Nature Based Solutions (NBS) for sustainable and resilient cities: experiences from Europe and Brazil

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Abstract. Although Nature-Based Solutions (NBS) is a relatively recent concept, it can provide effective means for cities worldwide to become more sustainable and to enhance urban resilience, thus improving the quality of life of their citizens. Moreover, cost-effective NBS can help improve the urban environment in multiple scales, from buildings to neighbourhoods, from public spaces to peri-urban areas, providing all kinds of co-benefits positively influencing the above-mentioned challenges. Depending on the context and the need, many different stakeholders may be involved in the co-creation of systemic, inclusive and locally attuned NBS supporting social cohesion and urban equality.

The learning alliance fostered by the EU-Brazil Sector Dialogue on NBS, is currently working together to identify common research and innovation agendas for cooperation, as well as mapping relevant examples of successful NBS that have been recently implemented or are under development in both Europe and Brazil. The cases selected have been studied and compared with a particular emphasis on their potential for replicability, scalability and adaptation to the local context. In addition, they should address the three pillars of sustainability: environmental, socio-cultural and economic.

Therefore, this paper discusses the opportunities offered by NBS (even in periods of economic downturn), but also the limiting factors hindering their wider dissemination. In addition, it will present through a few inspiring case studies from both regions, clear examples of successful implementation of NBS, which could be replicated and scaled in other locations in response to specific local conditions.

1. Introduction

As the world’s urban population is expected to double by 2050 according to the New Urban Agenda [1], cities will face enormous challenges related to climate threats, environmental quality, adequate services and infrastructures, mobility, affordable housing, employment, food security, etc. Even more in the case of those cities particularly affected by rapid urbanization [2].
NBS components such as parks, built wetlands, food gardens, among many others are key to reconnect people to nature and can be used as classrooms for environmental education [3]. NBS are essential do adapt cities to climate change impacts and contribute to mitigate GHG emissions [4].

The Sector Dialogue on NBS between EU and Brazil enabled the first broad research on the current scenario in the largest country in Latin America. The first Dialogue completed in 2016 “Innovating cities with nature-based solutions: co-creating knowledge on nature-based solutions with EU-Brazil Sectoral Dialogues”, provided a framework for identifying and assessing NBS as well as defining future topics for collaboration. The second Dialogue recently concluded, and of which this paper can be considered an epilogue, has deepened the analysis focusing on how to harness the Brazilian potential for NBS and how the EU’s experience can contribute to accelerate the process. It also maps relevant examples of successful NBS either already implemented or under development in both Europe and Brazil, with a special emphasis on their potential for replicability, scalability and adaptation to the local context, while addressing the three pillars of sustainability.

Therefore, this paper discusses briefly the opportunities offered by NBS (even in periods of economic downturn), through a few inspiring case studies from both regions, which could be replicated and scaled in other locations in response to specific local conditions.

2. NBS for sustainable and resilient cities
The EU defines NBS as “solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more and more diverse nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions”[1]. Therefore, in recognition of the role that NBS can play in providing sustainable, cost-effective, multipurpose options for more resilient cities and societies, the EU Research and Innovation Policy Agenda for NBS and Re-Naturing Cities aims at positioning the EU as a leader in “innovating with nature”. In practice, the Agenda is implemented through Horizon 2020 Programme [5].

In Brazil, the Ministry of Science, Technology, Innovations and Communications (MCTIC) created the thematic programme of Technologies for Sustainable Cities that aims to support cities to transition to a more sustainable development with the incentive to innovation and technologies in several fields. The programme includes as focal themes NBS, biomimicry and urban metabolism.

3. Experiences on NBS from Europe and Brazil. What can we learn?
In Brazil, the results have shown that there are several NBS planned, designed and implemented at different scales, from local to regional. At regional and city scales, the NBS are planned, designed and implemented by local authorities, with some participation of civil society representatives and NGOs. However, local NBS are usually bottom-up initiatives promoted by citizens (grassroots) and articulated with other residents and institutions, public and private, to transform sites that they see as opportunities to create a better place to live in. Also, there are institutional initiatives that are carried out due to legal requirements to protect and enhance the local environment. Even though there is certain academic involvement in NBS at different stages, with very few research labs working in this area, the funds in Brazil are limited in this field.

Being at the forefront of investing in a green economy, the EU features a large number of examples covering a wide array of NBS (storm water retention ponds, urban food production, green façades and roofs, green corridors, etc.) for different scales in very different contexts across Europe. NBS are used for different purposes like the regeneration of degraded urban areas, storm water management, flooding risk reduction, etc. Even though most of the European examples involve multi-stakeholder engagement, the ones chosen for this paper are a bottom-up initiative and a highly participatory NBS co-design process in order to show how such approaches can contribute to social inclusion and

[1] https://ec.europa.eu/research/environment/index.cfm?pg=nbs
cohesion. They also illustrate how cities can improve their environment and their citizens’ wellbeing with small-scale measures relatively cheap to implement even in times of economic downturn.

In short, NBS offer plenty of opportunities for cities to address contemporary local and global challenges such as: climate change impacts; urban heat island effect; floods and landslides; air, water and soil pollution; or human health improvement (among others). The case studies documented indicate that there is great potential for scaling up solutions, especially through international partnerships, which can contribute knowledge that can be adapted to different contexts, as well as financial support to develop innovations for climate change adaptation in tropical cities.

4. Relevant examples of bottom-up NBS initiatives and citizens participation

Bottom-up NBS initiatives offer many opportunities for improving the urban environment while enhancing social engagement and inclusion. More in particular, they allow the implementation of NBS when the economic conditions or the lack of institutional commitment are not favorable for top-down NBS development driven by the public administration, either local or regional. Similarly, citizens’ participation in the decision-making process, not only before, but also during the implementation of NBS projects, particularly large and complex ones, and even after their completion, can lead to: 1) new innovative ideas better tailored to the needs and preferences of the citizens; and 2) long-term appropriation and commitment to further development with multiple benefits for all stakeholders.

4.1. The Power of Food Festival (Edinburgh, UK) and citizens’ participation in co-creation of NBS (Tampere, Finland)

The Power of Food Festival\(^2\), takes place annually in Edinburgh since 2015. Founded by Marie-Amélie Viatte, who was inspired by the community food growing activities in her city, and also by other similar initiatives in the country related to urban food production like Incredible Edible\(^3\), the Festival was built on the idea of a “festival for the gardens and the gardeners”. There are a lot of community gardens in Edinburgh. Community gardens sometimes happen on a piece of grass that belongs to the local social housing blocks. Or in schools and offices, in a library courtyard, etc.

\(^2\) [https://poweroffoodfestival.wordpress.com/](https://poweroffoodfestival.wordpress.com/)
\(^3\) [https://www.incredibleedible.org.uk/](https://www.incredibleedible.org.uk/)

**Figure 1.** Live music at the Royal Edinburgh Community Garden during the Power of Food Festival 2018. (Picture: courtesy of The Power of Food Festival)
Reaching out to active groups like Granton Community Gardeners⁴, and supported by a small but dedicated group of volunteers, the Festival wanted to offer people the opportunity to travel to those neighbourhoods, many of them deprived, and to walk around the gardens and know the work of the gardeners. There is no entrance fee for the visitors to see the gardens. Since the beginning, the Festival is about growing, harvesting and sharing the food together, and some gardens even offer food for the visitors to enjoy.

Figure 2. Sustrans bikes. (Picture: courtesy of the Power of Food Festival)

Figure 3. New Haven Heritage Community Garden (left). Learning about bees in Starbank Community Garden (right). (Pictures: courtesy of the Power of Food Festival)

⁴ https://www.communityfoodandhealth.org.uk/community-based-activity/case-studies/granton-community-gardeners/
The gardens contribute to the promotion of the event, and therefore those that put more effort on communications typically receive more visits. Artists and artisans also participate on voluntary basis offering live performances to entertain the public. Clearly, music and the arts draw people in. After one edition ends and they thank everyone, the organizing team reflects on the results and starts planning the next edition, always looking for new ways to establish mutually beneficial partnerships in order to provide novel activities. E.g. the collaboration with Sustrans\(^5\), a British charity focusing on making it easier for people to walk and cycle, allows the Festival to offer bicycle rides for visitors around the gardens. In the future, it is envisioned that the gardens will take more ownership of the Festival and organize it by themselves, and together they will create their own identity. In addition, new activities could be offered, like walking tours.

Since some authors argue that NBS have not always been able to involve citizens adequately and have failed to properly address food security, poverty alleviation and urban inequality, the proponents of the Edible City Solutions (ECS) conceptual framework offer a strategic approach “towards the development of sustainable, livable, and healthy cities” \([6]\). The Power of Food Festival along with Edinburgh’s community gardens illustrate well the potential of edible urban green space to successfully involve citizens in the provision of socio-cultural ecosystem services.

\[\text{Figure 4. Visioning Vuores session for residents and other stakeholders (left). Children watching water insects under the microscope (right). 101 participants, pupils and teachers. (Pictures: courtesy of the City of Tampere)}\]

Located in Southern Finland, Tampere is a city of 225,000 inhabitants with an important industrial heritage. At present, Tampere is a centre for high-tech companies, technology, research, education, culture, sports and business. The city wants to become a global frontrunner demonstrator of NBS and in line with that objective, is currently a partner in UNaLab (Urban Nature Labs) project funded under the EU Horizon 2020 programme (2017-2022). Within UNaLab, Tampere is implementing an urban living lab demonstration area in Vuores eco-efficient district to address identified climate and water related challenges, more specifically flooding and storm water management, by co-creating NBS with local stakeholders and end users.

Vuores is a green district to be completed by 2030, providing residence for 13,000 people and 3,000 to 5,000 jobs. The NBS solutions co-created and demonstrated in Vuores will be scaled up and further developed in another area of the city called Hiedanranta. NBS demonstrated in Vuores include public green spaces and storm water ponds, green roofs and walls for buildings, and permeable

\[\text{\(^5\) https://www.sustrans.org.uk/}\]
pavements. A series of workshops have been organized in Vuores in the context of UNaLab project covering “Visioning”, “Ideating” and “Testing”, with 139 active participants, many of them children.

**Visioning Vuores workshops:**
- Urban Nature - Blue and Green Vuores Workshop;
- Session for residents and other stakeholders;
- Participatory design game - end users received information on NBS while experts received information on user experience and willingness to take part in the co-creation and maintenance of NBS.

**Ideating Vuores workshops:**
- Storm Water Day at Vuores School;
- Session for kindergarten children and Elementary School pupils (101 participants);
- Design Thinking: participatory design game and LEGO serious play.

**Testing Vuores workshops:**
- The Nature Trail and the Blue and Green Treasures of Vuores;
- NBS info desk during Vuores Day Festival.

The best ideas collected from the workshops will be further elaborated and implemented. The results of the workshops can be summarized as follows: in terms of recreation, the participants proposed more accessible green areas to encourage and support physical activities; more city green and wilder parks are needed to protect and increase biodiversity; whereas in relation to water management, more information on NBS along with novel NBS to protect water quality were demanded.

In the workshops that took place in the schools, teachers and pupils were given tools to monitor water quality and macroinvertebrates. The monitoring started in May 2018 and this activity is planned to be conducted twice a year. The pupils will have water monitoring backpacks, which include the equipment needed to monitor water pH, temperature, turbidity and oxygen. Experts will give advice on where to begin and how to report the results, which will be used to evaluate the impact of NBS.

4.2. **Springs Square and “Corujas” Food Garden (São Paulo, Brazil)**

São Paulo is the largest city in South America, with 21.2 million inhabitants in the Metropolitan Region. During the urbanization process ecosystems were eliminated, rivers disappeared from the landscape. The waters are very polluted by point (mainly sewage discharge) and diffuse contamination by storm water run-off. Food comes from distant places, and most of the fresh produce sold in the supermarkets is treated with chemicals and pesticides. Thus, people are neither connected to nature, nor to natural processes and flows of biodiversity, waters and food production. Urban green areas are mostly covered by lawn with ornamental vegetation that offers reduced ecosystem services.

In São Paulo the concept of park is a fenced green area, whereas squares are not. There is no relation to its size nor to the vegetation cover. In this paper, two Brazilian case studies located in squares in central areas of the city are presented: Owls’ Food Garden and Spring’s Square. Both were transformed by the action and co-creation of citizens that wanted to transform the public green areas in their neighborhoods to generate multiple ecosystem services to enhance their quality of life and well-being.

The first is located at the Dolores Ibarruri Square, its official name, but it is known as the Owls’ Square after the Owls’ river that flows in a canal in the lower area. It has a total area of 48,000m². In 2008 the square was renovated with rain gardens and bio-swales. Most of the slopes were covered by lawn that require high maintenance and could not prevent erosion caused by frequent strong storms. It is a very popular destination for community members in search of relaxation, exercise, birthday celebrations and other social events in contact with nature.

In 2011, two residents got informal authorization from the District Deputy Mayor to start a food garden in a lawn covered 800m² plot of land inside the square. Both had attended a permaculture course, which turned around their lives and the history of food gardening in São Paulo, and later expanded beyond city borders with the Facebook group Hortelões Urbanos (Urban Food Gardeners).
The group has more than eighty thousand members and a list of thousands waiting to be admitted. Their initial cultivation site was at Owls’ Square, now named the Owls’ Food Garden. The area produces all kinds of edible plants, including non-conventional food plants, plus flowers that attract pollinators and enhance the soil biota. The applied agroforestry techniques restored the water springs that restarted to flow, conveying the waters through bio-swales into small basins, where they store the needed water to irrigate the garden even during severe droughts that happen recurrently.

The food garden relies on the voluntary work of residents. They promote collective actions to plant, manage and clean the planted site. The biodiversity thrives, with a total transformation from the high maintenance grass covered slope to a high-performance landscape that offers a myriad of benefits for people and nature. They still need to educate those neighbours that don’t understand the concept of “messy” garden. The Owls' Food Garden is a social-ecological experience that has to be developed daily. The site is visited by schools and college students. The movement has gone further with events and publications that raise awareness about consumerism and the broad impacts caused by unsustainable lifestyles, organic food production compared to the conventional pesticide-based monocultural agriculture, and the value of nature in the city.

![Figure 5. Owls’ Food Garden: Before (left) and after (right) the planting of the community garden. The change in the landscape is remarkable with rich biodiversity and increased ecosystem services due to residents' participation. (Pictures: Cecilia P. Herzog)](image_url)

The second case in São Paulo is located in the Sumaré neighborhood on the other side of the hill, where the waters flow to the main river named Tietê. Sumaré is a mainly residential district where there are not many green areas for people to socialize. The 12,000m² Homero Silva square is the largest green space in the neighborhood. It was a derelict place where people used to throw garbage. It was insecure, nobody used to go there. In 2013 a grassroots movement called Ocupe&Abrace (Occupy and Embrace) started to take care of the place to recover the springs of the Água Preta (Black Water) creek and the biodiversity, aiming to have direct contact with nature and natural processes and flows.

After five years they achieved more than an oasis in the hard cityscape. Ocupe&Abrace restored eight springs building two ponds to receive the waters before they disappear underground, creating new ecological niches, and planted more than 600 native and food species in collective events. The city is vulnerable to mosquitoes that transmit dengue, chikungunya and other tropical diseases. To avoid the reproduction of the vector, one hundred aquatic species were introduced for biological control. It was so successful that in January 2017, when the city suffered a burst of mosquitoes with human health paying a high toll in most of its urbanized areas, the neighborhood was the only place that had avoided the proliferation of contagious viruses.

In the slope that was eroding, an independent project named “Cerrado Infinito” (Infinite Savannah) introduced Cerrado (Brazilian Savannah) vegetation – the native dry ecosystem that disappeared from the local landscape. This project was led by Daniel Caballero who is an artist passionate for this ecosystem. He has been collecting, planting and educating residents about the importance of having
back the vegetation that has deep roots, thus enhancing the water flows of the springs. So, the project “Cerrado Infinito” is an educational project that intends to raise awareness about the importance and the impact that has been caused to the water producer biome, where most of the important Brazilian rivers’ springs are located, in Central Brazil.

Figure 6. Spring’s Square: Built pond where native aquatic species were introduced (top left); Cerrado planting on the slope (top right); and interpretative signage to educate visitors (bottom left). (Pictures: Cecilia P. Herzog)

5. Discussion

In São Paulo, besides the ecological benefits, the grassroots movement also promotes festivals to educate about nature, and celebrate life and culture, with collective plantings, music, “Drums Circle”, among other activities. Social cohesion has surpassed the limits of the square and the group is now fighting in court to avoid the construction of a high rise building in its border that will impact the springs. Similarly, in Edinburgh the Power of Food Festival attracts an increasing number of participants due to a creative and varied programme that includes arts and crafts, but also educational activities, e.g. music, storytelling, pottery making, insect safaris, bicycle tours, etc., providing lots of fun and entertainment for visitors of all ages. By celebrating the contribution of the people that breathe life into the gardens and the neighbourhoods, the Festival wishes to promote greater social inclusion and wellbeing, environmental awareness and sustainability through community food growing.

NBS have intuitively been introduced in many places, some have had the contribution of professionals that give technical support and academia that enhances the benefits with scientific knowledge. There are people who know that we all depend on nature and natural processes and flows to survive, have a good quality of life and well-being, and many are working to transform the urban landscape at the local scale. It is more sustainable when residents lead the process, since top-down practices and actions are subject to political changes, especially in countries were policies may be changed without real public participation, which is the case of Brazil. The workshops organized in Vuores by the City of Tampere, Ramboll and VTT within UNaLab project, with a high participation of different stakeholders including citizens, and even children, have provided the opportunity for
mapping different viewpoints for further development of existing NBS. In addition, cooperation with local universities and a SME producing bio-char is leading to the development of new bio-filtration solutions to treat contaminated waters which also creates new business opportunities around NBS.

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