Urban Planning, Nature-Based Solutions and Local Sustainability

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Abstract

The 11th Sustainable Development Goal (SDG) summons cities to strive for sustainable development. Cities' resilience to the damaging effects of climate change must be enhanced. Urban sustainability is primarily the responsibility of local government. Nevertheless, it requires the participation of citizens, be they economic agents, workers, urban planners, or local leaders. Portuguese urban planning law already has legal instruments, namely municipal ecological structures (MES). As in other subjects, the law cannot and should not rule society without involving other areas of knowledge. Nature-based solutions (NBS) are already incorporated into legal planning instruments. Through natural processes, they contribute to counteracting the rise of urban temperatures, preserving public spaces and biodiversity, and promoting energy sustainability, thus, safeguarding public health, fighting harmful social effects such as energetic and social poverty, unemployment, and the breakdown of community ties. However, urban resilience requires networking with other urban centres. The paper will be a description of the state of the art involving three axes: urban planning, NBS, and the contribution of legal instruments to urban sustainability. To achieve this goal, the article will essentially be based on a survey of the literature and examples of NBS implementation.

Keywords: *11th SGD; urban resilience; stakeholders' participation; urban planning; municipal ecological structures; nature-based solutions.*

JEL Classification*:* K23, R14, Q24

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1. Introductory section

The 11th SDG summons cities to become humanly inclusive, safe, sustainable, and resilient. This SGD is directly related to the twofold role that cities play in climate change. On the one hand, the effects of these changes strike cities and their inhabitants in the most impressive and devastating ways. On the other

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hand, the cities' structure, their demography, building organisation, economic activities, and transport policy act as triggers for accelerating climate change. Therefore, the 13th SDG is directly involved.

The 11th SDG is subsequently substantiated in target 11.3 when it is proposed, 'By 2030, [to] enhance inclusive and sustainable urbanisation and capacity for participatory, integrated and sustainable human settlement planning and management in all countries'[2]. One of the target's indicators is 'Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically'[3]. In other words, the vital importance of the participation of all the stakeholders in achieving the goal. This outlines two of the axes of the analysis, essentially based on a literature review: the concept of urban resilience and the importance of the participation of cities' stakeholders in urban planning. It is important to reflect on whether law, particularly urban planning law, as a branch of the law that addresses the use, transformation, and occupation of urban territory, has and/or can play a role in this endeavour. As with many other subjects, the law cannot and should not be able to regulate society's behaviour without recourse to other fields of knowledge and must therefore embrace interdisciplinarity. One of the non-legal instruments that have been used in urban planning and management are so-called nature-based solutions. Although there are already, as the literature shows, many cities that apply NBS, we present a Portuguese legal tool that could be the vehicle for a wider use of NBS in urban planning and management in Portugal: Municipal Ecological Structures (MES).

2. Urban resilience – a multidisciplinary concept

Climate change refers to the significant disturbances and alterations in climatic patterns and conditions over time primarily attributed to human activities, such as the burning of fossil fuels, deforestation, and industrial processes. These changes manifest in a variety of ways, including rising global temperatures, changing precipitation patterns, increased frequency and intensity of extreme weather events (such as heatwaves, floods, and droughts), melting ice caps and glaciers, rising sea levels, and shifts in ecosystems and biodiversity. Importantly, climate change not only affects environmental conditions directly, but also has cascading effects on socio-economic systems and human well-being.

[2] 'Make cities and human settlements inclusive, safe, resilient and sustainable,' accessed 25 May 2024, https://sdgs.un.org/goals/goal11#targets_and_indicators. 'Participation processes are widely encouraged in international conventions, such as the Local Agenda 21 Action Plan (United Nations Conference on Environment and Development, 1992), the European Landscape Convention (Council of Europe, 2000), and the EU Aarhus Convention (Stec et al., 2000).'[Hanna Fors et al., 'Striving for Inclusion-A Systematic Review of Long-Term Participation in Strategic Management of Urban Green Spaces', *Frontiers in Sustainable Cities* 3 (2021), https://doi.org/10.3389/frsc.2021.572423.]

[3] Idem.

Therefore, addressing climate change requires global cooperation and concerted efforts to reduce greenhouse gas emissions, foment the transition to renewable energy sources, conserve natural resources, and adapt to the changes already underway[4]. Considering that 'the growing body of literature' is focused 'on urban-rural temperature differences, known as the Urban Heat Island, which does not provide insight into urban heat dynamics', the authors prefer the 'understanding of urban heat dynamics rather than an urban-rural comparison'[5]. The heat island effect is one of the greatest manifestations of the growth of cities, usually due to urban activities such as industrialisation and transportation, both highly responsible for 'increasing greenhouse gas emissions caused by the anthropogenic effect'[6]. On the other hand, precipitation patterns can disrupt agricultural productivity, leading to food shortages and price fluctuations. Extreme weather events can cause physical damage to infrastructure, homes, and livelihoods, and result in loss of lives and displacement of populations. Additionally, climate change can exacerbate existing socio-economic vulnerabilities, impacting marginalised communities disproportionately and exacerbating inequalities. Moreover, climate change can amplify existing shocks and stresses, even if not directly caused by climate-related factors. For instance, they can aggravate water scarcity issues in regions already facing water stress, worsen air quality in urban areas, and heighten the spread of vector-borne diseases in regions where they are already endemic.

In short, the impact of climate change is multifaceted and encompasses a wide range of environmental, social, and economic consequences that unfold over time. It is characterised by disruptions to natural systems and human societies, as well as the potential to exacerbate existing vulnerabilities and shocks. Furthermore, urban growth, rapid urbanisation[7], and the associated climate issues, are expected to increase even more in Countries of the Global North and of

[4] Nadja Kabisch et al., 'Nature-Based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action', *Ecology and Society* 21, no. 2 (2016), https://doi.org/10.5751/ES-08373-210239; Pritipadmaja, Rahul Dev Garg, and Ashok K. Sharma, 'Assessing the Cooling Effect of Blue-Green Spaces: Implications for Urban Heat Island Mitigation', *Water* 15, no. 16 (18 August 2023): 2983, https://doi.org/10.3390/w15162983; Merve Ersoy Mirici, 'The Ecosystem Services and Green Infrastructure: A Systematic Review and the Gap of Economic Valuation', *Sustainability* 14, no. 1 (4 January 2022): 517, https://doi.org/10.3390/su14010517; Federica Marando et al., 'Urban Heat Island Mitigation by Green Infrastructure in European Functional Urban Areas', *Sustainable Cities and Society* 77 (February 2022), https://doi.org/10.1016/j.scs.2021.103564.

[5] Noëmie Probst et al., 'Blue Green Systems for Urban Heat Mitigation: Mechanisms, Effectiveness and Research Directions', *Blue-Green System* 4, no. 2 (1 December 2022): 348–76, https://doi.org/10.2166/bgs.2022.028.

[6] Ersoy Mirici, 'The Ecosystem Services and Green Infrastructure: A Systematic Review and the Gap of Economic Valuation'; Yijian Xu and Yanhong Kong, 'Sponge-City-Based Urban Water System Planning: A Case Study of Water Quality Sensitive New Area Development in China', *Blue-Green Systems* 3, no. 1 (January 2021): 249–66, https://doi.org/10.2166/bgs.2021.022.

[7] Qiwei Ma, Yonghua Li, and Lihua Xu, 'Identification of Green Infrastructure Networks Based on Ecosystem Services in a Rapidly Urbanising Area', *Journal of Cleaner Production* 300 (1 June

the Global South[8]. These impacts highlight the urgent need for efforts to reduce greenhouse gas emissions, as well as adaptation measures. Therefore, strengthening urban resilience is imperative, and it can be pursued through physical infrastructure and systems to address robustness and flexibility issues for facing climate change, but also social networking to build cohesion, collaboration and engagement among cities' stakeholders[9].

Urban resilience is a dynamic and multidimensional concept that requires proactive measures, strategic investments, and collective action[10]. The goal is to better prepare cities to withstand shocks, adapt to changing conditions, and thrive in the long term. Environmental sustainability, as well as adaptative planning and governance, are also interesting and fruitful tools to build urban resilience. Our goal is to reflect upon whether the use of NBS can contribute to strengthening the cities' resistance to extreme weather events[11].

3. Local government and stakeholders' participation

Although urban planning issues are generally the responsibility of local

2021): 126,945, https://doi.org/10.1016/J.JCLEPRO.2021.126945; Mahmoud Mabrouk et al., 'Assessing the Effectiveness of Nature-Based Solutions-Strengthened Urban Planning Mechanisms in Forming Flood-Resilient Cities', *Journal of Environmental Management* 344 (15 October 2023): 118,260, https://doi.org/10.1016/J.JENVMAN.2023.118260.

[8] Ersoy Mirici, 'The Ecosystem Services and Green Infrastructure: A Systematic Review and the Gap of Economic Valuation'.

[9] Edoardo Croci and Benedetta Lucchitta, eds., *Nature-Based Solutions for More Sustainable Cities* (Emerald Publishing, 2022); Javier Babi Almenar et al., 'Nexus between Nature-Based Solutions, Ecosystem Services and Urban Challenges', *Land Use Policy* 100 (January 2021), https://doi.org/10.1016/j.landusepol.2020.104898; Wito Van Oijstaeijen, Steven Van Passel, and Jan Cools, 'Urban Green Infrastructure: A Review on Valuation Toolkits from an Urban Planning Perspective', *Journal of Environmental Management* 267 (August 2020): 110,603, https://doi.org/10.1016/j.jenvman.2020.110603; Renato Monteiro, José Ferreira, and Paula Antunes, 'Green Infrastructure Planning Principles: An Integrated Literature Review', *Land* 9, no. 12 (16 December 2020): 525, https://doi.org/10.3390/land9120525.; Judy Bush and Andreanne Doyon, 'Building Urban Resilience with Nature-Based Solutions: How Can Urban Planning Contribute?', *CITIES* 95 (December 2019), https://doi.org/10.1016/j.cities.2019.102483.; Yaella Depietri and Timon McPhearson, 'Integrating the Grey, Green, and Blue in Cities: Nature-Based Solutions for Climate Change Adaptation and Risk Reduction', 2017, 91–109, https://doi.org/ 10.1007/978-3-319-56091-5_6.; Grazia Brunetta et al., *Urban Resilience for Risk and Adaptation Governance*, Resilient Cities (Springer Cham, 2019). Niki Frantzeskaki, Nadja Kabisch, and Timon McPhearson, 'Advancing Urban Environmental Governance: Understanding Theories, Practices and Processes Shaping Urban Sustainability and Resilience', *Environmental Science & Policy* 62 (1 August 2016): 1–6.

[10] Grazia Brunetta et al., *Urban Resilience for Risk and Adaptation Governance*, Resilient Cities (Springer Cham, 2019); Vanessa Assuma et al., 'Scenario Building Model to Support the Resilience Planning of Winemaking Regions: The Case of the Douro Territory (Portugal)', *Science of the Total Environment* 838 (2022), http://dx.doi.org/10.1016/j.scitotenv.2022.155889.

[11] Alessandro Arlati et al., « Stakeholder Participation in the Planning and Design of Nature-Based Solutions. Insights from CLEVER Cities Project in Hamburg,' *Sustainability* 13, no. 5 (March 2021), https://doi.org/10.3390/su13052572.

authorities, the legal systems that regulate such issues provide for citizens' participation from the beginning (at least in Portugal[12]). However, the inclusion of new concepts such as NBS requires a broader participation.

It is no longer a question whether typical legal and construction decisions prompt any comment, but rather one of including solutions that address, in a different, more holistic and environment-friendly way, a set of problems that are not, strictly by definition, typical of urban planning. Furthermore, it is increasingly a question of implementing a holistic process of continuous participation of the different stakeholders. Thus, 'Deploying NbS in urban contexts requires the cooperation [therefore, the participation] of different public and private stakeholders to manage those processes'[13].

Hanna Fors et al. propose, 'a new holistic approach comprising a cyclic process model for long-term participation in the strategic management of urban green spaces, including analysis, design, and implementation phases, each followed by an evaluation'[14]. They include all the stakeholders, even the marginalised ones, usually more prone to be affected by the social effects of climate change.

It is not only the subjective scope of participation and its procedural extent that must be reconsidered and reflected upon, but also the ways in which it is implemented. The participants are all different because of their specific role in relation to the urban planning instrument. Some are responsible for the procedure of creating and including solutions (local authorities), others use these urban planning solutions (citizens), others design them and think about how to include these solutions in order to maximise their beneficial effects, and others are responsible for monitoring its implementation. Thus, the traditional means of participation must be updated. Arlati et al. refer to 'using the existing regulatory framework concerning participatory processes and eventually stimulating the finding of novel tools towards conducting a transparent and open process of co-creation. In this context, co-creation means allowing stakeholders to collaborate in the process of solution design, implementation, and monitoring. In this sense, the co-creation of NbS is understood as a combination of various expertise from

[12] The Portuguese law establishes the principle of citizen participation in the elaboration of the MMP through public consultation, thus summoning citizens to collaborate in the definition of solutions on their city space and on the more specific requirements of the buildings they inhabit – see. Articles 6 and 89 of Decree-Law no 80/2015, 14th May. The participation is possible through a proposal to prepare a territorial plan, through public consultation or even a stakeholder hearing.

[13] Arlati et al., 'Stakeholder Participation in the Planning and Design of Nature-Based Solutions. Insights from CLEVER Cities Project in Hamburg.'; Israa Hanafi Mahmoud and Eugenio Morello, 'Co-Creation Pathways as a Catalyst for Implementing Nature-Based Solution in Urban Regeneration Strategies: Learning from CLEVER Cities Framework and Milano as Test-Bed', *Urban Information* 278 (2018): 204–10.

[14] Fors et al., « Striving for Inclusion – A Systematic Review of Long-Term Participation in Strategic Management of Urban Green Spaces ».

different scientific fields and the local knowledge of civil society representatives'[15].

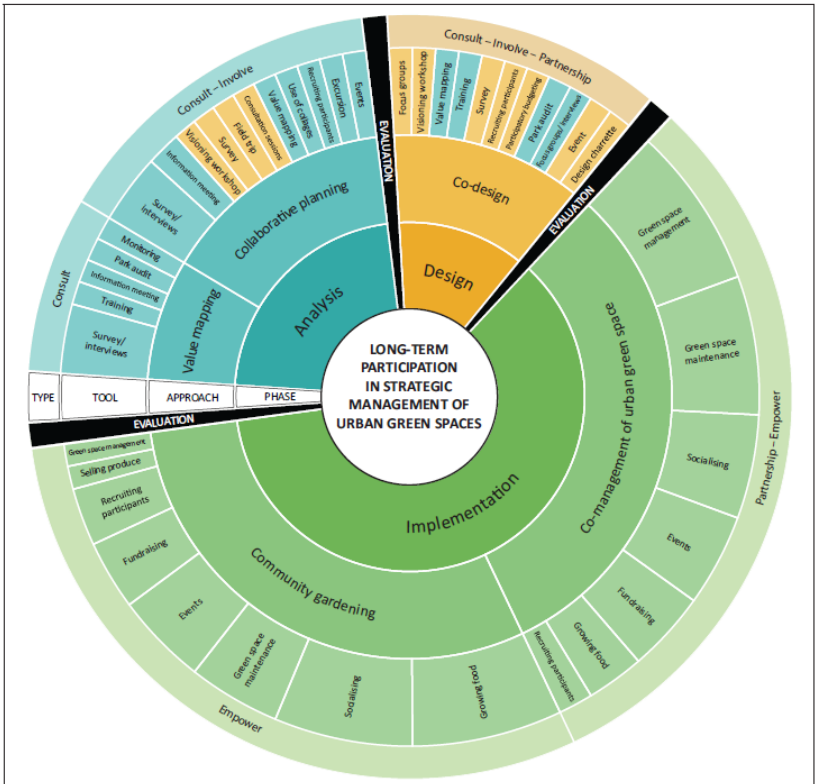

FIGURE 7 | Cyclic process model for long-term participation in the strategic management of urban green spaces (UGS). The inner ring shows the phases of participation in the strategic management of UGS. Analysis phase: turquoise slices; design phase: yellow-brown slices; implementation: green slices. An evaluation of the outcomes from the previous phase is carried out before moving to the next phase. The inner middle ring shows the participation approaches, with the outer middle ring containing the specific tools used within each approach. The outer ring shows the dominating participation type for each approach (based on **Figure 6**).

Figure 1[16]

Citizens, in general, are not used to participating in such procedures, for the following reasons: 'lack of trust in existing political decision-making structures, fear of not having any real political influence, direct exclusion from the physical or social landscape and lack of awareness among users of the possibility

[15] Arlati et al., 'Stakeholder Participation in the Planning and Design of Nature-Based Solutions. Insights from CLEVER Cities Project in Hamburg.'

[16] Fors, Hanna, Frederik Aagaard Hagemann, Asa Ode Sang and Thomas B. Randrup. 'Striving for Inclusion – A Systematic Review of Long-Term Participation in Strategic Management of Urban Green Spaces.' *Frontiers in Sustainable Cities* 3 (2021). https://doi.org/10.3389/frsc.2021.572423.

to participate'[17]. This means that the central government has a key role in disseminating and explaining NBS' public policies.

Nevertheless, participation and coordination are key for a successful implementation of NBS in urban planning.

4. Urban planning tools for fighting climate change – NBS

Given the conceptual scope of NBS, they cannot be considered an instrument, or set of instruments, restricted to the urban legal or urban planning dimension. Nevertheless, our scope is the NBS concept applicable to cities.

As can be easily understood from the literature, the concept is elusive, extensive, and encompasses solutions inspired by nature. They may be infrastructure, networks, and provide relevant ecological services. Therefore, our reflection will use the concepts of UBGI (urban blue, green infrastructure), GI (green infrastructure), and ES (ecosystem services) as more restricted concepts within the NBS concept. UBGI combine 'water management and green infrastructure to maintain natural water cycles and [enhance] environmental and urban renewal' above ground, on the ground, and/or under the ground[18]; GI focus on the green solutions, and ES are used when the perspective is a functional one. Even though there is no consensus regarding the content of the concept, the wide range of benefits – environmental, societal, and even economic ones[19] – of whatever called structure that uses natural solutions in the urban area is not disputed. Kimic

[17] Thomas J. Straka, Allan P. Marsinko, and Christopher J. Childers, 'Individual Characteristics Affecting Participation in Urban and Community Forestry Programs in South Carolina, the U.S.', *Journal of Arboriculture* 31, no. 3 (May 2005): 129–35.

[18] Kinga Kimic and Karina Ostrysz, 'Assessment of Blue and Green Infrastructure Solutions in Shaping Urban Public Spaces-Spatial and Functional, Environmental, and Social Aspects', *Sustainability* 13, no. 19 (October 2021), https://doi.org/10.3390/su131911041. Jan Kopp et al., 'Integrating Concepts of Blue-Green Infrastructure to Support Multidisciplinary Planning of Sustainable Cities', *Problemy Ekorozwoju* 16, no. 2 (2021): 137–46, https://doi.org/10.35784/pe.2021.2.14. Nafsika Drosou et al., 'Key Factors Influencing Wider Adoption of Blue-Green Infrastructure in Developing Cities', *WATER* 11, no. 6 (June 2019), https://doi.org/10.3390/w11061234.

[19] Kimic and Ostrysz, 'Assessment of Blue and Green Infrastructure Solutions in Shaping Urban Public Spaces – Spatial and Functional, Environmental, and Social Aspects.'; Mathew P. White et al., 'Blue Space, Health and Well-Being: A Narrative Overview and Synthesis of Potential Benefits', *Environmental Research* 191 (1 December 2020): 110,169, https://doi.org/10.1016/J.ENVRES.2020.110169.; Renato Monteiro, José Ferreira, and Paula Antunes, 'Green Infrastructure Planning Principles: An Integrated Literature Review', *Land* 9, no. 12 (16 December 2020): 525, https://doi.org/10.3390/land9120525. Rieke Hansen et al., 'Planning Multifunctional Green Infrastructure for Compact Cities: What Is the State of Practice?', *Ecological Indicators* 96 (January 2019): 99 – 110, https://doi.org/10.1016/j.ecolind.2017.09.042.; Stephan Pauleit et al., 'Nature-Based Solutions and Climate Change – Four Shades of Green', 2017, 29.–49, https://doi.org/10.1007/978-3-319-56091-5_3.; Christopher M. Raymond et al., 'A Framework for Assessing and Implementing the Co-Benefits of Nature-Based Solutions in Urban Areas', *Environmental Science & Policy* 77 (November 2017): 15–24, https://doi.org/10.1016/j.envsci.2017.07.008.

& Ostrysz (2021) describe 19 BGI solutions (table 1) considering their location on the surface (runoff troughs, grassed swales, infiltration trenches, vegetated swales – street-side – bioretention basins, grassed retention and infiltration basins, rain gardens, wetland ponds, surface water reservoirs, retention and infiltration of water reservoirs, water squares, permeable/pervious pavements), underground (infiltration wells, infiltration boxes, structural tree root cells, underground water reservoirs) or above the surface (blue roofs, green roofs, green walls)[20]. NBS, conceived as an umbrella concept, are a tool for enhancing urban resilience, namely within urban and adaptative planning[21]. There are already some examples of NBS regarding spatial strategy and regeneration, as Edinburgh, which has an open space strategy and uses a spatial assessment[22]. The rehabilitation and regeneration of 'vacant and derelict land' is a goal which can

[20] Kimic and Ostrysz, 'Assessment of Blue and Green Infrastructure Solutions in Shaping Urban Public Spaces – Spatial and Functional, Environmental, and Social Aspects'; Helena I. Hanson, Björn Wickenberg, and Johanna Alkan Olsson, 'Working on the Boundaries – How Does Science Use and Interpret the Nature-Based Solution Concept?', *Land Use Policy* 90 (January 2020): 104,302, https://doi.org/10.1016/j.landusepol.2019.104302.

[21] Sofia Castelo, Miguel Amado, and Filipa Ferreira, 'Challenges and Opportunities in the Use of Nature-Based Solutions for Urban Adaptation', *Sustainability* 15, no. 9 (26 April 2023): 7243, https://doi.org/10.3390/su15097243.; Peta Brom et al., 'A Decision Support Tool for Green Infrastructure Planning in the Face of Rapid Urbanization', *Land* 12, no. 2 (4 February 2023): 415, https://doi.org/10.3390/land12020415.; Javier Babi Almenar et al., 'Nexus between Nature-Based Solutions, Ecosystem Services and Urban Challenges', *Land Use Policy* 100 (January 2021), https://doi.org/10.1016/j.landusepol.2020.104898. Judit Boros and Israa Mahmoud, 'Urban Design and the Role of Placemaking in Mainstreaming Nature-Based Solutions. Learning From the Biblioteca Degli Alberi Case Study in Milan,' *Frontiers in Sustainable Cities* 3 (2021), https://doi.org/10.3389/frsc.2021.635610; Judy Bush and Andreanne Doyon, 'Building Urban Resilience with Nature-Based Solutions: How Can Urban Planning Contribute?', *Cities* 95 (December 2019), https://doi.org/10.1016/j.cities.2019.102483; Hade Dorst et al., 'Urban Greening through Nature-Based Solutions – Key Characteristics of an Emerging Concept', *Sustainable Cities and Society* 49 (August 2019): 101,620, https://doi.org/10.1016/j.scs.2019.101620. Pauleit et al., « Nature-Based Solutions and Climate Change – Four Shades of Green » ; E. Cohen-Shacham et al., eds., *Nature-Based Solutions to Address Global Societal Challenges* (IUCN International Union for Conservation of Nature, 2016), https://doi.org/10.2305/IUCN.CH.2016.13.en. Nadja Kabisch et al., 'Nature-Based Solutions to Climate Change Mitigation and Adaptation in Urban Areas: Perspectives on Indicators, Knowledge Gaps, Barriers, and Opportunities for Action', *Ecology and Society* 21, no. 2 (2016), https://doi.org/10.5751/ES-08373-210239.

[22] Rieke Hansen et al., 'Planning Multifunctional Green Infrastructure for Compact Cities: What Is the State of Practice?', *Ecological Indicators* 96 (January 2019): 99–110, https://doi.org/10.1016/j.ecolind.2017.09.042.

also be found in cities such as Chongqing, China[23]; Seoul, South Korea[24]; Brescia, Italy[25]; Milan[26]; subtropical Asian cities[27]; Malmö, Sweden[28]; Hamburg, Germany[29]; and Melbourne, Australia[30]. Milan also uses urban gardens – the Gardens of Porta Nuova – , as Barcelona[31]. On the other hand, Melbourne also uses urban forests: the whole process was collaborative and involved both public bodies and private actors: 'the strategy's focus included urban trees and tree cover, vegetation and greening, the urban forest, biodiversity, and nature[32]. In the building dimension, we can find several examples of the use of green roofs and living walls[33].

[23] Pengcheng Xiang, Yuanyuan Yang, and Zongyu Li, 'Theoretical Framework of Inclusive Urban Regeneration Combining Nature-Based Solutions with Society-Based Solutions', *Journal of Urban Planning and Development* 146, no. 2 (June 2020), https://doi.org/10.1061/ (ASCE) UP.1943-5444.0000571; Pengcheng Xiang, Yiming Wang, and Qing Deng, 'Inclusive Nature-Based Solutions for Urban Regeneration in a Natural Disaster Vulnerability Context: A Case Study of Chongqing, China', *Sustainability* 9, no. 7 (July 2017), https://doi.org/10.3390/su9071205.

[24] Ekaterina Shafray and Seiyong Kim, 'A Study of Walkable Spaces With Natural Elements for Urban Regeneration: A Focus on Cases in Seoul, South Korea', *Sustainability* 9, no. 4 (April 2017), https://doi.org/10.3390/su9040587.

[25] Mauro Masiero et al., 'Urban Forests and Green Areas as Nature-Based Solutions for Brownfield Redevelopment: A Case Study from Brescia Municipal Area (Italy)', *Forests* 13, no. 3 (March 2022), https://doi.org/10.3390/f13030444.

[26] Judit Boros and Israa Mahmoud, 'Urban Design and the Role of Placemaking in Mainstreaming Nature-Based Solutions. Learning From the Biblioteca Degli Alberi Case Study in Milan,' *Frontiers in Sustainable Cities* 3 (2021), https://doi.org/10.3389/frsc.2021.635610.

[27] Leslie Mabon and Wan-Yu Shih, 'Urban Greenspace as a Climate Change Adaptation Strategy for Subtropical Asian Cities: A Comparative Study across Cities in Three Countries', *Global Environmental Change-Human and Policy Dimensions* 68 (May 2021), https://doi.org/10.1016/j.gloenvcha.2021.102248.

[28] Johanna Alkan Olsson et al., 'A Just Urban Ecosystem Service Governance at the Neighbourhood Level-Perspectives from Sofielund, Malmo, Sweden', *Environmental Science & Policy* 112 (October 2020): 305–13, https://doi.org/10.1016/j.envsci.2020.06.025.

[29] Bernhard Scharf et al., 'NBS Impact Evaluation with Greenpass Methodology Shown by the Case Study 'Fischbeker Hofe' in Hamburg/Germany', *Sustainability* 13, no. 16 (August 2021), https://doi.org/10.3390/su13169167.

[30] Melissa Pineda-Pinto, Christian A Nygaard, and Niki Chandrabose Manojand Frantzeskaki, 'Mapping Social-Ecological Injustice in Melbourne, Australia: An Innovative Systematic Methodology for Planning Just Cities', *Land Use Policy* 104 (May 2021), https://doi.org/10.1016/j.landusepol.2021.105361.

[31] Johannes Langemeyer et al., 'Stewardship of Urban Ecosystem Services: Understanding the Value(s) of Urban Gardens in Barcelona', *Landscape and Urban Planning* 170 (February 2018): 79–89, https://doi.org/10.1016/j.landurbplan.2017.09.013.

[32] Niki Frantzeskaki and Judy Bush, 'Governance of Nature-Based Solutions through Intermediaries for Urban Transitions-A Case Study from Melbourne, Australia', *Urban Forestry & Urban Greening* 64 (September 2021), https://doi.org/10.1016/j.ufug.2021.127262.

[33] https://www.greenroofs.pt/en/projects.

Although NBS implementation faces some challenges[34], there is a consensus as to their usefulness for building sustainable cities[35]. We will consider all the urban spatial dimensions of the public space (such as streets, parks, gardens). Public and private buildings are very relevant due to their impermeable surfaces, which intensify the hazards of some climate effects. The literature converges on the range of benefits that cities can reap if they choose to include solutions of this type in urban planning. When elaborating the set of principles related to planning for the integration of green infrastructure, Monteiro R., Ferreira JC, and Antunes P. (2020) indicate the principle of multifunctionality as one of the fundamental principles and one of the three principles most mentioned in literature and in the European and international framework[36]. This feature can be very useful when combined with the urban planning functions.

Besides reducing the impacts of climate change in urban environments, such as the heat-island effect, 'Stormwater regulation, flood protection, microclimate regulation, improved water quality and air circulation'[37], NBS can promote other, less attainable, effects: urban well-being, environmental protection,

[34] Nadja Kabisch, Niki Frantzeskaki, and Rieke Hansen, 'Principles for Urban Nature-Based Solutions', *Ambio* 51, no. 6 (June 2022): 1388 – 1401, https://doi.org/10.1007/s13280-021-01685-w; John Deely et al., 'Barrier Identification Framework for the Implementation of Blue and Green Infrastructures', *Land Use Policy* 99 (December 2020), https://doi.org/10.1016/j.landusepol.2020.105108; Shahryar Sarabi et al., 'Uptake and Implementation of Nature-Based Solutions: An Analysis of Barriers Using Interpretive Structural Modeling', *Journal of Environmental Management* 270 (September 2020), https://doi.org/10.1016/j.jenvman.2020.110749; M. Wihlborg, J. Sorensen, and J. Alkan Olsson, 'Assessment of Barriers and Drivers for Implementation of Blue-Green Solutions in Swedish Municipalities', *Journal of Environmental Management* 233 (March 2019): 706–18, https://doi.org/10.1016/j.jenvman.2018.12.018.

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recreation, connectivity between urban and rural areas, and social inclusion[38]. That is, they can reduce urban vulnerabilities and 'counteract [t] the negative effects of climate change', particularly when combining BGI and ES[39]. This is why many authors emphasise the various functions associated with this type of solution: provision, support, regulation ('carbon sequestration, erosion prevention or pest control') and cultural functions[40]. There are several studies that support and recognise the effect of this kind of solution, namely GI, on temperature. Therefore, the implementation of microclimates in cities, through green roofs and walls, urban forests and trees, geographically adapted, are considered to be major advantages. Marando et al. conclude that 'trees significantly reduce UHI, with an impact that is dependent on the extent of green areas and the amount of transpiration inside a city. In particular, it has been observed that a tree cover of at least 16% is required in order to achieve a reduction of average summer temperature equal to 1◦C. Stakeholders and city administrators can take advantage of the cooling indicator in order to better foresee temperature mitigation strategies in cities in view of a sustainable and effective planning'[41]. A last concern is equal access to NBS for all urban actors[42].

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The first challenge faced by NBS is raising the awareness of spatial planners, public bodies, and developers to join green and blue solutions, namely, to incorporate infrastructure based on natural solutions in models traditionally thought for grey structures[43].

This incorporation and combination of different structures may not be technically easy in the dimensions of construction, development and maintenance, and they always imply a cost-benefit study demonstrating their immediate economic viability (in addition to that in the long term)[44]. This requirement is not new in law and urban planning, though. It should be recalled that in Portugal, as regards external administrative regulations, as is the case of Municipal Master Plans (at the most important urban level), the law obliges the elaboration of such a study, even without considering these BGI. It seems, however, that such a study applied to BGI faces added difficulties, given the absence of data and monitoring reports, the challenges associated with measuring environmental externalities in economic terms and budget difficulties[45]. Other methodologies not usual in the legal field refers to the need to implement NBS' assessment through tools such as LCC, evaluation, and monitoring of the applied solutions[46]. In essence, it is proposed that urban planning law should also embrace the perspective of sustainability in planning through a holistic approach[47].

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5. Municipal ecological structures (MES) – the Portuguese case

Portugal's legal order already has a tool where NBS can be enshrined – the above-mentioned MES[48]. Ecological structures (EE) are one of the territorial resources that must be included in municipal plans. EE is one of the public interests to be considered when drawing up planning instruments, particularly those that are directly binding on private individuals, as well as public bodies. They are now regulated in much the same way as before, albeit with the nomenclature adaptations that have taken place, in the meantime, and the issue of 'the risk of environmental imbalances' has been emphasised. The classification of land continues to be relevant (into urban and rural, and the classification of developable land has ended). The classification of land implies the ecological weighting of both urban and rural land.

Each Municipality in Portugal has a MES, and we can find several examples of NBS such as green corridors, building prohibitions, such as prohibition of construction in flood areas, and so on.

From the Portuguese 16 municipal plans consulted, it was possible to draw a set of relevant conclusions for urban planning:

a) there are different concerns depending on whether the municipality is coastal or inland;

b) inland municipalities (but not exclusively, e.g. Aveiro) have concerns about agriculture (Braga, Santarém);

c) almost all municipalities possess a municipal ecological structure, which normally includes green spaces of various features (Aveiro, Beja, Braga, Évora, Leiria, Lisbon, Portalegre, Porto, Setúbal, Viana do Castelo, Vila Real);

d) NBS related to urban planning are parks, gardens, gardened areas, green corridors; forests (Aveiro and Viana do Castelo);

e) articulation with other planning levels, namely the REN and RAN, is present in many MMP;

f) there are incentives for compliance with ecological goals in the arrangement of economic activities (Coimbra) and financial incentives (fund for environmental and urban sustainability – Oporto);

g) all PDMs establish prohibitions and limitations on building in green areas;

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[48] For a larger explanation of the tool, see Raquel Carvalho, 'Planeamento urbanístico e o impacto das estruturas ecológicas municipais no *ius aedificandi*', *Julgar*, 52, 2023, p. 182 and ff.

h) there are PDMs, such as Setubal's, that already use the concepts of ecosystem services referring to climate regulation, air and water quality regulation; noise reduction; food production; recreation and leisure; landscape value; application of circular economy principles to promote environmental efficiency, and enshrining the principle (and actions) of climate change adaptation and mitigation;

i) green and ecological solutions, including the limitations on building areas, are mandatory.

6. Conclusion

This paper intended to conclude whether urban planning and managing law could be of service to mitigate the adverse effects of climate changes in the cities through the use of NBS as an ecological friendly tool to be joined with other instruments to tackle climate change. Although this concept can be elusive, the multiple solutions already implemented in many cities, different in size, geographical location, and climate circumstances, have led to the conclusion that the introduction and use of NBS is very beneficial. As is proper for urban planning, considering its diversity as a result of the different territories to which it relates to, one of the main conclusions to be drawn is that NBS must be tailored-made. Therefore, it is difficult to establish a single methodology for all cities. Firstly, it is necessary to characterise the specific type of city, its biophysical, demographic and socio-economic features, and the area of land occupied by construction, as well as to identify the main climate change effects to be mitigated or resolved. Then, based on this characterisation and identification, and in the light of the many NBS that have been put into action, it is necessary to identify those that could help make the city more climate-resilient. Their inclusion in planning instruments will always require the broad participation of all stakeholders and a previous determination of the existing urban planning instruments. Both international and national experiences represent the *animus* to go deeper in NBS implementation through urban law, mainly within building regulations. Portugal already has an urban tool, which is mandatory in MMP, that already includes some NBS – yet it can be further explored to deepen the inclusion of NBS. We can also conclude that these tools are particularly adequate to pursue the SGD goals: not only the 13th, on Climate Change, but also the 11th, on resilient cities.

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