Thematic report

Ecomodernizing infrastructures with nature-based solutions
for urban resilience (resilient ecosystems)

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1. Introduction

For cities to be resilient, it is important to be supported and serviced by reliant infrastructures to climate and social change. Infrastructures are fundamental for basic services in cities to be ensured and equally provided such as drinking water, drainage and sanitation, mobility and accessibility, and electricity as well as healthcare and education. In the face of climate change, cities are now targeting to update and enlarge the existing infrastructures that are stressed with the every changing pattern of rainfall, heat and wind. The past decade, cities that were frontrunning in testing new infrastructures for climate change resilient showcased that infrastructure solutions based and inspired by nature prove more effective and cost-efficient on the long-term than traditional cement-based, or, as commonly named in literature: grey infrastructure solutions.

Nature-based solutions are inspired by nature, use nature and/or are supported by nature. Specifically, nature-based solutions have been defined as living solutions underpinned by natural processes and structures that are designed to address various environmental challenges while simultaneously providing multiple benefits to economy, society and ecological systems (European Commission, 2015).

The reason for a new concept of a sustainable solution such as nature-based solutions is the need from cities to update their infrastructures while ensuring that the new places receiving the new infrastructure are also livable and appealing to citizens. 'Green' solutions like nature-based solutions can well be combined with grey infrastructure and there is a design and operations' challenge on how these two infrastructure options can be combined to ensure reliable service to urban citizens. A celebrated example includes the raingardens and bioswalles infrastructure in Malmo's Augustinsburg neighbourhood already from late 1970s that showcases how the dual infrastructure system on water retention works. Other cities around the globe have also invested in nature-based solutions for flood management with promising and positive results, including Melbourne, New York, Rotterdam and Copenhagen. Another well celebrated example of a large-scale nature-based solution is the Room for the River program in the Netherlands, that put in place river renaturing projects across the Rhine in the country and influenced in many ways local projects in the city such as renaturing the Boomjes promenade and the water squares. These examples are populating cities in Europe and can be inspirational for other cities that are now in the process of rethinking and re-designing their urban infrastructures to deal with the climate pressures and stresses. As such, nature-based solutions become a valid alternative for

infrastructure development and update in cities that are considering (new) approaches and rethink their time horizon and costs in maintaining them.

Nature-based solutions are set to deliver multiple benefits for social and climate resilient in cities. Nature-based solutions are being taken up as solutions to restore ecological flows in cities and as new infrastructure solutions that increase resilience of a city in the face of climate change adaptation and disaster risk reduction. They are locally attuned solutions to societal contexts and challenges while contributing and maintaining natural capital in the location that are situated. As systemic solutions they further support the positioning of cities as spaces of innovation rather than spaces where problems and symptoms are located. As recently stated by Flint (2016) "nature-based solutions lay the foundation for sustainable development and human well-being". Nature-based solutions incorporate elements of green and blue infrastructures that enhance and contribute to ecosystem processes. Nature-based solutions are therefore socio-spatial interventions and have the potential for transformative impact in cities via creating new relations between people with their space/locality and between people and nature when integrated in the existing infrastructural nexus of cities.

Box 1: Definition of Nature-based solutions.

"Nature-based solutions are defined as actions to protect, sustainable manage, and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits." (International Union for Conservation of Nature, 2016)

Nature-based solutions are multifunctional. This means that they deliver multiple different services to cities and their inhabitants at the same time. For example, an urban park lowers surface and ambient temperatures during a warm summer day, providing cooling and temperature regulation. At the same time, the urban trees filter the air pollutants, hold the runoff water and provide habitat to birds, and other animals (depending on the region these differ from foxes in Berlin to tigers in Bangalore, India). Next to these benefits, urban parks also provide refugee to citizens to relax during the day, to contemplate and to connect with nature. In this way, nature-based solutions provide simultaneously ecological, social and economic benefits. As opposed to grey infrastructures that are single-purpose and often consider natural flows as 'risks to be dealt with' rather than inherent flows of the urban environment, nature-based solutions contribute in restoring and preserving natural flows such as water and air.

Nature-based solutions come in different forms and designs. Nature-based solutions such as green roofs, green walls, renatured urban wedges, urban parks, flood plains, constructed wetlands, bioretention swales, and raingardens are already tested across Europe. They have shown that they are effective solutions in dealing with urban challenges such as floods, temperature regulation and providing good quality public spaces for recreation and social activities. Specifically, permeable surfaces created by rain gardens, riparian forest systems, green roofs tackle with excess water in the urban environment, ameliorating the risks of flooding and

water 0logging. Bioretention swales, constructed wetlands and rain gardens can be stand-alone systems or combined with existing grey water infrastructure and collected and remove pollutants. Urban trees, green and blue urban spaces and green roofs and walls can help in temperature regulation, especially cooling during heat waves by increasing ventilation and decreasing ambient temperatures. In coastal cities, nature-based solutions like the urban dunes protect coastal cities from coastal flooding and erosion. Such areas also benefit from restoring and preserving wetlands, saltmarshes and dune systems that create natural buffers to continuous coastal stresses and erosion.
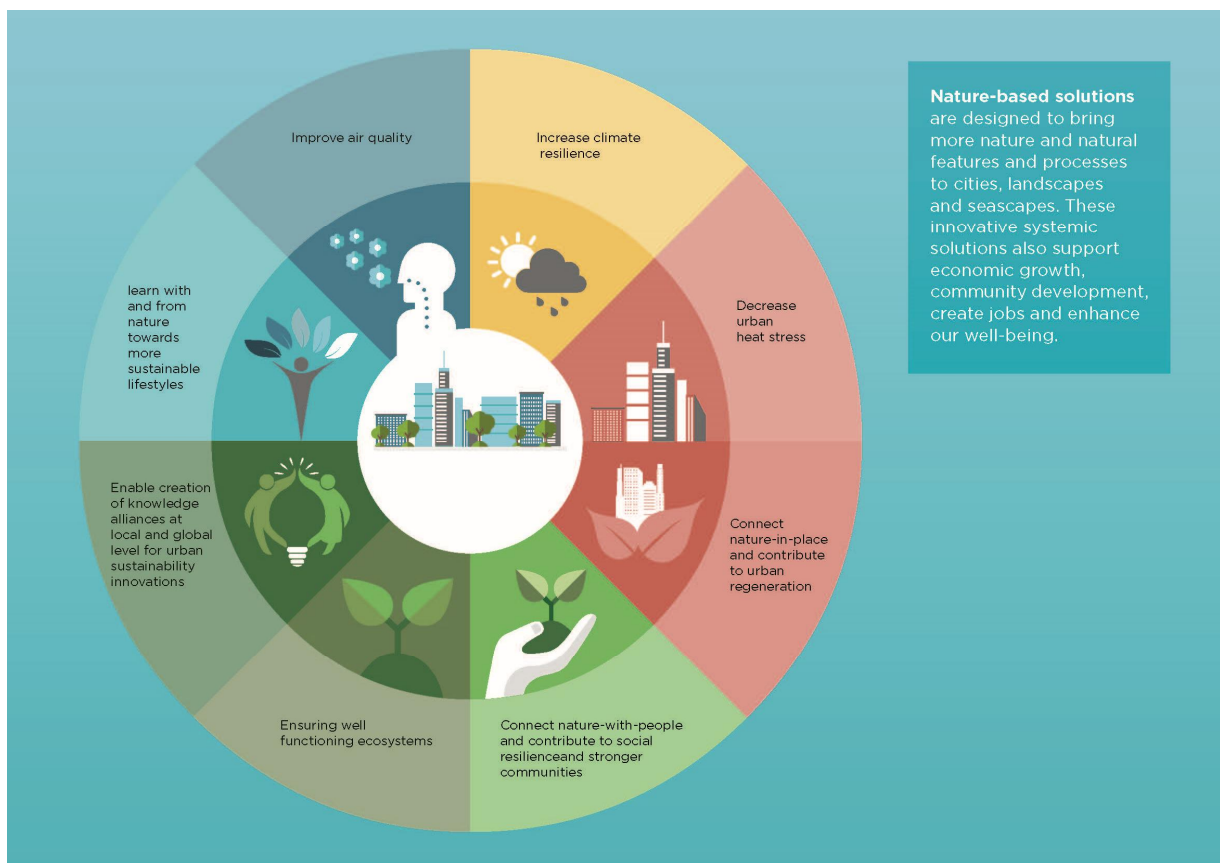
Figure 1: Illustration of the multiple benefits of nature-based solutions (Source: Frantzeskaki 2016 – EU-Brazil dialogues brief on nature-based solutions presented in UN Habitat III, Quito, Equador).

Nature-based solutions exactly because they are designed to be and to support nature, benefit the cognitive and mental health of people. Specifically, they provide space for people to relax, to recover from stress and to improve their health and well-being (Ambrey and Fleming 2014; Carrus et al 2015). Current literature both in scientific and in popular journals reports on the benefits of urban parks as remaining of the nature that once was in cities or of urban planning achievements, reporting lowering of stress levels, of blood pressure, and as recognized places for reconnecting with nature. The focus on parks all over Europe and the globe reasonates since parks are in every city, in different sizes and quality characteristics for urban use and for

biodiversity, and are in the maintenance and investment plans of all (or most) of the cities. Many cities that lost or compromised their parks over the years due to development pressures and austerity that resulted in poor maintenance, now have an opportunity to regenerate these parks as multi-functional spaces, employing ideas and tools (mainly design and engineering tools) from nature-based solutions. Examples include Singapore's central park that employed new concepts for vertical forests, re-introduced native biodiversity in the city and allowed for nesting and nurturing of urban bees and birds. Singapore may now casts all the lights in the global scene for how to bring nature back to the city with forward looking urban planning and design, there are however more European examples to look after for inspiration. One example comes from Barcelona, with the support from the city on urban gardens and urban parks to be well maintained and to be also connected with the city-wide greening project of green wedges, roof tops and roof gardens that will deal with the urban heat stress the city faces.

Nature-based solutions are also contributing to regenerating urban areas especially by creating or re-making connections between people and nature (Xiang et al 2017). This results in establishing or rekindling sense of place and in return, sense of community that are drivers to urban transformations. Specifically, accessibility and open use of good quality green spaces has been associated with increasing amenity and (perceived) quality of place and uplifting of stigma's in areas. Public green spaces are places of social encounter and social integration especially in multi-ethnic or arrival cities (Kabisch et al 2015). This is one of the reasons that makes cities invest in green areas and resurfacing blue areas (e.g. urban creeks or urban lakes) to provide attracting settings and remodel the make up of places.

Renaturing cities with nature-based solutions is frequently linked with new urban economies and remaking of places that have degenerated over time. Many cities have used green projects and especially urban parks as 'urban design instruments' to rebrand and remake urban areas. Especially in cities with areas of social deficit, that were not joyful and unused from communities, nature-based solutions and specifically (remake of) parks proved to be transformative for both space and the community (Montogmery 2013, p.31). Many large cities that face the results of post-industrialization in their space also employ greening strategies as effective means to regenerate previous industrial sites. Research has also found that green areas are essential for community building.

The examples are numerous, and a recent one comes from Bussan city in South Korea that has the ambition to turn a large area of its port area into parks, walkways and a marina but most of all into a waterfront linear park. Many port cities in Europe are undergoing a socio-economic transition due to the changing economic activities in their ports as well as the changing needs of space from cities for port activities. The city of Rotterdam and the city of Thessaloniki have been experiencing this transition as well, and nature-based solutions can be beneficial to the regeneration of the port areas that are left vacant from industrial activities. Rotterdam is already having a number of nature-based solutions' experiments showcasing how urban regeneration and space reclamation for urban life can be succeeded: the Boomjes promenade and Meerhavens. Recently, in the menu of innovative solutions Rotterdam has put a floating (demonstration) forest in City Ports area and a private floating farm, showcasing what floating

urbanization may look like, as clean-tech solutions that can also be considered as nature-based solutions to some extend (the floating forest).

Photo 1: Water Square in Rotterdam, the Netherlands (Source: Twitter feed of Rotterdam Municipality).

Photo 2: Platanakia forest, Panorama, Thessaloniki, Greece (Photo source: Thessaloniki Arts and Culture Photos, via Facebook group).

Box 3: How nature-based solutions transform degenerated areas (Source: ICLEI Briefing Sheet – Nature-base solutions, March 2017).

Examples of how nature-based solutions can contribute to urban regeneration include:
- The number of inner-city lanes is reduced to make space for greenways that improve air quality and encourage the use of alternative means of transportation.
- Polluted and degraded rivers and wetlands are restored to near-natural systems simultaneously increasing water quality and property values.
- Former factory sites and disused infrastructure are torn down and detoxified using bioremediation. In turn, they are transformed into public green spaces for recreation.
- Abandoned land is converted into community gardens and urban farms to enhance social cohesion and regenerate disadvantaged urban areas.

Box 2: Nature-based solutions establish lost connections between people and nature in cities and require multiple actors for their governance (text from Frantzeskaki et al 2017).

When investigating how transition initiatives change urban space and urban systems of provision, we found that a great number of those initiatives put in place and experiment with solutions that restore nature, imitate and build upon nature processes as ways to address environmental issues in place-explicit ways, known as nature-based solutions. Nature-based solutions have been defined as living solutions underpinned by natural processes and structures that are designed to address various environmental challenges while simultaneously providing economic, social, and environmental benefits (European Commission, 2015). Nature-based solutions as social-spatial interventions have a transformative impact in the relations between people and nature. First, nature-based solutions contribute in the mental and physical health and wellbeing of people in cities (Andersson et al 2015; Ambrey, and Fleming, 2014, p.1298; Bratman et al 2015; Buchel and Frantzeskaki 2015; Carrus et al 2015). Reconnecting with nature in cities can contribute to social ties, establishment of sense of community and social cohesion (Kazmierczak, 2013). Second, nature-based solutions are systemic ways on locally responding to climate change pressures. So far research has focused on the (potential) insurance value of nature-based solutions that revolves around the restorative capacity of these solutions deeming them effective for climate change adaptation and mitigation (Green et al 2016; Haase et al 2016; Kabisch et al 2016; Mullaney 2015; Andersson et al this volume). We add to this understanding is that nature-based solutions can have regenerative impact (Carrus et al 2015, p.226).

We argue that for understanding the impact of nature-based solutions in cities, we need to attend to their social production (Ernston 2013). In this way, we will understand how nature-based solutions as social-spatial settings, they mediate the need and ability of actors and communities to establish a positive dependence of place motivating them to restore it (Tidball and Stedman, 2012, p.297). Third, transition initiatives are instrumental in creating and localizing nature-based solutions, moving from a passive experience 'of nature' to an active experience 'with (making) nature'. In this way, transition initiatives experiment with nature-based solutions, learn-by-doing on how to adapt them to city-specific and place-specific situations and geophysical characteristics and create new narratives and understandings of their benefits. As thus, nature-based solutions are seeds of transformation of local practice and local space towards more sustainable ones.

Alongside with the multiple benefits of nature-based solutions come some disservices. With the majority of ecological disservices relating to pollen and the allergens associated with it, the bringing in animals to cities posing risks to humans in the absence of training and education on dealing with urban nature, a number of disservices are socio-economic. A documented in social sciences, geography and urban studies concerns the 'eco-gentrification': the phenomenon in which investing in green spaces in an area together with infrastructure improvements and development projects can uplift the 'investing' profile of a degenerated area but at the same time results in increasing the rent and buying prices of housing that in turn pushes low-income families/households out of the area and invites higher income families/households in the area. Many redevelopment projects from cities have seen this 'change of population profile' or demographic shift as a sign of positive outcomes of regeneration programs and projects. Recent

urban planning programs however when adopting a holistic integrative perspective request for new approaches for regeneration programs that will consider the needs of the existing communities in the targeted areas. As thus, cities now opt for inclusive regeneration with nature-based solutions. From research, we have found that the social production of nature-based solutions for urban regeneration contributes to inclusive transitions of these areas. Specifically, when citizens from these areas actively participate and even co-design the places that need to be changed, the spatial changes come along with social outcomes of new sense of place and stronger community ties with place. Empowerment of citizens through engagement, involvement, and activation or even partnering with civil society organizations from these areas is critical for inclusive regeneration approaches and outcomes.

It is thus important to consider how citizens participate and co-create nature-based solutions not only for a more fit-to-context design of these solutions but also for a socially inclusive approach to co-develop them.
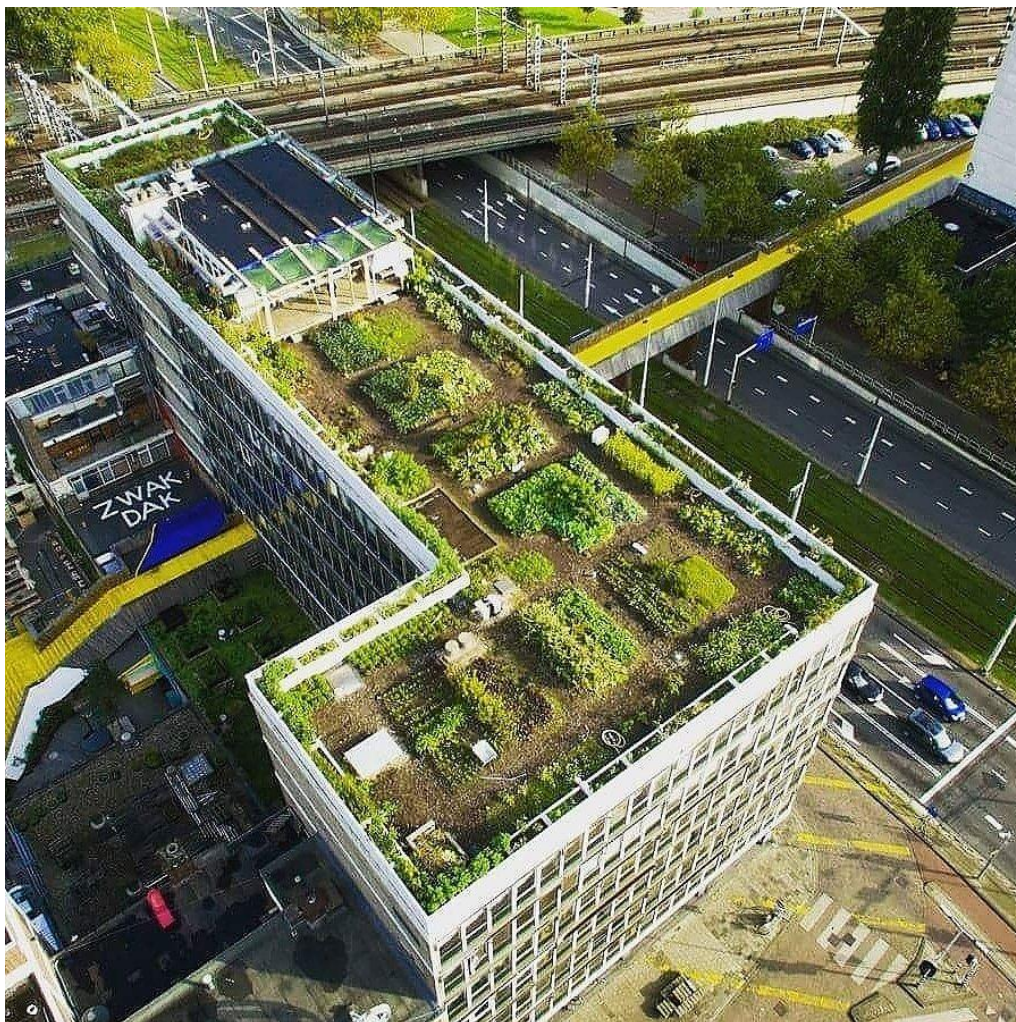

Photo 3: Dakakkers rooftop urban agriculture initiative, Rotterdam, The Netheralnds (Source : Twitter feed of Dakakkers initiative).

2. Experimenting with nature-based solutions

Experiments of nature-based solutions took place in deprived neighbourhoods, neighborhoods with derelict infrastructure, facing environmental pollution and a socio-demographic profile of low employment rates and higher urban poverty than the average of the city located in (agreeing with the definition of Vaz et al 2017 on urban deprived neighbourhoods). The cities used the theme on improving urban infrastructures with nature-based solutions as an entry point to address the multiple dimensions of urban resilience: social cohesion, accessibility, collaboration and partnership with society.

2.1 The nature-based solution experiments of Resilient Europe

Antwerp, Belgium
The green corridor (De groene ader)
The idea of this experiment was born at the beginning of the process. One of the ULG members was proactive in identifying the synergy between this project en possible funding sources. He submitted a project idea at the Participatory Budget in the initial phase of our project. The previous year the neighbourhood already conducted a local research project involving the area's walkability. The idea was to extend their vision of a pedestrian friendly neighbourhood with the aspect of climate adaptation.
During the various brainstorm sessions more and more ULG members became interested in the concept of creating a green corridor through the neighborhood that showcases and inspires climate proof measurements. On the long term the idea is to upgrade this corridor to a green, water infiltrating, cool climate robust area that connects different innovative experiments and functions as a living lab.

The experiment green corridor proved to be suitable to activate people to work on climate adaptation. One of the advantages is that a number of actions will take place in a rather small and defined area. This makes experiments tangible and allows people to take care of their own creations.

Dream day 17th of June: The experiment took off with a dream day organised on the 17th of June by the ULG to formulate and debate various proposals to carry out on the action day in September 2017. The promotion and call for participants for this day was carried out by the ULG. The ULG took care of the communication for the event and even got a local celebrity to promote the dream day on social media. The event was organised in the local community centre and approximately 60 people participated. It was an interactive workshop session in small groups. The participants could pick a theme to work on, for example 'water infiltration', 'green spots for playing' or 'functional green'. The workshop leaders provided a lot of working material for the various groups including inspiring examples and images of the current situation. All groups then created a collage (24 in total) of the way they would like their street to look like in the future.

Burgas, Bulgaria

In Dolno Ezrovo district in Burgas, in March 2017 citizens together with the city and its deputy mayor of European programmes and ecology, planted trees in the area also by removing discarded cement and opening the closed channel that has been creating flooding problems every winter. The unsealing of soil, the planting of trees by the community and the localization of the narrative on the importance and value of nature-based solutions for flood protection were the activities and outputs of this local experiment. This experiment is innovative in its own context since such actions performed in collaboration with citizens are unique in the context of Burgas city.

Potenza, Italy
"Adopt a Monument" experiment for Potenza's city center, was initially designed to be carried out with school's students to involve as more citizens as possible into a debate about the importance of some of the important architectural element present in the city centre. However, as the project management group was organising the activities to start working with schools, ULG members started to raise resilience on their own. Indeed, they organised several activities focused on raising attention toward the Guevara tower, the only remaining part of the ancient castle of Potenza. Main promoters of these activities were the Rotary Club of Potenza and the local section of the Italian Environmental Fund (FAI) – both the association were included in the ULG and took part to the meetings of the Resilient Europe project. Other associations belonging to the ULG decided to support the efforts of Rotary and FAI. Among these Planar, Visioni Future, Interact, Un passo Avanti, Avis Potenza, We Love Potenza, Potentialmente Onlus. Moreover, the Chamber of agronomists and forestry and the Province of Potenza supported the action.

Hence, the experiment resulted into a series of actions aimed at promoting the recovery of the deprived site where the Guevara tower is placed. Specifically, the Chamber of agronomists and forestry has taken on the commitment to manage the park surrounding the tower, ensuring its maintenance free. Moreover, free guided tour of the area were organised on June 9th 2017 by the FAI and the Rotary. On the same date, a petition was launched to propose the demolition of an abandoned building, located just in front of the tower, which limits the use of the park and prevents the possibility of seeing the tower from the main road crossing the city centre. To support the recovery of the area, Rotary Club has organised a design contest open to professionals from all over the world to submit possible solution for the improvement of the quality of the urban space of the area, even considering temporary solutions or the demolition of the building. This experiment took a complete different shape from its original design. However, this is a good example of a bottom-up experiment: citizens started working on it because they are aware of the importance of the monument for the city center in the ULG, and the municipality joined them to ensure an easy development of their activities.

Vejle, Denmark
The focus area/neighbourhood in Vejle was the West End in Southern Jutland. The nature-based experiment was set by a group of residents who had participated in the local working group (ULG) on urban resilience and decided to create an urban green common, a green space and a nature-based playground in the West End, called 'West End Common'. The municipality has contributed with land and soil and the local council facilitated the development of the area. In 2017 the citizen

group kicked off the emerging design of the green space, by putting a fence to orient visitors, and started with shaping the landscape for the playground.

These experiments that were realized during the Resilient Europe project time, have been also complemented with knowledge from past experiments as discussed during the partner meeting of the network in Ioannina in 2017 and are summarized in Table 1.

Photo 4: Picture from the visit of the Antwerp ULG to Rotterdam, showing the raingardens in Zoho district (Source: Twitter feed of Rottedam Climate Initiative).

Table 1: Past nature-based solution experiments shared by Resilient Europe cities to inform the design and operation of the experiments realized during the project lifetime.

Nature-based solution experiment	Characteristics	Recognized co-benefits of the nature-based solution that contribute to urban resilience
Past experiments		
Lambhill Stables, Glasgow, United Kingdom	Initiated in 2007, as a nature-based intervention to restore old minefield next to utilizing the space for environmental education of the community. Currently is run by a social enterprise that maintains the bioremediation part of the location, the constructed wetland is maintained in cooperation with the city and the social enterprise and the community garden and supports a social function on training and education. Types of NBS: constructed wetland, urban agriculture, bioremediation ponds	- restoration of ecosystems - social capital through community supporting - environmental education - green jobs
Courtyard Renovation "Plac na glanc", Katowice, Poland	Coutryard regeneration and rearrangement has been an initiative to restore sense of place by greening courtyards in Katowice historical buildings by young architects that started in 2013. Architects initiated the greening of these courtyards and residents participated in the planning and realization phase of the project in a series of workshops in which residents openly discussed and communicated their needs and actions in contributing to the regeneration. It is important to note that recycled material were used for the renovation and later in the project, private investors were also involved. Type of NBS: pocket park	- soil restoration - social capital through stewardship of places
Revitalisation of the River Valley Ślepiotka, Katowice, Poland	The restoration of the river banks and river valley Slepiotka in Katowic city brought together multiple actors from the city including citizens, engineers, planners and consultants to deal with the reestablishment of natural habitats in the river banks and the riverbasin overall, with the aim also to function as a water retention area to mitigate flood risks and the consideration of future uses from citizens. The previously abandoned and degraded spaces alongside the river banks were re-imagined with the consultation of citizens. The regeneration effort from the city was a pilot project in the EU project REURIS. Type of NBS: linear park, green waterfront	- ecosystems restoration - habitat - water retention/flood protection - recreation
Citizens stewarding the maintenance and	The maintenance of the Montreale park in Potenza city was taken up by a self-organised citizen group called 'Hoes armed citizens' who considered the park	- habitat - recreation - heat regulation

restoration of Montreale park, Potenza, Italy	an important urban space for their recreation and urban life. The replanting of wedges in this park was realized by the citizen group who used plants brought by shop owners. The citizen group stepped in for the maintenance and improvement of the quality of this urban green space when in the aftermath of the austerity crisis in 2008 the city was unable to take care of this park. Type of NBS: urban park	
Regeneration of urban space into green space, Serpentone neighborhood, Potenza, Italy	The regeneration of the urban space in the Serpentone neighbourhood in Potenza, Italy from a 'cemented' place to a green urban place started in 2010 after an architectural intervention was completed. The 'Ship' that is an underground building, was never used since it was perceived by the local community as an imposed structure to their area. With a series of self-organised workshops of citizens that later also invited urban planners resulted in a common project of a green space on top of the underground 'Ship' building so as to create a community recreation and connection place. During the visit of the author in 2016 to the area, the urban green space was used by youth and elderly. Type of NBS: urban park	- sense of place - water retention - recreation
Delfshaven Cooperative, Rotterdam, The Netherlands	A social enterprise with a place-focus of the Delfhave area in Rotterdam that by collaborating citizen initiatives, entrepreneurs, institutions and municipality works in creating social capital, supported residents in renovation of buildings owned by the housing corporation and establishing a 'park council' focusing on the restoration of a local park. Type of NBS: urban park	- restoration of ecosystems - social capital through civic empowerment and actions - social cohesion
Dakakkers Roofgarden, Rotterdam, The Netherlands	In a previously vacant building, a citizen initiative advocated to the city of Rotterdam that it will regenerate the building and create new links to sustainable businesses and start-ups by making the first green rooftop garden in the city. The Dakakkers roof garden is a successful nature-based solution created by citizens showing how urban farming in rooftops can provide not only new meanings to places, use urban farming for improving energy efficiency of the building, educate citizens about sustainability and healthy food. Type of NBS: Urban agriculture, green roofs	- water retention - food - recreation - sense of place
Boomjes promenade, Rotterdam, The Netherlands	The Boomjes promenade is a successful nature-based solution that concerns the restoration of urban river banks from sealed soil surfaces to green riverfront area. The promenade was realized as part of 'Give	- water retention - flood protection - recreation

	space back to the river' program of the Netherlands and its urban implementation in Rotterdam city. Type of NBS: linear urban waterfront park	
Raingardens, Rotterdam, The Netherlands	The raingardens in the Zomerhofkwartier district in Rotterdam were installed in 2016 as part of the climate adaptation strategy of the Rotterdam city and supported by a Life project on climate adaptation. The raingardens being 100 meters long are featuring a unique design of the tiles by designer Fien Dekker. Type of NBS: raingardens	- water retention - flood protection
Kipos, the city as a resource Thessaloniki, Greece	In Doxa district in a vacant space, the Landscape Architecture School of the Aristotle University of Thessaloniki in cooperation with the Municipality of Thessaloniki has developed urban community gardens since 2014. Overall 11 families and residents participated in its creation and operation of the urban agriculture initiative. What is unique in this initiative is that established a ground for collaboration between the University, the municipality and the residents in protecting the vacant space and creating new sense of place through it. Type of NBS: urban agriculture	- restoration of space - food production - sense of place

2.2 Lessons learnt from experimenting with and for nature-based solutions

The case studies in the growing literature and research on nature-based solutions frequently focus on the single case study lessons both for the effectiveness of nature-based solutions and for the implications they have for planning and governance. In this report, we take a meso-level view to the lessons learnt from the real-life experimentation with nature-based solutions in cities that work in targeted and strategic ways to foster urban resilience as an urban agenda priority. For doing so, we use the Raymond et al 2017 framework for expanded proof-of-concept and demonstration stages of nature-based solutions as a guiding framework to organize and synthesize the lessons learnt. The proof-of-concept evaluation framework includes the following seven planning stages for nature-based solutions: 1) identify problem; 2) assess and choose option; 3) design NBS implementation; 4) implement NBS; 5) inform policy makers about results, 6) revise project plans for implementation and upscaling and the transversal stage of 7) monitor and evaluate co-benefits. Multiple types of engagement and communication are required to reach stakeholders of different power, expertise and interest at each stage.

The lessons learnt from experimenting with and for nature-based solutions have been organized and presented across these stages in Table 2.

The lessons we draw show that overall nature-based solutions require multiple disciplines for their design, plurality in co-creation and recognition of the place-based transformative potential as 'superior' solutions to grey infrastructure (Keensstra et al 2018). What makes our case studies stand out is the balanced focus between the ecosystem and the social benefits of these nature-based experiments in contrast to the majority of published cases on nature-based solutions that have a weighted focus on the environmental scope of nature-based solutions (Brink et al 2016; Xiang et al 2017, p.2). Specifically, Brink et al (2016, p.117) argue that "there has been little focus on the question of who should take action and how society can sustain ecosystems providing such benefits". We aim to address this gap by elucidating implications for urban environmental policy, planning and science derived from the lessons learnt. Overall, with the array of contemporary case studies, we want to show how current urban planning and governance dealt with experimenting with nature-based solutions and what the cross-case study lessons learnt are, so future applications, designs, co-creation and upscaling of nature-based solutions in cities can benefit from these lessons.

Table 2: Lessons learnt from nature-based experiments of Resilient Europe Cities.

Expanded proof-of-concept and demonstration stages of nature-based solutions (adopted by Raymond et al 2017)	Lessons Learnt from NBS experiments for policy and planning	Supportive Case Studies of NBS experiments from Resilient Europe cities
Select and assess NBS and related actions	*Lesson #1: Nature-based solutions need to be aesthetically appealing for citizens to appreciate and protect them.*	Courtyard regeneration, Katowice, Poland; Zoho raingardens, Rotterdam, The Netherlands; Augustinborg district, Malmo, Sweden.
	Lesson #2: Nature-based solutions create new green urban commons.	West End Common, Vejle, Denmark; Serpentone urban park, Potenza, Italy; Montreale urban park, Potenza, Italy; Dolno Ezernovo, Burgas, Bulgaria; Kipos urban agriculture, Thessaloniki, Greece;
Design NBS implementation processes	*Lesson #3: Nature-based solutions experiments require and feed into trust between the city and its citizens both for the aim of the experiment and for the experimenting process itself.*	Courtyard regeneration, Katowice, Poland; Urban park nearby Guevara tower, Potenza, Italy; Sint Andries, Anterp, Belgium; West End Common, Vejle, Denmark.
	Lesson #4: Different settings and fora for co-creating nature-based solutions are needed that include and learn from urban social innovation.	Courtyard regeneration, Katowice, Poland; Courtyard regeneration, Katowice, Poland; Urban park nearby Guevara tower, Potenza, Italy; Serpentone urban park, Potenza, Italy; Sint Andries, Anterp, Belgium; West End Common, Vejle, Denmark
Implement NBS	*Lesson #5: Nature-based solutions are often initiated by local governments but require multiple actors to be designed, implemented and linked to urban life.*	Lambhill Stables, Glasgow, UK; West End Common, Vejle, Denmark; Potentini Armati di Zappa, Potenza, Italy; Kipos urban agriculture, Thessaloniki, Greece
Communicate co-benefits	*Lesson #6: Create an inclusive narrative of mission for nature-based solutions across different departments of the city to bridge departmental disputes.*	Andries, Anterp, Belgium; West End Common, Vejle, Denmark; Dolno Ezernovo, Burgas, Bulgaria
Transfer and upscale NBS	*Lesson #7: Nature-based solutions need to be designed in such a way and scale that lessons for their effectiveness can be easily harvested and as thus, to be easily replicated into other locations.*	Andries, Anterp, Belgium; West End Common, Vejle, Denmark; Potentini Armati di Zappa, Potenza, Italy; Dakakkers rooftop urban agriculture, Rotterdam, The Netherlands; Kipos urban agriculture, Thessaloniki, Greece

Lesson #1: Nature-based solutions need to be aesthetically appealing for citizens to appreciate and protect them.

From analyzing the cases presented in Table 1, we found that for nature-based solutions to be further fitting into the urban mosaic, they need to be appealing to citizens, as well as being multi-functional. To achieve this, it is important to collaborate with designers, architects and to rethink how it fits with the existing infrastructure. Co-creation and co-design with different actors becomes a strategy to generate appealing and socially acceptable nature-based solutions' designs.

From recent research, we also discern that design characteristics of nature-based solutions play an important role for their acceptance. Specifically, Vanstockem et al 2018 found how the aesthetics of green roofs (determined by vegetation gaps, weedy species and type of vegetation) play an important role on how they are perceived and thus accepted by citizens. Prestamburgo et al 2016 studied how aesthetics and functional design can work in establishing connections between nature and urban uses in ecoducts further showing the importance of aesthetics in nature-based solutions. Hofmann et al 2012 found that the naturalness – how natural it looks – is an important variable for accepting and liking urban green areas

From the real-life nature-based solution experiments, noticeable is the experiment of the raingardens in Rotterdam, the Netherlands that were designed to look like meanders and were well integrated visually to side walk greenery.

The courtyard renovation, "Plac na glanc" in Katowice, Poland also considered the aesthetics of the pocket parks in the courtyards as part of the architectural design that was co-created with citizens. The aesthetic value of the courtyard was brought to the attention of the architects by the citizens as an important dimension for the recreational use of the place in the future.

Drawing from this lesson, we see the following implications for policy and planning: First, urban planners need to consult multi-disciplinary teams when designing nature-based solutions to co-create appealing nature-based solutions. Second, urban planners need to be open to differences in preferences between their designs and citizens' perceptions and able to explain differences in expected benefits/services when designs of nature-based solutions are altered (Hofmann et al 2012; Buchel and Frantzeskaki 2016). Third, intermediaries or knowledge brokers between cities and citizens need to understand the images of nature of people especially in culturally diverse neighborhoods in order to assist the design of nature-based solutions in a socially inclusive way (De Vreese et al 2016).

ANTWERPEN

Sint-Andries werkt aan 'groene ader' door de wijk

Bewoners fleuren buurt op met steun van stad en district

En 'groene ader' doorheen het hart van de Sint-Andrieswijk, dat is de droom van enkele buurtbewoners. Zondag, met Antwerpen Autovrij, kreeg die droom al een beetje vorm, dankzij vergroende trottoirs, aanplantingen op boomspiegels en een regenwatertuintje. Zo'n 40 à 50 mensen staken een handje toe.

● Met de opwarming van het klimaat moet ook Antwerpen als stad aan de stroom zich gaan beschermen, zo klinkt het bij de initiatiefnemers. "Meer groen in de stad helpt om de hittestress te verminderen", legt Arduïn Cielen (42) uit. "De stad is sowieso warmer dan het platteland, dus alle beetjes helpen. Daarnaast zorgt meer doorlaatbare grond voor een betere opvang en afvoer van water, en helpt dit de riolen te ontlasten."

Die grond wordt op verschillende plaatsen vrijgemaakt door stoeptegels te vervangen door groentegels met een gat waar plantjes in gezet kunnen worden. "In de Lange Winkelstraat heeft de stad bovendien gaten laten boren waar ook plantjes in worden gezet, en enkele bewoners haalden al een tegel weg voor een geveltuin. Verder hebben we de boomspiegels op de Sint-Andriesplaats opgefleurd met extra grond en plantjes, staan er her en der ook bakken met planten en hebben we nu ook een 'gevelregentuin': een bloembak met een regenton eronder, die rechtstreeks gevoed wordt vanuit de regenpijp. Die is groot genoeg om ook andere plantjes mee te bewateren."

Sommige van de ingrepen zijn permanent, andere tijdelijk. Zo maakten de bewoners ook een groene kring met matten op het plein, om aan te tonen dat gras hier perfect zou kunnen met behoud van het basketbalveld.

ARDUÏN CIELEN
Liefde voor de wijk

"Meer groen in de stad helpt om de hittestress te verminderen. Daarnaast zorgt meer doorlaatbare grond voor een betere opvang en afvoer van water, en helpt dit de riolen te ontlasten."

Arduïn Cielen bij de 'gevelregentuin'.

Burgerbegroting

Sint-Andries werd door Stadslab 2050, een stedelijk 'labo' voor duurzaamheid, gekozen als locatie voor testprojecten. De bewoners, die zich verenigden via de Facebookpagina Liefde voor de wijk, kregen ook steun van de Burgerbegroting van het district Antwerpen. "Ik ben er zelf ingerold via de pagina Liefde voor de wijk", vertelt Arduïn Cielen. "Al was ik eerder ook al bij het Stadslab 2050 geweest. Het is fijn dat we zoveel steun kregen. Zo hebben we hier eenjarige plantjes die eerder gebruikt werden voor de Zomer van Antwerpen en nu nog kunnen uitbloeien in de buurt. We zien deze dag ook nog maar als een begin, en dromen van nog veel meer en structurelere ingrepen langs de groene ader. In het voorjaar komt allicht een vervolg op onze doedag van vandaag, en ook elders in de wijk staan nog dingen te gebeuren. Zoals een mosmuur aan het Heldenplein, waar nu een blinde muur is. En de Lange Ridderstraat wordt een van de vijf Antwerpse tuinstraten die de stad en het district hebben gepland. We praten ook met de mensen van Samentuinen, dus er beweegt veel in de wijk."

De initiatiefnemers doen een oproep aan alle bewoners van Sint-Andries en aan mensen buiten de wijk om een handje te komen helpen. Wie wil helpen, mag een mail naar liefdevoordewijk@gmail.com sturen. Komen kijken mag uiteraard ook.

BARBARA VANDENBUSSCHE

Sommige ingrepen zijn permanent, andere tijdelijk. Zoals de groene matten die tonen waar er gras zou kunnen komen. FOTO'S JEROEN HANSELAER

"We werken er zelf ook aan, maar de combinatie van privé-initiatieven en stad is nog krachtiger"

● "Al dit soort initiatieven die de stad een aangenamere aanblik geven, zijn een goed idee", vindt schepen voor Ruimtelijke Ordening Rob Van de Velde (N-VA). "Zeker in 'densere' woongebieden waar de straten er vaak grijs uitzien. We werken er zelf ook aan, maar de combinatie van privé-initiatieven en de stad is nog krachtiger. Of er echt één groene ader kan lopen door de stad, is moeilijk te zeggen, omdat je ook een evenwicht moet behouden met mobiliteit en de praktische haalbaarheid. Maar bepaalde straten lenen zich er uitstekend toe. Vandaar ook de tuinstraten, zoals in de Lange Ridderstraat. De eerste aanzet daarvoor is al gegeven. In de komende maanden wordt de wijk samengeroepen om de invulling van de straat te bespreken. Eerst gaan we de dialoog aan met de buurt, en dan zien we hoe we alles kunnen organiseren. In 2018 en 2019 worden de tuinstraten dan ingericht. (bava)

Photo 5: Sint Andries' Green Corridor experiment communication (Source: Antwerp city Integrated Action Plan 2018).

Lesson #2: Nature-based solutions create new green urban commons.

Nature-based solutions as being powered by nature and restoring natural flows in cities, create novel ecosystems that require multi-actor collaborations for their design and also sustainability. This in turn creates space for new relations between people and nature as well as between people in communities. Especially in the deprived neighborhoods, the small-scale experiments with nature-based solutions showed that transforming the physical components and appearance of space is coupled with the perceived benefits people assign to it in the form of sense of place. The narratives in describing the perceived benefits were altered from 'backyard' or 'abandoned places' to 'welcoming places' and 'community spaces'.

From recent research we draw on the writing of green urban commons to explain the positive impact of nature-based solutions to urban place-making. Colding and Barthel, 2013, define urban green commons as "urban ecosystems of diverse ownership that depend on collective organization and management." (p.157). In their work, they also point that the critical characteristic of urban green commons is how they are managed not how the land is owned, putting priority in the way they are governed – as 'commons'. In such settings, given that we refer to urban public space being transformed with nature-based solution into a green urban common, social pressure to preserve it, respect it and appreciate it plays an important role (also recognized by Colding and Barthel, 2013; Frantzeskaki et al 2018; Tidball and Stedman 2016).

Recent research shows that nature-based solutions positively transform the sense of place of local communities when these communities are actively engaged in co-creating them (Frantzeskaki et al 2018). Artman and Sartison (2018, p. 13) found that "residents doing urban gardening experience a sense of belonging" and this is further linked to "the demand of residents to reclaim public space and self-governance" and Larson et al 2016 (p.113) point to the experiential benefits of nature based solutions. Montgomery (2013, p.37,) also address that green spaces moderate the relationships with people and create new experiences between people and nature. At the same time, these spaces allow for accepting and appreciating cultural diversity given that 'people interact during gardening' and 'visiting' and this allows for open, unplanned social encounters (Buijs et al 2016). Especially in the deprived neighborhoods that the nature-based solutions' experiments took place, the 'commoning' in the regenerated public spaces is an important leverage for understanding cultural diversity and its benefits in the community. Scholars Vierikko et al (2016) address that bio-cultural diversity is another lens to understand how green urban commons are appreciated, co-managed and preserved together with communities. Simic et al 2017 with their analysis of community gardens in Belgrade, Serbia evince the importance of involvement of local community in creating and maintaining urban green commons and specifically that "small-scale greening projects could induce broader transformation of city's green infrastructure, which might be more extensive and economical than the one achieved via the conventional top-down planning" (p.2).

In this way, the risk of experimenting with nature-based solutions becomes a shared risk and the benefits as well: creating a commons implies that the benefits are shared or simply, public. What remains in this case a challenge for planning is how the costs for maintenance are to be shared

given that nature-based solutions are not yet immune from 'the tragedy of the commons', meaning that their operation, sustainability and maintenance also require an approach to share responsibilities. Also given that the majority of the cities involve citizens in tree planting programs to re-establish urban parks and urban forests (like Burgas, Vejle, Thessaloniki for Resilient Europe), it becomes important to extend participation to co-creation and co-management of those green urban commons in partnership with the city (Ordonez Barona 2015).

The Kipos project in Thessaloniki that is collectively managed and open to people, accessible to families and residents even in adjunct neighborhoods. What this urban agriculture area shows is that with small-scale interventions (the Kipos urban agriculture is 84 square meter in size) generate interest, and can catalyse new social relations as well as new relations between nature and people.

In Potenza, a citizen group self-organised in restoring and maintaining the Montreale park so as to ensure the quality of green space and its sustainability. The citizen group 'Hoes armed citizens' stepped in the role of maintaining the park in view of a failing responsibility from the city and reclaimed its importance for the urban life, experiencing it as a green urban commons.

Especially in the city of Burgas, created a sense of community in the Dolno Ezrovo district collaboratively removed discarded cement from the closed (inundation) channel and planted willow trees to start the renaturing of their district. The collaboration between citizens of all ages for this, the activation of the community due to the openness and willingness of the city officers to discuss and listen to their needs created the first seeds for a new urban green common in this area, even though it is a pocket greening solution for now.

Drawing from this lesson, we see the following implications for policy and planning: First, urban planners need to be open to communicate and to hand-over the leadership in projects to citizens, civil society groups and other urban actors. For doing so, it may be beneficial to invest in knowledge training and capacity building programs for city officers and planners on how to collaborate and co-operate public green spaces with communities can equip cities with skills to manage and sustain green urban commons. Second, urban planners need to account for the time is needed in every step of landscape management and implementation of nature-based solutions for communities to be involved and to experience the change of place so as to allow for a positive transformation of sense of place and resulting in generating green urban commons. Third, communities and even organized civil society groups need to professionalize in the ways of managing, operating and sustaining their involvement in green urban commons. One way this can be ensured is for community members and /or civil society groups to participate in training programs for communities on how to lead, operate and maintain public green spaces and to recognize the benefits as capacity building and empowerment means. Fourth, urban planners need to introduce a civic-reflection step in planning for celebrating together with communities the new sense of place as shaped by nature-based solutions and by contrasting it with the images of the past place.

Photo 6: Dakakkers rooftop urban agriculture initiative, Rotterdam, The Netherlands (Source: Giorgia Silvestri, 2016).

Lesson #3: Nature-based solutions experiments require and build trust between the city and its citizens both for the aim of the experiment and for the experimenting process itself.

Trust is an important condition for every participatory process regarding planning, policy and of course, experimentation. Trust building requires starting a relation with citizens based on clarity, transparency and openness to take on board contradicting (often) opinions and beliefs, unclear aspirations as well as frustrations over the wrongs of various preceding processes. In this process, it is important not to only communicate clearly on the aims of the nature-based solution experiment but also to create an environment of trust that the time spent experimenting and the commonly produced outcomes are trustworthy and time-worthy at the same time. Building trust between citizens and city is the first step, and it is a prerequisite for ensuring a trust in the experimentation process they embark in. In such situations where the trust to the aim and to the process of experimentation is a continuous effort, citizens are to be seen as equals in terms of knowledge and ideas' contributions to experts from the city and from science and consultancy.

Rotterdam city provided the example of the Benthamsplein watersquare where the involvement of citizens altered the initial design to be even more multifunctional as a basketball court, as a baptism theater and a skateboard theater as well. In addition to this, experience with participatory processes in cities especially on green space restoration or maintenance showed (as shared by many cities) that the city has to trust its citizens more for their capacity and ability to self-organise and steward these places.

The revitalisation of the River Valley Ślepiotka, in Katowice, Poland showcases a process that citizens together with the city collaborated in rethinking the value and the use of the river valley. A previously abandoned and degraded place, suffered from litter pollution, was brought to planning attention that utilized European funded project to experiment with new ways of participation and engagement with citizens for its future. To build trust to the process of revitalization, the planners of Katowice city engaged the citizens in an open way, shared information of possible solutions to protect biodiversity and restore the habitat in the river banks bringing the citizens with them alongside the process.

The restoration of the urban park in the periphery of the Guevara tower in the city center of Potenza is part of a multi-action experiment that was initiated by the city of Potenza and evolved in a multi-actor activation process. The city of Potenza with engaging multiple actors in dialogues about urban resilience as a way to rethink how to develop the city, how to regenerate areas and districts in collaboration with citizens established trust with the city but also trust in the process of 'finding new ways together' as it was framed by the urban planners. The openness and transparency of the process of engagement were critical drivers in establishing the trust in the experimentation itself as an open-way to rethink and develop the city for the future. This triggered also other actors such as the Rotary Club to open to experimental ways such as the design competition for experiments on recovering the urban park's identity and value next to the monuments' appreciation.

Drawing from this lessons, we recommend that urban planners employ experimentation as a way to de-risk new innovative solutions by considering how to build trust in the experimentation process itself by remaining open to questions, transparent on the vision of the experiment, and inclusive to new ideas to steer the experiment to new outputs additional to the ones expected initially. An open process to experimentation can facilitate trust building between the involved actors and to the experimentation process as a governance process.

Photo 7: Serpentone urban park, Potenza Italy – a view from the ground up (Source: Niki Frantzeskaki, 2016).

Lesson #4: Different settings and fora for co-creating nature-based solutions are needed that include and learn from urban social innovation.

Given that environmental problems like climate change challenge the capacities of cities to deal and manage solutions for them alone, the shifting focus is on partnering with other capable social actors over time. Many cities have creative and capable citizens to co-create and co-design nature-based solutions not in the shadows of city planning but on the forefront as a city-making practice. A frequent practice of urban planners when wanting to involve citizens in plans and planning decisions is to either involve the same citizens over and over (we name them 'the usual suspects') or to exhaust their innovators and face participation fatigue. A way to overcome this and to invite the unusual suspects is to make different fora for co-creation. Especially, when city officers and the city overall change role from regulating and consulting to enabling, participating and facilitating citizen-led projects and dialogues for urban futures, local infrastructure projects such as nature-based solutions become centers for new ways of working together with citizens, changing stakeholders' perceptions about each other and about the city and transforming relationships through the creation of new ones and of shifting of roles. The new ways of doing, relating and knowing are conceptualized as urban social innovation (Yamaki 2016, p.213). Social innovation is therefore important social capital to consider when co-creating nature-based solutions.

From recent literature on how co-creation supports inclusive designs of nature-based solutions, we found that co-creation is a way to cope with the complexity and uncertainty that sustainable solutions like nature-based solutions have in delivering on sustainability and resilience (Hysing 2015, p.30-31). Eckersley (2006) also points to the importance of empowering civil society and fostering "ecological responsibility" through new forms of deliberation and participation in decision-making and planning processes. Collier et al 2013 (p.24) also note about the need for "the creative and inclusive involvement by wider disciplines and stakeholders, with planners and practitioners as facilitators". Last but not least, Biggs et al 2010 suggest that different ways of involving interested stakeholders can benefit how social innovation emerges and links to sustainable solutions.

Antwerp experimented with foresight methods in imagining a green corridor to connect the people with nature and their place in the Sint Andries neighbourhood. A reimagining of a linear park that can establish socio-ecological connections was realized by bringing citizens, designers, planners together in a 'future walk' workshop, where pictures, narratives, scethces were put together as a collage to create the future green corridor. This allowed people with different backgrounds and knowledges to be included, since visual and verbal entries of ideas were allowed.

Courtyard renovation project in Katowice city shows that for the co-creation and co-design of nature-based solutions (even of small scale ones) traditional settings like architecture designs can be re-thinked as platforms for engagement and co-creation with citizens.

The regeneration of the urban park in the Serpentone district in Potenza demonstrates that through the participatory engagement of citizens in different roles, changing places with nature-based solutions enabled and stimulated a change of sense of place of these places. Local communities altered their views, perceptions and experiences in these places, captured by changes in use and changes in local narratives.

In addition to these, the cities of Glasgow (in United Kingdom), Katowice (in Poland), Vejle (Denmark) and Burgas (in Bulgaria) engaged with the citizens through food festivals, community organized lunched and dinners to deliberate on nature-based solutions, to co-define the needs and challenges in their neighborhoods and to co-decide on the experimental actions to take in their areas. Vejle's 'Young people eat together' experiment targeted the youth as a way to discuss the future of the city and the future robust nature-based solutions for making the city livable and socially cohesive. The dinners organized by the municipality and were attended by 70 first and 113 engaged young citizens who expressed future visions, and took action on continuing on thinking about small scale actions to improve their neighborhoods. These food-centered engagement practices not only attracted more people in an easy and sociable way but also broke down barriers in terms of role power (e.g. city officers and deputy mayors sat on the same tables, ate and talked in simple ways with citizens, allowing for open and direct dialogues) and in terms of knowledge sharing, by simplifying the narrative of nature-based solutions to respond to 'what it means for our life', 'what it means for our area'. In the city of Katowice, the local community initiative on sustainability education for youth was the central actor in organizing and networking with citizens and the city for the food festival, and played an important role in mediating with the community but also mediating in terms of localizing the meaning of nature-based solutions.

Drawing from this lesson, we see the following implications for policy and planning: First, urban planners need to think creatively about how to set up co-creation processes for co-designing nature-based solutions with citizens and other urban actors. This may imply connecting with social innovators and civil society initiatives and co-organising, searching for new formats for co-creation beyond workshops and be also open to simple activities as parts of a co-creation repertoire. Second, criteria for selecting which experiments to conduct with co-creation and active involvement of social innovators need to be reflexive and critical to avoid the selection of 'usual suspects', and/or trivial formats and in this way marginalizing innovation (Pancost 2016). Third, urban planners may consider social innovation initiatives or civil society organisations to take the lead in facilitating or designing the co-creation process and them being on the learning and enabling role rather than on the 'leading' role and establishing new institutional spaces for co-creation for nature-based solutions.

Lesson #5: Nature-based solutions require a collaborative governance approach. They are often initiated by local governments and require multiple actors to be designed, implemented and linked to urban life.

For nature-based solutions to be successfully implemented in cities, thinking only about who can invest in them is not sufficient. This may read as a trivial lesson, however a closer reflection on nature-based solutions in cities reveals that collaborative governance is important for constructing, operating and maintaining them. The analysis of the nature-based solutions experiments (Table 1) points to the fact that the majority of them are initiated by local governments but their design and operation relies on collaborative efforts of many local actors.

Recent research on nature-based solutions also points to the need for collaborative governance for nature-based solutions. Brink et al 2018 also note that co-creation of knowledge between participants in municipal-led projects allows for "(re)integration of knowledge from the transdisciplinary learning space into both societal and scientific practices" (p.3). This linking to the thinking and practice frames of different stakeholders allows for embedding of the nature-based solution's benefits and even presence in urban life. In the same vein, Fox-Kamper et al 2018 in their multi-case study found that community gardens are often initiated by municipalities involving citizens and as a progress step, operation and maintenance are passed on or acquired by citizen groups. Even community gardens that started as bottom-up initiatives still were supported by local governments in the form of land permits, knowledge and linking to other practitioners (Kamper et al 2018; Artman and Sartison, 2018, p.13). Ugolini et al 2018 (p.9) point that collaboration with scientific institutions is seen to contribute to innovation and to the 'transferability of results". Collaborative efforts are also important since they catalyse local and tacit knowledge in the full cycle of planning of nature-based solutions. Wamsler et al 2014 (p.197) point to the importance of leveraging local knowledge for the planning with ecosystem-based approaches – such as nature-based solutions – to bridge the gap of experience in planning systemic solutions.

The West End Common in Vejle city (Denmark) also shows how a nature-based solution can be facilitated by the local government but stewarded in its operation by citizens and community groups. It moves beyond the 'hand-over' of a vacant or under-used space of the city to stewarding and linking to urban life by the active engagement of local community. In the West End Common case, the citizen group got motivated by the openness of the local government to their ideas on the creation of a common green space and nature-based playground that moved to 'taking action' and further connecting it to other members of the local community.

The Lambhill Stables in Glasgow illustrates that for the sustainability of the nature-based solution, it is important to engage with multiple stakeholders and especially to embed it to urban life through community networks and civil society organisations.

Another example that illustrates this comes from Potenza, the Potentini Armati di Zappa (Hoes armed citizens in English) that is a civil society initiative that has stewarded the Montreale park, one of the largest green areas of the city, and are self-organised in cleaning and maintaining it.

Drawing from this lesson, we see the following implications for policy and planning: First, close collaboration between municipal staff (urban planners, officers) and other actors (citizens, NGOs, social innovation networks and knowledge brokers including scientists) is required to enable the salience of nature-based solutions from design to implementation to operation. Second, proper planning guidelines for the design, operation and maintenance of small and medium scale nature-based solutions are needed to ensure the sustainability of those solutions. Especially for edible nature-based solutions (e.g. urban gardens and urban agriculture), Russo et al 2017 (p.62) point that proper planning guidelines need to be developed but in collaboration with citizens and local NGOs. Third, urban planners need to think of collaborative governance and collaborative efforts as continuums, that may first require a leading role of the city to be followed by an enabling role later. When civil society or local business actors take up initiating roles, there is still space and need for collaboration with the city in multiple stages of the process of operating and maintaining nature-based solutions.

Photo 8: Planting trees, restoring urban park in Dolno Erzovo, Burgas, Bulgaria (sources: Burgas city, 2017).

Lesson #6: An inclusive narrative of mission for nature-based solutions across is important for bridging knowledges and agendas across different departments of the city and to tackle with bridge departmental disputes.

Nature-based solutions require a holistic and integrative approach to their planning, implementation and maintenance. For this to happen, it is important that from the very early start knowledge and expertise of different city colleagues and practitioners needs to weave in together. While much focus is on the collaborations between the city and citizens, it is paramount that different departments within the city are involved and informed when a nature-based solution is discussed and planned. For this, the initiating team of city planners and in occasions citizens, needs to be open to questions and to ideas across the city departments so as to make the solution a common solution and to create a common inclusive narrative of mission across departments. Early scepticisms, criticism even negativity can be turned into constructive points for improving the design and the process of planning and co-creation of the nature-based solution. During the workshop we had with the Resilient Cities partners in 2017, it was concluded that when a solution becomes an iconic project of one department there were many implementation barriers, especially including the loss of image from competitive departments and the creation of time delays. To think collaboratively and to reframe the solution by creating an inclusive narrative of vision and mission can help in bringing the solution forward. Thus, an inclusive narrative of mission can be an integration 'tool' in seeking consensus, attract support and salience in policy agendas for nature-based solutions.

For creating a narrative to inspire colleagues and make them feel needed and included, one can use the main objective of the nature-based solution project that (as indicated in all the solutions brought to the workshop) is the climate change pressure and the need to be adaptive to change. This touches multiple urban agenda points especially since nature-based solutions are multi-functional addressing climate change and social inclusion objectives/targets at the same time. Narratives and (narrative) frames can draw attention to specific topics and in this case, to specific benefits of nature-based solutions and inspire collaborations across departments. At the same time, narratives can also deflect attention away from an issue if not counter-balanced with narratives of 'reason and focus' (Frantzeskaki, Jhagroe and Howlett, 2016). As such, narratives can be instruments to foster collaborations across departments for successful communication of co-benefits and planning of nature-based solutions.

Recent research on nature-base solutions, also points to the importance of how knowledge and mission are communicated and shared. Martinez-Harms et al (2018, p.10) point at the importance of 'getting the discourse right (...) as this can provide a narrative through which individuals and communities can validate and initiate actions, addressing issues of agency and empowerment". van der Jagt 2017 (p.270-271) argue for a 'broadly shared urban food growing motivation' as captured in an inclusive discourse for urban gardening as being paramount in creating social inclusion and a "scope for socializing". Davies et al 2017 (p.104) also suggest that communicating the benefits of urban forests to politicians, citizens and urban managers (next to tree managers) is important for creating support and understanding of the importance of urban green. They also point out that scientific reports on urban trees need to present evidence both

on benefits/services and trade-offs/disservices to provide scientific base for urban management decisions. For this, it is also important to get broader knowledge sharing and weaving into the narrative. Arkema et al 2017 point that integrating different types of knowledge for designing and evaluating nature-based solutions "may help coastal planners confront disparities in disaster risk reduction and anticipate changes in the nature of demand for coastal protection services" (p.19). This is specifically relevant for the coastal/port cities of Rotterdam, Malmo and Thessaloniki. Baycan-Levent, T., and Nijkamp, P., (2009), point that for better planning and governance of urban green spaces in general, collaboration and coordination between different departments are paramount.

The cities of Potenza (Italy), Antwerp (Belgium) and Burgas (Bulgaria) worked in setting a common message across their departments and teams throughout the project and especially during the experimenting with nature-based solutions. Especially the city team of Potenza city engaged with all departments of the city in different times throughout the project in generating ideas and re-calibrating the narrative of urban resilience that brought a new understanding of 'why do we need good quality of green spaces in the city'. Instead of focusing on what is missing or 'what is the problem', the narrative of mission focused on 'the resilience of our city' and on the actions that will help realizing it. The early engagement across departments in the city of Antwerp for the Sint Andries experiment also established a ground for collaboration in the experiment and for making a common narrative for nature-based solutions as climate adaptation solutions.

Drawing from this lesson, we see the following implication for policy and planning: Urban planners need to consider communication tools such as narratives in creating shared understandings and also bridging departmental disputes for realizing nature-based solutions in their cities. Even when evidence on the effectiveness of nature-based solutions is paramount, the means of communication and of bridging knowledge and expertise existing in different departments are very important as intermediating and leveraging support, resources and access to networks and knowledge.

Lesson #7: Nature-based solutions need to be designed in such a way and scale that lessons for their effectiveness can be easily harvested and as thus, to be easily replicated into other locations.

The design and scale of a nature-based solution are critical factors on the viability for the solution to be replicable into other locations in the same city and in other cities. Specifically, concept designs of greening courtyards, green walls and green roofs even in medium scale require a localization when replicated, and the complexity of the concept design may deem some solutions too contextually bound to be replicable.

Recent literature on designing nature-based solutions further supports this lesson. Specifically, van Mechelen et al 2015 point at the biodiversity of green roofs as a design element that influences their multi-functionality and relatively their transferability. Polling and Mergenthaler 2017 point at the city-proximity and the diversification as critical design factors of urban farming for making urban farming socially benefiting. Brown et al 2015 found that designing urban parks to deal with heat stress requires a careful consideration of both the sunlight penetration through vegetation and the wind speed change from average in the urban environment. Montgomery (2013, p.174-175) argues that cities need to reconsider the ways they use and plan and even regenerate urban spaces. Even for urban spaces like streets that outlive generations of urban citizens are "malleable and fluid" hence rethinking how to use them and scale their regeneration and infrastructure update is important for improving quality of life in cities.

A bright example brought to attention include the inclusion of green areas and water drainage infrastructures in the Augustusburg neighborhood in Malmo that has been celebrated as a global example for integrating new infrastructure (at its time) to green development and has been replicated in other cities.

The same holds for the replicated Kipos example of urban agriculture experiment in Thessaloniki, in which the restoration of open vacant space as an urban agriculture patch was introduced inspired by other cities. The simple design and simple dual function helped in its easy replication.

Drawing from this lesson, we see the following implication for policy and planning: All sizes of nature-based solutions can contribute to more livable and resilient cities. The focus on upscaling nature-based solutions needs to be balanced with harvesting lessons from small-scale local applications.

3. Conclusion

Nature-based solutions should not be considered as "optional luxury" in cities (Montgomery, 2013, p.120). The investments and efforts in advancing and updating urban infrastructures to deal with climate change pressures and demographic changes require more holistic approaches that take nature into the equation. Nature-based solutions with the evidenced multiple benefits that they can deliver are strong candidate solutions to infrastructure ecomodernisation.

From our work with the cities of Resilient Europe, we have three overarching concluding lessons: First, resilience building at local scale is seen as possible to be programmable through experiments and collaborations between the city and citizens. This view holds amongst the urban planners (whom we interviewed during the validation phase) and our research findings. The experiments with nature-based solutions showed that new forms of urban infrastructure can be co-developed and accepted by citizens when a stepwise experimenting process is set up and facilitated. The role of the cities in this process is of facilitation and enabling testing, co-creating of ideas and mobilising bottom-up action.

Second, experimentation with nature-based solutions requires willingness to learn and to collaborate across departments and with citizens beyond consultative and regulative approaches. It may seem as a well argued lesson across the urban planning literature that participatory and collaborative governance is paramount when shifting to new solutions and new planning concepts, however nature-based solutions require open, inclusive and co-creation modes of governance for their implementation. Cities may not be equipped for a fully operational co-creation approach hence it is suggested to consider social innovators and other social actors to partner with and to facilitate the co-creation process together.

Third, city-to-city networks like the URBACT networks allow allow for quick learning from successes and failures when implementing nature-based solutions' experiments and their governance. Knowledge transfer partnerships with cities and SMEs can move lessons learnt about nature-based solutions forward and enable their transfer and upscaling (Collier et al 2013, p.24). It is therefore important for cities who want to build capacities and learn from other cities on know-how and on governance practices to enter such city-to-city networks as opportunity spaces for learning by peers as well as from learning by doing. In Resilient Europe project cities were also encouraged to partner in thematic groups for more intense learning and sharing experiences and the cities who pursued it communicated that it was of great value. The city team and ULG of Antwerp visited Rotterdam ULG team and the city team in 2017 and they also visited all climate adaptation initiatives. The cities of Ioannina and Thessaloniki were is frequent contact on how to navigate the social complexity in setting up their urban living labs. Next to the URBACT opportunities, cities can also consider city networks such as ICLEI, C40 or even thematic city-networks such as 100 Resilient Cities of the Rockfeller foundation. Antother thematic example is the Delta cities network initiated by Rotterdam about climate adaptation demonstrating eco-innovation such as floating urbanization also creates learning opportunities and transfer of knowledge and innovation (Huang-Lachmann and Lovett, 2016)

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