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Nature-based solutions: new challenges for urban planning

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Abstract: Nature-based solutions (NBS) are broadly defined as the use of solutions based on nature and ecological functions to address societal challenges, such as climate change adaptation and mitigation, population health, food security, and natural disasters, through the delivery of multiple ecosystem services (ES). This paper aims to outline some of the main challenges associated to the development and mainstreaming of NBS in urban planning, providing valuable insights for the integration of NBS in urban planning processes and instruments. To this aim, five challenges are proposed and discussed in this paper, namely: to provide decision-makers with tools and methods for mapping and assessing ES that substantiate evidence of NBS effectiveness in providing multiple benefits; to use more flexible and qualitative planning approaches that can foster the implementation of NBS such as performance-based planning; to develop indicators that can be used to evaluate and compare possible NBS during strategic environmental assessment of urban plans; to include the assessment of ecosystem disservices that may emerge when considering and comparing NBS interventions; to develop adequate measures of progress for the monitoring of NBS effects over time to strengthen the evidence base for their benefits and co-benefits.

Keywords: ecosystem services; nature-based solutions; urban planning; assessment of co-benefits

Introduction

Over the past years, an increasing number of perspectives have reflected an anthropocentric view of the management of nature and natural resources, including biodiversity and the environment (Nesshöver *et al*. 2015, 2017), focusing on the benefits that humans gain from nature (Díaz *et al*. 2015, MA, 2005, TEEB, 2010, Nesshöver *et al*. 2017). The most recent entry to this discourse is Nature-Based Solutions (NBS), a concept that brings together well-established ecosystem-based approaches, such as Ecosystem Services (ES), Green-Blue Infrastructure (GBI), ecological engineering, ecosystem-based management, natural capital (Nesshöver *et al*. 2017, Nature Editorial, 2017, Raymond *et al*. 2017) and urban forestry (Escobedo *et al*. 2018) with assessments of the social and economic benefits of resource-efficient and systemic solutions that combines technical, business, finance, governance, regulatory and social innovation (European Commission, 2015, Raymond *et al*. 2017). Although NBS approach shares similarities with the abovementioned approaches, its objective towards the management of the natural resources for human well-being is quite different, indicating that such a topic has evolved over time. In fact, although NBS concept shares a similar root for example (and particularly) with the concepts of ES and GBI, the latter pays more attention to the spatial pattern and connectivity of the natural network, whereas ES to the multiple natural functions that can benefit both nature and humans (Escobedo *et al*. 2018). Thus, the emergence of NBS denotes the recent expansion of the scope to particularly encompass the applications for addressing (i.e., resolving or mitigating) multiple urban environmental, socio-political, and ecological challenges (Escobedo *et al*. 2018), being directly relevant to several policy areas such as land use and spatial planning (Raymond *et al*. 2017). On a technological and applicative perspective, another difference with previous approaches, particularly ecological engineering, is the notion that NBS are explicitly considered as alternatives to human-made infrastructure that require large investments in materials and energy (Nesshöver *et al*. 2017).

The concept of nature-based solutions

Among the various definitions proposed for NBS, the IUCN (Cohen-Shacham *et al*. 2016) defined NBS as "actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits", while the European Commission defined NBS as "living solutions inspired by, continuously supported by and using nature, which are designed to address various societal challenges in a resource-efficient and adaptable manner and to provide simultaneously economic, social, and environmental benefits" (European Commission, 2015). The NBS concept suggests that natural (or self-regulating) ecosystem processes are essential for the definition and that it is implicit that a particular challenge or problem should be solved through the contribution of such ecosystem processes (Albert *et al*. 2019). In order to understand their functioning and added value with respect to alternative solutions, NBS can be described as actions that utilize ecosystem processes of green and blue infrastructure in order to safeguard or enhance the delivery of ES, which can in turn contribute to the alleviation of societal challenges, simultaneously providing economic, human security, social/cultural, and ecological co-benefits, in spite of technical alternatives which usually simply target the challenge without providing additional benefits (Albert *et al*. 2019).

Eggermont *et al*. (2015) classified NBS by considering two dimensions: (i) the required level of engineering of biodiversity and ecosystems involved in the NBS; and (ii) the level of enhancement of ecosystem services achievable by the NBS. Particularly, NBS are classified into three main types:

- Type 1 consists of "no or minimal intervention in ecosystems, with the objectives of maintaining or improving the delivery of a range of ES both inside and outside of these preserved ecosystems" (Eggermont *et al*. 2015). Solutions included in this typology are the ones that involve making better use of existing natural or protected ecosystems, such as measures to increase fish stocks in wetlands to enhance food security (Cohen-Shacham *et al*. 2016);
- Type 2 concerns "the definition and implementation of management approaches that develop sustainable and multifunctional ecosystems and landscapes (extensively or intensively managed), which improves the delivery of selected ES compared to what would be obtained with a more conventional intervention" (Eggermont *et al*. 2015). Solutions falling within this typology are based on the development of sustainable management protocols and procedures for managed or restored ecosystems, such as the re-establishment of traditional agroforestry systems based on commercial tree species to support poverty alleviation (Cohen-Shacham *et al*. 2016);
- Type 3 consists of "managing ecosystems in very intrusive ways or even creating new ecosystems" (Eggermont *et al*. 2015). Solutions included in this typology are the ones that involve the creation of new ecosystems, such as the establishment of green buildings – green walls, green roofs – to mitigate urban heat island effect and clean polluted air (Cohen-Shacham *et al*. 2016).

Examples of NBS are green buildings (e.g., green roofs, green walls), urban green areas connected to grey infrastructure (e.g., alley and street trees, railroad bank, house gardens, green playground/ school grounds), parks and (semi)natural urban green areas (including urban forests), allotments and community gardens, green indoor areas, blue areas (e.g., rivers, lakes, seacoasts, wetlands), green areas for water management (e.g., rain gardens or sustainable urban drainage systems), derelict areas (e.g., abandoned spaces with patches of wilderness) (Almassy *et al*. 2018).

Challenges for urban planning

As NBS development and evaluation spans the requirement of lowering of systemic trade-offs and increasing synergies (Maes and Jacobs, 2017), the task for planning and science is to critically assess, for each proposed intervention, to what degree it can alleviate the problem at hand and what kind of co-benefits and trade-offs the intervention might yield (Albert *et al*. 2019). The analysis of co-benefits and trade-offs (e.g., trade-offs among ES), as well as of gaps in ES supply and demand, can enhance the transparency and understanding concerning the respective advantages and disadvantages of proposed actions (Raymond *et al*. 2017). This enables more informed decision-making processes about sustainable development by informing urban land use and management decisions and maximizing an ecosystem's benefits to society (Lafortezza and Chen, 2016), implicitly referring to the spatial scale of the effects of an intervention. As the added value of the NBS approach is that they are strongly solution-oriented, such co-benefits and trade-offs (spatial) analysis need to be addressed taking into account the perspective of solving societal challenges (at different scales, from global to local). However, there still is lack of knowledge about how to assess the impacts of and the co-benefits simultaneously provided by NBS within and across different societal challenges, since existing frameworks do not cater for such complexity (Raymond *et al*. 2017) and previous studies mainly assessed (co-)benefits by making reference to single indicators or challenge areas (e.g., Maes, 2013, Bain *et al*. 2015, Rao *et al*. 2016, Mouchet *et al*. 2017). Moreover, in order to ensure the feasibility of NBS, these solutions require to be embedded within viable governance and planning frameworks due to the need for cooperation and knowledge integration of actors from different fields or sectors, the institutional context within which these actors operate, and the financial options that are available (Albert *et al*. 2019). Thus, for the development and mainstreaming of NBS in urban planning on the one hand evidence is needed to motivate, guide, and support decision-makers in decision-making processes, and on the other hand approaches supporting the development of NBS are required to be integrated into proper planning processes and instruments to guarantee their effective implementation. Below, some challenges associated to the development and mainstreaming of NBS in urban planning are outlined and briefly described. It has to be noted that these challenges are presented not necessarily in order of relevance but just randomly.

The first challenge is related to the development of methods and tools to support decision-making for NBS. Such methods and tools are aimed at substantiating evidence of their capacity and effectiveness to provide co-benefits and simultaneously address different societal challenges while contributing to human well-being, e.g., decision-making toolkits and processes that simplify and systematize the monitoring and evaluation of co-benefits in decision-support (Ürge-Vorsatz *et al*. 2014), as well as model, explore, and suggest solutions (Bell, 2012). Since the effectiveness of NBS is strictly related to the capacity to provide multiple ES, once identified the problem(s) that should be solved and potential solutions, it is essential to create/make use of scientific and spatial models to define, explore, and analyse the spatial scale of the co-benefits that such solutions can provide through the supply of multiple ES, as well as who and where are the beneficiaries. The spatial analysis and mapping of the effects of NBS on the provision of ES is essential to conduct ex-ante assessment – and provide ex-ante evidence – to inform decision-making, since makes it possible to analyse both ecological and socio-economic aspects of an intervention in a spatially-explicitly manner, as well as the beneficiaries of the services (and associated co-benefits) the interventions might yield. Different scientific models already exist and can be used to map and assess ES. However, some ES are considered as difficult to capture through scientific models and indicators, such as cultural ES (La Rosa *et al*. 2015, Cortinovis and Geneletti, 2018). In fact, cultural ES are characterised by intangible dimension, relation with non-material values, and inherent subjectivity (Chen et al. 2012) and can be investigated through stakeholder involvement (Luederitz *et al*. 2015, Wolff *et al*. 2015, Cortinovis and Geneletti, 2018) instead of applying scientific models that are typically used with biophysical data (e.g., for regulating ES). In general, methods for mapping and assessing ES are intended to:

- portray the current situation in relation to the supply and demand of ES, in order to identify those areas characterized by *low performances* in terms of ES that are associated to a series of social and environmental issues, or societal challenges, and, consequently, affect human well-being (e.g., urban and peri-urban areas that are difficult to access or have scarce presence of facilities have *low performances* in terms of recreational services; residential areas with scarce presence of vegetation have *low performances* in terms of regulating services, such as microclimate regulation or water flow regulation);
- develop scenarios associated to the implementation of NBS aimed at addressing societal challenges (e.g., to address the impacts of climate change, permeable areas for stormwater retention can be created) and enhancing human well-being (e.g., planting a large amount of trees can support the alleviation of health problems associated to air pollution or high temperatures thanks to their ability to capture pollutants and cooling capacity) through the provision of ES (e.g., by bridging the gap between ES demand and supply for stormwater retention; by creating areas characterized by *high performances* in terms of ES supply associated to the presence of trees such as microclimate and air quality regulation); potential ecosystem disservices and options to avoid or mitigate them should be investigated and included in the analysis when developing scenarios (for ecosystem disservices see also the fourth challenge presented below).

Once scenarios based on ex-ante assessments of ES associated to NBS are implemented, cost-effectiveness assessment of NBS projects can be performed on the basis of the evidence base, so that alternative solutions can be compared considering the place-specific implications of each alternative in relation to the expectations for solutions in any particular context. It has to be noted that cost-benefit analyses alone may not adequately capture the multiple benefits over time of NBS, thus methods including integrated sustainability assessment and mapping (long-term and short-term) multiple benefits and how they change over time are required for ex-ante assessments (Xing *et al*. 2017, Raymond *et al*. 2017).

The second challenge concerns the use of performance-based planning approaches, which support better land use integration as long as performance criteria are met instead of more traditional planning approaches and regulations that are typically based on zoning, thus on segregation of land use zones (Frew *et al.* 2016). Performance-based approaches are composed of two components: "first, criteria that describe the desired end result, and second, methods to define standards used to measure the acceptable limits of impact to ensure the desired end result" (Baker *et al.* 2006). Performance-based planning approaches are therefore more suitable to foster the implementation of NBS since it uses clear standards that set acceptable environmental performances (Porter *et al.* 1988; Blackwell, 1989; Frew *et al.* 2016), and can be tailored in order to include more qualitative objectives in urban planning. Performances of urban transformation and management options in relation to such objectives can be measured and assessed by making use of appropriate data and indicators (i.e., performance-based indicators) that are typically used to map and assess ES. Performance-based planning approaches can be linked, for example, to ex-ante assessment frameworks for the evaluation of i) the suitability of any urban development resulting in land use and/or land cover change with respect to some minimum standard requirements, desired results, and/or qualitative and quantitative objectives (in terms of ES supply), and ii) the effectiveness of NSB projects to meet agreed goals or desired end results, e.g., through the selection of a set of easily measurable criteria for the ecological, social, and economic effectiveness of the interventions.

The third challenge is associated to the development of appropriate indicators that consider direct effects and associated co-benefits and that can be used to assess and compare the effectiveness of possible NBS in addressing environmental issues during the strategic environmental assessment of urban planning instruments. It is argued that planning decisions would benefit from systematic considerations of their effects on ES (e.g., Geneletti, 2011). Since many of NBS benefits and co-benefits rely on the supply of multiple ES, systematic considerations of their effects on ES can be founded on the testing and assessment of alternative actions by using such indicators so that advantages and drawbacks of the different alternatives can be highlighted. When assessing NBS, it is of great importance to take into account also long-term benefits and effects, as NBS projects often show their advantages in a longer period of time with respect to traditional solutions (Kabisch *et al.* 2016). This could help to fill the knowledge gaps that exist with regard to long-term benefits and effects of NBS, as well as their contribution to increasing the resilience of cities against foreseen environmental changes (Kabisch *et al.* 2016).

The fourth challenge regards the inclusion of potential disservices or negative externalities that may emerge when analysing, assessing, and comparing the effects of NBS interventions. Some authors (e.g., Lyytimäki, 2015, Schaubroeck, 2017, Blanco *et al.* 2019) advocate that an integrated assessment of both ES and disservices will help towards a clearer understanding about the role that nature has for humans and human well-being, and towards the formulation of more effective and innovative sustainability policies. The inclusion of ecosystem disservices valuation is therefore crucial to estimate the sustainability of NBS (Schaubroeck, 2017). If properly applied during decision-making processes concerning NBS projects, the inclusion of ecosystem disservices in the assessment phase can help to develop ad-hoc management and policy instruments that address potential solutions to avoid or manage them (e.g., long-term management options, appropriate selection of species, or compensatory measures), as well as provide information to inform decisions on alternative solutions.

The fifth challenge concerns the development of adequate measures of progress and success towards agreed goals in order to strengthen the evidence base for the benefits and co-benefits provided by NBS projects, for example through a selection of a set of easily measurable criteria for the ecological, social, and economic effectiveness of the interventions (e.g., Heink *et al*. 2015, Hobbs and Harris, 2001, Nesshöver *et al*. 2017). Many indicators have the potential to be considered as success criteria, but these will need to be clearly related to the specific *solution* goals in terms of biophysical aspects and ES (e.g., carbon sequestration, water use efficiency, pollination, microclimate regulation, cultural and recreational services), and the same applies to the economic and social spheres in terms of value, capital or investment/revenue in the system, or to the effects on health and well-being (Nesshöver *et al*. 2017). Monitoring of NBS impacts/effects over time is considered a fundamental step of NBS development and assessment phases, as it is crucial for their continuous refinement and testing. In fact, when monitoring shows that targets are not met, the community is informed and corrective measures can be taken such as revising the goals, changing planning practices, or improving the implementation of the plan or project (Ahern *et al*. 2014).

Conclusions

The promotion of NBS builds on the increasing evidence and experiences showing that natural resources can play an important and cost-effective role in addressing societal challenges and enhancing human well-being through the provision of multiple ES. These evidence and experiences are largely related to the agricultural and forestry sectors, with relatively little focus on urban areas (Munang *et al*. 2013). This paper presented five challenges associated to the development and mainstreaming of NBS in urban planning, so as to provide directions for their promotion in urban areas. Such challenges are related to the development of decision support methods and tools aimed at providing evidence of NBS effectiveness, to the use of performance-based planning approaches instead of traditional zoning approaches since NBS are strongly performance-oriented, to the development of indicators to assess and compare the effectiveness of possible NBS during the strategic environmental assessment of urban planning instruments, to the analysis and assessment of potential disservices or negative externalities that may emerge from NBS interventions, to the development of adequate measures of progress and success towards agreed goals to monitor the effects of NBS over time and to strengthen the evidence base for their benefits and co-benefits. The main features of these challenges are introduced and discussed in order to provide insights for the integration of NBS in urban planning processes and instruments.

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