for implementation and maintenance			
very inexpensive	inexpensive	less inexpensive	hardly or not inexpensive
(4) time-horizon of the implementation			
realisable in the short term (< 5 years)	realisable in the medium term (5-10 years)	realisable in the long term (> 10 years)	

Table 1: Evaluation categories of each criteria

	(1) effectiveness regarding avoiding and reducing air pollution	(2) effectiveness regarding mitigating and adapting to urban heat islands	(3) costs for implementation and maintenance	(4) time-horizon of the implementation
3 points	very effective	very effective	very inexpensive	
2 points	effective	effective	inexpensive	realisable in the short term (< 5 years)
1 point	less effective	less effective	less inexpensive	realisable in the medium term (5-10 years)
0 points	hardly or not effective	hardly or not effective	hardly or not inexpensive	realisable in the long term (> 10 years)

Table 2: Point scheme

3.1.1.1 Parameter 'Effectiveness regarding avoiding and reducing air pollution'

The parameter 'effectiveness' refers in this respect to the contribution which the corresponding urban level intervention is able to deliver regarding the avoidance and reduction of air pollution. When assessing effectiveness, a distinction must be made between **direct** and **indirect** effects. The impact of an ULI is considered as direct if it actively contributes to reducing the concentration of air pollutants. This includes, for instance, the greening of public road spaces. An ULI is considered as indirect if the intervention helps to improve urban air quality through detours, e.g. the development of an intelligent parking system or the expansion and improved access to public transport. It reduces motorised private transport, which in turn contributes to the reduction of pollutant emissions.

An ordinal scale ranging from very effective to hardly or not effective was applied to assess the effectiveness of improving air quality (see Table 1 and Table 2).

3.1.1.2 Parameter 'Effectiveness regarding mitigating and adapting to urban heat islands'

The parameter 'effectiveness' refers to the contribution of an ULI to mitigating and adapting to urban heat islands. When assessing effectiveness, a distinction must be made between **direct** and **indirect** effects. ULIs have a direct mitigating or adapting effect if they immediately contribute to preventing heat islands and not via chains of effects. Desealing impervious surfaces and bright facade coatings/paints, for example, unfold direct effects. An example of an intervention that indirectly helps to reduce the formation of urban heat islands, is the alignment and position of buildings. If existing fresh air corridors are kept free from buildings, the ventilation of urban areas is ensured and unfolds a temperature reducing effect.

A four-step rating scale ranging from 'very effective' to 'hardly or not effective' was applied to assess the effectiveness of improving air quality (see Table 1). If an ULI is considered as 'very effective' it is weighed with three points (see Table 2).

3.1.1.3 Parameter 'Costs for implementation and maintenance'

With the 'costs for implementation' an economic parameter is included in the consideration of the ULIs. It is meant to give an overview of the costs incurred in implementing the ULIs. For sure, this parameter is of high significance for decision makers when it comes to selecting those ULIs that are meant to be implemented from a wide-ranging catalogue. This criterion is particularly helpful in detecting ULIs that correspond to the city's budget. Can the intervention be implemented at a reasonable expense? Do alternative interventions display a higher benefit or are more cost-efficient at the same benefit? These are exemplary questions that have to be answered in this context.

This parameter is, like the previous ones, evaluated on an ordinal scale ranging from 'very inexpensive' to 'hardly or not inexpensive' (see Table 1). With regard to the realisability of the ULIs, the points are allocated in descending order with the increase in costs (see Table 2).

3.1.1.4 Parameter 'Time-horizon of the implementation'

In the literature, the most common standard used for classifying the time are the three classes 'short-term', 'medium' and 'long-term'. Whereas these three categories are set, their specification by years is often less distinct. Within this deliverable ULIs are categorised as short-term if they can be realised within a period of five years. This category includes particular measures that require some capabilities and financial resources for the realisation and several steps of realisation are necessary. Five to ten years is the interval in which an ULI is understood to be feasible in the medium term. Interventions of that kind are partially associated with a greater effort, both personal and material. Furthermore, these interventions are frequently expensive and time-consuming. The category 'long-term' includes those ULIs that require more than ten years to be implemented. Many and multiplex steps for establishment are needed and the interventions require beyond governmental permission an integration in complex planning processes. This parameter frequently correlates with the 'costs for implementation'.

Compared to the other parameters the scale for the time-horizon deviates slightly and consist of three instead of four intervals (see Table 1). With regard to classification, the 'short-term planning horizon' is weighted with two points (see Table 2).

3.1.2 Fact Sheets

During the iterative process of discussing and evaluating urban level interventions with stakeholders in Bottrop, we developed a fact sheet for each ULI, based on literature research. The fact sheets explain the following characteristics of the ULI:

- time-horizon of the implementation,
- costs for implementation and maintenance,
- effectiveness,
- suitability,
- synergies, conflicts, and side effects with other interests.

Within the second stakeholder workshop (29 October 2018) the fact sheets were discussed with an interdisciplinary team with special regard to synergies, conflicts, and side effects and adjusted in accordance with additional findings. These fact sheets serve as evidence basis for decision-makers and will be included in the action plan for Bottrop and Hasselt.

The fact sheets contain the above mentioned information and are further itemised so that a well-founded portfolio of measures is created, which contains the relevant facts required for implementation. The interventions are structured according to the following symbols:

Time-horizon of the implementation
The measures include different steps of realisation and consequently different terms from conception to implementation: Short term, medium term, long term.

Costs for implementation and maintenance
To implement the measures, various degrees of financial resources are necessary. The costs for implementation differ between: very inexpensive, inexpensive, less inexpensive, hardly or not inexpensive.

Effectiveness regarding avoiding and reducing air pollution
The measures unfold different degrees of effectiveness regarding avoiding and reducing air pollution: effective, less effective, hardly or not effective.

Effectiveness regarding mitigating and adapting to urban heat islands
The measures unfold different degrees of effectiveness regarding mitigating and adapting to urban heat islands: effective, less effective, hardly or not effective.

Suitability
This category contains information about to whom the measure is addressed/for whom or what it is best suited and/or what preconditions are to bring along for implementation.

Additional information on costs for implementation
This category includes further information concerning the financial and personal resources required. Additional information is given e.g. under which conditions the costs could fluctuate.

Additional information on effectiveness
This category includes further information on the effectiveness (avoiding and reducing air pollution + mitigating and adapting to urban heat islands) of the measure.

Objectives
The measure strives for one or both of the following objectives: Improvement of urban climate (heat stress) and Improvement of air quality.

Synergies
Information is given on the general potential for synergies and synergetic effects with other proposed measures in particular.

Conflicts
Information is given on the general potential for conflict and conflicts that may arise between the proposed measures in particular.

Positive side effects
This category lists all those beneficial effects/advantages that the respective measure entails that are not directly linked to the objectives.

Negative side effects
This category lists all those undesirable effects/disadvantages that the respective measure entails that are not directly linked to the objectives.

Comments
Further remarks and thoughts concerning the respective measure are indicated.

If not applicable or not relevant for the measure, the boxes are left blank. Some of the parameters above will be explained in more detail in the course of the report.

Besides the standardised processing of the data in fact sheets, the measures, technical as well as organisational, are assigned to fields of action that are of high significance when it comes to addressing air pollution and the urban heat island. We identified the following main fields in which action is required or at least a great potential for action exists:

‘**settlement developmen**t’, ‘**green infrastructures and green elements**’, and ‘**eco-friendly transport and mobility**’.

3.1.2.1 Field of Action ‘Settlement Development’

The use of new land or the conversion of existing land has a significant impact on the environment. A sustainable planning and development of settlement structures is necessary and needs to be weighed carefully against other concerns as for example the preservation of large, undeveloped open and/or green spaces (see D3.4). Future-oriented planning of settlement developments is characterised by sustainable use of land as resource, a comprehensive land management focusing on re-densification and the promotion of mixed uses and functions (German Association of Cities 2013). Those principles refer to both, the existing building stock as well as to new settlement activities and so do the interventions assigned to this field of action.

At the building layer, these measures relate among others to components of individual buildings, but also to the position and density of building blocks or development sites.

3.1.2.2 Field of Action ‘Green Infrastructures and Green Elements’

Urban green is a characteristic element of European cities and assumes a variety of social, health, economic, ecological and climatic functions. Although their benefits in urban areas and their potential, e.g. in moderating temperature, are documented and acknowledged, however green amenities have often experienced less appreciation (Keeley and Benton-Short 2019). The increased settlement pressure that is particularly evident in larger cities endangers existing green structures. Nevertheless, it is necessary to preserve and further develop or expand existing urban green infrastructure and include it in planning and regulatory practice since the abundance of vegetation correlates with land surface temperatures (Keeley and Benton-Short 2019; Dulal 2017). At strategic level, this includes maintaining and developing regional green belts and ventilation corridors, that ensure the interlink between urban and rural spaces through green connections, improve greenery supply in highly sealed urban areas and preserve parks due to their positive recreational and climatic effects (German Association of Cities 2013).

The interventions assigned to this field of action address several types and scales of green spaces, ranging from greened roofs and frontages up to parks and green corridors in order to foster climatic and air quality functions.

3.1.2.3 Field of Action ‘Eco-friendly Transport and Mobility’

The loss of near-natural areas (such as unused forests), increasing material and energy consumption as well as the increase in traffic-related emissions lead to burdens on the environment and population. Many cities have therefore been relying for some time on the development of a city-friendly mobility culture/transit-oriented development – by creating the necessary prerequisites to reduce the adverse effects of transport (German Association of Cities 2013; Dulal 2017). These concepts aim at changing the modal split[7] by reducing the motorised individual traffic in urban areas through parking space concepts and the creation of alternatives such as the expansion of the public transport network and its improvement in user-friendly manner. It also requires attractive conditions for pedestrians and cyclists by filling gaps in existing networks. Besides changing the modal split, the promotion of electric mobility and services is a further aspect in this field of action (German Association of Cities 2013). A combination of various sustainable modes of transport is required to overcome automobile dependence and consequently fight urban externalities such as traffic related air pollution and congestions (Dulal 2017).

In addition, the aforementioned tasks of this field are complemented by measures that draw attention to the air pollution caused by traffic and stimulate behavioural change or rather changes in individual travel behaviour. All these tasks make a sustained contribution to the development of a sustainable, energy-efficient and eco-friendly form of mobility.

3.1.3 Qualitative Weighing of ULIs based on Interactions and Side Effects

Those measures that were best rated on average in the criteria analysis were qualitatively weighed with regard to their synergies, conflicts, positive and negative side effects. The qualitative weighing was part of the second stakeholder workshop (29 October 2018) with interdisciplinary experts from the city administration of Bottrop. The interdisciplinary group consisted of the following specialist areas: urban planning, integrated urban development, environmental planning, civil engineering and economic development.

Every participant was equipped with a total of 40 adhesive dots: 10 dots for each of the four evaluation criteria (① synergies, ② conflicts, ③ positive side effects, and ④ negative side effects). Using the multi-point survey method, the participants evaluated the ULIs according to their characters. Of course, the qualitative weighing is not free from subjective values, but it is not arbitrary since it is based on objective facts and the professional expertise of the attendant participants.

This method is particularly suitable to setting the stage for prioritising alternative interventions. When it comes to air pollution and urban heating it helped to detect those interventions that are tailor-made for city's challenges. When correctly applied, effective urban level interventions can be adjusted to city's/citizens needs can be identified. Those changes can be identified and subsequently incorporated in an action plan.

This procedure was intended to avoid negative effects and undesirable developments. Additionally, it allows a comprehensive consideration of the interrelations between the interventions. Consequently, one of the central challenges was to identify complex interactions, side effects, synergies and conflict potentials within this process. The assessment criteria to do so are described in more detail below.

[7] "The modal split of transport describes the relative share of each mode of transport, for example by road, rail or sea. It is based on passenger-kilometres (p-km) for passenger transport and tonne-kilometres (t-km) for freight or goods transport. The modal split is usually defined for a specific geographic area and/or time period." (Eurostat – Statistics Explained 2014)

3.1.3.1 Synergies

Synergies describe the result when "interaction or cooperation of two or more organizations, substances, or other agents [.] produce a combined effect greater than the sum of their separate effects." (Oxford Dictionaries 2019c) The use of synergies as a quality benchmark was first used by the economic sector. Efforts are directed both at economies of scale and economies of scope (Rhumbler 1993). Realising such advantages requires an understanding of synergy and the ability to manage complexity (Rhumbler 1993). Synergies can be found within many fields of urban development. In this study, we assessed only synergies between those ULIs discussed in the workshops.

Synergy effects are a key criterion in prioritising action requirements and determine interventions within the framework of an action plan. The aim is to identify and select those actions/measures that are compatible and enable the use of synergy potential.

Questions that have been addressed within this context:

- Does the urban level intervention show synergies with other ULIs or does it help to achieve more than one objective of the respective municipality?
- Does the measure facilitate the implementation of other interventions?

In climate and environmental policy, synergies arise when measures are implemented that simultaneously reduce the adverse impacts of climate change and address the atmospheric greenhouse gas concentrations. Referring to Walsh et al. (2011), planting trees in urban areas falls within the scope of synergies. Trees isolate carbon during growth and heat resistant species provide shape and unfold a cooling effect in summer. Thus, they contribute to mitigating urban heat stress (Walsh et al. 2011).

3.1.3.2 Conflicts of Objectives

An intervention can be successful in achieving one defined objective, but can simultaneously trigger conflicts with other stated objectives (Neil Adger et al. 2005). When coordinating the urban level interventions, potential conflicts have to be identified in order to prevent negative interactions before it comes to the implementation. Do the effects of these measures conflict with another objective? By using the example of the urban form, McEvoy et al. (2006) illustrate such conflicting objectives: Compact settlement structures may bring significant advantages such as the reduction of transport-related emissions and a decrease of energy demands. However, a high density and the sealing of surfaces may encourage the appearance of UHI and hamper the urban drainage. The combination of an increased urban heat island effect and ever-increasing temperatures, especially in summer, may, for example, result in heavy air conditioning usage or commuting to leave affected areas. In view of that interpretation, the result would even be an increase in emissions (McEvoy et al. 2006). A planner must be aware of such conflicts of objectives in order to be able to avoid, reduce or compensate them. Regarding these possible conflicts, the ULIs are weighed in an unbiased and comprehensive way by the local stakeholders.

3.1.3.3 Positive Side Effects

Besides synergies and conflicts a further category namely the 'positive side effects' of the interventions on urban level, was taken into account. This category comprises all those effects which arise for the respective city through the implementation of the intervention not necessarily directly related to the objectives of improving air quality or reducing heat islands. Thus, the key question within this category is:

- What other advantages does the intervention have and what are its inherent desirable effects for the respective city?

As an example: when using ground-covering vegetation an additional positive effect is that it contributes to improving the infiltration of rainwater in urban areas and thus prevents urban (flash) flooding in the case of extreme events such as heavy rainfalls.

3.1.3.4 Negative Side Effects

When taking into account positive side effects that can occur while implementing the urban level interventions, negative aspects should not be neglected. This category investigates those adverse effects that are indirectly triggered by the implementation of the respective measure. It mainly deals with the question:

- What disadvantages or undesirable impacts can be generated?

An example of inherent negative effects with regard to the intervention ‘preservation of open spaces’ could be potential conflicts on land use; especially in growing cities or regions with existing settlement pressure, the preservation of green connections and areas could be challenging. Pressure on land use within a built environment reduces the availability of land for thermal relief areas and can lead to conflicts in the conservation of contiguous open spaces.

3.2 The Process of Drafting Exemplary Urban Level Interventions

Making ULIs ready for implementation requires several steps, such as the conception, the cooperation, and the dialogue with different stakeholders and public participation. In the following section, the process of two organisational interventions applied in the iSCAPE cities Bottrop and Hasselt is exemplarily traced. In Hasselt, an application-based customised coaching with focus on individual travel behaviour (see fact sheet) was implemented whereas Bottrop initiated mobile green elements in form of ‘Wandering Trees’ (see fact sheet).

3.2.1 Wandering Trees / Mobile Green Elements

Besides creating an action plan, we also developed and tested an organisational urban level intervention for the City of Bottrop that focussed on the involvement of citizens and local stakeholders in city greening initiatives. This ULI aimed at raising awareness for greening road spaces, improving air quality, as well as enhance the well-being of local citizens and can be assigned to the topic of ‘green infrastructure’. One of the main collaborating stakeholders was the City of Bottrop itself. In cooperation with the city representatives, a first concept of the ‘Wandering Trees’ intervention was developed, which was continuously discussed and iterated. During the process of drafting the ideas, citizens were taken into account. The methodological procedure is illustrated by the following figure (see Figure 5).

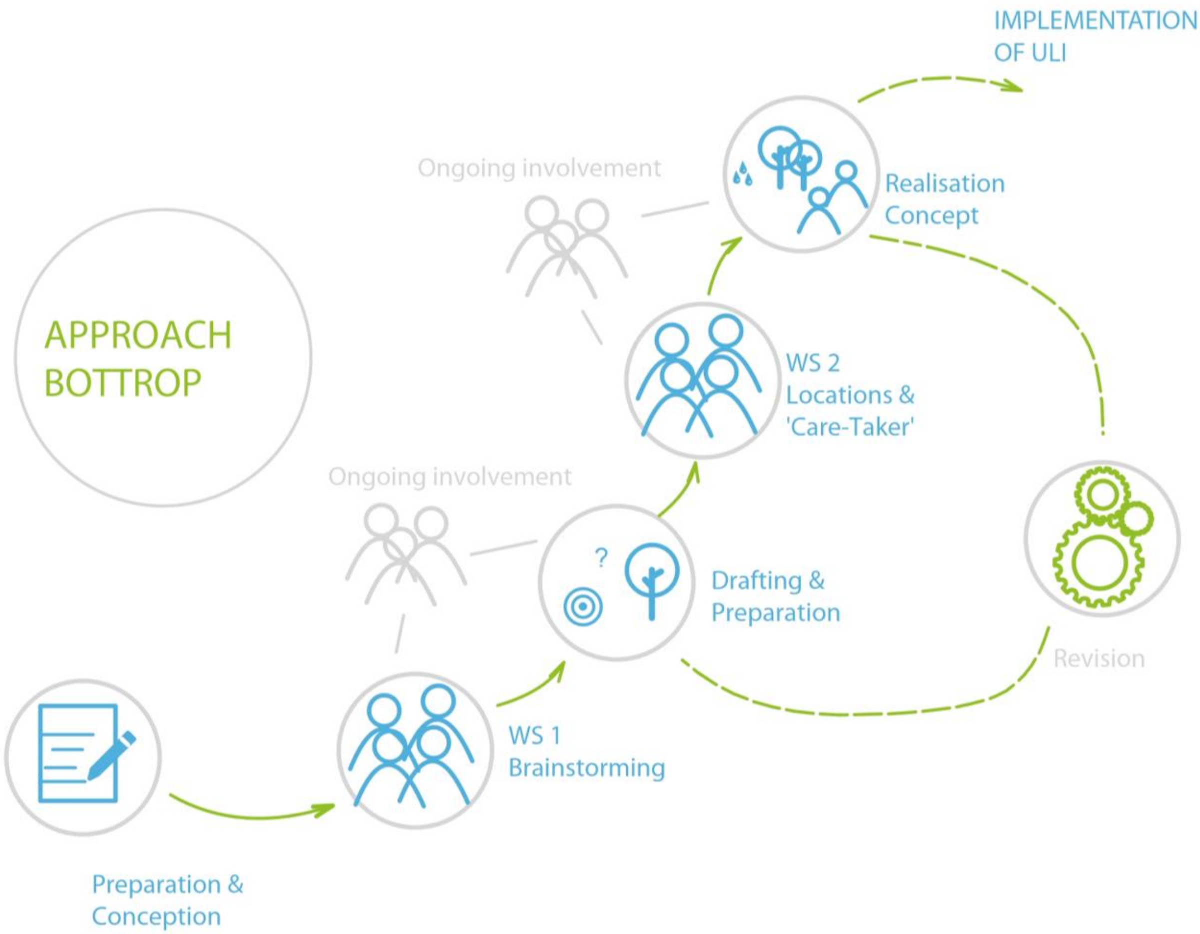

Figure 5: Process of drafting exemplary ULI in Bottrop (own figure based on e-pixler NEW MEDIA GmbH 2019)

During the first workshop, various tree species were discussed (prior to the purchase) in regards to their suitability and further activities have been considered in order to accompany the parade (see Figure 6). Based on the pool of ideas, generated through the citizens' participation the ULI was further specified and concretised. In the second workshop the route of the parade, the location of the mobile trees and caretakers (for watering the trees) were chosen (see Figure 7). At the end of the workshop, this procedure resulted in a fully fleshed out concept tailor-made for the Living Lab Bottrop and an implementation plan for the iSCAPE LL 'Wandering Tree Parade' (see *Community feedback reports* (D2.5)).

Figure 6: Impressions of the first workshop with citizens about the Wandering Trees (30 January 2018) (own figure, © U. Grützner)

Figure 7: Impressions of the second workshop with citizens about the Wandering Trees (12 April 2018) (own figure, © U. Grützner)

3.2.2 Customised Coaching

In addition to the concept of collaborative sciences, University of Hasselt also developed and tested an informational urban level intervention in Hasselt in order to encourage eco-friendly change in citizens' mobility behaviour (see *Community feedback reports* (D2.5) and *Report on environmental effects of behavioural actions* (D4.1)). This informational ULI describes an application-based and customised coaching of citizens in order to stimulate them to reduce their individual exposure to pollutants and increase their physical activity level by using more sustainable modes of transport (see chapter 5.3.2). During the development process of this informational ULI, the City of Hasselt is one of the main collaborators. A brainstorming workshop was carried out with representatives of the City of Hasselt to discuss initial plans and ideas for customised coaching. After the workshop, the results were shared via e-mail with the representatives of the city administration – who also helped to recruit participants by disseminating the ULI campaign in online and offline media channels (e.g., website, social media, and magazines). The methodological procedure used to develop the intervention is illustrated by the following figure (see Figure 8). To increase the chance of consolidating the cooperation with the city administration of Hasselt, some representatives participated in the 'study findings' and 'feedback workshop' at the end of the informational intervention campaign.

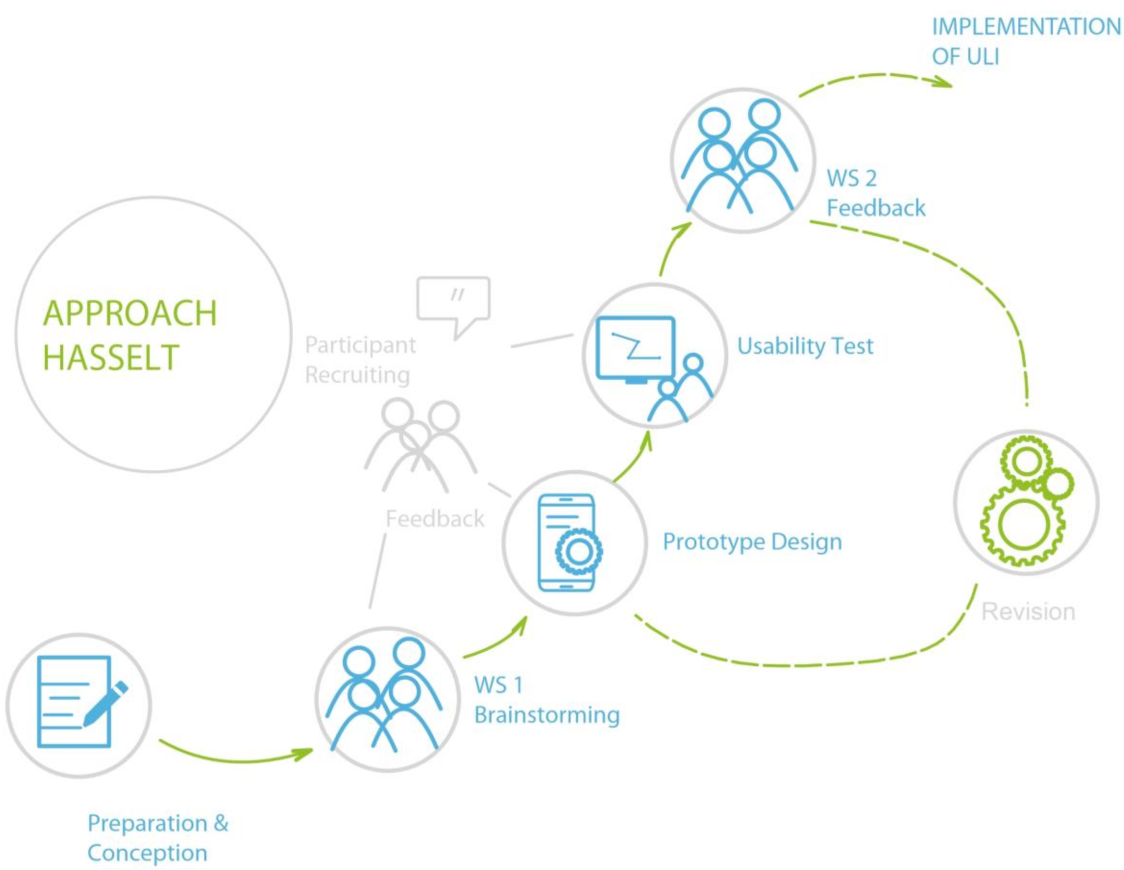

Figure 8: Process of drafting exemplary ULI in Hasselt (own figure based on e-pixler NEW MEDIA GmbH 2019)

Figure 9: Impressions of the LL mid-term event (own figure)

Customised coaching was used to encourage eco-friendly change in citizens' mobility behaviour and is based on a smartphone application, which collects information on users' daily travel routine. The design of this informational ULI consists of various steps:

(1) Participants collect data of their daily routes and their used transport mode through a smartphone application (see Figure 10). Individuals record their activity travel patterns for at least one week.

(2) This data is integrated with concentration data of the respective region and also various transport infrastructure supply data to provide information on their individual exposure to pollutants as well as customised recommendations and useful alternatives to citizens in order to promote eco-friendly travel behaviour.

(3) Participants again collect information on their daily travel routine through the smartphone application. This new recorded data is used to compare the travel behaviour of the participants and to measure if the provided information has a significant impact on the travel routine of the participants.

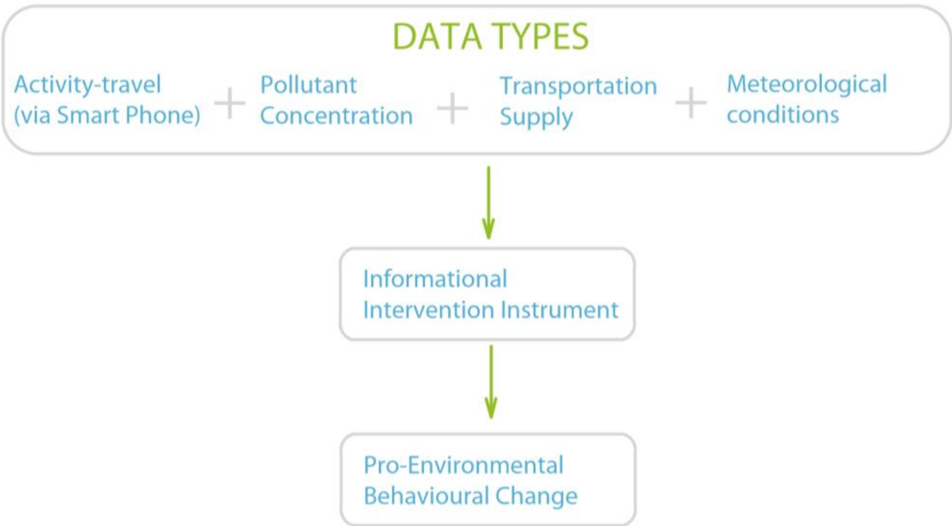

Figure 10: Data types (own figure)

4 Potentialities of Urban Level Interventions

As described in chapter 2.2.1, urban level interventions can be categorised in technical and organisational measures. In the context of urban planning, organisational measures mainly comprise conceptualisation in planning documents (e.g., land use plan), but also informal concepts, guidelines and strategies. Additionally, the broad field of public relations and information work is also part of the organisational measures. This includes ULIs to raise awareness or to change behaviour. Technical measures mainly include construction activities, greening and other physically feasible measures.

This chapter provides an overview of possible urban level interventions tackling air pollution and the urban heat island effect divided into the main fields of action: 'settlement development', 'green infrastructures and green elements', and 'eco-friendly transport and mobility'. The interrelations and interdependencies between air pollution, UHI, urban design and the transport sector have already been presented in the *Report on solutions on urban level* (Mägdefrau et al. 2018).

In addition, this chapter presents the results of the criteria analysis carried out in the first stakeholder workshop by an interdisciplinary team of experts in Bottrop (see chapter 3.1.1, see Figure 11). The analysis focused on the criteria 'effectiveness' (in terms of reducing air pollution on the one hand and reducing UHI on the other hand), 'costs for implementation', and 'time-horizon'. The underlying evaluation is based on the stakeholders' experiences.[8]

[8] Although some of these ULIs relate to the neighbourhood level, the evaluation is based on the assumption of implementing them on urban scale.

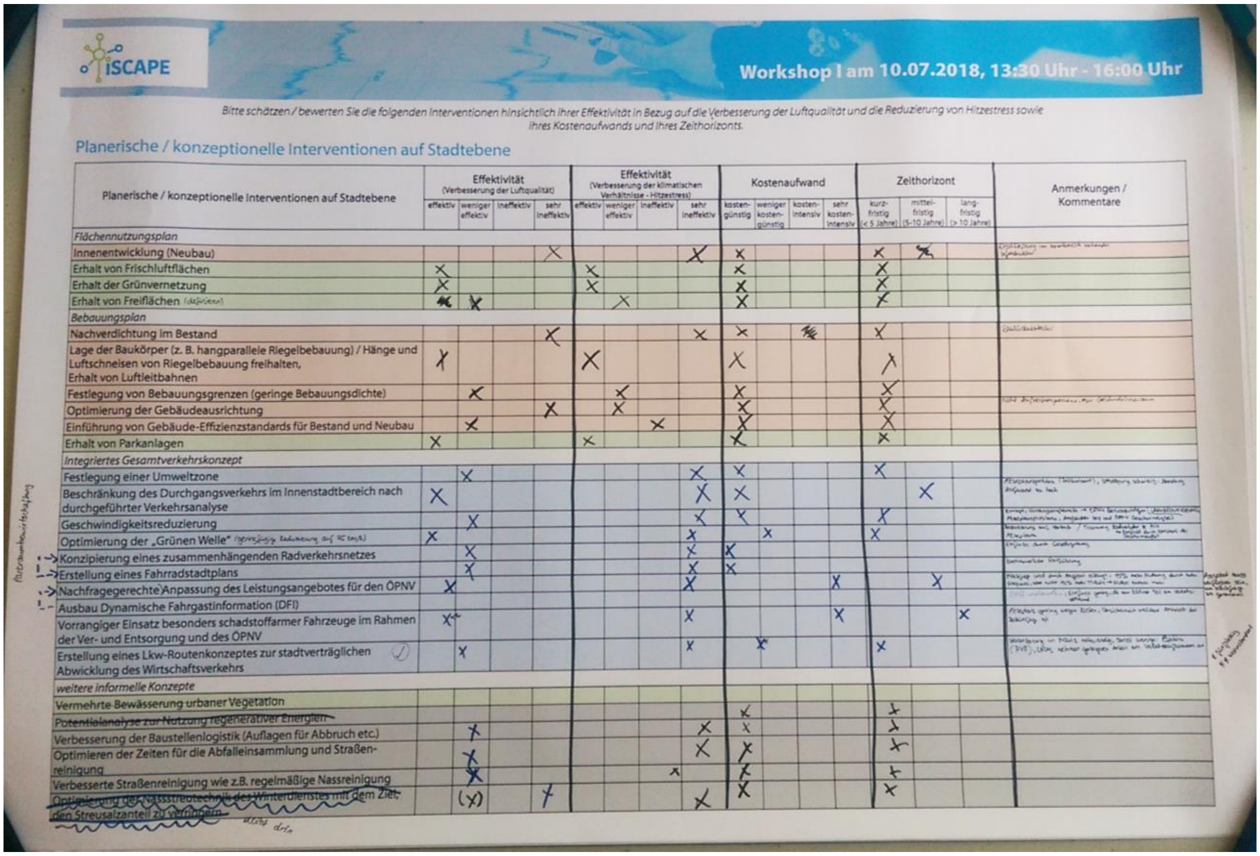

Figure 11: Some of the outcomes of the criteria analysis (iSCAPE Stakeholder Workshop I in Bottrop, 10.07.2019) (own figure)

4.1 Organisational Urban Level Interventions

Most of the included organisational urban level interventions base on an informational character and can be described by their strategic level. They consist of policies, procedures and instructions that help address the identified urban challenges of UHI and air pollution. The results of the criteria analysis of the measures assigned to this category are described below.

4.1.1 Field of Action: 'Settlement Development'

The following tables show possible organisational measures in the field of 'settlement development':

Urban Level Interventions	Effectiveness (avoiding and reducing air pollution): very effective	Effectiveness (avoiding and reducing air pollution): effective	Effectiveness (avoiding and reducing air pollution): less effective	Effectiveness (avoiding and reducing air pollution): hardly or not effective	Effectiveness (mitigating and adapting to urban heat islands): very effective	Effectiveness (mitigating and adapting to urban heat islands): effective	Effectiveness (mitigating and adapting to urban heat islands): less effective	Effectiveness (mitigating and adapting to urban heat islands): hardly or not effective	Costs for implementation and maintenance: very inexpensive	Costs for implementation and maintenance: inexpensive	Costs for implementation and maintenance: less inexpensive	Costs for implementation and maintenance: hardly or not inexpensive	Time-horizon of the implementation: short term (< 5 years)	Time-horizon of the implementation: medium term (5-10 years)	Time-horizon of the implementation: long term (> 10 years)	Points	Fact sheet
a) Position of the building structure (e.g. slope-parallel bar construction)/ Keep slopes and air corridors free of bar construction (b) preservation of air lanes	X					X			X				X			10	X
Determination of legal limitations of building development (low building density)		X				X			X				X			9	X
Participation in the certification procedure "European Energy Award" (EEA)			X			X			X				X			9	X
Participation in the certification procedure "European Climate Adaptation Award" (ECA)		X				X			X				X			9	X
Implementation of building efficiency standards for existing and new buildings		X					X		X				X			8	X

Table 3: Organisational Urban Level Intervention within the action field: Settlement Development 1/2

Urban Level Interventions	Effectiveness (avoiding and reducing air pollution)				Effectiveness (mitigating and adapting to urban heat islands)				Costs for implementation and maintenance				Time–horizon of the implementation			Points	Factsheet
	very effective	effective	less effective	hardly or not effective	very effective	effective	less effective	hardly or not effective	very inexpensive	inexpensive	less inexpensive	hardly or not inexpensive	short term (< 5 years)	medium term (5-10 years)	long term (> 10 years)		
Optimisation of the building alignment			X				X		X				X			7	
Ensuring Interior development (new building)				X				X	X				X			5	
Ensuring Re-densification in inventory				X				X	X				X			5	

Table 4: Organisational Urban Level Intervention within the action field: Settlement Development 2/2

The main advantages of these measures at urban level derive from their short-term feasibility and low cost. This is a general benefit of organisational interventions regardless of the field of action. However, there are differences in the assessment of effectiveness. Organisational ULIs have no immediate effect on air pollution or the urban heat island effect, as they are mainly instructions for action. However, the effectiveness can be indirectly increased by following these instructions. But this indirect effectiveness is also taken into account in the assessment (see chapters 3.1.1.1 and 3.1.1.2).

Even if the effects are only indirect, such organisational ULIs are a basis for later technical and physical implementation. This applies in particular to ULIs concerning local planning documents and strategies.

The *Detailed report based on numerical simulation of the effect of PCSs at the urban level* (D6.3) shows results of a numerical modelling of urban climate depending on the alignment and positioning of buildings. In D6.3, more detailed information on effectiveness is derived from the numerical models.

4.1.2 Field of Action: 'Green Infrastructures and Green Elements'

The following table shows possible organisational measures in the field of 'green infrastructures and green elements':

Fact sheet		X	X	X	X	X
Points		11	11	11	9	9
Time-horizon of the implementation	short term (< 5 years)	X	X	X	X	X
	medium term (5-10 years)					
	long term (> 10 years)					
Costs for implementation and maintenance	very inexpensive	X	X	X	X	
	inexpensive					X
	less inexpensive					
	hardly or not inexpensive					
Effectiveness (mitigating and adapting to urban heat islands)	very effective	X	X	X		
	effective				X	X
	less effective					
	hardly or not effective					
Effectiveness (avoiding and reducing air pollution)	very effective	X	X	X		X
	effective				X	
	less effective					
	hardly or not effective					
Urban Level Interventions		Preservation of parks	Preservation of fresh air areas	Preservation of green networks	Preservation of open spaces (sealed and unsealed)	Using mobile green elements

Table 5: Organisational Urban Level Intervention within the action field: Green Infrastructure and Green Elements

Similar to the field of action in chapter 4.1.1, these measures are also strong through low costs and short-term implementation due to their purely organisational character. In addition, the effectiveness of these organisational ULIs is indirectly taken by following the ULIs/instructions listed in Table 5. This indirect effectiveness is also part of the assessment (see chapters 3.1.1.1 and 3.1.1.2).

Besides, in these cases the same necessities apply as in the field of ‘settlement development’. The organisational ULIs, which refer to planning documents, make technical/physical implementation possible in the first place, therefore, they are indispensable.

4.1.3 Field of Action: ‘Eco-friendly Transport and Mobility’

The following tables show possible organisational measures in the field of ‘eco-friendly transport and mobility’:

Urban Level Interventions		Creation of a parking space concept	Providing an application-based customised coaching regarding individual travel behaviour	Citizen air measurements and collection of critical points on a climate map	Improved street cleaning such as regular wet cleaning	Implementation of an environmental zone	Restriction of transit traffic in inner city areas
Fact sheet		X	X	X		X	X
Points		8	7	7	8	7	7
Time-horizon of the implementation	short term (< 5 years)	X	X	X	X	X	
	medium term (5-10 years)						X
	long term (> 10 years)						
Costs for implementation and maintenance	very inexpensive	X	X	X	X	X	X
	inexpensive						
	less inexpensive						
	hardly or not inexpensive						
Effectiveness (mitigating and adapting to urban heat islands)	very effective						
	effective						
	less effective	X		X	X		
	hardly or not effective		X			X	X
Effectiveness (avoiding and reducing air pollution)	very effective						X
	effective	X	X		X	X	
	less effective			X			
	hardly or not effective						

Table 6: Organisational Urban Level Intervention within the action field: Eco-friendly Transport and Mobility 1/3

Urban Level Interventions	Effectiveness (avoiding and reducing air pollution): hardly or not effective	Effectiveness (avoiding and reducing air pollution): less effective	Effectiveness (avoiding and reducing air pollution): effective	Effectiveness (avoiding and reducing air pollution): very effective	Effectiveness (mitigating and adapting to urban heat islands): hardly or not effective	Effectiveness (mitigating and adapting to urban heat islands): less effective	Effectiveness (mitigating and adapting to urban heat islands): effective	Effectiveness (mitigating and adapting to urban heat islands): very effective	Costs for implementation and maintenance: hardly or not inexpensive	Costs for implementation and maintenance: less inexpensive	Costs for implementation and maintenance: inexpensive	Costs for implementation and maintenance: very inexpensive	Time-horizon of the implementation: long term (> 10 years)	Time-horizon of the implementation: medium term (5-10 years)	Time-horizon of the implementation: short term (< 5 years)	Points	Factsheet
Creation of a bicycle city map			x		x							x			x	7	
Speed reduction			x		x							x			x	7	
Optimisation of the 'Green Wave'				x	x						x				x	7	
Preparation of a truck route concept for the city-compatible handling of commercial traffic			x		x							x			x	7	
Improvement of construction site logistics (requirements for demolition, etc.)			x		x							x			x	7	
Optimising times for waste collection and street cleaning			x		x							x			x	7	
Optimisation of the wet spreading technology of the winter road clearance service with the aim of to reduce the proportion of road salt			x		x							x			x	7	

Table 7: Organisational Urban Level Intervention within the action field: Eco-friendly Transport and Mobility 2/3

Factsheet		Conception of a coherent cycling network	Public relations work to promote car pooling	Public relations work and advice on the promotion of e-mobility	Expansion of Dynamic Passenger Information (*DFI*)	(Demand-oriented) adjustment of the range of services offered for public transport	Priority use of particularly low-pollutant vehicles within the scope of supply and disposal and public transport
Points		6	6	6	5	4	3
Time-horizon of the implementation	short term (< 5 years)		x	x	x		
	medium term (5-10 years)	x				x	
	long term (> 10 years)						x
Costs for implementation and maintenance	very inexpensive	x					
	inexpensive		x	x			
	less inexpensive				x		
	hardly or not inexpensive					x	x
Effectiveness (mitigating and adapting to urban heat islands)	very effective						
	effective						
	less effective						
	hardly or not effective	x	x	x	x	x	x
Effectiveness (avoiding and reducing air pollution)	very effective					x	x
	effective	x	x	x	x		
	less effective						
	hardly or not effective						

Table 8: Organisational Urban Level Intervention within the action field: Eco-friendly Transport and Mobility 3/3

Apart of a few exceptions, the assessment of organisational ULIs in the field of 'eco-friendly transport and mobility' consistently shows benefits through low costs and short-term implementation. These advantages do not apply where the measure is or presupposes the creation of a new concept. This usually requires a lot of coordination and can therefore only be implemented within a medium term. In addition, the costs of creating new concepts are far higher than integrating individual measures into existing planning documents and concepts. Apart from that, some of the exceptions can be explained by the fact that most urban level interventions in this field of action primarily are instructions within an informal planning instrument. In contrast to measures in the other two fields, organisational ULIs in the field of 'eco-friendly transport and mobility' are mostly integrated into informal and therefore less standardised concepts.

The assessment of organisational ULIs in this field of action clearly shows that these measures hardly contribute to mitigating urban heat. The main objective of measures in this field is reducing air pollutants. That means that the effects are actually mostly indirectly induced, by following the organisational measures.

4.2 Technical Urban Level Interventions

Technical interventions at urban level consist of hardware, software and constructions and are often targeted at implementing instances, e.g. housing associations/cooperatives, real estate owners, and commercial enterprises. The catalogue of technical ULIs is presented for the three fields of action below.

4.2.1 Field of Action: 'Settlement Development'

The following table shows possible technical measures in the field of 'settlement development':

Urban Level Interventions		(a) deconstruction of unused building structures and/ or b) Creation of open spaces (impervious or pervious)	Use of bright facade coating	Use of suitable building materials to improve air quality (e.g. photocatalytic coating)	Use of suitable building materials to reduce heat stress (e.g. natural materials such as wood and marble)
Fact sheet		x		x	
Points		8	7	6	6
Time-horizon of the implementation	short term (< 5 years)	x	x	x	x
	medium term (5-10 years)				
	long term (> 10 years)				
Costs for implementation and maintenance	very inexpensive		x		
	inexpensive			x	x
	less inexpensive	x			
	hardly or not inexpensive				
Effectiveness (mitigating and adapting to urban heat islands)	very effective	x			
	effective		x		x
	less effective				
	hardly or not effective			x	
Effectiveness (avoiding and reducing air pollution)	very effective				
	effective	x		x	
	less effective				
	hardly or not effective		x		x

Table 9: Technical Urban Level Intervention within the action field: Settlement Development

Similar to the organisational ULIs in this field of action, the technical measures were also consistently assessed for short-term feasible and (less) inexpensive. In contrast to the organisational ULIs in this field, the technical ULIs are directed towards the building sector e.g., private real estate/homeowners, housing cooperatives etc. For a city-wide implementation these different (individual) owners have to come together, otherwise it would decelerate the large-scale process.

In terms of effectiveness, the assessment shows that ULIs are effective to either mitigate air pollution or urban heat. There is no measure listed in the table that has been assessed as being effective for both objectives.

4.2.2 Field of Action: 'Green Infrastructures and Green Elements'

The following tables show possible technical measures in the field of 'green infrastructures and green elements':

Urban Level Interventions		Installing green facades	Installing extensive roof greening	Installing intensive roof greening	Greening of public road space / Planting trees along streets	Use of ground-covering vegetation / avoidance or artificial covering of bare soil	Development and redesign of parks
Fact sheet		X	X	X	X	X	X
Points		11	10	10	10	9	9
Time-horizon of the implementation	short term (< 5 years)	X	X	X	X	X	X
	medium term (5-10 years)						
	long term (> 10 years)						
Costs for implementation and maintenance	very inexpensive	X	X	X			
	inexpensive				X	X	
	less inexpensive						X
	hardly or not inexpensive						
Effectiveness (mitigating and adapting to urban heat islands)	very effective	X			X		X
	effective		X	X		X	
	less effective						
	hardly or not effective						
Effectiveness (avoiding and reducing air pollution)	very effective	X	X	X	X	X	X
	effective						
	less effective						
	hardly or not effective						

Table 10: Technical Urban Level Intervention within the action field: Green Infrastructure and Green Elements 1/2

Fact sheet			
Points		7	6
Time-horizon of the implementation	short term (< 5 years)		
	medium term (5-10 years)		X
	long term (> 10 years)	X	
Costs for implementation and maintenance	very inexpensive		
	inexpensive		
	less inexpensive	X	X
	hardly or not inexpensive		
Effectiveness (mitigating and adapting to urban heat islands)	very effective	X	X
	effective		
	less effective		
	hardly or not effective		
Effectiveness (avoiding and reducing air pollution)	very effective	X	
	effective		
	less effective		X
	hardly or not effective		
Urban Level Interventions		Creation of fresh air areas	Creation of open water areas

Table 11: Technical Urban Level Intervention within the action field: Green Infrastructure and Green Elements 2/2

The effectiveness of technical ULIs in the field of 'green infrastructures and green elements' is generally assessed as (very) effective, both in terms of their potential to reduce air pollutants and urban heat. Only the potential of open water surfaces – to reduce air pollutants – is considered less effective.

However, the costs are significantly higher in this field of action than in the other fields. This is mainly due to the fact that this field of action includes green infrastructures and green elements that have to be newly created. By doing so, the green infrastructures and green elements also requires additional care and maintenance costs in the future. The technical ULIs in the ‘settlement development’ cause merely lower additional costs, which do not substantially increase the costs that would be incurred anyway.

With exception of the development of open water areas and fresh air areas, the technical ULIs in this field are characterised by the fact that they can be implemented at short notice, according to the assessing team of experts.

The *Detailed report based on numerical simulation of the effect of PCSs at the urban level* (D6.3) shows results of a numerical modelling of urban climate depending on roof greening, facade greening, and trees along the streets. In D6.3, more detailed information on effectiveness are derived from the numerical models.

4.2.3 Field of Action: ‘Eco-friendly Transport and Mobility’

The following table shows possible technical measures in the field of ‘eco-friendly transport and mobility’:

Urban Level Interventions	Effectiveness (avoiding and reducing air pollution): hardly or not effective	Effectiveness (avoiding and reducing air pollution): less effective	Effectiveness (avoiding and reducing air pollution): effective	Effectiveness (avoiding and reducing air pollution): very effective	Effectiveness (mitigating and adapting to urban heat islands): hardly or not effective	Effectiveness (mitigating and adapting to urban heat islands): less effective	Effectiveness (mitigating and adapting to urban heat islands): effective	Effectiveness (mitigating and adapting to urban heat islands): very effective	Costs for implementation and maintenance: hardly or not inexpensive	Costs for implementation and maintenance: less inexpensive	Costs for implementation and maintenance: inexpensive	Costs for implementation and maintenance: very inexpensive	Time-horizon of the implementation: long term (> 10 years)	Time-horizon of the implementation: medium term (5-10 years)	Time-horizon of the implementation: short term (< 5 years)	Points	Fact sheet
a) Redesign of road spaces (deconstruction, greening concepts, wider ancillary facilities, etc.) b) Optimisation of road space distribution (redesign in favour of the environmental network): Pedestrian-friendly traffic area design, construction of cycle paths, construction of pedestrian crossings, crossing aids for pedestrian and cycle traffic				X				X		X				X		8	X
(a) Signs for cycling and pedestrian traffic b) Opening of further one-way streets in the opposite direction for cyclists (c) Supplementing bicycle parking facilities			X		X							X			X	7	
Prevention of parking in the second row to stabilise the traffic flow			X		X							X			X	7	

Table 12: Technical Urban Level Intervention within the action field: Eco-friendly Transport and Mobility 1/2

Fact sheet							
Points		6	6	5	4	4	4
Time-horizon of the implementation	short term (< 5 years)	X		X	X		
	medium term (5-10 years)		X			X	X
	long term (> 10 years)						
Costs for implementation and maintenance	very inexpensive						
	inexpensive		X		X		
	less inexpensive	X		X		X	
	hardly or not inexpensive						X
Effectiveness (mitigating and adapting to urban heat islands)	very effective		X				
	effective						
	less effective			X			X
	hardly or not effective	X			X	X	
Effectiveness (avoiding and reducing air pollution)	very effective	X					
	effective					X	X
	less effective			X			
	hardly or not effective		X		X		
Urban Level Interventions		Creation of further Park & Ride and Bike & Ride facilities	Construction of traffic areas with lower thermal conductivity and -storage capacity (new building)	Modernisation of stations of public transport	Expansion of the 'Metropolradruhr '– station network (bike sharing)	Expansion of charging stations for e-mobility	Expansion of public transport acceleration

Table 13: Technical Urban Level Intervention within the action field: Eco-friendly Transport and Mobility 2/2

The technical ULIs within this field of action have been assessed quite differently with regard to the four criteria (① effectiveness regarding reducing air pollution, ② effectiveness regarding mitigating the urban heat island effect, ③ costs for implementation, and ④ necessary time frame. No clear assessment pattern emerges in this field of action. But with exception of two ULIs, it can be observed that whenever an ULI has been assessed as more effective in reducing air pollution, then it has also been assessed as less effective in mitigating the urban heat island effect and vice versa.

Apart from findings in regard to the assessment criterion 'effectiveness' it can also be seen that the ULIs tend to be feasible in the short to medium term. The costs for the implementation of the measures vary significantly in this field of action. The costs increase or decrease with the scale of the respective measure and its design. For example, signs for cycling and pedestrian traffic, an opening of further one-way streets in the opposite direction for cyclists and the prevention of parking in the second row are much cheaper than optimising the road space layout and the expansion of public transport acceleration.

5 Action Plans for the Living Lab Cities

As outlined in chapter 2.2.2, action plans in the sense of an implementation strategy require clear objectives and consist of several elements:

(1) basis analysis,
(2) identification of problems,
(3) definition of objectives,
(4) development of strategies,
(5) derivation of fields of action,
(6) development of suitable interventions and their prioritisation,
(7) development of implementation strategies and aids, and
(8) implementation, monitoring, and evaluation.

The key objective of the iSCAPE action plan is to strengthen the stakeholders' ability to take action. For this purpose, we presented a catalogue of ULIs that reduce local air pollutants and the urban heat island effects in chapter 4. The information in this chapter 5 delivers a transdisciplinary contribution to the urban development planning in relation to the iSCAPE objectives. In this sense, theoretical considerations are enriched by experiences already gained in the LL cities as part of the stakeholder workshops and field trials. The iSCAPE ULI action plan is positioned in the interplay of theory and practice.

In the following subchapters, the identification of appropriate objectives, strategies, and urban level interventions is explained in more detail. In addition, an especially developed portfolio of urban level interventions is integrated, which is neither binding nor exhaustive, but gives an idea of the direction to be taken and serves as a guidance and procedural framework.

5.1 Identification of Appropriate Objectives, Strategies, and Urban Level Interventions

As described above, one of the first steps of an action plan is to agree on project objectives. Having identified air pollution and especially particulate matters as one of the major environmental burdens of many cardiovascular diseases, which also correlates with the urban heat island effect (Europe, W. Regional Office for H.O. 2011), we aim to mitigate, reduce, and/or compensate air pollution and the urban heat island effect in the cities of Bottrop and Hasselt, which are addressed in this report. This also includes adapting the urban fabric to urban heat stress[9]. These objectives can also be found in common guiding principles such as 'eco-friendly and climate friendly city'.

When developing appropriate strategies, not only current problems have to be taken into account, but also a future perspective needs to be considered, such as future economic, demographic and social changes. Walsh et al. (2011) used an integrated assessment of greenhouse gas emissions also driven by demographic and economic projections to estimate greenhouse gas emissions from different (future) scenarios. Provided that the energy demand per capita and/or unit of economic activity remains constant and the energy production mix and efficiency do not change, increasing emissions in the household, financial, retail and other sectors are the result of population and employment growth in these sectors, while primary and construction emissions decrease (Walsh et al. 2011). At the same time, societal changes such as changes in individual travel behaviour must be taken into account. This illustrates the need for an integrated and interdisciplinary perspective during strategy development.

Taking this integrated and interdisciplinary perspective into account, we need for example:

- land use strategies,
- transportation strategies,
- energy strategies,

but also cross-thematic strategies such as

- communication and collaboration policies,
- resources management strategies,
- financial tools, and
- implementation and monitoring strategies (Tang et al. 2010).

We already developed locally suitable strategies for Bottrop and Hasselt with the help of a SWOT analysis carried out in Task 3.3. The *Report on solutions on urban level* (D3.4) describes the parameters used in the SWOT analysis. The strategies derived for Bottrop and Hasselt are as follows:

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[9] "The UHI effect increases the temperature in cities and thus makes urbanities more predisposed to heat stress compared with rural areas" (Ward et al. 2016). However, there is no commonly accepted or legally defined threshold at which heat stress occurs. For orientation, the *Deutscher Wetterdienst* ('German Weather Service') defines a low health hazard from 20° C apparent temperature and a high health hazard from 32° C apparent temperature (Deutscher Wetterdienst 2019).

Settlement development
Positive characteristics like an adequate mix of functions and sophisticated public transport should be preserved
Further settlement development should take place with respect to the preservation of urban green spaces with special consideration of the maintenance of ventilation channels and other ecologic functions such as groundwater production, habitats, etc.

Table 14: Strategies of Bottrop and Hasselt in the field of action: Settlement development (Mägdefrau et al. 2018)

Green infrastructures and green elements
Existing green and blue spaces should be qualitatively developed and re-evaluated in order to explicitly foster climatic and air quality functions
Further settlement development should take place with respect to the preservation of urban green spaces with special consideration of the maintenance of ventilation channels and other ecologic functions such as groundwater production, habitats, etc.
Build developments that reduce air pollution, e.g. use green walls, roofs and urban farming to improve air quality and temperature

Table 15: Strategies of Bottrop and Hasselt in the field of action: Green infrastructure and green elements (Mägdefrau et al. 2018)

Eco-friendly transport and mobility
Reduce the appeal of driving in a city
Increase the appeal of cycling and walking
Improve public transport
Move to electric vehicles
Better incentives from government to move to more sustainable transport options

Pedestrianise and provide cycle infrastructure in narrow streets (Hasselt)
Create shared use public spaces (Hasselt)
Introduce new urban models of mobility such as the ‘superblock’ - where existing gridded streets within a city are grouped together in small clusters. Traffic is then restricted to outside of this area while the streets inside the superblock become repurposed as community spaces (Hasselt)
Help businesses to understand the positive impact pedestrianisation and shared public space schemes can have in order to reduce fears of a drop in customers if people are unable to drive into the city centre (Hasselt)

Table 16: Strategies of Bottrop and Hasselt in the field of action: Eco-friendly transport and mobility (Mägdefrau et al. 2018)

Besides the three aforementioned content-related fields of action in which the cities crafted their strategies, D3.4 dedicated an additional area related to the cooperation and coordination of different stakeholders and governmental bodies. These collected strategies are not in the focus of the catalogue of ULIs, but the implementation of the interventions requires and fosters such networking activities.

Others
Use the iSCAPE LL Cities as a place to coordinate and bring together different government bodies
Encourage stakeholders to work together in a ‘round-table’ approach

Table 17: Additional Strategies of Bottrop and Hasselt (Mägdefrau et al. 2018)

In addition, we carried out a comparative analysis of strategies, measures and objectives of existing local planning documents and strategies within Task 3.3. On this basis, an appraisal can be made to what extent strategies and objectives need to be pursued more strongly and which are already implemented.

The strategies can be assigned to three fields of action which are important for developing an action plan to reduce air pollution and the urban heat island effect: ‘settlement development’, ‘green infrastructures and green elements’, and ‘eco-friendly transport and mobility’. According to the strategies, suitable and effective activities can now be undertaken in the respective field of action.

The catalogue of ULIs, presented in chapter 4, can be used to select suitable measures. As already described in chapter 3.1.1, we have carried out a criteria analysis during a stakeholder workshop. This analysis identified those ULIs that on average are the most effective, low-cost, and timeliest to implement. The information of this criteria analysis supported the selection of appropriate measures. The ULIs identified in this analysis from all three fields of action are presented in the following subchapter in the form of a fact sheet. These fact sheets also provide more information on different characteristics such as the time-horizon or the costs that need to be spent (see chapter 3.1.2). This information serves as a basis for decision-makers to further select appropriate urban level interventions. In this sense, particular attention should be paid to possible interactions such as positive side effects as well as synergies that can arise between different measures. At the same time, conflicts of objectives and – if possible – negative side effects should be avoided.

With all this information the suitable measures can be easily found in the following portfolio of urban level interventions. The portfolio can be scanned for ULIs from various perspectives on the basis of the respective city's priorities (e.g. costs, suitability) in a systematic approach and makes it easy to find those measure that fit best to initiate action.

5.2 Fact Sheets of Urban Level Interventions

In the following, some of the urban level interventions from the catalogue of measures presented in chapter 3 will be more precisely concretised and clearly presented in fact sheets. The selection of the following portfolio of measures is based on the stakeholder workshop in Bottrop, which functions as a particular pilot city. However, as shown in chapter 5.3 for the example of Hasselt, the measures presented in the following are also relevant for the other iSCAPE cities since they address central problems of heat stress and air pollution in urban areas and present related ULIs. The guidance on selecting appropriate ULIs described in the previous section helps to filter appropriate measures for the respective city that meet the strategy to be pursued.

The order of presentation is based on chapter 4, i.e. first, the organisational measures are illustrated followed by the technical measures. Within this subdivision, the various fields of action are depicted by different colours: orange indicates the topic of 'settlement development', the measures belonging to the field of action 'green infrastructures and green elements' are illustrated in green, and blue represents the subject area 'eco-friendly transport and mobility'.

5.2.1 Organisational Urban Level Interventions

The following fact sheets show organisational urban level interventions and are structured along the three fields of action (① settlement development, ② green infrastructure and elements, and ③ eco-friendly transport and mobility):

Determining the alignment and position of buildings / Keep slopes and air corridors free of barricaded buildings

Large open spaces with cold air production as well as valley locations with flow direction towards the city centre are regarded as particularly sensitive areas for city ventilation. Even in low winds, they contribute to ventilation by transporting cold air. To ensure fresh air ventilation even in low winds, building complexes on the outskirts of the city should be avoided or should not form a barrier. Slopes along cold air corridor should be kept free of building complexes that are parallel to slopes. An appropriate building arrangement and alignment can ensure adequate ventilation.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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This measure is effective for reducing the urban heat island effect in settlement areas and very effective for improving air quality. By keeping slopes and air corridors free of barricading building complexes, it is possible to preserve or rather ensure a free circulation of air. There are three different categories of air corridors:

I. Ventilation lanes ensure air mass transport, regardless the thermal or air-hygienic characteristics.

II. Cold-air paths transport cold-air masses. They are not specified in detail in terms of air-hygiene.

III. Fresh-air paths carry air masses, which are uncontaminated in terms of air-hygiene; but they are not differentiated in detail concerning thermal characteristics.

Efficient ventilation areas should have the following minimum characteristics: an aerodynamic roughness of ≤ 0.5 m with a length to width ratio of 20:1. In the case of valleys, the relief inside and outside a settlement area can additionally lead to channelling effects: fresh and cold air of the surrounding area can be led far into the city. During radiation nights - even when the air is circulated into the opposite direction - low-lying cold air can be led into the settlements and cool down these areas. Inversion weather conditions with inadequate ventilation can impair the air quality. This especially happens in valleys with existing emitters.

Improvement of air quality

Improvement of urban climate (heat stress)

Preservation of connected green areas

Preservation of open spaces (impervious or pervious surfaces)

Preservation of air corridors

Determination of legal limitations of building development (low building density)

Attractive residential areas on the outskirts, areas for recreation close to the city

Areas for biotope and species protection

Reduction of the surface run-off during heavy rainfall due to infiltration possibilities on pervious surfaces

Densely wooded areas disrupt the air flow

Loss of building land by keeping corridors free

Possible increase in wind speeds during storm events

Possibly higher heating demand in the winter months due to stronger cooling of the settlement area

Dispersed urban structures can lead to urban sprawl as well as larger commuter flows

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Participation in the certification procedure 'European Climate Adaption Award' (ECA)

The ECA-process is a quality management and certification process to identify adaptation capacity and to implement climate adaptation measures. The process starts with a qualitative analysis of exposure and sensitivity (climate impact analysis), which identifies the need for action and forms the basis of a structured and technically deposited adaptation process. In this process, the participating cities and municipalities are provided with an individually tailored catalogue of measures to exploit the municipal adaptation potential. In order to use the expertise, interests and design proposals all relevant stakeholders of a municipality are brought together in an interdisciplinary 'climate-unit'. This climate-unit is supported by a network of experts and manages the process of the European Climate Adaptation Award in the municipality.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

In general, all cities and municipalities are allowed to participate in the certification process. However, participation requires a certain amount of know-how. This can partly lead to an exclusion of smaller municipalities with possibly less technical expertise.

The costs may vary depending on the identified impairments, measures and consulting needs of the municipality.
In the first project cycle (four years), the average cost per year per municipality is € 14,488.25 (in 4 years, plus VAT). In the second and also in all the subsequent project cycles (each four years), the average costs per year per municipality are € 10,204.25 (in 4 years, plus VAT).

Improvement of air quality

Improvement of urban climate (heat stress)

Depending on the implemented measures, synergies emerge with other technical and organisational climate adaptation measures.

In general, the potential for synergies is high.

Conflicts arise depending on the measures implemented in the ECA-process

Networking and exchange between relevant stakeholders in working groups within the own municipality as well as exchange and comparison with other participating cities and municipalities The quality management provides the city administration with an overview of implementation statuses Used for dissemination and public relations work	---

Sources

cf. Bundesgeschäftsstelle European Climate Award 2018a; Bundesgeschäftsstelle European Climate Award 2018b; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b

Participation in the certification process `European Energy Award´ (EEA)

The EEA process is a quality management and certification process to promote energy efficiency and climate protection. The aim of the European certification and award programme is to contribute to a sustainable energy policy, to local environmental protection and thus to the sustainable development of cities.
The process steps are structured as follows:

- Analysis: Conducting the situation analysis: recording, analysis, and evaluation of energy and climate protection activities
- Planning: Preparing the work programme: identifying untapped potential in the field of energy efficiency and climate protection in the municipality and defining priorities; on this basis: Drawing up an energy policy work programme with a binding action plan
- Implementation: Implementing projects: continuously implementing measures defined in the Energy Policy Work Programme
- Audit: Internal and external audit of target achievement and quality standards
- Adjustment: Updating the situation analysis: subsequently updating the situation analysis and drawing up an action plan for the coming year
- Certification and award: Depending on the extent to which the objectives have been achieved, the city or municipality is awarded a prize

short term	very inexpensive	very effective	very effective
medium term	inexpensive	**effective**	effective
long term	less inexpensive	less effective	**less effective**
	hardly or not inexpensive	hardly or not effective	hardly or not effective

In general, all cities and municipalities are allowed to participate in the certification process. However, participation requires a certain amount of know-how. This can partly lead to an exclusion of smaller municipalities with possibly less technical expertise.

Has only an indirect positive impact on air quality through the implementation of the measures proposed therein.
In individual cases, effectiveness depends on the individual measures to be implemented.
Basically effective for improving air quality.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Depending on the implemented measures, synergies emerge with other technical and organisational climate adaptation measures.

In general, the potential for synergies is high.

Conflicts arise depending on the measures implemented in the EEA-process

Networking and exchange between relevant stakeholders in working groups within the own municipality as well as exchange and comparison with other participating cities and municipalities.

The quality management provides the city administration with an overview of implementation statuses.

Used for dissemination and public relations work

Sources

cf. Bundesgeschäftsstelle European Climate Award 2018a; Bundesgeschäftsstelle European Climate Award 2018b; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b

Determination of legal limitations of building development (low building density)

In order to reduce the number/size of urban heat islands and also to improve the air quality, sufficient supply of cool and fresh air masses from the surrounding area must be ensured. Cold air production areas outside the settlement area are of particular importance if they are connected to the polluted inner city areas via air corridors. For example, the supply of fresh and cold air from the surrounding area can significantly reduce heat stress in inner cities and improve the air-hygienic situation there.
To ensure a sufficient ventilation of the city even in weak flows, a reduced expansion of the settlement area as well as a lower building density are required. Thus, the supply of cold air masses can cause cooling of overheated areas with suitable wind directions or corresponding relief inclination. The cold air production areas and air corridors are of particular importance, especially when weather conditions restrict the exchange of air, as they can supply cold air in the form of cold air flows or local urban winds, even under limited ventilation conditions. In the surrounding area of a city there should therefore be sufficient open space for the exchange of air between the city centre and its surroundings.
In particular, if there are only a few open spaces as buffer spaces between closely adjacent urban districts or if further construction measures are expected to restrict the supply of cold and/or fresh air, building limits and low site occupancy indices should be set in the outskirts of the city. By doing so, the preservation of climatically valuable open spaces can be ensured. At the same time, lower building densities ensure reduced heating during the day and lower heat emission at night in summer. This is due to the comparatively smaller building volume.

short term	**very inexpensive**	very effective	very effective
medium term	inexpensive	effective	**effective**
long term	less inexpensive	**less effective**	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Particularly suitable for cities with a lower pressure on the development of settlements.

Improvement of air quality

Improvement of urban climate (heat stress)

Determining the alignment and position of the buildings / Keep slopes and air corridors free of barricaded buildings

Preservation of green connection

Advantages	Disadvantages
Preservation and expansion of green and open spaces promotes the development of biotope networks and the preservation of biological diversity	Economic interests partly remain unconsidered
Protection of inner-city regeneration areas from additional building development	Increases existing pressure on the development of settlements
Protection of the outskirts from further settlement development	Dispersed urban structures can lead to urban sprawl as well as larger commuter flows
Protection of open spaces for rainwater infiltration and water retention, reducing the risk of flooding during heavy rainfall by infiltration	Lower building densities can have a negative impact on social concerns in tense housing markets: can lead to or intensify social segregation

Source

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Implementation of building efficiency standards for existing and new buildings

For the implementation of building efficiency standards, energetic standards for refurbishment and new construction projects must be defined and adopted. This should be done in form of a guideline which undercuts the existing legal requirements. The standard criteria relate to the energy requirements of a building, for example primary energy, useful energy, final energy or heating requirements.

Some of the most well-known efficiency standards include:
- *Niedrigenergiehaus* ('Low-energy house') (sometimes also referred to as energy-saving house)
- *Drei-Liter-Haus* ('Three-litre house') (fuel oil requirement of max. 3 litres per m^2 per year)
- *Passivhaus* ('Passive house') (no active heating system needed (`passive´))
- *Null-Energie-Haus* ('Zero-energy house') (no self-sufficient building; the calculated amount of energy generated is equal to the amount consumed)
- *Plusenergiehaus* ('Plus energy house') (the amount of generated energy is higher than the consumed energy)
- 'Energy self-sufficient' house (no external energy is required - at least no heating energy)
  Solar house (active and passive use of solar energy; can also be a zero-energy house, plus-energy house or energy self- sufficient house)

Term	Cost	Effectiveness	Effectiveness
short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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The effectiveness depends on the implemented energy efficiency standard. Due to the significant contribution of energy consumption to the overall emissions of the city, the implementation of comprehensive energy efficiency standards could offer a high potential for energy saving and CO_2 emission reduction goals. By implementing a passive house standard, you could reduce CO_2 emissions by 9 kg/m^2.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Participation in the certification process of `European Energy Award´ (EEA)

Installing extensive and intensive roof greening

Installing green facades

Reduction of energy costs

Improving health and environmental protection

Increasement of the value of the property

The requirements for houses protected under preservation order may oppose the energetic reorganisation

Such standards make it more difficult to offer affordable rents in subsidised housing constructions

Energy efficiency standards must primarily be implemented through funding, incentives and public relations work in existing contexts.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Wüstrich 2018

Preservation of open spaces

Open spaces comprise different forms of use. They can represent both green spaces and (partially) sealed public spaces in the inner city. In outer areas, open spaces are primarily green spaces that supply fresh air. In order to guarantee the preservation of open spaces, they must be secured in the corresponding planning documents.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

---

Green areas in the outer area are the main source of fresh and cold air. Their climatic long-distance effect results from a minimum size of 50 hectares, whereas impervious inner-city open spaces can serve as an air path and to locally ventilate the settlement area, depending on wind direction, area size, design and linkage to the buildings. In the case of vegetation-influenced open spaces, the climatic effect and dust filtration vary depending on the vegetation volume and features. Overall, open spaces are effective in reducing urban heat islands and in improving air quality.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Developing air corridors

Preservation of connected green areas

Preservation of fresh air areas

Impedes urban sprawl and therefore promotes traffic avoidance

Areas for leisure and recreation

Reduction of surface runoff in case of heavy precipitation by infiltration on pervious surfaces

Vegetation-influenced areas for biotope and species protection

Increasing the attractiveness of inner cities

Structuring element in urban settlement areas, separating element between residential areas and emitting industrial and commercial areas or high-traffic roads

Increased wind speeds possible during storms

Loss of building land

When developing new settlements, a loss of open space is inevitable but should be kept as low as possible.

Source

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Preservation of connected green areas

Green networks create connections through green infrastructures, e.g. continuous, green corridors accessible to the public. These green networks are of great importance for the transport of low-pollutant and cooler air in residential areas and can therefore be preserved by securing them in planning documents.
In the sense of a so-called `double inner development´, the focus is not only on the structural re-use of land reserves, brownfield sites and gaps between buildings, as well as the re-densification of areas with originally low settlement density, but also on the development, upgrading and networking of urban green spaces.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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Linked green areas are generally more effective in fresh air production. The connection of the inner city to fresh air areas contributes to the interruption or reduction of urban heat islands and creates regeneration spaces. This connection via air paths should take place without enrichment with pollutants.

☒ Improvement of air quality

☒ Improvement of urban climate (heat stress)

Preservation of open spaces

Preservation of parks

Preservation of fresh air areas

Using as areas for leisure and recreational use, increasing the attractiveness of inner cities

Reduction of surface runoff in case of heavy precipitation by infiltration on impervious surfaces

Water reservoirs

Vegetation-covered areas for biotope and species protection, promoting the biotope network and biodiversity

Creation of evaporation areas, especially in highly dense areas, whereby the evaporation function is only guaranteed with sufficient irrigation

Structuring element in urban settlement areas, separating element between residential areas and emitting industrial and commercial areas or high-traffic roads, distance function

Simultaneous use as mobility routes, partly high potential for parallel use as pedestrian and cycle path connections

Loss of building land

Rethinking plant species to keep effort low in hot summers

Source

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Preservation of fresh air areas

Areas producing fresh air are vegetation-influenced open spaces such as forests and parks as well as agricultural land such as arable land and grassland. The production of cold and fresh air over a natural surface is determined by the thermal properties of the surface substrate. Soils with a high density store heat and are therefore worse producers of cold air than those with a low density and thus lower heat storage capacity. Field and meadow areas cool down more and thus produce more cold air than forest areas. In addition to their function as fresh air producers, these urban green areas and forest areas have a very high climate-ecological significance for the population due to their filtering function of air pollutants and their function as regeneration areas.

short term
medium term
long term

very inexpensive
inexpensive
less inexpensive
hardly or not inexpensive

very effective
effective
less effective
hardly or not effective

very effective
effective
less effective
hardly or not effective

The effectiveness of fresh air surfaces strongly depends on their size.

Improvement of air quality

Improvement of urban climate (heat stress)

Preservation of open spaces

Areas for leisure and recreational use

Reduction of surface runoff in case of heavy precipitation by infiltration on impervious surfaces

Water reservoirs

Vegetation-covered areas for biotope and species protection, promoting the biotope network and biodiversity

Creation of evaporation areas, especially in highly dense areas, whereby the evaporation function is only guaranteed with sufficient irrigation

Loss of building land

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Preservation, development and redesign of parks

Urban green spaces are of great importance for air quality due to the dust filtering function of vegetation and for the local climate, as they have a cooling effect. During the day, an open area, which ideally consists of a meadow with shrubs and low-density tree populations, provides shade and energy consumption due to evapotranspiration to create a thermally balanced area for the built environment. At night, open spaces can have a cooling effect on the environment through cold air production and air exchange. Therefore, it is important to preserve them by securing them in the urban land-use planning, but also to develop or redesign parks.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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Preservation: very inexpensive; development and redesign: less inexpensive

The climatic effectiveness of inner-city green spaces varies depending on the size of the area, its features, design, and linkage to the buildings. Studies have shown that cooling effects can be measured from a park size of 2.5 ha, whereas the cooling effect of an inner-city park extends as far as its diameter. A climatic effect that exceeds the parks' boundaries (long-distance effect) can only be achieved with extensive parks of 50 ha and more. When connected, smaller green areas also contribute to mitigating urban heat islands.

Improvement of air quality

Improvement of urban climate (heat stress)

Preservation of connected green areas

- Dispersed building structures promote ventilation
- Increasing the attractiveness of inner cities, local areas for recreational use
- Contribution to soil protection and increasing its buffer function
- Reduction of surface runoff in case of heavy precipitation by infiltration on impervious surfaces, increase of groundwater recharge
- Creation of evaporation areas, especially in highly dense areas, whereby the evaporation function is only guaranteed with sufficient irrigation
- Noise reduction
- Promoting biotopes, substitute habitat for animals, thus ecological compensation area
- Structuring element in urban settlement areas
- Promoting quality of housing, increasing the market value in residential areas

- Loss of building land

- Rethinking plant species to keep effort low in hot summers

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Implementation of an environmental zone

Environmental zones are areas in which only vehicles complying with certain emission standards are allowed to drive. The environmental zone is a Europe-wide form of municipal measures against traffic-related air pollution if the national limits of air pollution are exceeded.
Currently, four groups of pollutants exist whereas fine particulate emissions are emphasised: the lower the fine particulate emissions, the higher the group of pollutants. According to the respective pollutant group, emissions stickers are available in the three colours marking the respective emission red, yellow, and green.

short term	**very inexpensive**	very effective	very effective
medium term	inexpensive	**effective**	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	**hardly or not effective**

Data evaluations from 26 measuring stations in the Ruhr area showed a decrease in pollution of 2.1 $\mu g/m^3$ or 2.4 $\mu g/m^3$ for particulate matter (PM_{10}) and 3.7 or 1.2 $\mu g/m^3$ for NO_2 on an annual average. This could also be confirmed in model calculations for the change of the air pollution of traffic-polluted roads in the environmental zones with constant meteorology and background pollution.
A reduction of the NO_2 concentration is strongly dependent on whether a green sticker was implemented by retrofitting particulate filters to the existing vehicle fleet or by renewing the vehicle fleet to vehicles with higher exhaust emission standards. In the latter case, an average reduction of about 2 $\mu g/m^3$ (equivalent to approx. 5%) could be achieved on main roads in the Ruhr area due to the environmental zone.
The total mileage has changed only slightly as a result of implementing the environmental zones. The great added value of environmental zones in terms of reducing fine dust is less to be assessed in terms of particle mass reduction than in terms of the type of particles reduced and their health hazard potential.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Has a positive impact on the customer's decision which car to buy, since vehicles with low emissions are preferred

Relocation of emissions and the corresponding environmental pollution (bypassing the environmental zone)

In Bottrop, this measure has already been implemented, in some cases very effectively.

Due to the fact that 90% of cars currently meet the emission standards for a green sticker anyway, the environmental zones with their current criteria have hardly any effect.

In addition, these measures require an effort for controlling the compliance of restrictions.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Green Zones GmbH 2018; UBA 2018; Thüringer Landesanstalt für Umwelt und Geologie 2011

Developing a parking space concept

Parking space concepts help to reduce search traffic, entail the targeted guidance and concentration of stationary traffic and guarantee the optimal use of parking spaces. They prevent parking in the second row to stabilise the traffic flow and optimise residents' parking.
Appropriate individual measures are to be developed based on a user group-specific analysis of supply and demand of parking space. Individual measures are:

- New parking fee regulations including the definition of new fee zones
- Determination of a new fee level and maximum parking duration
- Improvement of the parking guidance system: Partial parking guidance system with information on available parking spaces that are displayed at the respective entrances/exits, information on walking times on a city map or in online navigation systems or smartphones

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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The effectiveness of the parking concept depends on the individual measures it proposes and their implementation.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Greening of public road space / planting trees along streets

Increase in the quality of stay due to reduced parking search traffic

Reduces parking spaces as an incentive to switch to car-sharing

To a lesser extent: deregistration of rarely used cars and of second or third cars

Decrease in the number of car commuters, promotion of a job ticket for public transport

A limited range of parking spaces and/or higher parking-fees could have negative effects on the local retail trade

According to analyses conducted in the City of Bottrop, more parking space is currently available than demanded. Thus, reducing the parking facilities and planting trees in street areas is conceivable although considered with problems from a political point of view. Reducing parking spaces or raising parking fees is not a good starting point for reducing motorised private transport. Rather, it is necessary to additionally implement pull measures for public transport in the context of a parking space concept to guarantee its success and acceptance.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Thüringer Landesverwaltungsamt n.d.

Restriction of transit traffic in inner city areas

In order to relieve the highly frequented inner city area, transit traffic can be restricted. To limit transit traffic in the inner city area, a comprehensive traffic analysis (source, destination and transit traffic) is required beforehand, resulting in appropriate and tailor-made follow-up measures.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

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The effectiveness of the parking concept depends on the individual measures proposed therein and their implementation. Based on experiences in other cities and municipalities, a parking space concept is generally assessed as less effective for reducing heat stress in residential areas and effective for improving air quality.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Promotion of public transport and bicycle traffic

Reduction of noise emissions in heavily polluted inner city areas

Upgrading the quality of life for the resident population in the inner city area

Possible increase in market values in the inner city area

Gentrification processes in inner-city residential neighbourhoods possible

Relocation of transit traffic (bypassing the city centre) in other neighbourhoods, disproportionate traffic loads on bypasses that have not been designed for such a volume of traffic, resulting in higher maintenance costs and the necessary expansion of relevant junctions on these bypasses

Possible weakening of inner-city retail trade

In Bottrop, acceptance problems among the population exist, that hamper the implementation.

In addition, this measure requires a comprehensive analysis of the potential redistribution of traffic volumes, the expansion of possible alternatives (e.g. expansion of public transport) as well as a high effort for controlling the compliance of restrictions.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b

Citizen climate and air measurements and collection of data points in an online map tool

Citizens use cost-effective measurement sensors to collect relevant data on climate and environmental conditions, e.g. airflow, temperature, air quality, and noise pollution. The mobile sensors can be used spatially variable according to own interests in WLAN or SD Card mode. Using a wireless network connection, the data is transferred directly to the online map tool or entered manually. In this way, hot spots can be identified with regard to certain characteristics and information about the own exposure can be derived.

In this way, a close-meshed monitoring network can be created, which can also be used as a decision-making basis for further planning.

It is important that the sensors produce reliable data. Otherwise, the measured data would have to be linked to scientific climate and environmental analyses.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	**less effective**	**less effective**
	hardly or not inexpensive	hardly or not effective	hardly or not effective

There are no restrictions. All cities and municipalities can use this measure.

This is primarily a measure to raise awareness and does not necessarily lead to a reduction in air pollutants and UHI. Nevertheless, it can provide a good information basis for other measures.

☒ Improvement of air quality

☒ Improvement of urban climate (heat stress)

With reliable data, it can be a good decision-making basis for further planning and at the same time be used as a monitoring instrument.

The citizens build up a personal relationship to the topic, more awareness in their daily life and change in habits

Technical problems or unreliable data can give the citizens a false picture of the amount of air pollution and other measured characteristics

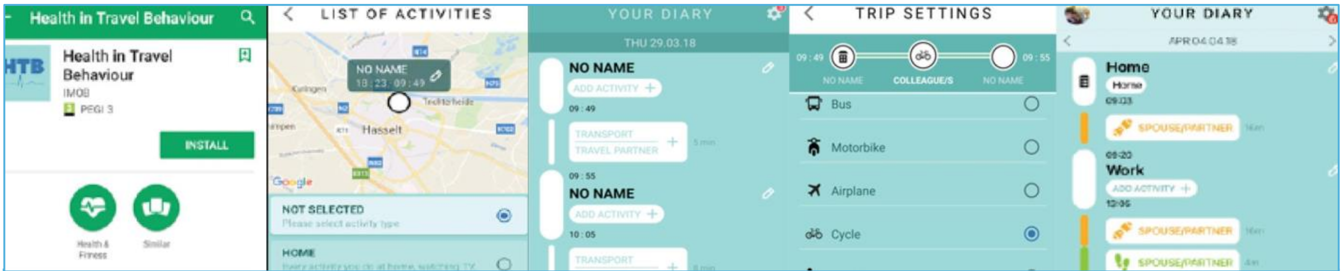
Probably restricted number of users due to limited technical devices

If the weather is suitable (very hot/cold/windy…), people give most reliable information in terms of climate and pollution points without measuring.

More information about citizens using low-cost sensors can be found in *Citizen science communities report* (D4.7).

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; L.I.S.T. Lösungen im Stadtteil Stadtentwicklungsgesellschaft mbH 2017



Providing an application-based customised coaching regarding individual travel behaviour

Using a smartphone application, the individual travel pattern is recorded and examined for exposure to pollutants and alternative, more environmentally friendly travel options, which are summarised in a 'Behavioural Intervention Tool' (customised information package).

This information increases the user's awareness of the consequences of their individual travel behaviour while providing eco-friendly alternative suggestions.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

This application can be used in any city, as long as the necessary data bases are available (e.g., pollutant concentrations/emissions of the respective city or region as well as various supply data of the transport infrastructures).

Rather inexpensive. Up to now, the evaluation has not yet been automated, which consumes comparatively higher personnel resources. However, this can be remedied with further development.

In a study, the iSCAPE team found out that 28% of the users are willing to change their mobility behaviour based on the understanding of the suggestions given in the customised information package.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Possible reduction of motorised private transport.

If the physical movement is promoted by the customised coaching, the health is also promoted.

The application collects highly sensitive data that could reduce the willingness to use it.

Using the application is essential but a bit time-consuming at this early stage, which could make its use unattractive over a longer period of time.

More information about application-based customised coaching can be found in *Report on environmental effects of behavioural actions* (D4.1).

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b
Figures: own figures

5.2.2 Technical Urban Level Interventions

The following fact sheets present technical urban level interventions and are structured along the three fields of action (① settlement development, ② green infrastructure and elements, and ③ eco-friendly transport and mobility):

Deconstruction of unused building structures and / or development of open spaces (impervious or pervious)

A distinction must be made between 1) the creation of unsealed patches (small-scale) on individual properties and 2) the dismantling of one or more building complexes.

1) Soil sealing can be avoided or reduced by using materials with permeable surfaces, especially if the type of usage does not necessarily require highly impervious coverings such as concrete or asphalt. In courtyards, parking spaces, access roads, garage entrances, storage areas, terraces, garden paths, cycle paths and footpaths, concrete and asphalt can easily be replaced by water-permeable alternatives, as long as the rainwater is not heavily polluted.

2) Developing inner-city open and green spaces is hampered by a lack of space. In order to develop more open spaces and vegetation areas as well as possibly air paths unconventional possibilities such as the deconstruction of unused building complexes should also be used. This intervention is e.g. applied in many cities in Eastern Germany. Shrinking phenomena (demographic and economic) require an urban restructuring land generate a framework for green space development. The implementation differs depending on the respective landowner or owner of the building.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

For smaller-scale unsealing measures, impervious areas that do not require traffic are particularly suitable. Road surfaces and parking lots can be partially unsealed and made water-permeable with water-bound coverings, paving with pores or gravel turf.
For reasons of water protection, the distance between the infiltration surface and the groundwater should be at least 1-1.5 m.

1) The costs of small-scale unsealing on individual sites are low. The costs for a gardening and landscaping measure amount to approx. 25 to 40 € per m^2 and depend on the material of the sealed surface.
2) The deconstruction of a building is time-consuming and cost-intensive. At the same time, the potential for improving air quality and urban climate is significantly higher.

The effectiveness depends on the scale of the deconstruction and the subsequent land use.

☒ Improvement of air quality

☒ Improvement of urban climate (heat stress)

Development of air corridors
Development of green and open spaces
Optimisation of road spaces

Energy saving

Contribution to soil protection and increasing the buffer function of the soil

Increasing the quality of housing

Increasing groundwater recharge

Rainwater infiltration, superficial runoff and thus reducing the risk of flooding and inundation

Possible restriction of the possibilities to use the property, claims for compensation

Possible restriction of accessibility

Not possible on contaminated sites

(Unorganised) deconstruction can lead to perforation, which has negative impacts on the urban design

Water-permeable coverings require a suitable substrate so that subsidence can be avoided and water drainage can be ensured. The permeability of ecoplastes can decrease considerably if the pore spaces become clogged. Impervious areas for car traffic such as roads, parking spaces and garage yards offer great potential for deconstructing, but climate adaptation measures are often difficult to implement there.
The measure is currently being implemented primarily for business reasons and less for climate adaptation reasons.

This measure is also partly used for properties whose owners cannot be found or where there are no heirs.

Sources

cf. Beckmann et al. 2014; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Use of photocatalytically active paving stones and / or coatings

Photocatalytic paving stones and coatings function according to the principle of photocatalysis: the non-toxic titanium dioxide (TiO_2) is used as the catalyst. The catalytic effect of titanium dioxide is produced under the influence of UV radiation, i.e. sunlight. In this natural phenomenon, the substance acting as a catalyst accelerates the speed of a chemical reaction, in this case the oxidation of toxic nitrogen oxides. The reaction product is water-soluble nitrate, which is dissolved and discharged by rainwater. The nitrate can then serve as a nutrient for plants.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Particularly suitable and effective is the use of photocatalysis in the immediate proximity of emission sources.

The additional material price for paving stones is around 8-10 € per m^2. There is currently no information available on the costs of photocatalytic coating.

A scientific study proves that under optimum conditions and maximum solar radiation up to 80% of nitrogen oxides are degraded in a few hours. According to the manufacturing group, this process usually requires seven days without the photocatalytic surface. In case of low solar radiation, a reduction in pollutants of up to 70% can be achieved - measured in the `human recreation area´ (0 to 2 m above the pavement).
At a height of 3 m and at average illuminance levels (30% below the annual regional average) reduction rates of 18% for NO_2 and 29% for NO were demonstrated in a long-term field trial under changing conditions (wind and light). In calm conditions, the NO_2 reduction rates reached up to 70%. Considering the general conditions prevailing in the field experiment, annual reduction rates of 25% for NO_2 at a height of 3 m were achieved under the average brightness conditions in Central Europe.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Photocatalytic surfaces are 'self-cleaning', saving of opportunity costs for floor and/or facade cleaning (incl. energy and labour costs)

Maintenance-free when surfaces are coated, reducing maintenance costs and effort

The nitrate produced during the conversion of exhaust gases can be used as a plant fertilizer

The stones would not be suitable for rural areas with heavy fertilisation due to the risk of groundwater pollution.

So far, results from long-term studies do not exist and therefore reliable information on longevity cannot be provided. It is assumed that the stones will last about 25 years. Like all catalysts, titanium dioxide is not consumed. Its effectiveness is thus maintained throughout the entire 'lifespan' of the pavement or coating. Studies on vulnerability to frost, dew and other possibly damaging climatic and environmental influences require more detailed research.

More information about the iSCAPE study on photocatalytic coatings can be found in the *Report on photocatalytic coating* (D3.6).

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Müller 2006; Oebbeke 2008; STEAG Power Minerals GmbH 2015; University of Kassel 2012

Installing intensive roof greening

Intensive roof greening includes planting of shrubs and woods as well as lawns and trees. With the appropriate equipment, they can be compared with ground-based open spaces in terms of the variety of uses and designs. These plants place high demands on the layer structure and on the regular supply of water and nutrients. The height of the overall structure is about 15 to 100 cm, the load to be considered is between 1.5 and 3.0 kN per m^2, in roof gardens also over 3.0 kN per m^2.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Plants for intensive roof plantings must be resistant towards dryness and insensitive towards wind and frost. Depending on the thickness of the soil layer, small or medium-sized shrubs as well as perennials and grasses are suitable.
Only professionally sealed roofs with a corresponding static load capacity or load reserve are suitable for intensive planting. Therefore, intensive roof greening is only suitable for new buildings. In addition, they only make sense on flat roofs.
In some cases, the preservation order is opposed to planting greenery.

This form of greening can only be maintained permanently through regular, intensive care; irrigation is necessary in dry phases. Experts see the life of green roofs as `infinite´ if they are laid and maintained properly - practical experience to date has been 30 to 40 years.
The cost guideline values amounts to approximately 60 euro per m^2 in case of a 1.000 m roof surface. Anyway, the costs depend on the structure, equipment and plant selection.

Significant effects on the microclimate only arise in a larger network. The thermal effects of green roofs are mainly due to the attenuation of temperature extremes over the course of the year. For example, grass can reduce maximum surface temperatures by up to 24° C.
The foliage, the air cushion and the evaporation in the vegetation layer reduce the heating of the roof surface in summer and the heat loss of the building in winter. This leads to a more balanced air conditioning of the rooms below.

Improvement of air quality

Improvement of urban climate (heat stress)

Ground-covering vegetation, avoidance or artificial coverage of bare soil

Participation in the ‘European Energy Award’ and ‘European Climate Adaptation Award’ certification procedures

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Advantages	Disadvantages
Protection of the roof seal against extreme temperatures and weather conditions such as hail and thus doubling the service life of the roof seal Energy savings through insulated roof areas (green overlay) Rainwater retention, thus relieving the sewerage system and saving on wastewater charges Development of biotopes Noise protection Visual upgrading of the building Improving the quality of stay and recreation	Very high maintenance efforts (comparable to gardens), irrigation necessary during dry periods No long-distance effect

Sources

cf. Armson et al. 2012; Beckmann et al. 2014; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Installing extensive roof greening

Extensive plantings are near-natural forms of vegetation that are largely self-preserving and self-developing. Especially, plants which easily adapt to extreme site conditions as well as plants with a high regenerative capacity are used. The largely closed, extensive vegetation stands are formed from rather low-growing mosses, succulents, herbs and grasses.
Functional layers of the roof greening: protective layers, drainage layer, filter layer, vegetation support layer.
Planting construction (single-layer or multi-layer): Low-nutrient, mineral substrate layer. The height of the layer structure is approx. 5 to 20 cm, the weight approx. 50 to 170 kg/m². Extensive plantings weigh about 120 to 150 kg/m² in water-saturated condition, depending on the height of the structure.

Time	Cost	Effectiveness	Climate
short term	**very inexpensive**	**very effective**	very effective
medium term	inexpensive	effective	**effective**
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Extensive greening can easily be implemented on flat and inclined roofs, up to an inclination of approx. 15 degrees. Anyway, it is also possible to implement roof plantings, as long as the inclination of the roof surpasses 15 degrees. In these cases, the measurement is technically more complex as constructive measures are required to secure the thrust of the green roof structure. Due to their low weight, extensive green roofs unlike intensively planted roof gardens can be retrofitted to almost all buildings.

Extensive green roofs can be realised from 25-35 Euro per m². Care and maintenance costs are low and limited to one to two inspections per year. The service life of professional care is 30-40 years.

Significant effects on the microclimate only arise in a larger network. The thermal effects of green roofs are mainly due to the attenuation of temperature extremes over the course of the year. The foliage, the air cushion and the evaporation in the vegetation layer reduce the heating of the roof surface in summer and the heat loss of the building in winter. This leads to a more balanced air conditioning of the rooms below.

☒ Improvement of air quality

☒ Improvement of urban climate (heat stress)

Ground-covering vegetation, avoidance or artificial coverage of bare soil

Participation in the 'European Energy Award' and 'European Climate Adaptation Award' certification procedures

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Advantages	Disadvantages
Simultaneous use of photovoltaic systems possible: The cooling effect of vegetation, especially on warm summer days, contributes to an improved efficiency of the individual cells Protection of the roof seal against extreme temperatures and weather conditions such as hail and thus doubling the service life of the roof seal Energy savings through insulated roof areas (green overlay) Rainwater retention, thus relieving the sewerage system and saving on wastewater charges Noise reduction Substitute habitat for animals, thus ecological compensation area Visual upgrading of the building	Possibly not feasible due to the statics of roof surfaces, roof loads, etc. Maintenance effort, irrigation in dry periods to maintain the cooling function Unwanted growth possible Snow loads must be removed to maintain function So-called ‘carpet formation’ due to secondary vegetation: water lies on the surface. That can sometimes induce counterproductive effects. No long-distance effect

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Installing green facades

Facade greening serves to protect and beautify a building as well as to improve the microclimate of the built environment. A distinction is made between wall-based and ground-based facade greening. The ground-based vegetation is planted on an outer wall with climbing plants, which are either self-climbing or which require an appropriate climbing aid. There are also newer forms of vertical greening ('vertical gardens', 'green walls'). Wall-based greening systems usually form the facade of the outer wall and replace other materials.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Both self-climbing and scaffold climbing plants can be used. There are also wall systems without ground connection. Almost all climbers need climbing systems, usually with steel ropes or wooden grids.
Self-climbing plants include Virginia creeper, ivy and hydrangea. Climbing aids are required for wine, honeysuckle, clematis, wisteria and rambler roses. For wall-based vegetation systems, geraniums, evergreens etc. can be used. Self-climbing systems should only be implemented on resistant facade surfaces which can withstand additional vertical loads and are free of joints and ruptures. Buildings which are classified as historical monuments may not be suitable.

The installation costs at least 30 Euro per m^2. The costs for care and maintenance are about 400 Euro per m^2.

Significant effects on the microclimate only arise in a larger network. The thermal effects of facade greening are mainly due to the attenuation of temperature extremes over the course of the year. The foliage, the air cushion and the evaporation in the vegetation layer reduce the heating of the wall surface in summer and the heat loss of the house in winter. This leads to a more balanced air conditioning of the rooms behind.

☒ Improvement of air quality

☒ Improvement of urban climate (heat stress)

Participation in the 'European Energy Award' and 'European Climate Adaptation Award' certification procedures

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Energy saving through thermal insulation in winter

Protection of the facade against moisture loads

Development of biotopes

Noise protection

Visual upgrading of the building

Improving the quality of recreation

High maintenance efforts

Plants can affect the building materials

Preservation order can be opposed to planting greenery

No long-distance effect

Wall-based facade planting cannot or just hardly be retrofitted due to static conditions

Sources

cf. Beckmann et al. 2014; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Greening of public road space / Planting trees along streets

Motorised transport is one of the main sources of air pollutant emissions. The environmental impact can be reduced by planting dust filtering vegetation along existing transport infrastructures. This includes planting trees and small hedges at the roadside as well as greening separation strips or track beds with grass.
In street canyons with a high traffic volume, it should be noted that the ventilation situation can be restricted by having a closed tree crown system, so that air pollutants can no longer be easily removed. Therefore, trees with smaller treetops or with sufficient spacing or other vegetation measures should be favoured.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

In order for trees to develop in a species- and function-appropriate manner, the corresponding development area of approx. 1,000 to 4,000 m^3 must be available both above and below ground. A tree pit of at least 12 m^3 is required underground. This seems to be hardly feasible in road space due to competition for land use; only parking strips are available as space.
Appropriate street trees are characterised by the fact that they are adapted to the extreme urban climate conditions and, for example, can survive dry periods in summer and at the same time withstand the low winter temperatures and have a high pollutant tolerance. Other favourable factors are deep root penetration, robust bark, a low proportion of dead wood, and a lack of fruit fall. Typical street trees include lime trees, ash trees, hazel trees, horse chestnuts and plane trees. Due to climate change and global warming, the proportion of foreign tree species will increase (e.g. honey locust and hop-hornbeam). At the same time, an increased diversity of species in urban areas can prevent possible risks from new, heat-loving pests.

The cost of a road tree including planting lies between 900 and 1,000 €, depending on the tree species and size. The expenditure for the tree disk by means of demolition work, high board etc. also needs to be added. According to information from the Department of Environment and Green of the City of Bottrop, a total of 4,000 to 5,000 € per street tree can be expected.

Effective and cost-effective measure. Basically, the effectiveness varies depending on the vegetation volume planted. Tree shade reduces maximum surface temperatures by up to 19 °C, while tree plantings can reduce the physiological equivalent temperature value by up to 100 times (compared to facade and roof plantings).

Improvement of air quality

Improvement of urban climate (heat stress)

Preservation and development of connected green areas

Use of ground-covering vegetation /avoidance of bare soil areas or usage of artificial covering

Creation of a larger range of parking facilities as part of a parking space concept

Reducing energy consumption and waste heat in shaded buildings

Noise absorption depending on vegetation volume

Increase of aesthetics, improvement of the quality of stay, shading

High maintenance efforts, irrigation necessary during dry periods

Conflicts with profitable uses of road space, competition space utilisation claims with sidewalks, bicycle lanes and parallel parking spaces (alternative collective parking spaces are often not accepted by the citizens)

Trees and plants should not create any obstacles to cold and fresh air flows in air paths

Ventilation situation can be restricted by having a closed tree crown system; this may lead to increased pollution levels at significant emission sources below the tree crown

Canals or routed cables along the roads can make it difficult to plant trees

Road safety concerns (e.g. necessary visible areas) may be opposed to trees from being planted

Different tree species emit different amounts of volatile organic compounds, which contribute to the formation of ozone. These trees can thus contribute to an increase in ozone pollution and are not suitable for greening roads

Raising awareness and acceptance among the population possible through mobile green elements such as wandering trees. In Bottrop, the priorities set for the use of traffic areas are currently in favour of motorised private transport and environmental modes of transport (bus, train, bicycle, and walk).

Urban trees are particularly affected by sealed and compacted soils due to limited ventilation of the root area, nutrient deficiency and water shortage, which usually require intensive tree care (watering, ventilation measures, etc.).

Traffic areas are often reduced in size, so that there is hardly any additional space for greening roads.

Sources

cf. Armson et al. 2012; Beckmann et al. 2014; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b

Use of ground-covering vegetation / avoidance or artificial covering of bare soil

Dried-out and vegetation-free soil surfaces warm up to the same extent as sealed surfaces do and can promote heat stress in cities in summer months. This effect can be reduced by planting or covering non-sealed areas with soil-covering vegetation at best and artificial coverings at worst.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

The suitability of the measure and especially of greening depends on the size of the area concerned. Where planting is not feasible or appropriate, bare soils can be covered with (artificial) materials such as bark mulch to reduce evaporation from the soil.

The effect of the measure increases with the size of the area planted or covered, but significant impacts on the microclimate of an urban district only occur on a larger implementation scale. For example, grass reduces maximum surface temperatures by up to 24 °C, but has little effect on local air temperatures and, thus, is hardly perceived by humans.

Improvement of air quality

Improvement of urban climate (heat stress)

Greening of public road spaces

Improving the infiltration of rainwater in urban areas

During the next precipitation event, severely dried out soils lead to a situation in which a larger part of the water cannot seep away and therefore drains off superficially, this has negative effects on soil erosion and groundwater recharge and increases the risk of flooding during the heavy rainfalls

Conflicts of land uses in limited road spaces

Due to a frequent lack of personnel resources, the necessary care can be lacking, therefore, artificial covering (paving) is preferred

Risk of littering

Sources

cf. Armson et al. 2012; iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Steinrücke 2016

Using mobile green elements

Mobile green elements can take various forms, but are essentially characterised by being mobile and, to a certain extent, temporary interventions. Exemplary forms of mobile green are:

- Wandering Trees (LL Bottrop or other case studies such as Munich)
- *Prinzessinnengarten* ('Princess Gardens') (Case study in Berlin)
- *Mobiles Grünes Zimmer* ('Mobile Green Rooms') (EU project TURaS)
- City Trees (Case studies: Oslo, Glasgow, Paris, Dresden, and Hongkong)

Using mobile green elements provides information and raises awareness on environmental topics in local politics, in city administrations and among citizens. Topics such as 'Cooling by Green', 'Climate', 'Noise Reduction' and 'Pollutant Filtering' are addressed through planning and implementing those interventions and can be experienced.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

Permanent use of mobile green elements is particularly suitable in areas where no planting is possible due to pipes in the ground.

The climatic effectiveness of mobile green elements varies depending on the size and features of the green element.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Greening of public road spaces / Planting trees along streets

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Increasing the quality of stay

Raising awareness and increasing acceptance of green elements in public spaces

Very high maintenance and irrigation efforts (especially in warm periods)

High organisational and planning efforts for the use of mobile green elements in the context of Living Lab events

Acceptance problems in the installation of mobile green elements

Possibly stress for the plants

Acceptance problems may arise in residential streets, especially with regard to the possible elimination of parking spaces. These measures are more suitable for raising awareness rather than actually improving air quality or urban climate.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b; Journal Frankfurt 2018

Figure: own figure

Optimisation of road space and road space layout

This measure comprises several individual measures, including the deconstruction of unused road spaces to create wider ancillary installations in combination with greening concepts, but also the redesign of the road space layout in favour of more environmental modes of transport. This includes, for example, a pedestrian-friendly traffic area design and the construction of cycle lanes as well as the construction of pedestrian crossings or crossing aids for pedestrian and cycle traffic.

short term	very inexpensive	very effective	very effective
medium term	inexpensive	effective	effective
long term	less inexpensive	less effective	less effective
	hardly or not inexpensive	hardly or not effective	hardly or not effective

The suitability must be assessed for each individual measure and depends on the respective spatial conditions.

The costs are to be assessed for each individual measure. In principle, however, the set of measures is rather cost-intensive.

Very effective for reducing heat stress in residential areas (in connection with greening concepts) and very effective for improving air quality by promoting eco-friendly transport modes.

☒ Improvement of air quality

☐ Improvement of urban climate (heat stress)

Deconstruction of unused building structures
Greening of public road space / planting trees along streets Use ground-covering vegetation / avoidance or artificial coverage of bare soil

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Increasing the attractiveness of pedestrian and cycle traffic

Promotion of public transport

Reducing the attractiveness of the motorised individual transport, reducing noise emissions

Improvement of the quality of stay and aesthetics of the street space

Conflicts with accessibility requirements possible

Technical rules may prevent an allocation in favour of environmental modes of transport

Greening of roads should be carried out taking into account the volume of traffic and thus pollutants, i.e. it should not restrict the ventilation situation. On heavily frequented roads, only one-sided tree planting along the roads is generally recommended. This measure requires a consideration of usage requirements of all road users. An interesting side note: in contrast to car traffic and bicycle traffic, pedestrians do not have lobbies or other representatives of their interests in Germany. Even pedestrian concepts are hardly or never available, so that pedestrian interests might not be equally involved.

Sources

cf. iSCAPE Workshop 2018a; iSCAPE Workshop 2018b

5.2.3 Qualitative Weighing with regard to Interactions and Side Effects

As part of the cooperation with the Bottrop LL, a qualitative assessment of the interactions between the urban level interventions presented in the fact sheets was also carried out by an interdisciplinary team during a stakeholder workshop, as described in chapter 3.1.3 (see Figure 12). This weighing is based on the experiences with already applied ULIs and focuses on the interactions between ULIs as well as possible side effects.

Figure 12: Some of the outcomes of the qualitative weighing (iSCAPE Stakeholder Workshop II in Bottrop, 29.10.2019) (own figure)

First of all, in the complex system of a city, all interventions trigger interactions or side effects with other parts of the system. Therefore, an integrated and interdisciplinary approach, as described in chapter 2.2.3, is urgently needed. In the sense of a resource-saving and efficient implementation, these interactions and side effects are the basis for a prioritisation within the framework of the iSCAPE action plan. Synergies received a slightly higher weighting than positive side effects and conflicts of objectives received a lower weighting than negative side effects. The results of the qualitative weighing are shown in the following figure.

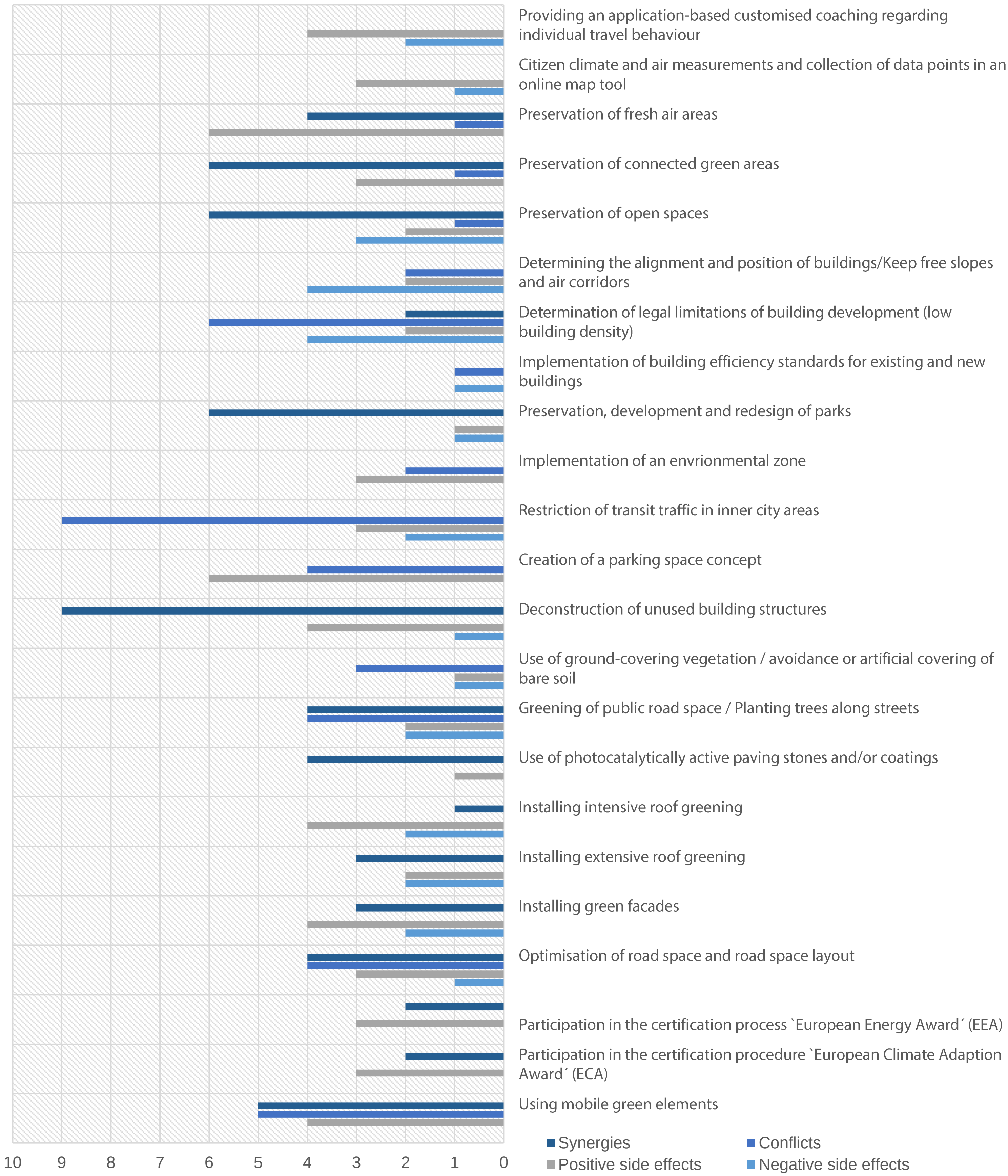

Figure 13: Results of the qualitative weighing (own figure)

The figure illustrates that some of the presented ULIs are particularly impressive because of their valuable synergy effects (see chapter 3.1.3.1 for the definition of synergy effects). Such 'win-win' measures that are having numerous synergy effects with other measures include the preservation of open spaces and green networks, the usage of mobile green elements and the deconstruction of unused building structures. Where appropriate and feasible, these measures often are preferred according to the results of the qualitative weighing. These ULIs should therefore be prioritised in the selection of appropriate measures.

According to the participants, other ULIs do not necessarily trigger valuable synergy effects, but generate particularly positive side effects: the participation in the certification processes 'European Energy Award' and 'European Climate Adaptation Award', as examples, entail additional desirable developments. These side effects may have various dimensions: economic, social, and ecological. The individual side effects can be found in the fact sheets. Measures with valuable positive side effects should have a second priority in the selection of appropriate measures.

According to the results of the qualitative weighing, some of the proposed and discussed urban level interventions have to be carefully considered since they could also trigger or foster undesirable developments. The weighing within this category is less pronounced than the positive side effects. Nevertheless, determining legal limitations of building development or the determination of the alignment and position of buildings were assessed as 'critical' since they may increase existing settlement pressure or foster the phenomenon of urban sprawl due to further dispersing of urban structure. It is difficult to make a general recommendation for implementing, however, in individual cases these measures can be sufficient enough. These measures should have third priority in the selection of appropriate measures.

At the same time, other ULIs trigger conflicts of objectives to avoid. For this reason, these measures should either not be applied or compensation options should be taken into account. For example, the restriction of transit traffic in inner city areas is heavily weighted and again the limited building development is striking in a negative sense. Such measures that cause strong conflicts with other stated objectives should be taken into account when selecting appropriate measures with the lowest priority.

5.3 Field Trial of Urban Level Interventions in the Living Labs Bottrop and Hasselt

This subchapter describes the experiences of the LL cities Bottrop and Hasselt in regard to the implementation of two urban level interventions to raise awareness. Local action plans should provide comprehensive awareness of air pollutions and UHI (Tang et al. 2010). The information about the field trials helps decision-makers to select and design appropriate measures.

5.3.1 Field Trial Bottrop – Wandering Trees

In the Living Lab Bottrop, we developed a Wandering Tree parade together with the city administration and local citizens (see *Community feedback reports* (D2.5); see Figure 14). The Wandering Trees are planted in pots on wheels and temporarily green the streets of the city centre. The intervention enables citizens to experience the effects of the trees on the local air quality and other benefits first hand. It becomes particularly important when it comes to land use competitions in limited street space, especially in relation to the provision of parking spaces. In case of competing uses, opportunity costs are often one of the decisive characteristics.

This means for citizens and their judgment of green infrastructure interventions:

- which advantages do I have from sufficient parking space and which advantages do I have from trees in my immediate surroundings?

The publicity-effective Wandering Tree parade and the active participation of the citizens helped to raise the awareness on the advantages of trees and to increase the acceptance of trees in street space. For this reason, the LL intervention is to be seen as a public relations measure at urban level with the aim of changing behaviour or mind-set.

Figure 14: Impressions of the LL event when the Wandering Trees first move into the neighbourhood (own figure, © Silva Ritter & Jana Wilhelm)

The lessons-learned

The feedback from the citizens involved in the Wandering Tree parade was mostly positive (see *Community feedback reports* (D2.5)). During the parade, a broader consideration for the environment and air quality in general has been observed across all participants. At the same time, the participants were actively involved in the process, which increased their willingness to participate. The active participation and co-creation of knowledge were particularly highlighted by many participants. After the parade, some of them confirmed that they would make specific behaviour changes – including more environmentally friendly travel behaviours and improved waste management/recycling etc. (see *Community feedback reports* (D2.5) and *Report on interventions* (D5.3)).

However, we also learned that it is difficult to maintain the motivation and commitment of participants over a longer period of time. Appropriate ways must be found to keep up the motivation of the citizens involved. In addition, we experienced already known difficulties in reaching people who are usually not involved in participation processes. People who take part in such measures usually have a basic interest in the respective topic. However, measures to raise awareness should also reach people who do not necessarily have a certain level of pre-interest. Therefore, the appropriate form of address and public relations work is an essential aspect.

However, the LL was successful because it brought together many different actors of an urban society and contributed to improving the relationship between the municipality and the citizens. The relationship is decisive when developing and implementing urban level interventions, including the development and implementation of action plans. For this purpose, the co-creation of knowledge processes like those of the Bottrop LL are an essential foundation.

Furthermore, the representatives of the City of Bottrop expressed themselves positively about the intervention (Representatives of the City of Bottrop 2019). If this urban level intervention unfolded a direct impact on Bottrop's air quality policy cannot be clearly determined at this early stage (Representatives of the City of Bottrop 2019). However, the Wandering Tree parade is undergoing a second iteration for 2019 based on the successful parade in 2018 (Representatives of the City of Bottrop 2019). The implementation creates a high degree of public recognition and added value that might be achieved through simple political beliefs or statements (Representatives of the City of Bottrop 2019).

5.3.2 Field Trial Hasselt – Customised Coaching

In the Living Lab Hasselt, University of Hasselt conducted a behavioural change study together with city administration of Hasselt on urban level (see *Community feedback reports* (D2.5) and *Report on environmental effects of behavioural actions* (D4.1)). The aim of this study was to encourage pro-environmental behaviour among citizens by designing informational-based behavioural interventions. The Hasselt LL focused on how to influence travel behaviour by recording individual activity travel patterns using a smartphone application (see Figure 15) and providing a 'Behavioural Intervention Tool' i.e. a customised information package (see Figure 16) that can provide users the 'consequences' (air pollution effect) of their travel behaviour and suggestions to organise moves that are more environmental friendly.

This approach may help citizens become more active and healthy while improving the air quality in the city at the same time. However, it should be noted that this ULI include highly sensitive data on daily movements of individuals which may reduce a positive participation of individuals in the campaign.

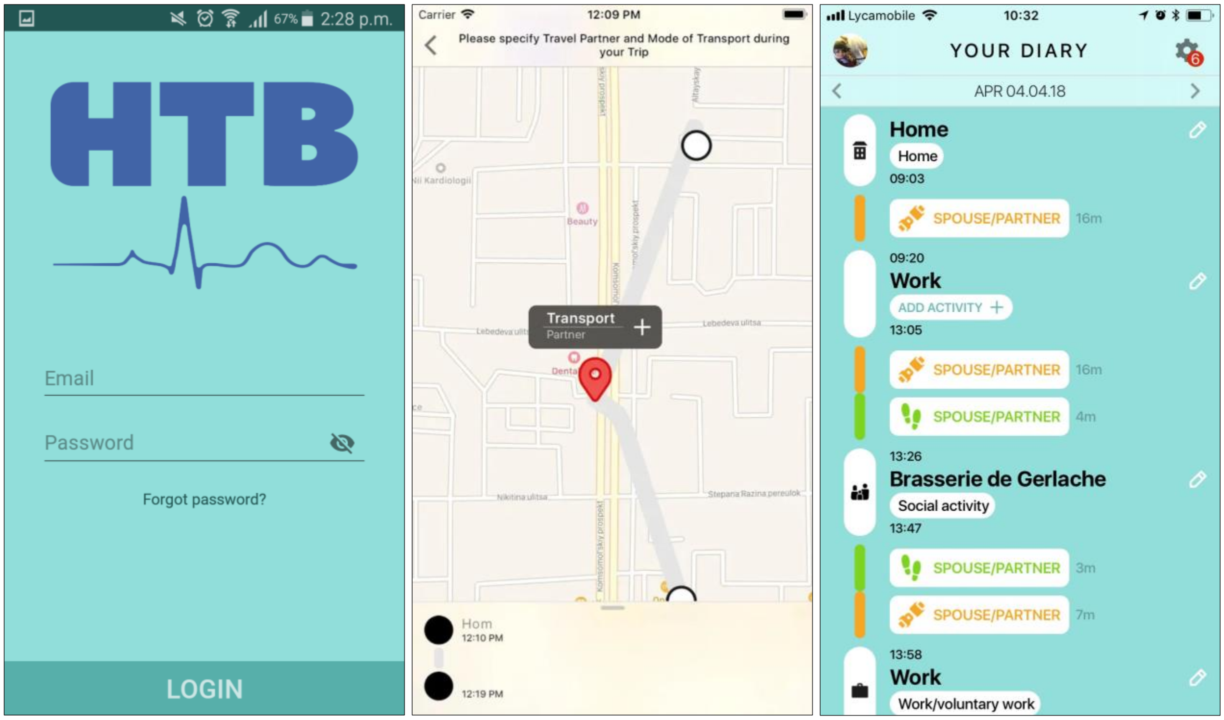

Figure 15: Some screenshots of the smartphone application (own figure)

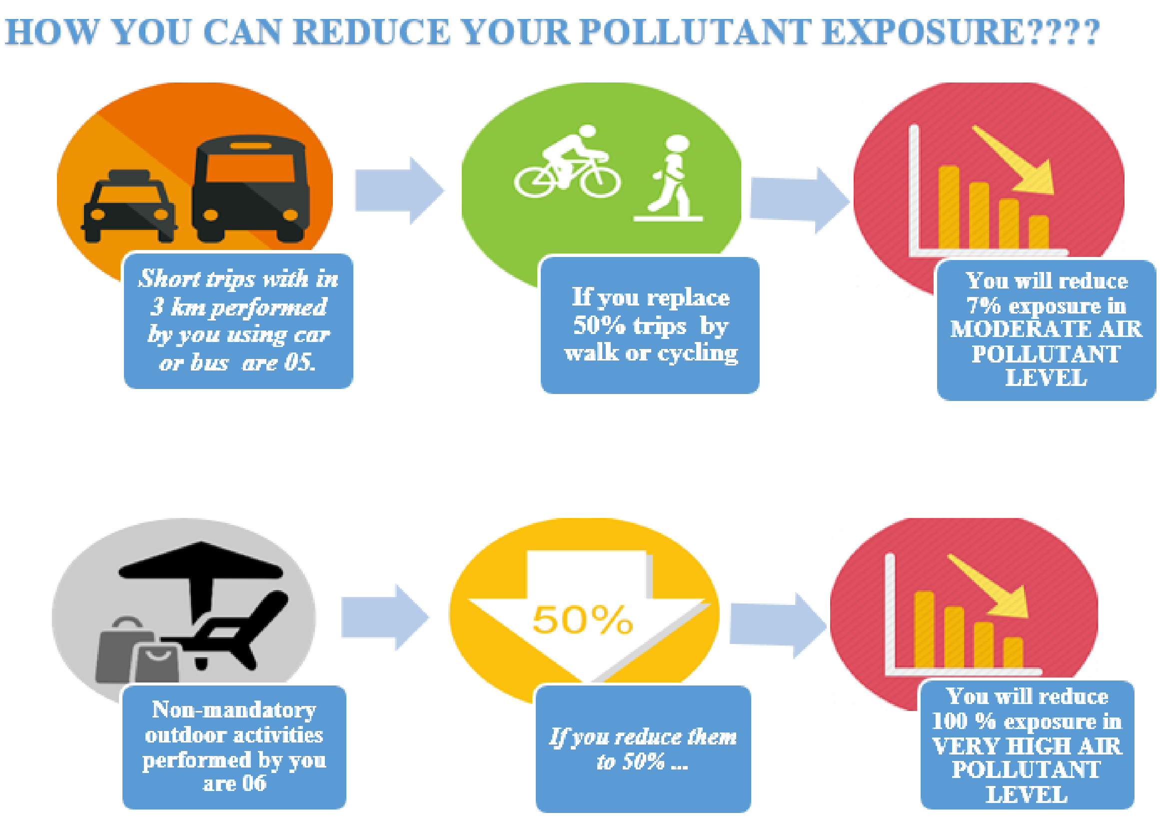

Figure 16: Part of the customised information package (example) (own figure)

<u>Study results</u>

The results of the intervention are promising: based on the records of the movement, there is a significant potential for the transition to a more sustainable travel/activity alternative. In addition, it was found that more than 40 percent of the study participants do not travel often on foot and/or bicycle. Furthermore, the results show that 40 percent of the participants were willing to change their mobility behaviour based on the understanding of the suggestions given in the customised information intervention (see *Report on environmental effects of behavioural actions* (D4.1)).

<u>Space for improvement</u>

The study showed that the participants see a great importance to the user-friendliness of the smartphone application.

- They prefer to have the entire execution process automated.

  At the moment, there are several steps that are performed incoherently:

  1) The daily travel routine of participants is recorded by the smartphone application.

  2) Data processing, for example to find out how many trips can be changed in terms of modes, is done offline.

  3) Once the processing is completed, the participants receive a customised information package (in the form of a document).

  4) The participants are asked to read this information so that they can learn more about the consequences of their activity travel pattern and also try to change it in a positive direction.

  The idea is to do this as a fully automated process, from start to end. Automation is possible, but requires considerable resources.

- Perfect technical conditions such as the data collection mechanism must be created. Due to bad signals, GPS-based data cannot always capture locations.
- The information provided about the consequences of the activity travel pattern needs to be very specific. The University of Hasselt currently only provide information on exposure reduction when a certain change in the activity travel pattern is made. Information regarding health effects should also be provided in the future.

The representatives of the City of Hasselt expressed themselves positively about the intervention, but there were some reservations about a large-scale implementation since the methodology is currently not fully automated and important sensitive data are collected. The City of Hasselt stated that more studies could be carried out in a reduced scale, e.g. not the whole travel pattern, but a part of it, such as commuting to work or school. The data collection of such a regular activity will be very simple and the information provided can be more effective. It is decided that a few similar types of this intervention can be designed and experimented especially with schoolchildren. With a number of such studies, more results would be available and there would be more confidence to make a decision for implementation on a larger scale.

6 Recommendations for further Action and Implementation

To successfully develop and implement an action plan and its urban level interventions, essential requirements have to be considered: developing suitable implementation strategies, integrating ULIs into implementation instruments and financing as well as the cooperation with/and acceptance by the population and other relevant stakeholders. In this regard, we provide the following various information and recommendations.

A good action plan is oriented along developing implementation strategies, ...

There are various strategies that can be used for the implementation of action plans, e.g., mainstreaming or dedicated implementation. Actions to reduce air pollution and the urban heat island effect require resources, objectives and a formal distribution of responsibilities for these topics (Uittenbroek 2012). However, scientific analyses found out that the approach in practice requires strategies that do not only address these challenges, but consider a wider range and solutions (Uittenbroek 2012). This is also the case for 'mainstreaming' approaches which aim to integrate air pollution and the urban heat island effect into intersecting fields of policy-making, which lead to a framework for innovation. These approaches have a positive impact on policy making itself since they increase its effectiveness/efficiency (Uittenbroek 2012). Integrating or 'mainstreaming' these topics into relevant policy areas makes them visible to stakeholders and enhances the opportunities for consideration of environmental concerns in decision-making (Uittenbroek 2012). Mainstreaming can be understood as holistic/cross-sectoral involvement that helps to promote a targeted use of resources, both financial as well as personal (Schipper and Pelling 2006; Klein et al. 2007).

Various obstacles can occur within mainstreaming institutional requirements, which must be met to guarantee its success. Missing political support or insufficient attention of the general public and a not helpful management could complicate the process of mainstreaming. Barriers also might arise in organisational terms due to a lack of existing organisational structures or the absence of an effective coordination (Uittenbroek 2012). Some of the designated barriers can also function as opportunities when it comes to reducing air pollution and UHI. A competition with other objectives can be inspiring and in the best case scenario leads to interlacing and intertwining with other ambitions within the political realm (Uittenbroek 2012). The mainstreaming process itself is expected to entail obstacles and chances with regard to technical, organisational, institutional, economic, and social issues (Uittenbroek 2012).

Whether in a mainstreaming strategy or in a dedicated stand-alone strategy, some action plans are criticised because they do not provide sufficient guidance on aspects which are crucial to achieve its objectives. Examples of such aspects are the definition of responsibilities, the associated working structures and processes to support the implementation processes. Furthermore, estimation and availability of the necessary resources in terms of labour force, know-how and costs, the integration in governmental and municipal budgeting, and a timetable to facilitate progress monitoring are essential (Marletto et al. 2012; Mickwitz et al. 2009; Ribeiro et al. 2009; Swart et al. 2010;

Representatives of the City of Bottrop 2019). In some cases, the implementation of measures is simple, in others, there are lengthy procedures to finance or develop the technical design (Marletto et al. 2012). Appropriate precautions must therefore be taken in advance.

In the sense of a mainstreaming or stand-alone strategy, successful implementation and realisation of an action plan require the incorporation in politics and public administration. Existing institutional structures should be used for observing, accompanying and advancing the process. Moreover, these structures should be enlarged and further developed during the drafting of an action plan. Consequently, the topic of UHI and air pollution must be comprehensively anchored in municipal structures, political decisions or convictions/commitments and urban policies. Referring back to the investigated case studies, particularly with regard to the stakeholder workshops, sensitisation to the topic as fundamental step can definitely be assumed and might engage the stakeholders to introduce/weigh in the topic into their various areas of responsibility (Representatives of the City of Bottrop 2019).

… merged with existing implementation instruments and tools, ...

In order to be able to efficiently implement ULIs, they must be transferred to context-specific existing implementation instruments that differ from member state to member state and partly even between cities being located in the same country. Both formal and informal instruments are available. While the formal ones are binding, informal instruments are mainly based on self-commitment.

Formal instruments are usually laid-down in the respective planning laws of a member state (Hübler 2005). Informal planning instruments are less formalised and are primarily used to influence the behaviour of spatial users (property owners, producers, road users, house builders, leisure users, nature conservationists, etc.) through information, incentives, etc. in accordance with predetermined principles and objectives (Hübler 2005). In many cases these informal instruments are consensus or acceptance oriented and intended to be convincing rather than ordered and developments are to be encouraged (Hübler 2005). Therefore, the choice of implementation instruments depends on the stakeholder group to whom the measure is addressed, e.g. state actors, economic actors or the citizenship.

The possibilities for implementing action plans result from the respective planning systems in Germany and Belgium. A selection of the given options can be found in the following table (see Table 18).

	Germany, North Rhine Westphalia, Bottrop	Belgium, Limburg, Hasselt
Formal planning instruments	• *Flächennutzungsplan* ('Preparatory Land Use Plan') • *Bebauungsplan* ('Legally-binding Land Use Plan') • *Städtebaulicher Vertrag* ('Urban Development Contract')	• *Gemeentelijk ruimtelijk structuurplan* ('Municipal Spatial Structure Plan') • *Ruimtelijk uitvoeringsplan* ('Spatial Implementation Plan')

	Germany, North Rhine Westphalia, Bottrop	Belgium, Limburg, Hasselt
	• *Gestaltungsrichtlinie* ('Design Guideline') • *Grünentwicklungsplan* ('Green Development Plan') • *Grünordnungsplan* ('Open Space Plan') • *Eingriffs-Ausgleichs-Regelung* ('Impact Regulation') • *Landschaftsplan* ('Landscape Plan') • *Biotopverbundplanung* ('Biotope Network Planning') • ...	• *Bijzondere plan van aanleg* ('Special Plan of Construction') • *Stedenbouwkundige voorschrift* ('Urban Planning Regulation') • *Klimaatadaptatieplan* ('Climate Adaptation Plan') • ...
Informal planning instruments	• Integrated urban development concept • Masterplan • Energy concept • Greening concept • Road space greening concept • Funding programme • Consulting service • ...	• Masterplan • Energy concept • Greening concept • Housing concept • Mobility plan • Funding programme • Consulting service • ...

Table 18: Examples of formal and informal planning instruments in Bottrop, Germany and Hasselt, Belgium

When choosing the adequate implementation instrument, different needs and necessities come together: How effective is the instrument in term of its contribution to the objectives such as the necessary behavioural change of the addressees and the formation of new structures (Knieling and Roßnagel n.d.)? What are potential (intended and non-intended) side effects?

The city administration often prefers the binding character of a formal instrument as it facilitates implementation due to legal and planning security. Formal instruments tend to have a long-term character, whereas new environmental and societal challenges such as air pollution and climatic impacts require an up-to-date and sometimes flexible urban planning response (Priebs 1999). Here, informal instruments offer greater flexibility. In addition, it is undisputed that in view of the complexity of the task, coordination and cooperation between all relevant stakeholders are becoming increasingly important (Knieling and Roßnagel n.d.). Therefore, both binding instruments and flexible, non-formalised instruments should be combined for implementation. In any case, informal instruments do not compete with formal planning, but are intended to support its implementation.

Besides, formally and informally regulated economic instruments promise to expand the scope for action for reducing air pollution as well as climate mitigation and adaptation (Knieling and Roßnagel n.d.). Funding means are a powerful lever for the implementation of planning objectives. Financial incentive structures must be created, depending on whom the measures in an action plan are aimed at. This concerns measures that are the implementation responsibility of the city administration, but even more interventions that are to be implemented by the citizenship (iSCAPE Workshop 2018b). On the one hand, national or European funding must be made available, but on the other hand, it also must be made available for citizens to implement certain measures.

… requires cooperation with and acceptance by the citizens and other relevant stakeholders, …

Legitimacy and implementation of action plans are not automatically justified by superordinate and subordinate relationship between planning instances and implementing instances or plan addressees (Ritter 1998). Planning objectives, contents and their acceptance are interwoven by the cooperation of actors in the planning process (Ritter 1998). Information, conviction, acceptance and willingness to cooperate are therefore becoming increasingly important planning resources (Representatives of the City of Bottrop 2019; Ritter 1998). There are different possibilities of participation, cooperation, co-creation, and bringing stakeholders together depending on the target group. Scenario workshops [10] or roundtable discussions [11] are only two of many opportunities.

Important target groups need to be involved, including administrative stakeholders which represent the various departments, but also the civil society/citizens. In the field of air pollution and UHI, these are the following actors:

- representatives of the department of urban planning,
- representatives of the department environment,
- representatives of the department transport and mobility,
- representatives of the business development, and
- corresponding thematically involved civil society interest groups.

It is important that the diverse group of stakeholders come together when discussing air pollution and UHI and that they are integrated into the planning process of the interventions, as shown by the second iSCAPE stakeholder workshop (see chapter 3.1.3). The participation of an interdisciplinary team while creating an action plan enabled us to bring conflicting interests together for the first time. Moreover, it promotes the ability to reach a consensus (Representatives of the City of Bottrop 2019). At the same time, resulting networks represent an essential added value, also in the sense of integrated

[10] "A Scenario Workshop is a participatory method encouraging local action with a mix of scenario and workshop which aims to solve local problems and anticipate future ones. […] scenarios direct attention to causes, areas for development and the span of exigencies that may be met in a local community issue [.]. The workshop is the […] [interactive element] of this method in which participants from a local community engage in discussion, produce some sort of action through deliberative discussion and act as decision-makers or create a communal plan of action." (Smith 2012)

[11] "Roundtable Discussions are small group discussions where everybody has an equal right to participate. This method can in reality encompass a number of different formats. […] Roundtables are generally not open to the wider public, but involve a relatively small number of participants who discuss or deliberate on a topic" (Parry 2018).

planning (Representatives of the City of Bottrop 2019). The relationships established through the workshops can be utilised and maintained for future planning initiatives (Representatives of the City of Bottrop 2019). In addition, the participants of these workshops act as multipliers, bringing the topic into their specialist area and other parts of the urban society (Representatives of the City of Bottrop 2019).

Further advantages and benefits can result from the chosen cooperative approach through the target group citizenship (Representatives of the City of Bottrop 2019). As described in chapter 2.2.2, the local knowledge of citizens significantly contributes to the improvement of action plans. At the same time, a broad participation of citizens in the process of developing action plans can increase the legitimacy of the respective plan (Burby 2003).

Finally, the support of political actors is crucial for implementation (Representatives of the City of Bottrop 2019). There must be powerful political actors who have committed themselves to the mission of reducing air pollution and mitigating UHI. Additionally, they have to be informed about the costs of increasing air pollution and heat stress and how these can be minimised by using various sectoral ULIs in a synergistic manner (Dulal 2017). Knowledge on positive welfare effects of these measures eases their implementation (Dulal 2017).

… and is completed by an evaluation before revised in the next cycle.

An action plan is neither fixed nor static, but dynamic and flexible in terms of adjustments to changing framework conditions: “The strategic plan is no more than a momentary reflection of agreements” (Faludi 1989, p. 138). In this sense, strategic spatial planning is based on collective learning, building consensus, and changing or adjusting existing routines according to new evidence (Wiechmann 2008).

As described above, air pollution and UHI are challenging issues for cities in many ways. However, it is possible and even likely that new fields of action arise and need to be targeted or new priorities need to be set by urban development (Marletto et al. 2012). This makes continuous monitoring of the baseline trend and subsequently an evaluation of the impacts of the action plan necessary in order to flexibly adjust it to new challenges or fields of action.

The setting-up of an action plan, based on an integrated and strategic approach, can be guided by the scheme of the urban development control cycle (see Figure 17). Such a cycle is also used within the field of climate adaptation strategies, where it refers to the policy cycle for adapting to the consequences of climate change (see e.g., BBSR 2016). Usually, the process is divided into six consecutive phases, which can serve as an orientation for the complex and demanding task of developing, implementing and evaluating strategies. However, the cycle also allows it to enter at a later stage.

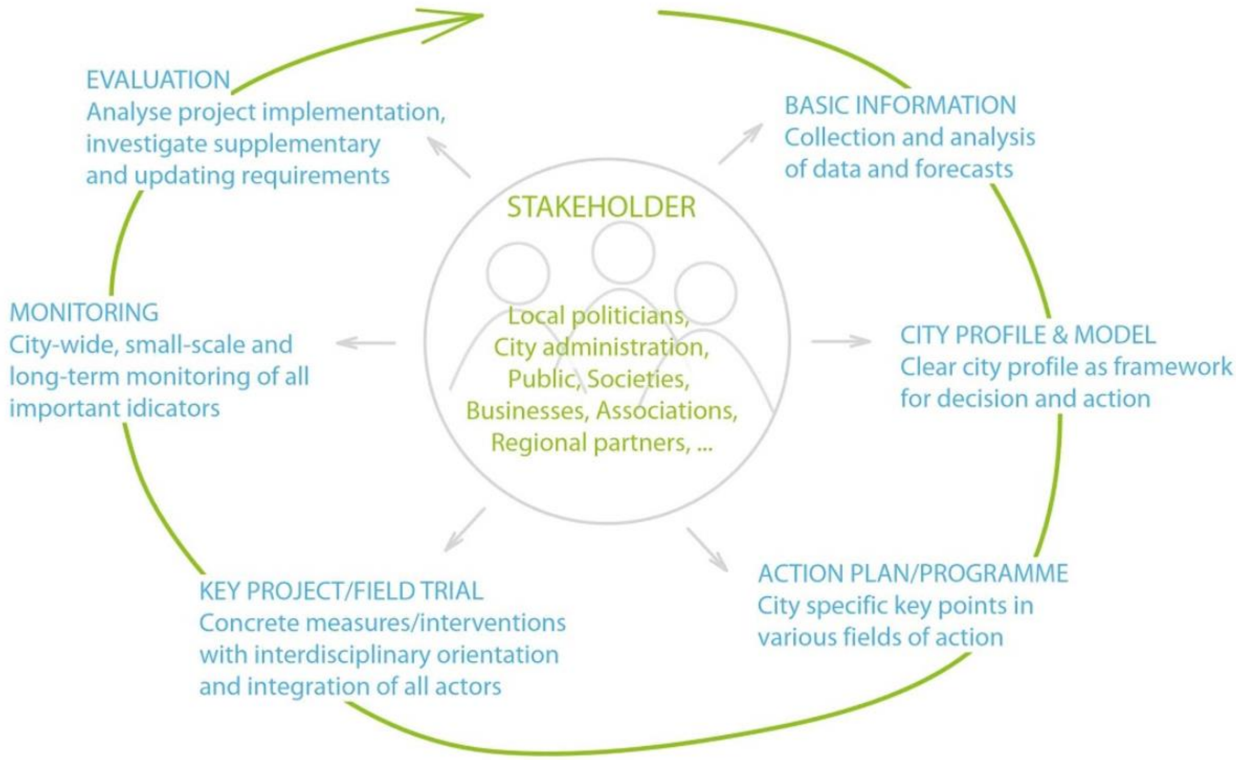

Figure 17: Urban development control cycle (own figure based on German Association of Cities 2013)

The results of both stakeholder workshops that took place in Bottrop and Hasselt are essential attributes to the 'key projects' phase. The previous steps 'basic information', 'city profile and model' and 'action programme' have been developed in a similar form in Task 3.3 and presented in D3.4. The two steps 'monitoring' and 'evaluation' are still pending.

The evaluation is an important quality management tool (German Association of Cities 2013). Concerning integrated urban development strategies, the evaluation cannot be fully carried out by using standardised and quantified methods (German Association of Cities 2013) as objectives and strategies in action plans are complex/mutually dependent. Furthermore, these specifications for a targeted pathway are difficult to express in terms of quantity which occurs only partially and they remain sometimes vague at the measure level (German Association of Cities 2013). In addition, the impacts of action plans cannot always be clearly distinguished from other social and economic factors so that a mix of methods is useful to evaluate integrated action plans at the urban level (German Association of Cities 2013). If possible and practicable, quantitative methods can be used to measure the fulfilment of objectives (German Association of Cities 2013). Guiding questions can be: were air pollutants reduced and was the reduction lower or higher than expected, and what were the costs (Marletto et al. 2012)?

The analysis of documents, expert discussions or workshops with relevant actors allow to qualitatively evaluate the impacts of action plans (German Association of Cities 2013). In addition to the objectives, the evaluation should also consider planning, communication and decision-making processes (German Association of Cities 2013). One example of the guiding questions could be: what were the problems and how were they solved (Marletto et al. 2012)? The evaluation should go beyond the mere assessment or measurement of impacts and should be used as a learning process for all actors involved in the development and improvement of the urban action plan (German Association of Cities 2013). In this way, process problems can be identified and, if necessary, external procedural support can be requested (Representatives of the City of Bottrop 2019). The evaluation can be carried out after the planning and implementation processes, but can also be conducted parallel to the process or, as ex-ante evaluation of potential effects of measures, even precede it (German Association of Cities 2013).

As Figure 17 shows, developing and implementing an action plan is a cyclical process where monitoring and evaluation is similar to basic analysis at the beginning of the development process (Marletto et al. 2012).

7 Conclusions and Outlook

For flexible planning of the spatial and settlement structure, existing and appropriate informal and formal instruments or alternative urban development strategies and procedures can be used. Action plans, as well as pilot projects or model and lighthouse projects, are suitable for implementing priority measures or innovative and integrated solutions. This applies especially to municipalities which prefer complex strategies (e.g. energy, climate protection and adaptation concepts, air pollution control plans, master plans or urban development plans). Here, informal instruments such as action plans (self-binding if the implementation is regulated by contractual agreements) make an important contribution. In contrast to formal instruments, informal instruments can be used in a more flexible and problem-oriented way. They should be taken into account when drawing up formal plans and offer valuable planning alternatives.

In the chapters above, we have presented a transdisciplinary contribution and basis for the development of an action plan aiming at mitigating air pollution and UHI. As described before, selective use of urban level interventions is not the optimal way to handle complex urban challenges such as air pollution and to achieve environmentally friendly and climate-friendly urban development (Dulal 2017). Instead, an integrated use of several instruments and interventions in different sectors, at various spatial levels and fields of action are necessary (Dulal 2017). This is the basis of the development steps for an integrated action plan as propagated by this report.

These steps include a catalogue of possible ULIs (based on strategies presented in D3.4) that were discussed and assessed regarding their effectiveness, costs, and time-horizon on the basis of the experiences of an interdisciplinary team in collaboration with city administration employees. The assessment of organisational interventions on the urban level shows that they are often cost-effective and can be implemented at short notice, regardless of the field of action. Technical measures are of course more cost-intensive, but have, opposite to many organisational ULIs, immediate effects. In principle, effectiveness and required resources must be considered more closely and weighed against each other. Altogether, the presented catalogue of ULIs offers many possibilities and information, also for other European cities.

We have also presented specific fact sheets of those ULIs that were most effective, low-cost and implementable in short term. These fact sheets were supplemented by experts and then qualitatively weighed with regard to their interactions and side effects in order to be able to prioritise measures. This way, they serve as a decision-making tool for urban planners in Bottrop and Hasselt, but also in other European cities.

Moreover, we have illustrated the development process of two ULIs and both interventions were successful in terms of raising awareness. The field trials showed what we have learned during the development and implementation process, but also how important such measures are for raising the awareness of the population and the city administration. Due to the success of Bottrop LL intervention the Wandering Trees will be repeated next summer. Next time, there will be a specification of the target group and adjustments in public relations to address the identified motivation problems. The study on customised coaching was also very positive and was successfully tested not only in Hasselt, but also in Bologna and Guildford.

Enabling cities to implement the suggested ULIs in an effective and beneficial manner, calls for a closer cooperation and coordination between agencies of various sectors. In doing so, it can be ensured, that measures addressing urban externalities such as congestion and air pollution foster mitigation and consider other side effects. Local authorities are asked to promote a more flexible and accommodating approach for solving cross-sectoral challenges in urban contexts (Dulal 2017). Before this takes place, however, existing barriers in implementation have to be faced by the respective cities. In particular, these include: the given lack of understanding and information of increasing air pollutants and heat stress, political support and funding, personal and institutional capacity and collaboration between authorities (Dulal 2017).

In a next step, the suggested interventions at the urban level are to be agreed upon by city administrations in Bottrop and Hasselt and implementation barriers need to be removed. This requires appropriate implementation strategies and budgetary planning that define responsibilities and provide funding. Afterwards, the ULIs must be adopted by local assemblies.

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