

Nature Based Solutions: More than Just Greening the City?

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1 ABSTRACT

Today's relation between humans and nature is arguably still rooted in the enlightenment philosophy, or the "age of reason", asserting that nature exists to be tamed and submitted to the needs and wants of humans (Wallace et. al. 1996). This premise shows scant concern for social, cultural or economic consequences, let alone care for the survival of the planet. Accelerating adverse effects of climate change and rapid decline of biodiversity demonstrate that this exploitation principle of nature by humans has severe limitations (Folkard-Tapp H et.al. 2021). Facing this undeniable evidence, science and technology are envisaging alternative approaches, such as applying Nature-Based Solutions (NBS) to benefit people and nature conjointly (British Ecological Society 2021). This raises the issue whether NBS would be capable of moving away from the antagonism between nature - narrowly understood as the physical world of plants, animals and inorganic matter- and the human-made environment and its uses, and instead to conceive humans and their actions as an integral part of nature.

The paper attempts to explore this question from the perspective of physical planning of cities and territories by identifying the various and possibly contradictory characteristics of NBS and their interventions (Sowinska-Swierkosk et.al. 2022) and to discuss whether and how NBS may differ from previous measures to protect the environment and to combat adverse effects of climate change (Stavroula Melanidis et.al. 2022). To this end, the paper reflects on academic deliberations on the meaning (Osaka et.al. 2015) and purpose (Kiss et.al. 2019) of NBS and their site-specific, comprehensive, integrated and preferably co-beneficial effects at multiple spatial scales (Johnson et.al. 2022). It aims to review how NBS currently contribute to the protection of nature and biodiversity by reversing ecosystem degradation, and how they are applied to achieve a more sustainable and liveable built environment. Finally it identifies changes needed for the current fragmented planning system to become more NBS-friendly, and to prevent further inequalities (Herrmann-Pillath C 2022).

The evidence-base of the paper relies on freely available references on the internet in solidarity with academics and professionals who are willing to share their knowledge and experiences widely.

2 CLIMATE CRISIS AND UN SUSTAINABLE DEVELOPMENT GOALS

The World Meteorological Organisation forecasts a 98% probability that in the next five years the heat record reached in 2016 will be surpassed driven by the natural phenomenon of El Niño (WMO 2022). This situation will cause global temperatures to rise, alternating intense rains and droughts in some areas of Latin America, Africa and South Asia, with global effects and increasing the temperature of the oceans. The organisation also warns that the average annual temperature on the earth's surface could rise transiently by more than 1.5 degrees Celsius compared to the pre-industrial era, which is what the Paris Agreement COP15 seeks to avoid. At COP27 researchers explained and forecast that global warming is set to break the key 1.5 Celsius limit for the first time before 2027 (McGrath 2023). In 2022, the Intergovernmental Panel on Climate Change provided a summary for policy makers on Climate Change and its impacts, adaptability and vulnerability (IPCC 2022).

The impact of climate change on cities will be formidable in all aspects, making it imperative to reinforce the Sustainable Development Goals (SDGs) proposed by the 2030 United Nations Agenda and adopted in 2015 (UN DESA 2015). Relevant specifically to planning and design are SDG 11, Sustainable Cities and Communities, SDG 13 Climate Action and SDG 15 Life on Land. Interrelated and strongly linked to the political dimension, these goals have been transposed into national, regional and local actions, albeit of an ad hoc nature with irregular compliance. At its 7th session in March 2023, The Regional Forum on Sustainable Development for the Economic Commission for Europe region focused on "Ensuring the implementation of the 2030 Agenda for sustainable development in the ECE Region in times of multiple crises" and organised peer learning round tables (UNECE 2023).

Scientific evidence on the acceleration of global warming (IPCC 2007) demands urgent action to counteract its effects on the environment, human welfare and human activity in general. Policies, measures and actions that address the challenges of climate change define a specific cross-cutting area of action, whose implementation should be promoted by all levels of government in the interests of sustainability of the planet as well as human life, fauna and flora. Local governments are responsible for the direct management of these measures in their respective jurisdictions.

From a technical point of view, reducing the adverse effects of climate change on the territory implies alternative measures that are easy to implement and maintain. SDGs and NBS are applied at different scales, globally, at regional, city and neighbourhood level, down to local everyday urban life, relevant to SDG 3 Good Health and Wellbeing, SDG 8 Decent Work and Economic Growth, and SDG 12 Responsible Consumption and Production. In this context, the concepts of sustainability and more specifically of NBS are used extensively by those involved in the built environment.

3 VISIONS OF NBS: TOWARDS A DEFINITION

NBS are one of the most recent approaches to combat global warming, focused on increasing urban resilience by harnessing the ecosystem services of natural capital. NBS differ from the traditional approaches to biodiversity conservation and management promoted since the 1970s in that their implementation must apply jointly to biodiversity and people (Folkard-Tapp et al. 2021). NBS can be construed as one among many other methods of contributing to more sustainable cities. However, the concrete manifestations of sustainability and NBS are not easy to grasp, let alone to measure, not least because their effects and how to achieve them do not necessarily share commonly agreed criteria.

Scientific evidence has confirmed the role of natural habitats and its preservation and restoration for territorial sustainability in all its dimensions:

- environmental – improving ecosystem functioning, increasing biodiversity, reducing greenhouse gas concentrations, facilitating carbon storage, mitigating flooding, protecting coasts from rising sea levels and hillsides from landslides, reducing urban heat islands, providing clean air;
- economic – generating green jobs, producing business benefits, encouraging circular and regenerative economies;
- social – improving human well-being in all aspects, especially health and food security.

Although the benefits of NBS in either the short or long term have not been fully quantified, their effects are nevertheless undeniable (British Ecological Society 2021). Given the many stated positive effects of NBS on biodiversity and the quality of human life, their use was adopted by the United Nations in 2005 when it launched the Millennium Ecosystem Assessment project to analyse the state of the planet's ecosystems. In 2013, the International Union for Conservation of Nature (IUCN) coined a first definition of the NBS: "actions to protect, manage and address the remains of society in an effective and adaptive manner, while simultaneously providing benefits for human well-being and biodiversity" (IUCN 2022).

This vision was adopted and expanded by the European Commission in 2015, when considering NBS as a planning and urban design tool to re-naturalise European cities. In 2019 and during the UN Climate Action Summit, the European Commission promoted the use of NBS and adopted the European Green Deal, which favours their inclusion in a wide range of policies (European Commission 2021a). In the same vein, the EU Biodiversity Strategy 2030, adopted in 2020, promotes the integration of NBS in urban planning, public spaces, urban infrastructure and the design of buildings and their environment (European Commission 2021b). The launch of specific programmes and projects on the subject has been fruitful: Urban Green Up, Clearing House, Clever Cities, Connecting Nature, EdiCitNet, Grow Green, Nature 4Cities, Naturvation, Regreen, etc. These initiatives gave rise to responses of all kinds, understood as a complement - not a substitute - for other measures aimed at mitigating the effects of climate change. Given their potential, the NBS have been integrated into the agenda of policy makers at different executive levels (Rey Mellado et al. 2021). NBS are also considered able to offer a transition path in realistic, incremental steps towards a sustainable economy (Maes et al. 2015).

4 NBS IN PRACTICE: SCOPE AND EXPERIENCES

The numerous NBS experiences in the regions, cities, municipalities and neighbourhoods which have opted for their implementation demonstrate their potential to meet the objectives for which they were intended, while confirming the possibility of their incorporation into urban and territorial policies. Empirical evidence makes it possible to classify concrete NBS projects into two generic types according to their territorial coverage -regional and urban - regardless of the ecosystems on which they operate: soil, water and vegetation. In both cases, their declared aim is to result in socio-economic effects in favour of local or broader communities while fostering biodiversity.

In terms of technical measures NBS focus on improving the impact of the built environment on climate change or, conversely, on how the built environment can be adapted to climate change or mitigate it. Concrete-technical implementations of NBS are applied to the environment at regional level on the one hand (landscape, agriculture, resource extraction, biodiversity, ecosystem services, etc) and to the built environment on the other hand (cities, transportation networks, infrastructure, neighbourhoods, individual buildings and their uses, etc). NBS are also the subject of a more tactical discussion, exploring how NBS distinguish themselves from other interventions to preserve nature and whether they have a specific distinct purpose. For example, the UK House of Lords Science and Technology Committee explored the use of NBS to reduce carbon emissions and sequestering carbon towards zero greenhouse gas emissions and concluded that NBS could play an essential role in compensating residual emissions where total elimination would be impossible to achieve within the targeted timeframe (House of Lords, 2021-22).

4.1 Regional scale

Regional-scale NBS actions are strategic in nature and their implementation is linked to the conditions of the territory when seeking resilience to storms and intensive weather. They tend to be focused on specific issues, such as: erosion protection - combining afforestation(Throp et.al. 2023), reforestation (Webster, 2023) and conservation of natural forests in watersheds, or restoration of herbaceous and shrub vegetation on slopes;inland flood protection - through reforestation of headwater watersheds, regeneration of watersheds affected by forest clearing, regeneration of river banks to reduce flood damage or maintenance of wetlands(Thorslund et.al. 2017); protection against coastal hazards and sea level rise- through the construction of natural (Doelle et.al. 2021) or artificial (Morales et.al. 2021)reefs to stabilise coastlines; or protection of natural resources in hot, dry regions - through agroforestry systems that combine trees, livestock, grasses and crops to reduce erosion, prevent fires and increase soil fertility(Seddon, 2020).

Overall, the impacts of NBS on ecosystems and the regional and/or general socio-economic context are numerous, including diversification of income sources, increased food security, community management of common resources and access to institutional services. Nevertheless, at the regional level biodiversity is a prominent objective of NBS whilealso focusing on landscape conservation and reinstating nature(WEF, 2022). From the economic perspective, NBS areoften seen to contradict growth promoted by governance, although somepoliticians such as the Irish President Michael Higgins (Leahy, 2023)are contesting the growth paradigm.However,according to theconcept of NBS economic security and competitiveness aredirectly dependent on the sustainable use of natural resources. Maes(2015) proposes specific criteria to focus, guide and evaluate the implementation of NBS towards producing both widereconomic and social benefits, essentially provision of jobs and low-carbon technology innovations.

4.2 Urban scale

With regard to the urban scale, as the urban fabric is essentially an anthropic space, the general objectives of NBS are convergent:integrating nature into the city as a mechanism of conserving biodiversity, regulating the climate and promoting socio-economic activities. NBSadopt different approaches depending on space specificitiesand scale of intervention: cities, neighbourhoods, buildings. Generally, interventions are of a one-off nature,butthey may be grouped into systematic proposals: eco-districts and green blue infrastructures. Pineda-Pinto et.al. (2020) carried out a literature review on the potential of NBS to deliver ecologically just cities, with lessons for urban planning. Arup (2014) have produced numerous projects, pamphlets and articles on their approach to NBS, including lessons for urban designers.

The objectives of these interventions focus on biodiversity and habitat conservation, climate change, urban resilience, public health and well-being, and the attractiveness of the built environment. The areas of action

are varied - forests, parks, gardens, urban woodland, orchards, lakes, ponds, drains, wetlands, permeable surfaces, rain gardens. The benefits are substantial: reduced heat island effects and flood risks, improved air quality (Mayor of London 2021), carbon dioxide sequestration, reduced energy use, benefits to public health and well-being, access to food, physical activity, mental health, improved community relations, and contributions to innovation, economic growth and job creation (Kiss et al. 2019). The latter are also related to more general city greening initiatives (Froy et al. 2023). Microclimates are capable of moderating climate change, due to their contextual characteristics such as local water management, drainage and permeable surfaces, seasonal shading, riverbank restoration, re-vegetation of brownfield sites, green corridors, which cities are increasingly including in their sustainable planning strategies (Ayuntamiento de Madrid 2016).

Applied to specific built environments, NBS tend to focus on technical-material measures. Akin to well established and practised methods of urban environmental improvements (e.g. ARUP undated), they are resorting to green infrastructure, green roofs, green walls, improved insulation and air tightness of buildings; tree planting in streets, even creating urban forests to reduce heat island effects, as well as managing stormwater to prevent flooding of insufficient drainage, creating sponge cities, building protections against rising sea levels, but also extending wetlands and woodlands to absorb excess water (Thames21, 2020). Other initiatives which could be construed as informal NBS are initiated by inhabitants, such as growing eatable plants on unclaimed spaces. Most urban experiences of NBS tend to be sectoral in nature, with diverse spatial coverage, leading to varied results. Their contribution could be greater if they would be included in comprehensive urban policies to facilitate planning, design and management processes.

Kabisch et al. (2022) propose 5 principles for urban nature-based solutions capable of contributing to resilient urban futures. In their view NBS (i) require a systemic understanding and need, (ii) benefit both people and biodiversity, (iii) contribute to inclusive long term solutions, (iv) consider context and local conditions, and (v) foster communication and learning. However, NBS rarely include behaviour change, such as reducing energy consumption, motorised and air travel and meat consumption among many others which may have significant effects on urban resilience.

5 CONCEPTUAL RESEARCH: THE LIMITS OF NBS

Based on current, openly available literature on NBS and their implementation, the deliberations on NBS seem to divide functionally into two categories: concrete-technical and conceptual-theoretical. In terms of comparative reviews and case studies, research investigates the various empirical applications of NBS, their impacts on the environment and society, as well as their applicability to planning at regional and urban levels (e.g. Pineda-Pinto et al. 2020). Scientific research on NBS explores conceptual-theoretical aspects of NBS including how to define them (e.g. Kiss et al. 2019; Hanson et al. 2020).

In their comprehensive review of research publications on NBS Hanson et al. (2020) explored the use and interpretation of the nature based solution concept by science. They discuss various definitions and note that most empirical studies focus solely on environmental benefits delivered by NBS. They found few studies across scientific disciplines which assess social and economic benefits as well, despite both benefits being a central ambition of the NBS concept. They propose four core ideas relevant to planners: how to use NBS in the pursuit of sustainable development by handling societal challenges and how to seek co-benefits by including relevant stakeholders. In the Naturvation Project, another international comparison of NBS, Kiss et al. (2019) map existing experiences and practices in the use of NBS. Based on 54 NBS interventions in 18 cities, their comparative analysis focused on governance arrangements, public participation, financing mechanisms, innovation patterns and social impacts. Their research concentrated on what is enabling NBS implementation. They noted that NBS, usually applied in complex institutional and governance structures, are multi-functional and resort to public-private collaborative arrangements when addressing sustainability challenges. Their findings show that municipalities are playing a key role in financing policy, but that the distribution of costs and benefits was encountering contradictions regarding transparency, accountability, justice and democracy. Discussing the definition of NBS, Seddon et al. (2021) acknowledged the benefits of NBS, but affirmed that NBS are not a substitute for rapidly phasing out fossil fuels. Other academic deliberations are related to resilience (Ruiz-Mallen et al. 2022), a concept intrinsically linked to climate change and the role of NBS. More specifically, Baro et al. (2022) explored the co-benefits NBS could create when making schools resilient to climate change impacts and saw potential in upscaling this approach to city level.

Other researchers are more sceptical about the merits of NBS. Stavroula Melanidis et al. (2022) discussed the competing languages of NBS. Based on contributions to the 2019 UN Climate Action summit and the 2019 UN Climate Change Conference (COP 25) they analysed the narratives connected with proposals for and against NBS and found two opposing standpoints: NBS as a powerful multifunctional instrument to leverage the power of nature; or as dangerous distraction perpetuating the unsustainable, unjust status quo. Others also adopt a critical, even politicised standpoint towards NBS. Marsh & Swyngebouw (2002) see NBS as socially divisive and inequitable, thus in need of political redress with focus on the most deprived parts of society when implementing them. Hanson et al. (2020) consider NBS possibly as a buzzword, solely delivering environmental benefits, without the expected economic and social benefits incorporated in the NBS concept, instead of being a pathway to broader and deeper development. Kotsila et al. (2020) criticise NBS as resting on assumptions from positivist science providing space for neo-liberalisation processes of nature. They reckon that urban nature can serve economic elite players at the expense of widespread socio-ecological benefits. Conversely they see the possibility of NBS laying the ground for open participatory spaces beyond controlled stewardship of nature or market mediated interactions with it. Other researchers position themselves in between those stances when debating the value and limits of NBS (Seddon et al. 2020).

Based on the comprehensive surveys of NBS scientific research, the following key problematic aspects of NBS seem to emerge:

- **Definition:** There is a lack of a single definition of NBS that determines the conditions to single them out from other approaches. Despite institutional attempts to define NBS, there is no agreement on a single definition. The current diversity of definitions fails to define a specific profile that categorises a wide range of NBS actions and can respond to different objectives and this may be attributable to internal contradictions of the concept of NBS.
- **Scope:** The use of NBS is applied to a broad diversity of interventions. Most of the empirical studies point to the environmental benefits that NBS provide, while there are few studies that also evaluate their social and economic benefits, despite being a central ambition of the NBS concept (Hanson et al., 2020). Some studies highlight the role of NBS in resilience linked to climate change (Ruiz-Mallen et al. 2022), its application in specific buildings, as well as in the urban environment more generally (Baro et al., 2022). The most relevant contributions of NBS to the urban environment are the ones aimed at reducing the effects of climate change and at increasing the quality of life in public spaces.
- **Evaluation:** Evaluating the results of NBS in practice encounters many obstacles. A difficulty lies in the lack of appropriate indicators and metrics to assess biophysical, ecological, and socioeconomic effectiveness, which inhibits the creation of appropriate frameworks to estimate the scope of the benefits and long-term monetisation of NBS (Seddon et al., 2020). This may be due, inter alia, to the coexistence of numerous interacting and context-specific factors that vary over time, besides depending on the standpoints and needs of those involved.
- **Financing:** This is one of the main obstacles to the implementation and monitoring of NBS. Regardless of the origin of investments - public or private agencies, bilateral or multilateral funds, national or international the focus on the economic growth model and the need to obtain short-term benefits tend to reduce the option to implement NBS, exacerbated by the context of budgetary restrictions. The management of NBS projects, based on coordination between different levels of government and stakeholders is difficult to organise and can even contradict other projects. Overcoming these challenges requires strong institutions, well-established planning and stable available structures (Seddon et al. 2020).
- **Collateral effects.** Although there is consensus that NBS do not replace measures to restrict the use of fossil fuels, nor that they should distract from the need to protect a wide range of ecosystems (Seddon et al., 2020), some authors understand the use of NBS as a multifunctional instrument to harness the power of nature, or as a distraction to perpetuate the unsustainable and unfair status quo (Melanidis, et al. 2022). Others see NBS as socially divisive and inequitable, necessitating political redress with a focus on the most disadvantaged parts of society when implementing them (Marsh & Swyngebouw, 2002). Others view NBS as a buzzword that only offers environmental benefits, without the expected economic and social benefits that lead to broader and deeper development

(Hanson et.al. 2020). Others point out that excessive use of tree planting is an easy measure to implement for which there are no scientific criteria to link its benefits to specific ecosystems and human contexts, and which could eventually amount to "green gentrification". More radical views criticise NBS for relying on assumptions of positivist science that provide space for processes of neo-liberalisation of nature and serving elite economic actors at the expense of widespread socio-ecological benefits, rather than to see NBS as a possibility to lay the foundations for open participatory spaces beyond controlled stewardship of nature or market-mediated interactions (Kotsila et al. 2020). There is also concern about the occurrence of adverse social consequences of implementing NBS without the consent of the communities involved (Seddon et al. 2020).

6 Reducing Uncertainties

Even though the multifunctionality of NBS is recognised, scientific analysis indicates the presence of important conceptual and technical barriers that must be eliminated. The concepts and practices of NBS developed over the last decades have been numerous, including the multifunctionality of NBS. However, despite the benefits NBS bring, their adoption is far from widespread, possibly due to uncertainty about what is meant by NBS and their scope.

With respect to cost-effectiveness, there is some evidence that the benefits of NBS can outweigh the costs of their implementation and maintenance in a variety of contexts and that they may be more cost-effective than engineering alternatives (World Bank, 2019). Nevertheless, lack of funding for NBS which often requires long-term commitment, is a major obstacle to their implementation and follow-up, especially during severe budgetary constraints.

The issues that encourage uncertainty can be summarised in three generic themes:

- the challenges of measuring the effectiveness of NBS in relation to other alternatives;
- the difficulties in assessing costs and benefits in attracting public and private investment; and
- the institutional barriers that limit the incorporation of NBS into territorial policies.

IUCN adopted a Global Standard in 2020 to reduce these uncertainties. Aimed at national, municipal and local governments, planners, companies, donors, financial institutions and NGOs working on issues of global concern, The Global Standard consists of 8 criteria and 28 indicators valid for both small-scale interventions and large-scale actions, setting out the conditions NBS have to meet to perform their tasks (IUCN, 2022). These criteria give considerable weight to social and governance aspects when assuming the risks that could result from the outcomes of NBS implementation on ecosystem processes. The criteria propose the following principles:

- criterion 1: NBS are to respond effectively to one or more societal challenge(s), identified as a priority for directly affected societies, supported by transparent and inclusive consultation processes.
- criterion 2: The design of NBS will be adapted to the complexity and uncertainty of the context in which they are implemented, taking into account the biophysical or geographical perspective, economic systems, regulatory frameworks, cultural perspectives, synergies between sectors, and the identification and management of the risks involved.
- criterion 3: NBS should produce a net gain in terms of biodiversity and ecosystem integrity, ensuring their protection, functional integrity and connectivity in the long term.
- criterion 4: NBS must be economically viable, both in the design phase and during implementation, distributing costs and benefits equitably in the short and long term.
- criterion 5: NBS are based on inclusive, transparent and empowering governance processes, which delineate responsibilities and legitimise the sharing of burdens and benefits arising from the process in accordance with existing legal and regulatory provisions.
- criterion 6: NBS should strike an equitable balance between the achievement of their objectives, the benefits obtained and the necessary financial rewards based on credible assessments, transparency of information and stakeholder agreements.
- criterion 7: NBS are adaptively managed in response to uncertainty in ecosystem functioning, using data provided by continuous monitoring and periodic assessment.

- criterion 8: NBS are sustainable actions and are integrated into an appropriate jurisdictional context, taking into account existing sectoral and national policy frameworks, strategic communication and promotion of their use.

The application of these criteria is expected to guide both the actions of the institutional and governance bodies in charge of leading the implementation processes of NBS in their respective territorial jurisdictions, as well as the technical process involved in the design of these initiatives. Likewise, the criteria offer a reference framework for private initiatives that address NBS projects in rural territories and urban spaces. The role of urban and regional planning could play a determining role, but for this the NBS concept would have to undergo two structural changes: adopting them into comprehensive urban policies that facilitate their implementation and including them as a specification when drafting further planning instruments.

6 NBS, PLANNING AND GOVERNANCE

What use can planning and planners make of this discussion on research on the current state of NBS in terms of their practical implementation in regions and cities and at conceptual level to rebalance the ecosystem, combat climate change and make cities more sustainable?

The analysis of existing NBS experiences reveals that most of them are punctual and sectoral in nature, applied to very diverse spatial coverage, producing uneven results, but are scarcely included in traditional planning instruments. Instead, NBS tend to be implemented through ad hoc modalities, without anchoring them in the current regulatory structures, although this could also favour their development and acceptance over time and warrant their eventual inclusion in the monitoring and evaluation mechanisms of planning instruments.

The absence of a convergent definition of NBS may explain their slow take-up in plan making and regulations. Conversely, the diffuse meaning of NBS can provide planners with an opportunity to interpret them to their own advantage. The argument that NBS are just another term to describe measures already incorporated in development plans and planning regulations to protect the environment and mitigate climate change may provide incentives to refine and innovate existing planning instruments.

It has to be kept in mind that measures to safeguard and improve the environment have long been part of planning, thus NBS would essentially be an additional instrument, preferably in synergy with existing ones. The special characteristics of NBS demand the adoption of a comprehensive vision including their vertical and horizontal relationships between disciplines and sectors, their funding conditions and their inclusion of community participation, which require the involvement of specialists in the design of proposals, as well as in decision-making. Like any other aspect of spatial planning, the adoption and scope of an active NBS policy would depend on the priorities given to it by the political, economic and social context.

Assuming the potential of NBS in relation to climate change and quality of life, and given that plan making and project design are the key functions of planning, their adaptation into planning instruments requires a transposition of the concept into practice. For this, the role of academic research is essential, in identifying and assessing the environmental, social and economic benefits, as well as the adverse effects and possible contradictions associated with NBS. Such a research effort is directly dependent on adequate funding to advance this subject.

Planning instruments have their own mechanisms of monitoring and evaluating their long-term performance. Experiments with NBS at regional, city and neighbourhood levels could provide lessons for planners to incorporate findings into their approach to site-specific conditions and to adjust planning instruments accordingly.

Insights into the financing and funding of NBS implementation may lead to new ways of assessing environmental protection measures and their efficiency in relation to other planning objectives, in particular those aimed at improving living conditions and greater environmental and social equity. In the longer term, including the necessary public funding for NBS actions in the budgets of plans could foster the confidence of private investors.

A remarkable aspect of the NBS concept is the inclusion of public participation in the design process, a resource open to multiple competences but scarcely implemented. Incorporating NBS in planning would

provide a valuable opportunity to reach out towards greater interdisciplinarity and more genuine public engagement from the conception of an intervention to its completion, thus NBS could become a trigger of much needed transformation of planning to become fit for coping with the challenges of the 21st century.

7 BY WAY OF CONCLUSION

As an outcome of this discussion, there are reasons to assume that, even with high costs and implementation difficulties, NBS can contribute positively to the fight against adverse climate change and enhance the sustainability of cities and regional ecosystems. NBS alone will not be able to overcome the lack of connection between a comprehensive application of NBS at regional level and fragmented NBS implementations at city and often only at building levels without being linked to a cohesive integrated policy for sustainable development and climate emergency. Incorporation of NBS into existing planning measures to protect and enhance the environment may provide an opportunity to improve the current fragmented planning system, subjected to multiple, uncoordinated, possibly contradictory policies and governance modes to become more effective in contributing to sustainable development while preventing further inequalities.

8 REFERENCES

- ARUP (2014). Cities Alive, Rethinking green infrastructure. ARUP Design Book, Wardour.
- ARUP (undated). Bringing nature-based-solutions to life (harness nature to improve flood risk management; use green building facades to lower the temperature; improve disaster recovery; apply climate-positive materials).
<https://www.arup.com/climate-change/bringing-nature-based-solutions-to-life>
- Ayuntamiento de Madrid (2016). Programa Madrid + Natural.
<https://www.madrid.es/UnidadesDescentralizadas/Sostenibilidad/EspeInf/EnergiayCC/04CambioClimatico/4c3Mad+Natural/M+N2019/Ficheros/FichasMad+Natural2019.pdf>
- Baro, Francesc, David A. Camacho, Carmen Perez del Pulgar, Isabel Ruiz-Mallen, Pablo Garcia Serrano (2022) Nature based climate solutions in European schools: a pioneering co-designed strategy towards urban resilience, Ch 6, Isabel Ruiz-Mallen, Hug March, Mar Satorras (eds), Urban Resilience to the Climate Emergency, Unravelling the transformative potential of institutional and grassroots initiatives, Springer 2022.
- Doelle, Meinhard, Tony George Puthucherril (2021). Nature based solutions to sea level rise and other climate change impacts on oceanic and coastal environments: a law and policy perspective. *Nordic Journal of Botany*, Vol 2022, Issue 1, January 2023, e03051.
- European Commission (2021a). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions EMPRY. 'Fit for 55': Delivering the EU's 2030 Climate Target on the way to climate neutrality. COM(2021) 550 final, Brussels 12.7.2021.
https://commission.europa.eu/publications/delivering-european-green-deal_en
- European Commission (2021b). EU Biodiversity Strategy for 2030. Bringing nature back into our lives. European Union 2021.
https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030_en
- Folkard-Tapp, Hollie, Cristina Banks-Leite, Emma L Cacan (2021). Nature-Based Solutions to Tackle Climate Change and Restore Biodiversity, *Journal of Applied Ecology*, 2021;58:2344–2348, British Ecology Society, DOI: 10.1111/1365-2664.14059.
- Froy, Francesca, Samuel Heroy, Elvira Uyerra, Neave O'Clery (2023). What drives the creation of green jobs, products and technologies in cities and regions? Insights from recent research on green industrial transitions, *Local Economy*, Vol 0 ahead of print, 2023, Sage Publications, ISSN 0259-0942
<https://journals.sagepub.com/doi/epub/10.1177/02690942231170135>
- Hanson, Helena I, Bjorn Wickenberg, Johanna Alkan Olsson (2020). Working on the boundaries—How do science use and interpret the nature-based solution concept? *Land Use Policy* 90 (2020) 104302 Elsevier.
- Herrmann-Pillath, Carsten, Julia Hiedanpaa, Katriina Soini (2022). The co-evolutionary approach to nature-based solutions, a conceptual framework. *Nature Based Solutions* 2 (2022) 100011, Elsevier.
- House of Lords, Science and Technology Select Committee, UK (2021-2022). Nature based solutions – rhetoric or reality? The potential contribution of nature-based solutions to net zero in the UK. 2nd Report of Session 2021-22.
- International Union for Conservation of Nature (IUCN) (2022). Global Standard for Nature-based Solutions: first edition.
- IPCC (International Panel on Climate Change) (2007). Le Treut, H., R. Somerville, U. Cubasch, Y. Ding, C. Mauritzen, A. Mokssit, T. Peterson and M. Prather, 2007: Historical Overview of Climate Change. In: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.
- IPCC (International Panel on Climate Change) (2022). *Climate Change 2022, Impacts, Adaptation and Vulnerability, Summary for Policymakers. Sixth Assessment Report. WHO UNEP.*
- Johnson, Brian Alan, Oanhaj Kumar, Naoyuki Okano, Rajarshi Dasgupta, Binaya Raj Shivakoti (2022). Nature-based solutions for climate change adaptation: a systematic review of systematic reviews. *Nature Based Solutions* 2 (2022) 100042.
- Kabisch Nadja, Niki Frantzeskaki, Rieke Hansen (2022). Principles for urban nature based solutions. *Ambio* 2022, 51:1388-1401. Springer.
- Kiss, Bernadett, Filka Sekulova, Panagioti Kotsila (2019). The nature based innovation Naturvation project, international comparison of nature based solutions, project report. Naturvation (cities-nature-innovation): Durham University and 14 EU institutions funded by EU Horizon 2020 research and innovation programme.

- Kotsila, Panagiota, Isabelle Anguelovski, James JT Connolly (2020). Nature-based solutions as discursive tool and contested practices in urban nature's neoliberalisation. *Environment and Planning E: Nature and Space*, Volume 4, Issue 2. Sage Journals.
- Leahy, Pat (2023). President condemns 'obsession' with economic growth'. *The Irish Times*, 28 April 2023.
- Maes, Joachim, Jacobs Sander(2015), Nature-Based Solutions for Europe's Sustainable Development. *Conservation Letters*, doi: 10.1111/conl.12216.
- Marsh, Hug, Erik Swyndgedouw (2022). Resilience for All or for Some? Reflections Through the Lens of Urban Political Ecology. Ch 1, Isabel Ruiz-Mallen, Hug March, Mar Satorras (eds), *Urban Resilience to the Climate Emergency, Unravelling the transformative potential of institutional and grassroots initiatives*, Springer 2022.
- McGrowth, Matt (2023). Global warming set to break key 1.5C limit for first time. *Environment correspondent*. BBC news. <https://www.bbc.co.uk/news/science-environment-65602293>
- Rey Mellado, Raquel, Cristina del Pozo, Teresa Franchini (2021). Soluciones Basadas en la Naturaleza: estrategias urbanas para la adaptación al cambio climático. *Habitat y Sociedad* N° 14.
- Morales, Roberta PL, Borha G Reguero, Ines Mazarrasa, Max Ricker, Jose A Juanes (2022). Nature-Based Solutions in Coastal and Estuarine Areas of Europe, *Frontiers in Environmental Science*, Vol 19, 29 June 2022. <https://doi.org/10.3389/fenvs.2022.829526>
- Osaka, Shannon, Rib Bellamy, Noel Castree (2015). Framing 'nature-based' solutions to climate change. *WIREs climate change*, Vol 12, Issue 5. September/October 2021 e729.
- Pineda-Pinto, Melissa, Niki Frantzeskaki, Christian A Nygaard (2020), The potential of nature-based solutions to deliver ecologically just cities: lessons for research and urban planning from a systematic literature review, *AMBIO* 2022, 51: 167-182. *Kungl. Vetenskaps-Akademien*.
- Seddon Natalie, Chausson, A, Berry, P, Girardin, C, Smith, A, Turner, B (2020). Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of the Royal Society of London*.
- Seddon, Nathalie, Alison Smith, Pete Smith, Isabel Key, Alexandre Chausson, Cecile Girardin, Jo House, Shilpi Srivastava, Beth Turner (2021). Getting the message right on nature based solutions to climate change. *Wiley online library. Glob Change Biol.* 2021;27:1518–1546. <https://onlinelibrary.wiley.com/doi/10.1111/gcb.15513>
- Sowinska-Swierkosz, Barbara & Joan Garcia (2022). What are natural based solutions (NBS)? Setting core ideas for concept clarification. *Nature-Based Solutions* 2 (2022) 100009, Elsevier.
- Stavroula Melanidis, Marina & Shannon Hagerman (2022). Competing narratives of nature-based solutions, leveraging the power of nature or dangerous distraction. *Environmental Science and Policy* 132 (2022) 273-281, Elsevier.
- Thames21 & London Borough of Endfield (2020). Major new woodlands and wetlands partnership begins; project will create large-scale improvement in Endfield's rivers. <https://www.thames21.org.uk/2020/12/major-new-woodlands-and-wetlands-partnership-begins/>
- Thorslund, Josefin, Jerker Jarsjö, Fernandi Jaramillo, James W Jawitz, Stefano Manzoni, Nandita B Basu, Sergey R Chalov, Matthew J Cohen, Irena F Creed, Romain Goldenberg, Anna Hylin, Zahra Kalantari, Antonis D Koussis, Steve W Lyon, Katarina Mazi, Johanna Mard, Klas Persson, Jan Pietron, Carnen Pietro, Andrew Quin, Kimberly Van Meter, Georgia Destouni (2017). Wetlands as large-scale nature-based solutions: status and challenges for research, engineering and management. *Ecological Engineering* 108 (2017) 589-497. Elsevier.
- Throp, Henry, Ana Yanf, Suzannah Sherman, Roberto Waack (2023). How forest bio-economies can support NBS. *Sustainability Accelerator briefing paper*, Chatham House.
- UN DESA (United Nations, Department of Economic and Social Affairs) (2015). Sustainable Development, the 17 Goals [1 no poverty, 2 zero hunger, 3 good health and well-being, 4 quality education, 5 gender equality, 6 clean water and sanitation, 7 affordable and clean energy, 8 decent work and economic growth, 9 industry innovation and infrastructure, 10 reduced inequalities, 11 sustainable cities and communities, 12 responsible consumption and production, 13 climate action, 14 life below water, 15 life on land, peace, 16 justice and strong institutions, 17 partnership for the goals. <https://sdgs.un.org/goals>
- UNECE (United Nations Economic Commission for Europe, (2023). Report of the Regional Forum on Sustainable Development for the Economic Commission for Europe region on its seventh session. United Nations. *RFSD2023 Report*.
- Mary G Wallace, Hanna J Cortner, Sabrina Burke (1996). Taming Nature, the enlightenment's legacy for the future, *Journal of Forestry*, November 1996: 39-44.
- Mayor of London Plan (2021), ULEZ (Ultra Low Emissions Zones) expansion to GLA boundaries by August 2023. Greater London Authority.
- Webster, Ben (2023). UK airlines' new 'sustainable' fuels may be causing deforestation in Asia, *Open Democracy*. Exclusive Experts fear lack of industry regulation means virgin palm oil is being passed off as 'used' cooking oil. <https://www.opendemocracy.net/en/uk-airlines-sustainable-fuel-used-cooking-oil-deforestation-palm-oil/>
- World Bank (2019). Nature-based Solutions: a Cost-effective approach for Disaster Risk and Water Resource Management. World Bank <https://www.worldbank.org/en/topic/disasterriskmanagement/brief/nature-based-solutions-cost-effective-approach-for-disaster-risk-and-water-resource-management>
- WEF (World Economic Forum) (2022). BiodiverCities by 2030: Transforming Cities' Relationship with Nature. Insight Report, in collaboration with Arup and AphaBeta. *WEF_BiodiverCities_by_2030_2022.pdf*
- WMO (World Meteorological Organisation) (2022). State of the Global Climate in 2022. <https://public.wmo.int/en/our-mandate/climate/wmo-statement-state-of-global-climate>