NBS Design and Implementation in Urban Systems: Dimensions, Challenges and Issues to Construct a Comprehensive Evaluation Framework

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Abstract. The paper explores the recent challenge of implementing Nature-Based Solutions (NBS) in urban systems, as they represent an opportunity to address social, economic, and environmental issues.

Furthermore, the design and implementation of NBS in the urban context are also supported by international and national policies, such as the European Green Deal, the Sustainable Development Goals (SDGs) and the Italian Recovery and Resilience Plan (PNRR). However, despite the growing attention on this topic, there are some critical aspects still unexplored. The European Commission discuss in-depth about these aspects, declaring them as the key points to set future research. Specifically, it has been pointed out that one of the main critical issues to be investigated concerns the development and test of Decision Support Systems (DSS), evaluation tools and models to comprehensively assess NBS interventions to support their design and implementation in urban systems. According to this scenario, this paper is inserted into this research topic. More in detail, the present dissertation is a position paper that underlines the main criticalities concerning the NBS evaluation and identifies a methodological framework and some evaluation techniques that could be used to structure an evaluation framework to overcome the highlighted gaps to answer real operative requirements.

Keywords: Nature-Based Solutions (NBS) · evaluation framework · multidimensional scales and impacts · monetary and non-monetary evaluation · PNRR

1 Introduction

Societies are dealing with a wide range of issues and stresses, related to both local and global phenomena including climate change and natural catastrophes [1]. These pressures imply threats to human health and well-being, the depletion of natural resources, and the security of food, water, and energy [1–3].

According to this scenario, Nature-Based Solutions (NBS) have been suggested as a possible policy strategy to address and solve several urban challenges due to their

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potential to provide multidimensional impacts and advantages and promote the wellness of people and communities [1].

In fact, the European Union (EU) is approaching these multifaceted societal issues through the new and innovative perspective represented by NBS design and implementation in urban systems [3, 4]. The objective is trying to maximize the interactions among nature, society, and the economy [1, 4–7]. Scholars and practitioners discuss the fact that the suitability of NBS design and implementation to achieve multidimensional benefits has never been more relevant, important or urgently needed than now to address the multifaceted stresses and pressures of societies and urban systems [8].

Among various NBS definitions and descriptions, the most commonly adopted is the one provided by the European Commission (EC) [7] which describes NBS as "*solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes through locally adapted, resource-efficient and systemic interventions*" [9]. This description provides a broad framework that includes several interpretations and practical applications [3, 10].

In this sense, NBS have emerged as both a challenge and an opportunity to assist urban communities in the transition to greater sustainability and adaptation to climate change [11]. According to this scenario, NBS have been proposed as a sustainable approach to supporting the transition of sustainable and resilient development in cities [12]. According to this scenario, exponential attention has been observed in implementing NBS in urban systems. In fact, from the research on the Scopus platform, considering the keywords "Nature-Based Solutions" AND "cities" it has been possible to see an

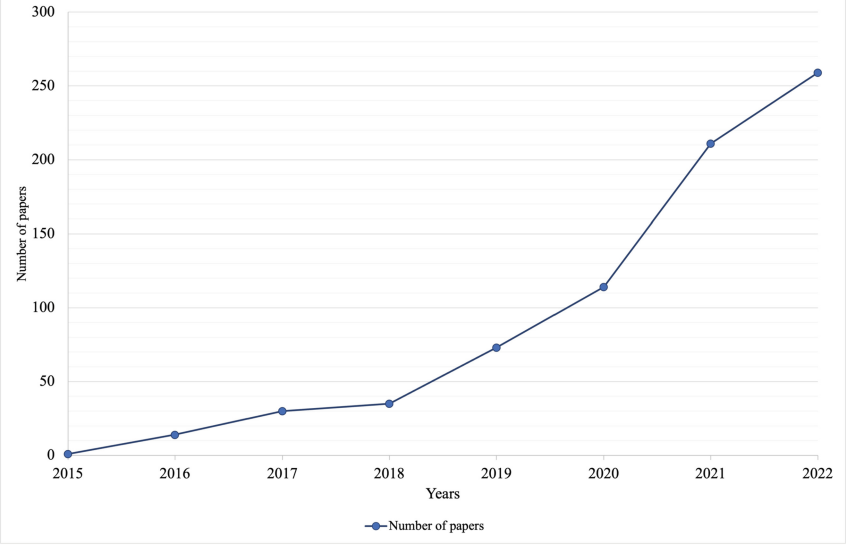

Fig. 1. Development of the literature about NBS and cities

exponential increase in production paper since 2018, as Fig. 1 represents. From the year 2015 with only one paper, moved to 2022 with 259 papers.

In this sense, it is possible to stress the fact that NBS within their design and implementation in urban systems have recently emerged as one of the main policy drivers for transitioning cities [1]. Therefore, NBS can be considered a great opportunity for innovation [1, 5–7].

According to the observed great attention on NBS design and implementation in urban systems, this paper addresses the NBS alignment with the international frameworks to underline their significance in supporting the transition of cities to sustainable and resilient development. Moreover, this paper aims at exploring the criticalities observed in the field of the evaluation of NBS intervention, to stress the necessity of the development and testing of Decision Support Systems (DSS), evaluation tools and models that can conduct a comprehensive assessment to consider all the multifaceted aspects concerning NBS. More in detail, the present research is configured as a position paper to identify some evaluation techniques that could be used to structure an evaluation framework to overcome the highlighted gaps and answer real operative requirements.

2 NBS Alignment with International Frameworks

The regeneration, requalification and transformation of urban areas and territories is the current challenge, which must consider environmental quality and social justice [14]. As stated in the previous part, transforming cities and regions into sustainable and resilient living places has become a key global priority and the NBS implementation can contribute to this global challenge [6]. According to this scenario, it is necessary and useful to point out the alignment of NBS implementation with some of the most important international frameworks [1, 13, 14].

From different works proposed by several scholars [1, 13, 14], it is possible to address that NBS design and implementation in urban systems is aligned with several international frameworks.

First of all, the New Urban Agenda specifically refers to NBS for urban and territorial planning [15]. Article 157 says "*we will support science, research and innovation, including a focus on social, technological, digital and nature-based innovation, robust science-policy interfaces in urban and territorial planning and policy formulation and institutionalized mechanisms for sharing and exchanging information, knowledge and expertise, including the collection, analysis, standardization and dissemination of geographically based, community-collected, high-quality, timely and reliable data disaggregated by income, sex, age, race, ethnicity, migration status, disability, geographic location and other characteristics relevant in national, subnational and local contexts.*"[1]

As well as, the NBS design and implementation are aligned with:

– The EU adaptation strategy [16];
– Paris agreement [17];

[1] United Nations, 2016, p. 39.

– Sendai Framework [18]

Moreover, it can be stated that NBS can enhance and contribute to a number of Sustainable Development Goals (SDGs) [1]. More specifically, NBS address not only SDGs concerning nature and natural processes such as SDGs 14 and 15. In fact, researchers highlighted that NBS should improve in a general manner the access to recreational/green areas [1]. As well as, the improvement of green areas and green infrastructure networks should engage the SDGS 10 (reducing inequalities) and SGD 3 (improving well-being) [1]. Moreover, NBS should contribute considerably to SDG 11 related to "making cities and human settlements inclusive, safe, resilient and sustainable". In fact, NBS implementation can achieve target 11.3, or rather "inclusive and sustainable urbanization", as well as target 11.4 "protect the world's cultural and natural heritage", target 11. 5 "reduce the adverse effects of natural disasters", target 11.6 "reduce the environmental impact of cities", target 11.7 "provide access to safe and inclusive green and public space". In the same way, NBS can support the reaching of some SDG 13 targets, such as 13.1 "strengthen resilience and adaptive capacity to climate related disasters" and 13.2 "integrate climate change measures into policies and planning",

Moreover, NBS are also engaged in the European Recovery and Resilience Plans (RRPs), and in the Italian National Plan of Recovery and Resilience (PNRR) [19]. The RRPs are focused on the mitigation of the economic and social impacts due to the coronavirus pandemic and on the enhancement of sustainable and resilient development to face both digital and climatic and transitions challenges [19]. The EU defines the six pillars that have to be investigated by RRPs, or rather: (1) green transition, (2) digital transformation, (3) economic cohesion, productivity and competitiveness, (4) social and territorial cohesion, (5) health, economic, social, and institutional resilience, and (6) policies for the next generation [19]. Therefore, the RRP is a plan based on the enhancement of economic growth and increasing job opportunities. The Italian PNRR is organized into 16 Components, that are grouped into six missions: (1) digitalization, (2) ecological transition, (3) sustainable mobility, (4) research and education, (5) social cohesion and inclusion, and (6) health. More in detail, the ecological transition takes the highest percentage of the total funding program with respect to the other missions [19]. Therefore, the design and implementation of NBS intervention is engaged in the mission of PNRR.

3 Problem Statement

As declared in previous sections, NBS have been proposed as a promising approach.

To address several multidimensional urban problems due to the potential, they have to deliver multiple benefits and foster well-being for individuals and communities [1, 12]. However, there are some gaps that need to be explored in the context of NBS design intervention. The EC analyses these lacks and states that one of the main critical issues to be investigated concerns the development and the test of DSS, evaluation tools and models to comprehensively assess NBS interventions to support their implementation in urban systems, as well as the monitoring and assessment of their impacts are needed to guide urban policy-making. In fact, the analysis of the existing and proposed evaluation frameworks highlights several issues and empirical gaps that have to be addressed to

define a robust evaluation framework to support and inform policy decisions in European urban projects [12].

In general, the debate is focuses on the necessity of understanding and evaluating the economic, social, political and cultural dimensions of the design and implementation of NBS [4].

Therefore, this section lists the most discussed criticalities concerning the evaluation of NBS design and implementation. More in detail, these gaps have been collected from the combination and the comparison of research papers [1, 3, 10–12, 20] and the report by the EU focused on the NBS state-of-the-art [4].

These main issues can be listed as follows:

– *NBS is an umbrella term that engages a wide range of concepts and practices* [4].

In the literature, NBS is an umbrella term in which different interventions can be classified and engaged. There are several solutions that can use nature ranging from small scales such as green rooftops or green walls in cities to broad-scale for climate change mitigation and adaptation such as forestation [10]. This condition influences in a negative way the organization and structuring of an effective evaluation framework, according to the wide range of possible solutions to evaluate. Therefore, it is necessary to draw and define the limits of what can be classified as NBS or not.

– *Issue of economic evaluation, quantification and monetization of NBS* [5].

One of the main issues concerning the evaluation of NBS implementation regards the evaluation of economic efficiency. In fact, NBS have the potential to be cost-efficient and resource-efficient [1]. Moreover, it is necessary to quantify and monetize NBS benefits to support the decision process.

Whiteoak in the EU report on the state of the art of NBS intervention in the European context stresses that the rigorous use of economic analyses may reveal more NBS options than would otherwise be identified [4].

– *Issue of the consideration in the evaluation framework of the time scale.*

The topic of how different impacts can affect over time urban systems is not an issue in the context of urban sustainability and transformation. Therefore, also the theme of NBS implementation is engaged in this trouble. In fact, interventions should be investigated according to their short-, medium-, and long-term effects [12].

From the literature review, it has been observed that the short-term effects are the most investigated [12]. Moreover, the analysis of the short-term effects is appropriate for specific environmental impacts, but not suitable for other aspects, such as climate change which requires a long-term approach, as well as social impacts [6, 12, 13].

Therefore, in the literature, it is unclear and less explored which approaches would be more suitable in the long-term evaluation and which would be more effective immediately after implementation [21].

In fact, it is necessary to point out that regarding the different solution types, the achievement of benefits required can vary in time scale, or rather different co-benefits can be produced at different time steps [22]. Therefore, NBS implementation effectiveness should be assessed according to different time thresholds in order to evaluate short-time

effects (1–5 years), medium-time effects (5–10 years) and long-time effects (over 10 years) [4].

– *Criticalities in considering spatial scale in the evaluation, supporting the definition of the adequate spatial scale of intervention.*

As discussed before, there are different types of NBS implementation interventions, that can embrace the different level scale of interventions [5]. In fact, NBS can be related to the micro-level of a single building (e.g., green walls), the meso-level of a whole city (e.g., constructed wetlands) and the macro-level of an entire country [20]. Moreover, it is important to underline that the scale of a solution affects effectiveness in terms of the provision of services and the level of tackling challenges.

– *The challenge of social impacts valuation and the differentiation of impacts for different socio-economic group.*

In the literature, it is discussed that NBS can have different impacts concerning different social groups [23]. In fact, it has been observed that certain social groups are sometimes excluded from engaging with NBS, or others implying the effect of the green gentrification [23]. To be effective, the evaluation framework should include methodologies to assess the magnitude of these social impacts, as well as their different nature and implication according to different social groups.

– *Issue of considering the interactions between different impacts.*

As underlined by the literature, NBS affect social, environmental, and economic spheres, which are interrelated due to the fact cities are conceptualized as ecosystems [24]. Therefore, it should be recognized also in the evaluation phase the interaction between these dimensions, as well as impacts. Evaluation frameworks should identify potential interactions and interrelations (cause-effects relations) among different types of impacts [3].

4 Proposing Method

As stated in the previous section, NBS address social, economic, and environmental dimensions. According to the analysis of the observed lacks in the field of NBS evaluation, the authors also move their reflection about some aspects that should be addressed in the assessment of NBS design and implementation.

These aspects mainly concern (1) the changing value of the real estate market, that is also strictly related to the gentrification phenomenon [25], and (2) the issue of budget evaluation [4].

Thus, above these reflections and the issues discussed in the previous section, it is possible to underline that when dealing with NBS design and implementation it is necessary to support the definition of the strategy by addressing: the cost of intervention and the economic revenues, the real estate market and the real estate value, the social and environmental impacts, and the spatial and temporal scales.

Therefore, this section aims at proposing some methodologies that should be applied to investigate these aspects.

First of all, a taxonomy of NBS intervention to support the evaluation process is required. In detail, the authors aim at proposing a taxonomy that collects different types of NBS intervention, according to their nature and scale of intervention to clarify their design and better support the selection of the most suitable evaluation framework, as well as to support the evaluation of the intervention cost. In this sense, this proposal aims at making the several NBS interventions more accessible to different stakeholders and improving the coherence in research and policy dialogue [1].

Concerning the issue of the spatial scale of the intervention, the method of alternative design should be selected to explore this topic [26, 27]. More in detail, the alternative design method should be used to investigate and compare micro-scale and large-scale intervention in an urban context to identify the better alternative and scale of intervention according to the objective and purposes.

Moreover, also the application of the Geographic Information System (GIS) is suggested to map the intervention and evaluate its effectiveness [28].

For what concerns about the cost of the investment is important to address the available budget and how to invest it. Therefore, it should be useful and interesting to explore the method of the Portfolio Decision Analysis also in the context of the NBS evaluation [29], in order to purpose to include urban NBS into institutional investment portfolios through regulatory and supervisory action and certification schemes [4].

On the other hand, for the evaluation of the changing in the value of the real estate market, one of the possible methods to use is the Hedonic Price Method (HPM), as it is widely used in the literature to evaluate how urban green infrastructure should affect the market value of housing [30].

Moreover, according to both the multifaceted effects of NBS and to the fact that urban systems are ecosystems [24], it is necessary to address the combination and the relationships among these effects. In this sense, Cognitive Maps and/or System Dynamics Model (SDM) should be an efficient method to design the causal relationships that occur among different dimensions and effects [31–34]. As well, SDM should be also used to evaluate the effects of NBS intervention on temporal scale, thanks to its ability to describe the evolution of complex systems over time and support the definition of development strategies by considering their effects in the temporal scale [2], addressing also the long-term effects. Moreover, in the context of the temporal scale, monitoring evaluation methods can be proposed, such as co-axial matrix [35] by using indicators that are able to address peculiarities of the context, as well as SDGs targets.

Table 1 summarizes the discussed issues of NBS evaluation with the proposed method to overcome these criticalities.

Table 1. List of evaluation issues within the proposed methods to overcome them

Evaluation issue	Proposed method or combined methods
Economic evaluation	Portfolio Decision Analysis; Hedonic Price
Time scale of intervention	System Dynamics Model (SDM) for scenario evaluation over time and impacts assessment; Co-axial matrix for monitoring the intervention
Determination of the properly spatial scale of the intervention	Alternatives Design and GIS
Social impacts of different socio-demographic group	System Dynamics Model (SDM) as a participative process
Interaction between multidimensional impacts	Cognitive Maps and System Dynamics Model (SDM)

5 Discussion and Conclusion

This paper briefly explores the current interest in NBS implementation as an opportunity and challenge to face social, economic, and environmental issues. According to this scenario, the present research highlights how NBS implementation is aligned and can contribute to the different national, and international frameworks (Sect. 2).

Moreover, this paper analyses which are the main lack of NBS evaluation addressed in the literature [4]. According to this statement and some critical reflections, the authors propose and list some methodologies that should be used, among others, to address some of the discussed issues.

As an example, the method of the alternatives design and the GIS should be integrated to support the definition of the properly scale of intervention. As well as, these methodologies should be used to create a multimethodological framework with SDM which can be used to evaluate the designed alternative according to its multidimensional impacts over time.

Therefore, above this discussion, it is possible to state and underline that the evaluation of NBS interventions is a crucial step in implementation design. In fact, NBS evaluation is related to the governance in supporting, defining and designing the most suitable intervention [4, 12, 13]. In fact, what clearly emerged is that it is required an evaluation framework able to support the project selection, according to the assessment of its multidimensional aspects and impacts (economic, social and environmental) in both spatial and temporal scales.

Therefore, according to the discussed statement, future research in NBS evaluation should address the integration of quantitative and qualitative evaluation approaches to understanding the multifaceted issues, as well as their interaction and distribution over time [4, 8–10, 12, 13, 20, 36, 37]. Moreover, the proposed evaluation framework should also be a repeatable and context-sensitive approach at the same time. This condition

should be achieved by using indicators able to be used in different contexts and addressing the peculiarities of the evaluation [8].

According to the complexity of these challenges, an accurate NBS implementation requires the contribution of experts and stakeholders across different disciplines and sectors to be implicated in the design, financing, and decision-making processes [4, 8–10, 12, 13, 20, 36, 37].

In conclusion, it can be addressed that this paper explores the current attention of NBS design and implementation in urban systems to support cities in sustainable and resilient development. At the same time, it underlines how NBS can address the tasks of different international and national frameworks, highlighting which are the main operative needs and proposing a reflection on some points and suggestions for other researchers engaged in this field with a specific focus on the PNRR challenges.

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References

1. Faivre, N., Fritz, M., Freitas, T., de Boissezon, B., Vandewoestijne, S.: Nature-based solutions in the EU: innovating with nature to address social, economic and environmental challenges. Environ. Res. **159**, 509–518 (2017). https://doi.org/10.1016/j.envres.2017.08.032
2. Gómez Martín, E., Máñez Costa, M., Egerer, S., Schneider, U.A.: Assessing the long-term effectiveness of nature-based Solutions under different climate change scenarios. Sci. Total Environ. **794**, 148515 (2021). https://doi.org/10.1016/j.scitotenv.2021.148515
3. Davies, C., Chen, W.Y., Sanesi, G., Lafortezza, R.: The European Union roadmap for implementing nature-based solutions: a review. Environ. Sci. Policy **121**, 49–67 (2021). https://doi.org/10.1016/j.envsci.2021.03.018
4. Calfapietra, C., Whiteoak, K., Innovation, Bulkeley, H., Naumann, S., Vojinovic, Z., Wild, T.: Nature-based solutions : state of the art in EU-funded projects. (T. Freitas, S. Vandewoestijne, & T. Wild, Eds.). Publications Office of the European Union (2020). https://doi.org/10.2777/236007
5. Sowińska-Świerkosz, B., García, J.: A new evaluation framework for nature-based solutions (NBS) projects based on the application of performance questions and indicators approach. Sci. Total Environ. **787**, 147615 (2021). https://doi.org/10.1016/j.scitotenv.2021.147615
6. Dumitru, A., Wendling, L., Eiter, S., Pilla, F.: Evaluating the Impact of Nature-based Solutions: A Handbook for Practitioners (2021). https://doi.org/10.13140/RG.2.2.10757.47843
7. Hanson, H.I., Wickenberg, B., Alkan Olsson, J.: Working on the boundaries—How do science use and interpret the nature-based solution concept? Land Use Policy, **90**, 104302 (2020). https://doi.org/10.1016/j.landusepol.2019.104302
8. Cohen-Shacham, E., Walters, G., Maginnis, S., Janzen, C.: Nature-based solutions to address global societal challenges. (E. Cohen-Shacham, G. Walters, C. Janzen, & S. Maginnis, Eds.).

IUCN International Union for Conservation of Nature (2016). https://doi.org/10.2305/IUCN.CH.2016.13.en
9. Bauduceau, N., Berry, P., Cecchi, C., Elmqvist, T., Fernandez, M., Hartig, T.: Noring, L. (2015). Towards an EU research and innovation policy agenda for nature-based solutions & re-naturing cities: Final report of the horizon 2020 expert group on'nature-based solutions and re-naturing cities'
10. Nesshöver, C., et al.: The science, policy and practice of nature-based solutions: an interdisciplinary perspective. Sci. Total Environ. **579**, 1215–1227 (2017). https://doi.org/10.1016/j.scitotenv.2016.11.106
11. Frantzeskaki, N., et al.: Examining the policy needs for implementing nature-based solutions in cities: Findings from city-wide transdisciplinary experiences in Glasgow (UK), Genk (Belgium) and Poznań (Poland). Land Use Policy **96**, 104688 (2020). https://doi.org/10.1016/j.landusepol.2020.104688
12. Dumitru, A., Frantzeskaki, N., Collier, M.: Identifying principles for the design of robust impact evaluation frameworks for nature-based solutions in cities. Environ. Sci. Policy **112**, 107–116 (2020). https://doi.org/10.1016/j.envsci.2020.05.024
13. Raymond, C.M., et al.: A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environ. Sci. Policy **77**, 15–24 (2017). https://doi.org/10.1016/j.envsci.2017.07.008
14. European Environment Agency. Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction. EEA Report (2021). https://www.eea.europa.eu/publications/nature-based-solutions-in-europe
15. United Nations. New Urban Agenda Habitat III: Summary. Habitat III Secretariat (2016). 978-92-1-132731-1
16. European commission. Communication from the commission to the european parliament, the council, the european economic and social committee and the committee of the regions an eu strategy on adaptation to climate change (2013). Brussel
17. Delbeke, J., Runge-Metzger, A., Slingenberg, Y., Werksman, J.: The Paris Agreement. In: Towards a Climate-Neutral Europe, pp. 24–45. London: Routledge (2019). https://doi.org/10.4324/9789276082569-2
18. UNISDR. Sendai Framework for Disaster Risk Reduction. UN World Conference (2015)
19. Di Pirro, E., et al.: The embeddedness of nature-based solutions in the recovery and resilience plans as multifunctional approaches to foster the climate transition: the cases of Italy and Portugal. Land **11**(8), 1254 (2022). https://doi.org/10.3390/land11081254
20. Raymond, C., et al.: An impact evaluation framework to support planning and evaluation of nature-based solutions projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology and Hydrology (2017)
21. Kabisch, N., Korn, H., Stadler, J., Bonn, A. (eds.): Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice. Springer International Publishing, Cham (2017)
22. Giordano, R., Pluchinotta, I., Pagano, A., Scrieciu, A., Nanu, F.: Enhancing nature-based solutions acceptance through stakeholders' engagement in co-benefits identification and trade-offs analysis. Sci. Total Environ. **713**, 136552 (2020). https://doi.org/10.1016/j.scitotenv.2020.136552
23. Sowińska-Świerkosz, B., García, J.: What are Nature-based solutions (NBS)? Setting core ideas for concept clarification. Nature-Based Solutions **2**, 100009 (2022). https://doi.org/10.1016/j.nbsj.2022.100009
24. Douglas, I., Goode, D., Houck, M.C., Maddox, D.: The Routledge Handbook of Urban Ecology. Taylor \& Francis (2010). https://books.google.it/books?id=5J%5C_HBQAAQBAJ

25. Sax, D.L., Nesbitt, L., Quinton, J.: Improvement, not displacement: A framework for urban green gentrification research and practice. Environ. Sci. Policy **137**, 373–383 (2022). https://doi.org/10.1016/j.envsci.2022.09.013
26. Pluchinotta, I., Kazakçi, A.O., Giordano, R., Tsoukiàs, A.: Design theory for generating alternatives in public decision making processes. Group Decis. Negot. **28**(2), 341–375 (2019). https://doi.org/10.1007/s10726-018-09610-5
27. Colorni, A., Tsoukiàs, A.: Designing alternatives in decision problems. J. Multi-Criteria Decis. Anal. **27**(3–4), 150–158 (2020). https://doi.org/10.1002/mcda.1709
28. Mahmood, R., Zhang, L., Li, G.: Assessing effectiveness of nature-based solution with big earth data: 60 years mangrove plantation program in Bangladesh coast. Ecol. Process. **12**(1), 11 (2023). https://doi.org/10.1186/s13717-023-00419-y
29. Salo, A., Keisler, J., Morton, A. (eds.): Portfolio Decision Analysis: Improved Methods for Resource Allocation. Springer New York, New York, NY (2011)
30. Dell'Anna, F., Bravi, M., Bottero, M.: Urban Green infrastructures: how much did they affect property prices in Singapore? Urban For. Urban Greening **68**, 127475 (2022). https://doi.org/10.1016/j.ufug.2022.127475
31. Axelrod, R.: Structure of decision: The cognitive maps of political elites. Structure of Decision: The Cognitive Maps of Political Elites (2015). https://www.scopus.com/inward/record.uri?eid=2-s2.0-85016362307&partnerID=40&md5=fc296bd0c6fcbb681e0ac7c5545189a5
32. Bottero, M., Datola, G., Monaco, R.: The use of fuzzy cognitive maps for evaluating the reuse project of military barracks in Northern Italy. In: Calabrò, F., Della Spina, L., Bevilacqua, C. (eds.) ISHT 2018. SIST, vol. 100, pp. 691–699. Springer, Cham (2019). https://doi.org/10.1007/978-3-319-92099-3_77
33. Forrester, J.W.: Lessons from system dynamics modeling. Syst. Dyn. Rev. **3**, 136–149 (1987)
34. Bala, B.K., Arshad, F.M., Noh, K.M.: Systems thinking: system dynamics. In: System Dynamics. STBE, pp. 15–35. Springer, Singapore (2017). https://doi.org/10.1007/978-981-10-2045-2_2
35. Assumma, V., Datola, G., Mondini, G.: New Cohesion policy 2021–2027: the role of indicators in the assessment of the SDGs targets performance. In: Gervasi, O., et al. (eds.) ICCSA 2021. LNCS, vol. 12955, pp. 614–625. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-87007-2_44
36. Nika, C.E., Gusmaroli, L., Ghafourian, M., Atanasova, N., Buttiglieri, G., Katsou, E.: Nature-based solutions as enablers of circularity in water systems: a review on assessment methodologies, tools and indicators. Water Res. **183**, 115988 (2020). https://doi.org/10.1016/j.watres.2020.115988
37. Sandin, L., et al.: Working with nature-based solutions. Nordisk Ministerråd (2023). https://doi.org/10.6027/temanord2022-562