Article:
Wild, T. orcid.org/0000-0001-8622-3982, Baptista, M., Wilker, J. et al. (8 more authors) (2024) Valuation of urban nature-based solutions in Latin American and European cities. Urban Forestry and Urban Greening, 91. 128162. ISSN 1618-8667

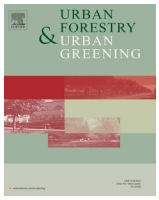
https://doi.org/10.1016/j.ufug.2023.128162

Urban Forestry & Urban Greening 91 (2024) 128162

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug



Original article

Valuation of urban nature-based solutions in Latin American and European cities

Tom Wild [a,*], Mariana Baptista [a], Jost Wilker [b], Juan Miguel Kanai [a], Mariana Giusti [c,d], Hayley Henderson [e], Demián Rotbart [c,f], Juan-David Amaya Espinel [g], Jaime Hernández-Garcia [g], Otto Thomasz [c], Daniel Kozak [c,h]

[a] The University of Sheffield, Firth Court, Western Bank, Sheffield S10 2TN, United Kingdom
[b] Department of Nature Conservation, Ministry of the Environment, Nature and Transport of the State of North Rhine-Westphalia, Emilie-Preyer-Platz 1, 40479 Düsseldorf, Germany
[c] Faculty of Architecture, Design and Urbanism, University of Buenos Aires, Pabellón 3, Piso 4, Ciudad Universitaria, 1428 Autonomous City of Buenos Aires, Argentina
[d] Department of Human Geography, University of Seville, Calle San Fernando 4, Seville 41004, Spain
[e] Institute for Infrastructure in Society, The Australian National University, Canberra, ACT 2601, Australia
[f] Secretaría de Obras y Servicios Públicos, Municipalidad de San Martín, Belgrano 3747, CP B1650 San Martín, Buenos Aires, Argentina
[g] Pontificia Universidad Javeriana, Carrera 7 # 40-62, Bogotá, Colombia
[h] CONICET, Godoy Cruz 2390 Piso 1, Ciudad de Buenos Aires, Argentina

ARTICLE INFO

Keywords:
Values
Green infrastructure
Economic
Cost-benefit analysis
Indicators
NBS

ABSTRACT

The potential of urban nature-based solutions (NBS) to provide significant benefits to citizens and to address societal challenges is undervalued, yet the valuation of NBS impacts remains contentious. Further development of monetary and non-monetary valuation of the costs and benefits of urban NBS is required, and effective knowledge exchange on these themes is required at the international level. However, an important gap in research relates to the uptake and application of existing techniques for monetary valuation. This research explored how monetary values of urban NBS are assessed, and how NBS valuation is viewed by city government authorities in particular. Results are presented from a review of peer-reviewed articles reporting urban NBS valuation techniques development and application. Over 200 articles relating specifically to urban NBS interventions were reviewed. The literature indicates that many valuation techniques have been researched, but most studies tend to address just a few indicators of NBS impacts, which are mainly physical-environmental in their focus. To generate deeper insights into perceptions of monetary valuations in NBS impact assessments and their application, focus groups and semi-structured interviews were conducted with local and regional government staff in seven cities in Latin America and Europe. Although a wide range of economic valuation tools exist and can be applied to support NBS development, limited evidence was found for their uptake and application in practice across the contexts examined. We discuss potential reasons for limited uptake, which may include overburdensome data demands, incommensurability with existing decision-making and accounting practices, and limited staffing, financial and technical capacity - even within large cities. Results suggest that successful NBS interventions may portray economic impacts, but NBS propositions should not depend upon monetary valuations alone; social and ecological criteria remain centrally important. Participatory impact assessment methods may support improved business cases and monetary valuations for urban NBS.

Urban nature-based solutions (NBS), such as urban forestry, sustainable urban drainage systems (SUDS), deculverting and additions to blue-green infrastructure networks (e.g. D'Arcy, 1998; Konijnendijk et al., 2005; Kozak et al., 2020; Barona et al., 2020) can deliver multiple benefits, including reduced flood risk, water pollution, air pollution and heat island effects (EEA, 2021). Nature-based solutions is a useful

* Corresponding author.
E-mail addresses: t.wild@sheffield.ac.uk (T. Wild), m.d.baptista@sheffield.ac.uk (M. Baptista), Jost.Wilker@munv.nrw.de (J. Wilker), miguel.kanai@sheffield.ac.uk (J.M. Kanai), mgiusti@us.es, mariana.giusti@fadu.uba.ar (M. Giusti), hayley.henderson@anu.edu.au (H. Henderson), demian.rotbart@gmail.com (D. Rotbart), jamayae@javeriana.edu.co (J.-D.A. Espinel), hernandez.j@javeriana.edu.co (J. Hernández-Garcia), daniel.kozak@conicet.gov.ar (D. Kozak).

https://doi.org/10.1016/j.ufug.2023.128162
Received 24 April 2023; Received in revised form 24 November 2023; Accepted 25 November 2023
Available online 8 December 2023

umbrella term for several intervention types, but the assembly of such broad sets of activities may also mask important differences (Pauleit et al., 2017). Urban NBS provide multiple functions and benefits drawing on natural mechanisms, enabling cities to adapt to environmental changes and socio-economic challenges whilst also enhancing biodiversity (Miyahara et al., 2022). These interventions offer the potential to bring nature back into urban areas where it has been depleted and where restoration can help solve social and economic challenges (UNEA, 2022).

At present, three main approaches have gained ground in assessing NBS impacts: (1) the Eklipse framework (Raymond et al., 2017); (2) IUCN's Global Standard (Cohen-Shacham et al., (2019)); and (3) the EC's Impact Assessment Handbook (Dumitru and Wendling, 2021a). These converge on the need to enhance biodiversity and ecosystem integrity (Seddon et al., 2021). By addressing multiple policy priorities, NBS can provide cost-effective responses covering diverse agendas (EC, 2023). Publications about NBS impacts have grown rapidly across a wide range of disciplines (Escobedo et al., 2019; Ruangpan et al., 2020). In March 2022, the urgent priority to understand and communicate NBS impacts was addressed at the United Nations Environment Assembly Fifth Session (UNEA, 2022). However, paradoxically, cities across the world face critical shortages in investment in NBS to respond to challenges such as climate adaptation ('urban adaptation finance gap'; Swann et al., 2021).

Interest has grown rapidly in NBS business cases and their role in a 'nature-positive economy' (Mayor et al., 2021; EC, 2022a). Traditionally, little evidence existed of private sector investment in nature conservation and restoration (Dempsey and Suarez, 2016). The role of nature is undervalued in alleviating multiple societal challenges, and NBS remain on the margins of global finance, with private sector finance accounting for just 3% of funding for NBS (EIB, 2023). Cities have received less than 5% of global adaptation finance (GCA, 2019; Richmond et al., 2021), representing a lost revenue stream for urban NBS (Swann et al. 2021). Marsters et al. (2021) call for the increased monetisation of NBS, with performance metrics to support private sector participation and unlock new and diverse funding streams. This repeats similar demands for better evidence quantifying NBS impacts, e.g. Whiteoak (2020) stresses the value of assessing NBS cost-effectiveness whilst noting the rarity of shared data on the values- and prices- sides.

NBS impacts are often difficult to quantify monetarily, partly because they deliver multiple public benefits that do not necessarily produce direct financial revenue streams (Wild et al., 2017). The use of typical market mechanisms, such as private developments e.g. housing schemes, to deliver green infrastructure (GI) is restricted; with the arising goods having a high degree of non-excludability and non-rivalry (Wilker and Rusche, 2013). The application of valuation methods also requires careful attention to the realities of cities in the Global South (Pineda-Guerrero et al., 2020). Vásquez and Dobbs (2020) highlight that in South America, the lack of economic valuation of NBS benefits remains a key barrier to implementation.

Despite considerable differences in socio-ecological dynamics, cities in Europe and Latin America share global-local challenges to tackle inequalities, biodiversity loss, and climate change. Many cities face problems of landscape fragmentation caused by rapid growth, urban sprawl, and (re)development. Due to diverse geographical and climatic contexts, Latin America is one of the most biodiverse regions in the world but is urbanising rapidly (with 89% predicted to live in urban areas by 2050; UN, 2018). Studies in such cities highlight the crucial role of NBS to improve quality of life and restore ecosystems, where barriers to adoption include the lack of indicators to monitor co-benefits and establish economic, ecological, and social impacts (Marques et al., (2022)). Significant losses in 'ecosystem services' are accompanied by unequal access to their benefits (Laterra et al., 2019) and increasing vulnerability to climate change (Hardoy and Pandiella, 2009). Urbanisation is predicted to expected to increase to $>$ 80% in Europe by 2050 (UN, 2018).

New research is therefore needed on NBS costs and benefits, including monetary valuation and non-monetary impact assessment addressing social, environmental and cultural effects. Improved evidence and guidance bridging gaps between NBS performance data and valuation will be vital to support robust proposals to access funding (El Harrak et al., (2023); Toxopeus and Polzin, 2021). For instance, the United Nations Adaptation Fund will require strong business cases, and robust treatment of management interventions' logic chains. In Europe, this issue came into sharp focus in the Nature Restoration Law proposals, highlighting that monetisation of NBS impacts remained problematic, due to underestimation of the value of co-benefits e.g. pollution control, aesthetic quality and reduced emissions (EC, 2022b). Croci et al. (2021) assert that while the "literature on [ecosystem services] valuation has grown in recent years, its application to urban contexts is still limited", noting their conclusion was "based on limited available literature".

Different reasons exist for undertaking monetary valuations, and it is important to understand the situations surrounding valuation decisions. Such *decision contexts* can include (1) awareness-raising; (2) accounting; (3) priority-setting; (4) designing; (5) calculating economic liability; and (6) understanding development dynamics and viability (Barton, 2015; 2022; Wild et al., 2017). The ways in which co-benefits of NBS are framed, synthesised and integrated thus becomes centrally important in understanding their monetary values. Key frameworks developed to assess NBS effects include sets of indicators, or measures of success, by which the impacts of NBS can be gauged (Raymond et al., 2017; Cohen-Shacham et al., (2019); Dumitru and Wendling 2021a). Indicators tend to address a broad range of social, environmental and economic criteria.

An economic approach based on cost-benefit analysis (CBA) can provide a robust evidence base to support investment-decision appraisal, but the full suite of impacts should be considered (NCC, 2017). Furthermore, accounting is only one of several reasons to perform such valuations (Barton, 2015). Monetary valuation of natural assets (generally present in NBS) may be restricted by the absence of a market and therefore prices to convert quantities into monetary values (Velasco-Muñoz et al., 2022). In these cases, different valuation methods are used to assess multiple impacts, e.g. willingness to pay (WTP), travel cost, opportunity cost and replacement cost, among others (Velasco--Muñoz et al., 2022; Pisani et al., 2021; Garcia, 2019). Total economic value was traditionally used in valuing nature's services (Pearce and Turner, 1990), incorporating non-use-and use- values (direct and indirect). Use values relate to current benefits, valued using market prices; non-use involves subjective valuations of existence, even where direct benefits may be absent (García, 2019). Valuation may also entail comparison with other (conventional, grey) infrastructures (e.g. Duffy et al., 2008 - comparison of SUDS vs. traditional drainage).

Economic valuation of nature has been criticised on philosophical grounds around intrinsic values and practical bases for determining costs and benefits of non-traded goods (Henneberry et al., 2020). Monetisation, as the last step in economic valuation, seeks to transform individual or social preferences into monetary values, mostly using market prices (Walras, 1877; Pareto, 1906; Paul et al., 2020; von Neumann and Morgenstern (1953)). However, a key problem that arises with natural assets, as a critical element of NBS, is the inexistence of market prices. The economic value of NBS is not adequately reflected in market prices, and novel economic valuation methods are needed (Hsu and Chao, 2020). Using monetary values for non- marketed services such as clean air provision or biodiversity protection has been criticised (Tinch et al., 2019). Monetary valuation also assumes full knowledge of how changes in environmental goods and services influence utility, but these linkages are often complex and poorly understood (Cardinale et al., 2012). Another line of argument relates to perceived threats of neo-liberalisation (Kotsila et al., 2021; de Souza and Torres, 2021; Chausson et al., 2023) contending that monetary valuation may serve to capture, enclose and financialise natural assets or worsen environmental injustice. Kallis et al. (2013) set out criteria to mitigate against these

risks. Other critiques relate to the utility concept itself: conservation should not be based on perceived human interests but on ecocentric values (Taylor et al., 2020, see also 'nature-based thinking'; Randrup et al., 2020). However, urban nature in particular has been undervalued by decision-makers, highlighting a key role for monetary valuation of NBS in cities (Papineu Salm et al., 2023; see also Flórez Yepes et al., (2020)). Balancing these viewpoints, limits to what can be effectively measured through monetisation can be acknowledged, in performing monetary valuation within wider sustainability appraisals *alongside* other impact assessments (social, environmental, cultural), addressing strengths and weaknesses of each form of evaluation.

Although much research effort has been dedicated to developing NBS valuation methodologies (Bockarjova and Botzen, 2017) a key gap in the literature relates to the uptake and application of these methods. Barton et al. (2018) researched the operationalisation of ecosystem services appraisal for governance support, but did not specifically address NBS or urban contexts. Toxopeus et al. (2021) identify integration of NBS benefits into valuation and accounting methods as one of two main overarching barriers to NBS finance. This is despite significant historical research, e.g. Gómez-Baggethun and Barton (2013) comprehensive review of urban ecosystem services valuation methods and economic values data. Mok et al. (2021) examined the applicability of an NBS valuation framework, but focussed primarily on potential for application rather than actual uptake by stakeholders. Viti et al.'s (2022) literature review highlights that in practice NBS valuations may be limited by their narrow focus. Croci et al. (2021) suggest that ecosystem services valuation literature pertaining to urban contexts is limited, but focus on evidence for economic benefits and the scope of methods, rather than uptake. Actual NBS valuation experiences of city government staff – critically important stakeholders in NBS decision-making processes – remain largely unresearched.

New research on the role of monetary valuation and effective knowledge exchange is thus required at the international level, to complement NBS policies and cooperative efforts from local to global scales. The research reported here, funded through the H2020 Conexus project, drew upon city cases in Latin America and Europe and the exchange of knowledge with stakeholders and between different sectors of society. It examined relationships between NBS impact assessment and monetary valuations, along with the uptake of these methods in the studied cities. The study sought to understand relationships between two key challenges – to secure funding for NBS to deliver multiple benefits, and the need for monetary values evidence.

The central ***aim of this study*** was to establish how monetary valuations have been applied to urban NBS projects in the literature and in practice, by investigating the methods, socio-political contexts and decision-making processes surrounding NBS. Specific research questions were:

1. ***How have valuations been applied to understand the economic impacts of urban NBS?***
2. ***How do urban NBS valuations relate to other impact indicators and assessment frameworks?***
3. ***What evidence is there of uptake of these methods in Latin American and European cities?***

The research investigated applications of monetary valuation, and associated impacts of proposed or realised interventions, through literature reviews, focus groups and semi-structured interviews. Research question 1 was addressed by reviewing literature (see Methods and Results, first subsections). A database was created linking case studies of published monetary valuation methodologies with other impact assessment criteria and indicators (tackling question 2, second subsections). Focus groups and interviews were held with city authority staff in Europe and Latin America (question 3, third subsections).

1. Methods

1.1. Literature review on the valuation of different types of urban NBS

Addressing research question 1, the literature review focused on the monetary valuation of urban NBS interventions. Searches were undertaken using Scopus and limited to the period from 2017 to present (earliest peer-reviewed paper on NBS valuation using that specific phrase published in December 2016: Liquete et al., 2016). Search terms for NBS interventions employed were kept broad to enhance coverage across different research fields and global contexts. These included NBS, urban forestry, GI, SUDS, urban greening and urban ecosystems / ecology. Phrases for valuation techniques (Fig. 1) were derived by analysing: source literature from a set of NBS cases (Amaya-Espinel et al., 2021); categories reported in Bockarjova and Botzen (2017); and monetary valuations described in Ozdemiroglu and Hails (2016).

Fig. 1 summarises methods employed in this review drawing on the PRISMA systematic review reporting approach (Liberati et al., 2009; Moher et al., 2009) and restricted review methods (Plüddemann et al., 2018). Abstracts, keywords and titles were screened for relevance and classified according to specified monetary valuation techniques, with categorisation being undertaken by two researchers. Abstracts were reviewed 'blind' (author and journal names hidden) to reduce bias in developing, refining and applying the codification system and screening methodology. An iterative process to review and compare coded contents was undertaken for each category (Glaser, 1965). Each dataset was screened using the following exclusion criteria: (a) does not address NBS interventions in the urban fabric, e.g. pertains to rural ecosystems, conventional infrastructures or no NBS interventions were being tested; (b) does not involve monetary valuation; (c) does not entail empirical study e.g. reviews; (d) not peer-reviewed.

Literature review results were stored and processed in MSExcel. Abstracts were screened twice, once at the domain level (NBS, urban forest etc), and again within a combined spreadsheet including all results (conservatively, i.e. abstracts retained for further scrutiny). Where abstracts were excluded, reasons for screening out were recorded, enabling cross-comparison between search results across domains or by different researchers. Once more, screened-out entries were retained for further scrutiny. Duplicates were removed prior to analysis of full manuscripts to code relevant content. The results are included in Supplementary Materials (Supplement A). Results were passed to Conexus cities' contacts for capacity-building purposes and are reported in the introduction and discussion. For the contemporary literature review, 905 abstracts were screened, 729 did not meet selection criteria; 272 full texts were reviewed (Fig. 1).

1.2. Researching links between NBS monetary valuations & other impact indicators

A central objective was to establish whether NBS research involved monetary valuation and if projects addressed wide-ranging multiple impacts, or relatively few criteria (research question 2). Published NBS case studies from Amaya-Espinel et al. (2021) were used to create a new database (Supplementary Materials, Supplement B) then examined to understand relationships between impact assessments and monetary valuations. Since the focus of this research was on *urban* NBS, this part of the study focussed on NBS *within cities* themselves, and in Latin America and Europe in particular. Over 400 cases were screened to establish (a) what kinds of societal challenges were assessed using which NBS impact indicators; and (b) applications of monetary valuation methods reported. This provided a database of cases enabling comparison of different types of monetary assessments and their relationships with other indicators, drawn from a broad range of contexts (climatic, geographical, ecological, socio-political). Indicators identified within cases - covering diverse social, ecological, technical, environmental, political and cultural aspects - were categorised using broad themes

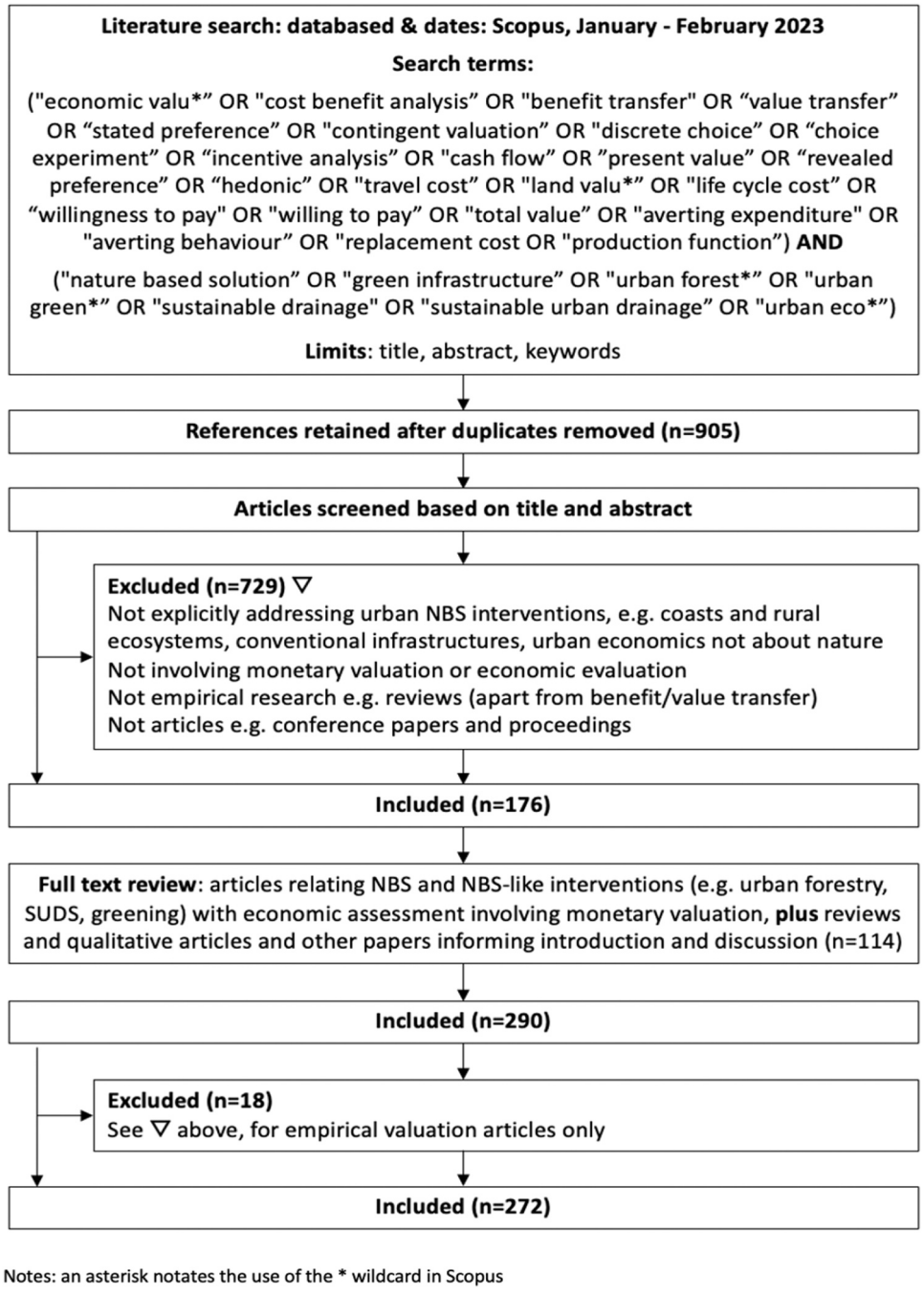


Fig. 1. Flow diagram of record selection (Liberati et al., 2009; Moher et al., 2009).

from an NBS impact assessment framework (Dumitru and Wendling, 2021a). Each reference was recorded as a unique record in MSExcel, with associated indicators being noted for the relevant study. Details of monetary valuation methods applied were logged alongside other impact indicators. Categories and terms for this inventory of valuation methods and cases were discussed and agreed between authors. Through this classification, indicators used to evaluate NBS co-benefits were matched with reported monetary valuation methods.

1.3. Focus groups to co-produce understanding of NBS valuation and applications

Research addressing question 3 involved conducting focus groups and interviews with city stakeholders in Latin America and Europe, undertaken in partnership with seven 'Life-Labs' (cross-sector collaborative NBS research partnerships; https://www.conexusnbs.com/life-labs). This gave the chance to re-examine NBS framings globally and to provide insights into opportunities and constraints affecting their uptake across diverse settings. To jointly establish how valuations may be applied by city government staff in diverse contexts using different impact indicators, a workshop was organised involving cities and other partners participating in Conexus. The workshop, held in person in São Paulo, Brazil (May 2022) involved local and regional government authority representatives responsible for delivering urban NBS programmes and pilots, from six of the seven Conexus cities.

Six city-specific focus group discussions were held, involving delegates from the public sectors, NGOs, researchers, and representatives of SMEs. Numbers of participants were as follows: Barcelona, Spain (6

participants); Bogotá, Colombia (7); Buenos Aires, Argentina (7); Santiago, Chile (9); São Paulo, Brazil (16); and Torino, Italy (8). Focus groups were held in local languages for each city, except Torino (held in English). A participatory approach was applied to understand cities' urban NBS impact indicators (van der Jagt et al., 2023) across societal challenge areas. Dialogues in focus groups sought to investigate: (a) what drove the need for economic data and other performance data; (b) which impacts were centrally important to participants; and (c) the relevance or otherwise of valuation methods to participants' professions and their work. References were filtered according to the most relevant topics and themes, based on indicators selected by the cities (see Results Table 4, indicators lists). References were sent to workshop participants in advance (15–20 abstracts per group, drawn from the database (Supplement B)). Abstracts were translated using DeepL Pro (v4.1), along with an introductory briefing and the workshop agenda. During the workshop, summary explanations for each monetary valuation technique were provided, again translated into local languages.

Workshop participants were asked in advance to review the abstracts and highlight any cases that were 'very relevant' or 'irrelevant' to their city in preparation for the group discussions. Pros and cons of reported monetary valuation methodologies and indicators were discussed in sessions convened by researcher-facilitators. Participants identified studies of interest linked with perceived societal challenges in each city, noting why cases were felt to be relevant or not for their city and NBS projects, and using unique reference numbers for each abstract. Facilitators captured key points of these discussions live, using flipchart paper. Individual participants were then asked to 'vote' for their most preferred methods, using sticky dots attached to the flipcharts, alongside relevant source references.

Breakout group participants debated whether and how different monetary valuations were applied for different impacts, e.g. heat island mitigation, flood risk management, air pollution amelioration, etc. To generate an overview of the kinds of topics and impacts relevant across the cities, a poll was organised using Menti.com during a conference plenary session. This poll, conducted in such a way as to allow the 39 individual respondents' answers to be tracked across different questions, covered participants': (1) names; (2) organisation; (3) Conexus city; (4) NBS projects; (5) societal challenge area categories; and (6) most pertinent indicators of NBS impacts. Since individual responses could be cross-referenced (with informed consent), it was possible to confirm that no double entries took place.

Focus group results were summarised during a plenary session and circulated to participants afterwards. Based on the discussions, recommendations were made for a subset of valuation techniques of relevance in each Conexus city, for use in subsequent project tasks concerned with NBS economic assessments and business planning.

1.4. Semi-structured interviews on how monetary valuation methods are viewed & used

To further understand the application of monetary valuation methods to urban NBS (research question 3), semi-structured interviews were held with key contacts having a role to perform valuations and/or support decision-making in each city studied. Semi-structured interviews were used to understand stakeholders' knowledge, values, beliefs or decision-making (Young et al., 2018), providing a flexible approach to focus on participants' experiences whilst enabling comprehensive analysis. The aim was to establish whether and how economic assessments were applied in decision-making and how NBS impacts and co-benefits were formulated. Potential interviewees were identified by project partners during and post- workshop discussions. Partners were asked to identify appropriate participants such as economists, accountants or policymakers working in municipal or regional government authorities (see Results, Table 6); further participants were recruited using the snowballing method.

Interviews were held in 2022 with 12 participants holding a range of

Table 1
Summary of references reporting monetary valuation methods applied to urban NBS (see Supplement A).

Methods	References and context for application of valuation methods
Benefit transfer / value transfer	• SUDS:Brent et al., 2017;Ossa-Moreno et al., 2017;Nordman et al., 2018;Rizzo et al., 2021 • Urban greenspace enhancement:Diluiso et al., 2021;Bockarjova et al., 2020a • Urban forests:Tapsuwan et al., 2021;Bherwani et al., 2022; Zhao and Sander, 2018 • Blue & green infrastructure:Skrydstrup et al., 2022;Teotónio et al., 2022;Stroud et al., 2023 • Urban ecosystem restoration: Zhao et al., 2018; Bockarjova et al., 2020a, 2020b
Stated preference methods (general; mixed methods)	• Urban greening:Vanstockem et al., 2018; Łaszkiewicz et al., 2019 • GI:Teotónio et al., 2020;Tanaka et al., 2022 • NBS:Hagedoorn et al., 2021;Hekrle, 2022; Skrydstrup et al., 2022 - meta-analysis
Contingent valuation method	• Urban forestry:Tran et al., 2017;Lagbas, 2019; Suarez et al. 2021;Balasha et al., 2022;Jiang et al., 2023 • GI and NBS:Zhang et al., 2020;Wild et al., 2017 • SUDS:Reynaud et al., 2017;Jarvie et al., 2017; Tanaka et al., 2022;Wang et al., 2022b; Oladunjoye et al. 2022 • Urban regeneration:Idczak et al., 2019 • Restoration of rivers & water quality: Islam et al., 2019;Yaacovi et al., 2021 • Urban greenspace enhancement:Sabyrbekov et al., 2020;Liu et al., 2020;Martínez-Paz et al., 2021;Okada et al. 2021;Mäntymaa et al., 2021; Kalfas et al., 2022 • Maintenance of NBS:Qiao & Randrup, 2022
Discrete choice experiments	• SUDS and GI for water management:Brent et al., 2017;Ando et al., 2020;Johnson and Geisendorf, 2022;Kim et al., 2021a;Hérivaux and Coent, 2021 • Street trees & vegetation planting:Fruth et al., 2019, 2020;Botes and Zanni, 2021 • Green walls & roofs:Collins et al., 2017; Vanstockem et al., 2018;Zhang et al., 2019; Teotónio et al., 2020;Manso et al., 2021; Benoliel et al., 2021;Netusil et al., 2022 • NBS and urban nature restoration –Papineau Salm et al., 2023 • Urban forestry:Japelj et al., 2017;Hong et al., 2018;Pineda-Guerrero et al., 2020;Alvarez et al., 2021; Zhi-Ying et al., 2021;Davies et al., 2023 • Urban agriculture:Kyoi, 2021 • Urban river restoration:Sarvilinna et al., 2017
Revealed preferences (general; mixed)	• Urban greenspace enhancement:Engström and Gren, 2017;Łaszkiewicz et al., 2019 • GI:Derkzen et al., 2017 • NBS:Skrydstrup et al., 2022 - meta-analysis
Hedonic pricing	• NBS & GI:Roebeling et al., 2017;Augusto et al., 2020;Jia and Zhang, 2021;Li et al., 2021;Sinha et al., 2021 • SUDS:Irwin et al., 2017;Irvine et al., 2020; Hoover et al., 2020;Sohn et al., 2020;Fraga et al., 2022 • Urban forestry:Plant et al., 2017; Franco et al., 2018;Zhang and Dong, 2018;Donovan et al., 2021;Sachs et al., 2023 • Urban greenspace enhancement:Iváncsics et al., 2019;Piaggio, 2021;Schwarz et al., 2021;Wu and Rowe, 2022;Xu et al., 2022;Łaszkiewicz et al., 2022 • Urban river restoration:Chen, 2017
Travel cost methods	• Urban forestry:Bertram and Larondelle, 2017; Herwanti et al., 2021 • Urban greenspace enhancement:Kim et al., 2021b;Okada et al. 2021 • Urban river restoration:Mäntymaa et al., 2021; Cetin et al., 2021

(*continued on next page*)

Table 1 (*continued*)

Methods	References and context for application of valuation methods
	• Green walls, green roofs & green corridors: Zhang et al., 2020
Land values and land valuation	• NBS and GI:Wild et al., 2017;Dyca et al., 2020 • Urban trees:Morgenroth et al., 2017 • SUDS & urban river daylighting:Kozak et al., 2020 • Urban greenspace:Picard and Tran, 2021;Buck, 2021;Cuvi and Vélez, 2021; Molar-Cruz, 2022
Net present value & cash flow analysis	• SUDS:Vincent et al. 2017;Nordman et al., 2018; Alves et al., 2019;Johnson and Geisendorf, 2019;Locatelli et al., 2020;Johnson et al., 2021a;b;Godyń et al., 2020, 2022;Fraga et al., 2022;Jato-Espino et al., 2022;Khan et al., 2022; Neumann and Hack, 2022;Wilbers et al., 2022; Ciasca et al., 2023 • Green roofs & walls:Matos Silva et al., 2019;He et al., 2021 • Urban green space enhancement:Quaranta et al., 2021;Neumann and Hack, 2022;Chen et al., 2023 • Urban energy crops:Sikorska et al., 2020
Life cycle cost analysis	• Urban agriculture:Zidar et al., 2017 • SUDS & GI:Mei et al., 2018;Alves et al., 2019; Tavakol-Davani et al., 2019;Xu and Zhang, 2019;Bixler et al., 2020;dos Santos et al., 2021; Qiu et al., 2021;Abdeljaber et al., 2022; Garbanzos et al. 2022;Heidari et al., 2022;Khan et al., 2022;Lu et al., 2022;Quaranta et al., 2022;Reu Junqueira et al., 2022;Wang et al., 2022a;Ciasca et al., 2023 • Brownfield greening:Zhong et al. 2020 • Green façades:Tudiwer et al., 2019
Incentive analysis	• GI:Conrad and Yates, 2018 • SUDS:Fu et al., 2019;Boguniewicz-Zabłocka and Capodaglio, 2020;Godyń et al., 2020, 2022; Wilkerson et al., 2022 • Urban ecosystems restorationClaron et al., 2022
Replacement costs	• SUDS:Silvennoinen et al., 2017;Jarvie et al., 2017;Assaad et al., 2023 • Urban forestry:Medeiros et al., 2019;Masiero et al., 2022;Shah et al., 2022 • Urban green space enhancement:Okada et al. 2021;Chen et al., 2023
Production function	• Urban blue-green infrastructure:Wong et al., 2017, 2018 • Urban forestry:Masiero et al., 2022

roles in local or regional government (Results, Table 6). The first part of the interview involved questions covering participants' professional backgrounds, experience and roles. Subsequent questions addressed participants' current work, daily tasks performed, and the processes, skills and knowledge involved. The final part focussed on opinions and knowledge about NBS, and economic valuation of impacts linked with urban NBS investment decision-making. It was ascertained whether interviewees were involved in monetary valuation of interventions, under which circumstances, and how they understood the methods involved. Perspectives of different valuation methods and local relevance were discussed to help understand what drove the need for economic data and other NBS performance data. Interview methods were piloted in a separate city to test and refine the sequencing of questions.

All interviews were transcribed in original languages and later translated to English using Deepl Pro. Resulting information was examined and summarised based on original transcripts versions. Information relevant to the research questions was highlighted alongside important contextual details. Textual analysis was carried out in MSWord and data organised in MSExcel. Thematic analyses were conducted using a hybrid approach; firstly deductive, to identify broader interview themes, and then inductive, to establish emerging sub-themes and explore theoretical perspectives concerning the observed evidence and narratives using these labels.

Table 2
NBS impact indicators used in case studies reported in the database (Supplement B) categorised within the 12 broad societal challenge themes used in the ECs' NBS Impact Assessment Handbook (Dumitru and Wendling, 2021).

NBS Impact Handbook challenges areas (2020)	Indicators used in manuscripts (with number of studies, in brackets)
Climate resilience	Biomass provision, incl. timber & fuel (10); $C0^2$ - Greenhouse Gases (GHG) storage, reduction & mitigation (30); Disaster risk reduction, natural hazard reduction (8); Energy efficiency - avoided emissions (7); Evapotranspiration (18); Heat, urban heat island (85); Resource efficiency (6); Shade provision, reduced solar irradiation (21); Soil quality (8); Tree cover & vegetation cover, incl. Normalised Difference Vegetation Index (NDVI) (86).
Water management	Disaster risk reduction, natural hazard reduction (8); Drought prevention - water resources (5); Evapotranspiration (18); Flood risk management (40); Infiltration & soil sealing (18); Runoff-flow-retention (48); Water quality, water pollution & waterbody conditions (22).
Natural & climate hazards	Disaster risk reduction, natural hazard reduction (8); Drought prevention - water resources (5); Flood risk management (40); Runoff-flow-retention (48);
Green space management	Biomass provision, including timber & fuel (10); Greenspace access, visits, use, accessibility (62); Food supply & provision (25); Human-nature experience (18); Land use change incl. urban sprawl (27); Recreation & amenity (60); Tree cover & vegetation cover, incl. NDVI (86); Soil quality incl. erosion (8).
Biodiversity enhancement	Biodiversity, incl. pollinators & biological control (79); Soil quality incl. erosion (8); Ecological structural & functional connectivity (25).
Air quality	Air quality incl. air pollution & allergens (79); $C0^2$-GHG storage, reduction & mitigation (30).
Place regeneration	Aesthetics, incl. attractiveness (47); Energy efficiency - avoided emissions (7); Place - quality, sense of, attachment, identity (24).
Knowledge & social capacity building	Dialogue incl. knowledge exchange (9); Educational opportunity & provision (7).
Participatory planning & governance	Dialogue incl. knowledge exchange (9); Governance (26); Participation & salience (26); Trust (4).
Social justice & social cohesion	Environmental in/justice (11); Population density (13); Safety-security-danger-crime (12); Social capital, cohesion, connection (19); Social inclusion (12).
Health & wellbeing	Human health & morbidity (15); Human-nature experience (18); Noise & sound pollution, insulation (20); Quality of life (19); Wellbeing, stress relief, restorativeness (36).
Economic opportunities & green jobs	Socio-economic status & deprivation (35); Tourism (6).

Notes: Indicators in the NBS Impact Handbook (Dumitru & Wendling, 2021b) often appear in/across multiple societal challenge area categories; here numbers given include the same studies for indicators duplicated in the Handbook, and sub/totals are not provided since studies used multiple indicators.

2. Results

2.1. Literature review on monetary valuation urban NBS

Table 1 summarises publications reporting the application of a range of monetary valuation methods (Supplement A). Urban NBS economic valuation literature was closely related to urban ecosystem services themes (e.g. Johnson and Geisendorf, 2019; Mäntymaa et al., 2021; Papineau Salm et al., 2023). Some valuation publications referred to NBS explicitly (e.g. Derkzen et al., 2017; Wild et al., 2017; Okada et al., 2021; Sikorska et al., 2020; Masiero et al., 2022; Neumann and Hack, 2022; Skrydstrup et al., 2022). This research builds on a longer heritage of valuations relating to urban forestry, GI, SUDS and urban greening (e.

Table 3
Indicators most frequently addressed by monetary valuation studies of NBS: top 10 (Supplement B).

Indicators (top 10 indicators covered by valuations)	**Monetary valuations**	**Total no. of studies using indicator**
Tree cover & vegetation cover	18	86
Recreation & amenity	16	60
Aesthetics, including landscape attractiveness	15	47
Air quality, air pollution & allergens	14	79
Biodiversity, pollinators & biological control	14	79
Flood risk management	13	40
Runoff of urban water (flow, retention, detention)	9	48
Heat, urban heat island effect	9	85
$C0^2$- Greenhouse Gas storage, reduction, mitigation	8	30
Socio-economic status & deprivation	8	35

Table 4
Criteria and indicators used in identifying references for valuation methodologies of relevance.

Conexus city	**NBS impacts: key societal challenge areas**	**Specific indicators of relevance as regards valuation**
Barcelona, Spain	Greenspace management, air quality, social capacity.	Greenspace accessibility and coverage, food production, air quality, structural and vegetation biodiversity.
Bogotá, Colombia	Knowledge and social capacity, water management, climate resilience, greenspace management, place regeneration, social justice and cohesion, biodiversity enhancement.	Environmental education, social learning, trust, water quality, place attachment, soil carbon storage, biodiversity.
Buenos Aires, Argentina	Water management, air quality, knowledge and social capacity, biodiversity enhancement, participatory planning and governance.	Openness of participation, air quality, water quality and pollution, water quantity, biodiversity, particularly vegetation.
Lisboa, Portugal	Green space management, place regeneration, participatory planning and governance, biodiversity, knowledge and social capacity.	Greenspace coverage, reclamation of derelict land for NBS, uptake in terms of number and diversity of NBS types, environmental justice, biodiversity, knowledge exchange.
Santiago, Chile	Climate resilience, health and wellbeing, knowledge and social capacity, biodiversity, greenspace management, social justice, capacity building.	Greenspace accessibility, greenspace coverage and share per inhabitant, environmental education and pro-environmental behaviour, urban temperatures, public-private partnerships, wellbeing, safety and security, biodiversity, GI connectivity.
São Paulo, Brazil	Climate resilience, place regeneration, biodiversity, participatory planning and governance.	Carbon sequestration and storage, perceived quality of space, urban temperatures, vegetation biodiversity, openness of participation processes, recreational value, evapotranspiration, tree growth including carbon flux and energy balance.
Torino, Italy	Climate resilience, water management, greenspace management, biodiversity and air quality.	Heat mitigation, greenspace accessibility, air quality, and water runoff, quality and permeability.

Table 5
Most relevant valuation techniques for each life lab identified during São Paulo workshop.

City	**Most relevant techniques**
Barcelona, Spain	CBA focusing on health and wellbeing; WTP using Choice Experiments including visuals
Bogotá, Colombia	CBA; Contingent Valuation; WTP
Buenos Aires, Argentina	Hedonic pricing; CBA, including flood risk management and water quality
Santiago, Chile	Land values; Multi-objective optimisation (multi-criteria analysis)
São Paulo, Brazil	WTP and Choice Experiments using visuals; CBA – socio-economics of greenspace access
Torino, Italy	WTP (pilot scale); Urban ecosystem services – benefit transfer (broader scale)

Notes: WTP: willingness to pay; CBA: cost-benefit analysis. Lisboa, Portugal staff were unable to attend the workshop.

g. Escobedo et al., 2015a; Vincent et al., 2017; Tudiwer et al., 2019).

Valuations covered diverse scales from micro-level interventions (e.g. green roofs and walls, Almeida et al., 2021) through to large networks (e.g. extensive urban forestry, Bertram and Larondelle, 2017). Studies involved individual treatments such as street-level greening (Fruth et al., 2019; 2020), various NBS elements combined (Wild et al., 2017), and NBS integration within urban design interventions (e.g. Roebelling et al., 2017). Cost-benefit analyses explicitly addressing NBS in urban settings were relatively common, covering: air pollution (e.g. Nemitz et al., 2020); brownfield remediation (e.g. Masiero et al., 2022); recreation and aesthetics (e.g. Teotónio et al., 2020, 2022); and water pollution, drought and flood risk (e.g. Turkelboom et al., 2021; Quaranta et al., 2022; Reu Junqueira et al., 2022; Ciasca et al., 2023). The CBA literature around urban forestry, greening and GI is extensive (Table 1). CBA studies less often covered: urban food (Dubová and Macháč, 2019; Kyoi, 2021); irrigation (Zubelzu et al., 2019); regeneration (Hsu and Chao, 2020; Zhong et al., 2020); sound (Almeida et al., 2021); tourism (Lim and Xenarios, 2021); or energy provision (Sikorska et al., 2020).

Relatively few studies involved monetary valuation of biodiversity impacts of NBS (Collins et al., 2017; Gwak et al., 2017; Riley et al., 2018; Wan et al., 2018; Rezwan et al., 2022). Explicit links with urban climate change issues were common (water scarcity - e.g. Wang et al., 2022a; heat island - e.g. Sinha et al., 2021; energy - e.g. Sikorska et al., 2020; flooding - e.g. Mei et al., 2018, dos Santos et al., 2021). Few articles addressed the economic valuation of social, cultural and political impacts of NBS. Exceptions included combinations of qualitative and quantitative valuations (Neumann and Hack, 2022; Teotónio et al., 2022; Derkzen et al., 2017).

2.2. Links between NBS economic valuations and other impact indicators

A total of 41 different impact indicators were recorded in the database of NBS case studies (Supplement B). These indicators related to many different criteria addressing a vast range of societal challenges. However, most studies addressed only a few indicators (*mean*: 3 indicators). Fig. 2 and Table 2 summarise impact indicators covered by cases (Supplement B), categorised according to broader societal challenge themes from Dumitru and Wendling (2021a & b).

Clustering of specific impact indicators according to the 12 broad societal challenge areas assisted with validation and in mapping out indicators of interest in specific cities. Duplication was a significant issue: indicators were often nested under multiple 'parent' challenge areas (Dumitru and Wendling, 2021b). Of all cases analysed in the database (Supplement B), 62 reported the application of monetary valuation methods. Thus, the majority of NBS cases in this database did not entail monetary valuation (Fig. 2). Table 3 shows the 'top 10' indicators addressed by valuation studies within that subset of manuscripts. Several papers applied more than one indicator or valuation

Table 6
Summary of responses in semi-structured interviews.

Cities	Participant ID	Area of expertise	Monetary valuation	Purpose of valuation	Techniques	Benefits	Indicators
Bogotá, Colombia	Participant 1	Economic valuation	Yes	Support public policies	Contingent valuation; Benefit transfer	Air quality; Carbon sequestration	Carbon removed or stored
	Participant 2	SUDS planning	No	x	x	x	x
	Participant 3	Urban planning	No	x	x	x	x
Buenos Aires, Argentina	Participant 4	Urban economics	Yes	Support public policies	Hedonics	New economic opportunities	Mean land and/or property value in proximity to green space
Lisboa, Portugal	Participant 5	Urban parks	No	x	x	x	x
	Participant 6	Environmental planning	No	x	x	x	x
Santiago, Chile	Participant 7	Urban parks investment	Yes	Support public policies	Not known	New economic opportunities	Use of ground floor building space for retail, commercial or public purposes in area around created park
	Participant 8	Territorial planning	No	x	x	x	x
	Participant 9	Investment analysis and valuation	No	x	x	x	x
São Paulo, Brazil	Participant 10	Environmental planning	Yes	Calculate environmental assets of city	Emergy valuation	Park value	Thermodynamics
	Participant 11	Budget planning	No	x	x	x	x
Torino, Italy	Participant 12	Innovation funding	Yes*	Green infrastructure planning	Benefit transfer	Heat, energy, air quality (I-Tree)	x

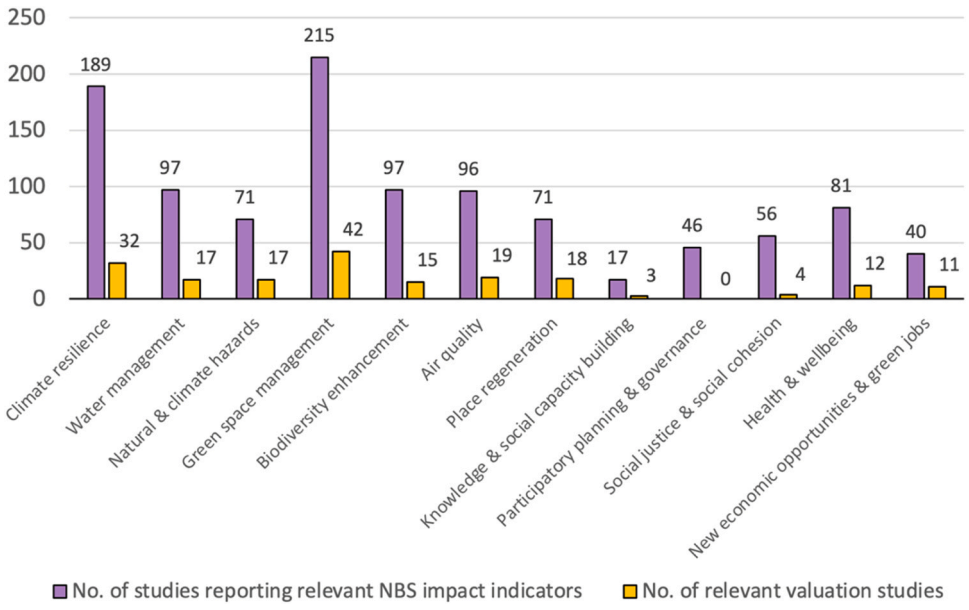


Fig. 2. Numbers of NBS valuation studies analysed (see Supplement B) addressing indicators, categorised according to the 12 'societal challenge areas' in Dumitru and Wendling (2021a & b).

methodology, so Table 3 does not include sub/totals.

Most of this subset of studies (entailing monetary valuation) addressed physical-environmental aspects only (Table 3 and Supplement B). Monetary valuation studies rarely focused on indicators covering socio-cultural, political or governance aspects (e.g. participation: 1 reference; social inclusion: 3; quality of life: 3). Valuations tended to be clustered together with indicator types, e.g. travel-cost methods were commonly applied for projects involving recreation, biodiversity, land-use change and amenity. Hedonic pricing was frequently applied in relation to greenspace and vegetation cover. Discrete choice experiments often addressed aesthetics and recreation; CBAs were broadly applied across indicator types (Supplement B).

2.3. Focus groups with cities: co-producing understanding of NBS indicators & valuations

In preparation for the São Paulo workshop, summaries and details of publications reporting economic valuation of NBS were sent to participants. Information sharing about societal challenge areas and NBS impact indicators of relevance to each city (as defined by city staff) provided a focus and frame of reference for discussions. Table 4 lists the criteria used in this process (these subsets of interests are not presented in order of importance).

During the plenary session, 39 participants responded to the Menti poll exploring societal challenges addressed by the cities' NBS programmes and projects. Respondents identified key criteria and

indicators (Fig. 3) addressing important impacts and co-benefits of those interventions.

Table 5 provides a summary of the valuation methods in which participants showed most interest i.e. those considered most relevant to their NBS. Focus group discussions highlighted cities' priorities for NBS impacts (and associated indicators) within categories of *participatory planning and governance*, *social justice and social cohesion*, and *knowledge and social capacity building* (Fig. 3; see also Table 6) alongside other impacts (e.g. physical environmental benefits).

Focus groups involved discussions between stakeholders responsible for developing NBS projects, debating impact indicators of relevance to the societal challenges that drove their initiatives. These discussions revealed that all city partnerships held ambitions to deliver a wide range of NBS co-benefits across the whole spectrum of indicators (all cases), and that some - but not all - of those impacts could be relevant in terms of monetary valuations (Table 5).

2.4. Interviews: how monetary valuations of urban nature & NBS were viewed & applied

Table 6 summarises key points raised in semi-structured interviews with local governments contacts. Participants' perspectives about relevant economic assessment techniques highlighted relationships between those methods and specific challenges at play in each city.

Analysis of interview subthemes provided further insights into how cities considered the valuation of multiple impacts of urban NBS. Table 7 summarises which of the cities used monetary valuations, for what purpose, in which contexts. It also provides details of techniques, benefits and indicators applied, where relevant. Labels used in the sub-thematic analysis, derived inductively from transcribed discussions, included "decision-making", "economic valuation of benefits", "barriers and opportunities "and "financing for urban nature".

In considering the contexts for NBS, focus group and interview results (Tables 5–7 inclusive) serve to highlight that cities differed greatly in their political priorities and societal challenges - as well as the state of the art in NBS valuation. Important differences related to the role of economics in decision-making, support or otherwise for this notion, and cities' experiences with valuation (Tables 6–7). The results indicate there is a willingness in local and regional governments to further develop the use of valuations if necessary to secure funding for NBS projects. With the limited number of cities involved, Latin American cases appear to have advanced further in their application of monetary valuation methods relating to NBS (Table 7). Relatively little evidence was found for NBS funding being derived from private finance (Table 7).

Another key finding was that city- and regional- government staff hold clear and nuanced understandings of the roles and limitations of economic valuation, and inherent risks (Table 7):

- "*…if the monetary valuation leaves out the main issue, which I think is the improvement of the ecosystem and ecological enhancement*" (Participant 8).
- "*I cannot simply arrive and make an economic assessment without also knowing how it is at the social level, without knowing how it is at the ecological level*" (Participant 1).

Stakeholder interviews indicated that economic evidence may sometimes have relatively little importance in cities' decisions around NBS interventions, or may be applied post-hoc in supporting existing decisions, or may be rather peripheral when it comes to the ecological impacts (Table 7). Furthermore, a key barrier to the application of urban NBS valuation stems from dataset availability and quality, combined with cities' capacities to apply those techniques (Table 7):

- *"The problem we have encountered is the availability of data to make those evaluations"* (Participant 4).
- "*It is a tool that not everyone knows how to use"* (Participant 1).

It is striking that even in some of the largest cities in the world the limitation of the paucity of datasets applies, despite their significant capacities for innovation.

3. Discussion

3.1. Literature review

In line with Derkzen et al. (2017), several valuation studies linked

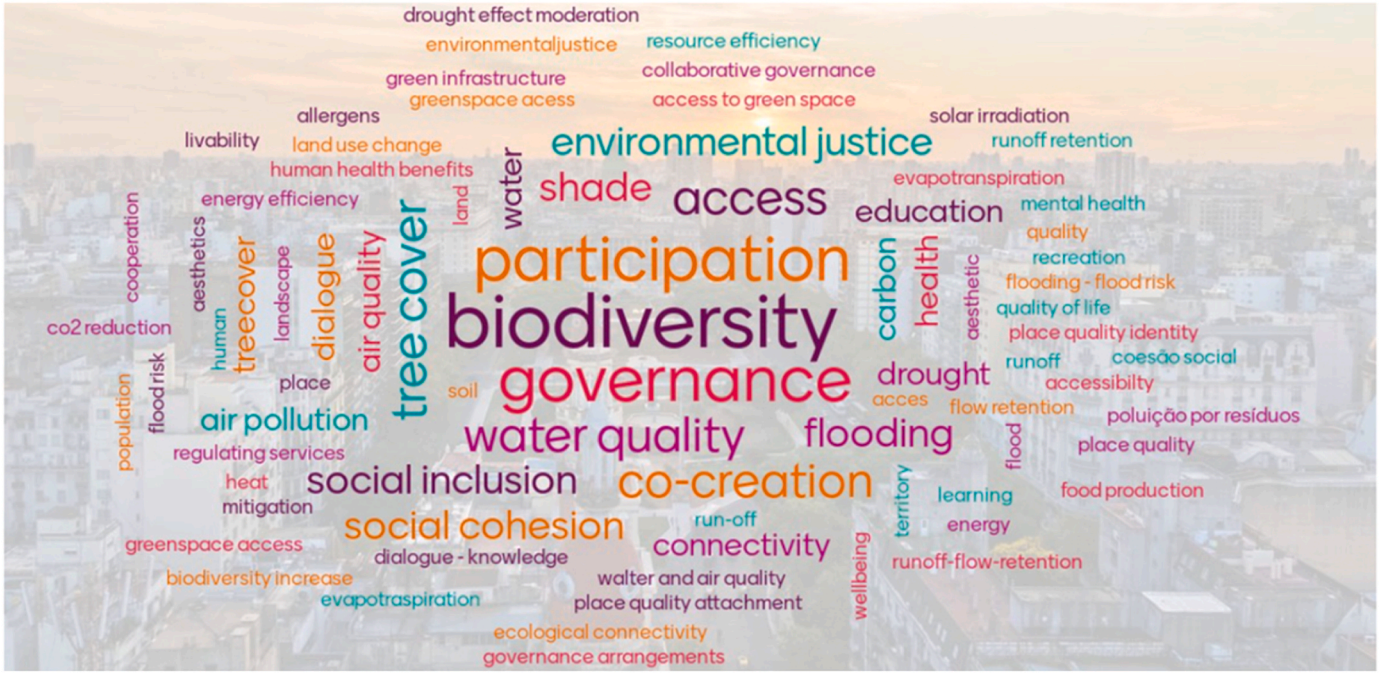


Fig. 3. Overview of societal challenges of interest and key impact indicators across 6 Conexus cities.

Table 7
Themes and subthemes identified on semi-structured interviews.

Broader themes	Sub-themes	Examples
Decision making	Siloed approaches	"(…) the innovation service acts a bit as a promoter, as internal project manager, as the stimulator, as the enabler. But clearly, all opinions of technical competence remain with the correct departments. We are responsible for the overall expenditure concerning the project goals, so generally, the physical works of the green area remain within the competence of the green area department" (Participant 12). "(…). So, [the green department] has the capacity to calculate carbon inventories, nitrous oxide inventories, but it has no influence on political-administrative decisions in this area of transport (…)" (Participant 11).
	Economic valuation of benefits	"(.) the environmental patrimony division wanted to do an economic valuation for the record, so they could say: look at the parks in São Paulo, they provide environmental services worth so many billions of reais or they are worth so many billions of Reais. The prioritisation of new investments is being done by another plan" (Participant 10). "(.) I understand that they [the water company] evaluate alternatives, in which they evaluate the scenario without SUDS and the scenario with SUDS. But as far as I understand it, they don't take into account the environmental benefits in monetary terms to make that decision, the decision is more about the capacity of the system. If the system has the capacity and the conventional system is cheaper, they go that way, but if the issue is that the capacity in that area is not sufficient, they consider SUDS. But the issue of assessing the benefits for decision making is just starting so far" (Participant 2).
	Short-term decision-making cycle	"(…). When we work with natural resources, we don't work by electoral cycles. And the decision right now is made in four-year cycles. (…) We live in a society of immediate reactions and therefore all these investments that are made for a longer period are very difficult to make a decision" (Participant 5).
Economic valuation of benefits	Added property value	"(…) we use hedonic price models to determine in the different areas of the city the influences of the different urban facts on the cost of selling a flat, so we know that if it is near a certain green space, you will pay more, or a flat will be more expensive if it is near a green space or if it is near an underground station" (Participant 4).
	New economic opportunities	"The measurements of the economic parameters of the tool have to do with (.) how the park can generate local economies, how it can promote work in the communities, how it can be a platform that generates income for the communities. We measure whether the park has spaces to support fairs, event centres that generate local economies, for example" (Participant 7).
	Carbon credit	"No, there is no valuation of NBS, what is done at the national level, and what is established, is carbon sequestration. In fact, there is a social price per tonne of carbon, but it is very low, so it is marginal" (Participant 9).
Barriers and Opportunities	Reliability of data	"(.), the problem we have encountered is the availability of data to make those evaluations. So, we have made some attempts to take into account the CO_2 emissions from the trees, and to account for them and include them as another variable in this model, but we do not have the measurement data that would allow us to evaluate them more precisely (.)" (Participant 4). "There is a great uncertainty in any evaluation of monetisation, so it doesn't make sense to come in with big IT resources or to do a very big survey for each park, for each green area" (Participant 10).
	Monetisation of nature	"However, it is an issue if it [the valuation] is only economic because there is a tendency to monetise nature. So, it is complex, because, in the end, we want to achieve a specific objective (…). So, it [the valuation] is [negative] if the monetary valuation leaves out the main issue, which I think is the improvement of the ecosystem and ecological enhancement" (Participant 8).
	Lack of expertise and knowledge	"Well, I think that as such, [the economic valuation] it is a tool that not everyone knows how to use. So, I think that this is a challenge and, as I said, I think that to make a good economic assessment, you must know the sector very well and you need time, you need resources" (Participant 1). "So, the first challenge is which indicators I'm going to bet on, how those indicators are measured, who monitors them and how they are put into money and how I measure the impacts" (Participant 3).
	Communication tools	"I have been working more on the topic of adaptation and it is very important to communicate and try to understand what the costs are of not adapting, right? If we didn't do anything, what does it cost us? It's very important to quantify this for decision making, (.) because it may or may not give more strength to governments, local and national authorities, to really move forward or not, and stop pretending that it's for the next ones, right?" (Participant 6).
	Holistic methods of assessment	"(…) I cannot simply arrive and make an economic assessment without also knowing how it is at the social level, without knowing how it is at the ecological level. I think it is like an umbrella that is always needed from all three to be able to give good results. So, I believe that the challenge is perhaps to find the three methods at the same time, that I also have ecological information, that I have social information to be able to obtain data" (Participant 1).
Financing for urban nature	Increase in budget for urban nature projects	"Today, a regular source that has been approved year after year, it's a public source, which is a fairly large budget, and which has been growing over the years" (Participant 7). "(…), our budget is increasing more and more, society demands more and more and there is also more criticism and demands on our work (…)" (Participant 11).
	Differences between Latin America and Europe in accessing international funding	"(.)I don't remember cases or at least I am not aware of cases where money has come from outside to finance these projects (.) " (Participant 4). "(…) there is funding, including through European programmes and the budget, the partnership with the State, or in partnership with the district. So, there are several partnerships to try and reconcile financing to undertake major works. I'm talking about a drainage plan for Lisbon, for example, which is a huge undertaking, perhaps millions… and therefore this type of project has European capital, municipal capital, State capital, and now PRR (Portuguese National Recovery and Resilience Plan) capital, so several funds are being lent (…)" (Participant 5).
	Public-private finance	"(.) in these last years since 2020 approximately, a management instrument has been developed which is called "*convenios urbanísticos*". What these urban development agreements do is to negotiate with the private party against, for example, a person who wants to build a building with different characteristics to those allowed by the code in an area where it is justified to build with more height or other things, the government says: Well, I allow you to build this with certain conditions, but I allow you to build these floors, in other words, in exchange, you have to give me money or green spaces" (Participant 4). "(.) an important source of funding is sometimes private funding, that which comes through, for example, banking foundations. We in Turin have two large bank foundations: Fondazione CRT, and Fondazione Compagnia di San Paolo. In other Italian territories, there are others, so it is quite a present form of financing. And these foundations have increasingly focused on nature-based solutions, somewhat in line with European priorities" (Participant 12).

together or referred interchangeably to different NBS terms (e.g. Sikorska et al., 2020; Lim and Xenarios, 2021; Masiero et al., 2022). Hekrle (2022) notes that often such analyses relate generically to greenspace or GI.

Since most valuation studies ultimately involve some form of CBA (Ma et al., 2021), it is unsurprising that much of the monetary valuation literature refers to this approach. Often CBAs assessed crosscutting benefits (e.g. SUDS urban cooling impacts - Johnson et al., 2021a and b). Some CBAs addressed multiple benefits (e.g. Alves et al. 2019; Iváncsics et al., 2019; Matos Silva et al., 2019; Rizzo et al., 2021; Shah et al., 2022) or involved multicriteria analysis (Teotónio et al., 2022; Claron et al., 2022). Few investigated trade-offs in ecosystem dis/services (Speak et al., 2018; Fu et al., 2019; Wu et al., 2019; Hérivaux and Coent, 2021; Shah et al., 2022) with implications for research question 2: several authors reported increased cost-benefit where multiple benefits and intangibles were valued (e.g. Vincent et al., 2017; Alves et al., 2019; Oladunjoye et al., 2022).

3.2. Links between monetary valuations & other impact indicators

Key findings relating to research question 3 were that most NBS cases examined in the database (Supplement B) did not entail monetary valuation, and that NBS monetary valuations tended to address a limited number of indicators. Few studies addressed multiple impacts, in contrast with Raymond et al. (2017). Fewer still involved monetary valuation (exceptions included Escobedo et al., 2015b; Langemeyer et al., 2015; Kozak et al., 2020). Overall, however, the wide diversity of indicators applied to measure NBS impacts is striking. Pauleit et al. (2017) note that NBS is a useful umbrella term for several valuable intervention types; these are accompanied by diverse methods to assess NBS effects (Table 2). This is evident from Dumitru and Wendling's (2021a) guidance - many indicators reported in the literature match well with their (2021b) Appendix of Methods at the level of indicators. Nevertheless, prospects for holistic and comprehensive assessments of NBS addressing multiple indicators (social, cultural, technical, environmental etc.) are less clear (Kumar et al., 2021).

Also of interest were the *kinds* of impacts that NBS monetary valuations tended to address. The top 10 indicators most often researched were heavily weighted towards physical-environmental and technical outcomes (Table 3). Few studies in the database (Supplement B) involved valuation of impacts covering social, cultural or political aspects. Notable exceptions included socio-cultural valuations (Derkzen et al., 2017) or combinations of qualitative and quantitative valuations (Neumann and Hack, 2022; Teotónio et al., 2022). Whilst these methods incorporate monetary valuation they echo ambitions for deliberative valuation, in seeking to integrate various disciplines, tools and techniques bridging academic and citizens' inputs (Raymond et al., 2014; Wild et al., 2015; Kenter et al., 2016; Andersson-Sköld et al. 2018; Venter et al., 2021; Stange et al., 2022). There is a need for improved, applied NBS governance indicators (van der Jagt et al., 2023) despite this being a major research focus in many NBS projects. Placing a monetary value on impacts such as capacity-building can be problematic, whereby indicators that relate to inputs and processes are equally important to outcomes that can be monetised (Fig. 3; Table 6 and 7). Economic valuation should only be used in conjunction with other forms of data and broader conceptions of values (Kallis et al., 2013; IPBES, 2022).

3.3. Focus groups and semi-structured interviews

Focus group and interview results confirmed that cities' socio-political and environmental contexts were centrally important in shaping staff's perspectives of NBS monetary valuation (Tables 5–7). The findings indicate nuanced views as to the challenges and dilemmas involved in monetary valuation pertaining to urban nature. Officers clearly understood that monetary valuations had a place alongside rather than instead of other forms of impact assessment (Kallis et al., 2013). This points to a sensitivity to the importance of non-use and existence values, and the significance of governance and institutional contexts (Barton, 2022). The relatively high interest in monetary valuation methods in Latin American cities is an interesting result, bearing in mind Global South cities' governance contexts (Pineda-Guerrero et al., 2020; Devisscher et al., 2022). This finding warrants further research; we could find no other relevant references on this topic.

A second key theme in relation to question 3 is that economic assessments may be viewed as being just one useful tool in the toolset (Tables 6–7). Monetary values for ecosystem services do not always reflect citizens' perspectives (Suarez et al., 2021), but context-appropriate valuation methods can be developed to address concerns over valuations of benefits, in line with policy realities (Escobedo et al., 2008). Care must be taken to address common concerns around monetisation, using complementary socio-ecological impact assessments and wide stakeholder input (Haase et al., 2017; Toxopeus et al., 2020; Okada et al., 2021; García-Lamarca et al., 2022).

Two other key issues emerged from focus groups and interviews. Firstly, urban NBS valuations had only limited influence in decision-making processes, but provided important tools to communicate with decision makers - especially around the relative costs of different climate and biodiversity scenarios (Table 7, 'decision-making'; see Agrawala et al., 2008; Sanderson and O'Neill, 2020). Secondly, although city budgets for urban greening had increased in some cases, relatively little NBS funding appeared to be derived from private finance (Table 7; Dempsey and Suarez, 2016; Seddon et al., 2020; EIB, 2023).

3.4. Synopsis: common themes & critical discussion of findings

Overall the findings indicate that although the field of NBS monetary valuation may be advancing, its impacts in the cities studied are limited as concerns interventions within the urban fabric (Table 7). Why might this be the case? The signs are that whilst applications of urban NBS valuations are reasonably commonplace in academia, these studies tend to be limited to particular types of interventions and impacts using relatively few indicators (Supplement B). Information costs associated with valuations become greater as spatial resolution increases (Barton et al., 2018). Ecosystem services assessments applied across multiple impact domains often involve benefit transfer (value transfer) methods (Grammatikopoulou et al., 2023). Applying CBA techniques is more complex in urban areas (EC, 2022b), where land use and ownership patterns are more fragmented, heterogenous and complex than in rural settings (Elliot et al., 2019; Angel et al., 2012; Keita et al., (2020)).

Vásquez and Dobbs (2020) identify the lack of economic valuation of NBS benefits as a key barrier in their development and implementation in Latin America. Drawing on these findings, a specific challenge is to clarify which particular impacts should be addressed through monetary valuations of urban NBS. Evidence exists in the literature for the application of monetary valuation to NBS (Table 1), however methodologies do not correspond well with urban NBS impact assessments (EC, 2022b). ***But why does this matter?*** Dumitru and Wendling (2021a) offers "a comprehensive NBS impact assessment framework… indicators and methodologies to assess impacts of NBS across 12 societal challenges" in the European context. Notably, two criteria have economic themes i.e. 'place regeneration' and 'economic opportunities & green jobs', but the coverage of valuation methods is not particularly comprehensive. The Appendix of Methods (Dumitru and Wendling, 2021b) could therefore be updated to include synopses of applied valuation techniques.

It is evident that many monetary valuations have been reported, for diverse urban settings. In this respect, our findings do not concur with those of Croci et al. (2021). We did not find that economic valuations of urban ecosystem services were scarcely reported in the literature. That is not to say that improved frameworks are not required to support the valuation of natural and non-market impacts; there is clearly a policy need (EC, 2022b) for more effective economic valuation of the net

benefits of NBS investment (Ma et al., 2021), especially for retrofitted interventions in urban settings. It is evident from Finance Earth's (2021) NBS market review that the vast majority of investment in ecosystems restoration fund schemes in rural areas, and rarely within the urban fabric. Low levels of private sector funding have been available for NBS for urban climate adaptation (CPI, 2020; Swann et al., 2021), reflecting the lack of private finance for biodiversity conservation (Dempsey and Suarez, 2016). A common idea discussed during focus groups and stakeholder interviews was that these challenges may be interwoven (Table 7). Participants identified that this may stem from poor assessments of NBS impacts (i.e. benefits and costs), either in terms of systemic flaws (e.g. double counting; incommensurability of data) or indicators lacking relevance (Table 7). Such problems can undermine the case for NBS implementation within cities (Wild et al., 2017). Furthermore, innovative accounting approaches often employed in NBS research may sit far from cities' socio-political realities, extant calculative practices, and norms as regards economic planning and decision-making processes. The result may be a mismatch between research evidence and policy decision-making (Velasco-Muñoz et al., 2022). Additionally, a lack of region-specific information and methods may result in ill-fitting processes or erroneous outcomes (Dobbs et al., 2019; Pineda-Guerrero et al., 2020; Devisscher et al., 2022).

3.5. Prospects for advancing NBS impact assessment involving monetary valuations

Despite these challenges, city staff saw potential in the application of monetary valuations alongside other forms of impact assessment and co-benefits evaluation (Table 6 and 7). In seeking to remove an important barrier to increase the robustness of urban NBS business cases, cities might focus in on more targeted and valuable benefits to citizens and businesses, maintaining coherent, consistent and straightforward narratives for NBS (Nesshöver et al., 2017). Our findings indicate that this may be achieved by basing NBS arguments on less complex economic modelling, addressing modest sets of impacts (with lower data demands; Table 7) matched with contemporary socio-political contexts for NBS. Doing so may help urban NBS proponents to better handle the complexity of data demands. Case studies of cities' investment in NBS programmes can serve to illustrate how a more targeted assessment of economic values of NBS can be powerful, and sensitivity to case study contexts is vital (Schwarz et al. 2021). Establishing an economic case remains important if local authorities and private enterprises are to continue to invest in urban greening (Wilker and Rusche, 2013), as is the need to balance socio-ecological needs with economic viability (Mell et al., 2013). However, which impacts to focus upon, and which indicators to apply, depends on the specific place considered. Here, it is important to highlight the effects of the socioeconomic structural differences between Europe and Latin America on the type of NBS plans and projects that align to local priorities. In Latin America, and particularly in contexts of extreme poverty and grave infrastructural deficits, it is reasonable that NBS would be oriented to address those deficits and alleviate poverty as a priority (Hardoy, et al. 2022). In such contexts one may expect to see NBS projects addressing basic sanitation and other unsatisfied basic needs. Weak governance environments and structures as described in CPI (2020) are not unusual in European and Latin American cities alike, nor are socioeconomic inequities.

An important difference is that in Europe, NBS funding often comes from governments whereas in Latin America funding comes mostly from loans by e.g. the Inter-American Development Bank or the World Bank, or sometimes from donors. Finally, the sheer number and scale of materialised NBS projects also affects the ways in which NBS valuations are made. In interviews in Latin America it emerged that economic analyses played only a minor role in decision-making (Table 7), which tends to be dominated by political factors, institutional inertia or path dependencies (Henderson et al., 2023).

Certain unique conditions also apply in retrofitting *urban* NBS. Firstly, urban NBS are often placed in settings that involve aging city infrastructures (Hoover et al., 2020), urban renewal (Hsu and Chao, 2020), brownfield regeneration (Masiero et al., 2022) and vacant lots (Riley et al., 2018), all affecting NBS dynamics. Secondly, whilst potential benefits of NBS retrofits include recreational, socio-cultural and tourism-related values (Mäntymaa et al., 2021; Lim and Xenarios, 2021), concerns about the potential for eco-gentrification must be addressed, and monetary valuation studies can provide relevant insights (Hunter et al., 2019, Bockarjova et al., 2020a, 2020b; Basu and Nagendra, 2021; Donovan et al., 2021; Wu and Rowe, 2022; Sachs et al., 2023; Stroud et al., 2023). However, monetary valuation primarily addresses issues of economic efficiency. Although valuation can give insights into socio-economic dynamics (Wild et al., 2017) it cannot alone address issues of sustainability, and says little about equity, justice, and governance. Alongside resources, funding and staff, social acceptance is vital to NBS uptake – improving trust, awareness and collective decision-making is critical to implementation (Barona et al., 2023), and in understanding citizens' perspectives of costs and benefits (Pineda-Guerrero et al., 2020). Further scope exists to develop more participatory NBS assessment frameworks (van der Jagt et al., 2023; Viti et al., 2022). Integrating governance and impact assessment may also help with valuation and business case development.

Analysing the market for NBS, in terms of demand (buyers) and supply (sellers), can assist in understanding barriers to adoption, and strategies and instruments to overcome those challenges (Whiteoak, 2020). Policymakers can seek to better understand the market for urban NBS in terms of *cities as customers*, and the NBS benefits that those cities want or need to 'buy'. Whereas NBS valuations are widely reported in the literature, for diverse urban interventions, few pertain to actual city decision-making processes. Whether this is due to mismatches between decision processes, NBS valuation methods, and standard accounting methods is a topic for further research. Toxopeus and Polzin (2021) note that various valuation strategies do not allow for integrated accounting of NBS benefits (see also Langemeyer et al., 2015; Stange et al., 2022).

Current NBS impact assessment frameworks have in common their ambitious scope as regards the breadth of impacts to be assessed, and complex technical support requirements. It is not yet clear if and how monetary valuation of urban NBS can become more comprehensive or holistic, when the majority of published monetary assessments quantify just a handful of indicators (Supplement B). In urban settings, such assessments could become hugely demanding of data. The uptake of these frameworks by cities in Europe and Latin America has been limited (Kauark-Fontes et al., 2023), echoing earlier findings that overly complex tools and approaches are rarely applied in urban greenspace planning (Davies et al., 2015). Current regulatory and governance processes can be cumbersome and tend not to address the multiple benefits of NBS compared to traditional assessments (Henderson et al., 2022). Wider discussions around successes and limitations in the application of innovative methods are likely to prove fruitful in advancing the state of the art in urban NBS valuation, if proponents for urban NBS are directly involved in research and innovation processes. *Knowledge exchange is key*.

3.6. Limitations and areas for future research

Certain limitations were apparent, within the three main research phases. First, literature reviewed focussed mainly on monetary valuation limiting the possibility to draw on knowledge from the wider field of urban ecosystem services assessments. Second, setting the scope of the review to manuscripts from 2017 onwards, and excluding grey literature, meant that many of the references relevant to cities may be absent (especially practical guidance). Third, literature from the case study database (Supplement B) was not incorporated in the systematic review (Supplement A; Fig. 1.). This was a downside, especially since studies from a broad range of contexts were covered therein. As regards workshops and interviews with practitioners, policy stakeholders and so on,

despite strong efforts, only a modest number of participants could be reached. This limits the conclusions relating to the uptake of NBS valuation methods and links with impact indicators. The following knowledge gaps and research opportunities associated with the shortcomings are as follows. Firstly, with NBS research growing rapidly, future literature reviews may focus on specific monetary valuation methods and their results, remaining mindful of benefits associated with diverse NBS types, and especially in diverging contexts. Secondly, data from the literature review (Supplement A) and case study database (Supplement B) may be combined to provide more comprehensive sets of references. Thirdly, in researching the application of monetary valuation of NBS in cities, international web-based surveys could be employed to reach a much wider set of cities in the Global South and Global North.

4. Conclusions & recommendations

Urban municipal and regional authorities face multiple challenges, some of which can be addressed using NBS. Numbers of research publications on NBS have increased exponentially and a significant proportion of these studies address monetary valuation of urban NBS (Table 1). When used alongside other forms of evidence on impacts such as benefits for biodiversity, equity and sustainability, these results may serve to strengthen arguments for implementation of NBS. Whilst the multifunctionality of NBS represents their key strength this also means that monetary valuations can become complex and onerous. Steadily, NBS impact assessment and evaluation frameworks are becoming more readily available, but tend towards ambitiously comprehensive analysis, requiring extensive datasets and expertise. Overly demanding assessment frameworks may be less frequently applied in cities, where land use information is more complex and fragmented than in rural environments. NBS assessments can be narrow or broad in their span of impacts and geographical scale. Data demands increase exponentially where both the substance and scale of the assessment are widened. Thus, assessments of environmental, social and economic outcomes at the city scale may require such extensive data gathering as to become impractical (Table 7), or build in so many assumptions that they may be unconvincing or readily unpicked.

NBS valuations can be developed that are both sensitive to, and challenge, established institutionalised approaches to accounting, finance and governance. A promising option is to develop locally relevant, iterative processes of scoping, interpretation and evaluation. When NBS assessment is more contextualised and co-productive, it can also generate useful data for valuations. NBS interventions and the metrics used to ascertain their benefits may be matched more closely with urban contexts, signposted through relevant city strategies and plans (Table 4 and 6). Valuations can accompany other assessment methods addressing social and ecological impacts, to support communication and planning, but valuations are not a panacea and should be applied carefully (Table 7). Context appropriateness and stakeholder participation may be critical in many cities, not only in NBS co-design, but also in co-defining measures of success and understanding values.

CRediT authorship contribution statement

Rotbart Demian: Investigation, Methodology, Writing – review & editing. **Amaya Espinel Juan-David:** Data curation, Formal analysis, Methodology, Writing – review & editing. **Hernandez Garcia Jaime:** Investigation, Writing – original draft, Writing – review & editing. **Wild Thomas:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing. **Baptista Mariana:** Data curation, Investigation, Writing – original draft, Writing – review & editing. **Kozak Daniel:** Data curation, Formal analysis, Supervision, Writing – original draft, Writing – review & editing. **Thomasz Esteban Otto:** Writing – original draft, Writing – review & editing. **Giusti Mariana:** Investigation, Methodology, Writing – review & editing. **Henderson Hayley:** Writing – original draft, Writing – review & editing. **Wilker Jost:** Methodology, Writing – review & editing. **Kanai Juan Miguel:** Methodology, Writing – review & editing.

Declaration of Competing Interest

We assert that there is no conflict of interest regarding the content of this manuscript and that the work has not been published elsewhere and is not under consideration by another journal.

Acknowledgements

This research was funded by the European Commission's Horizon 2020 research and innovation programme through the CONEXUS project, under Grant Agreement no. 867564. We would like to thank the participants and partners in the project, including Livia Marchetti for her support with translation of the Italian transcripts, and anonymous reviewers for their help in improving this manuscript. Copyright (c) of the Authors (2023).

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2023.128162.

References

Abdeljaber, A., Adghim, M., Abdallah, M., Ghanima, R., Aljassem, F., 2022. Comparative performance and cost-integrated life cycle assessment of low impact development controls for sustainable stormwater management. Environ. Impact Assess. Rev. 95, 106805 https://doi.org/10.1016/j.eiar.2022.106805.

Agrawala, S., Crick, F., Jetté-Nantel, S., Tepes, A., 2008. Empirical estimates of adaptation costs and benefits: a critical assessment. OECD, Paris.

Almeida, C., Teotónio, I., Silva, C.M., Cruz, C.O., 2021. Socioeconomic feasibility of green roofs and walls in public buildings: the case study of primary schools in Portugal. Eng. Econ. 66 (1), 27–50. https://doi.org/10.1080/0013791X.2020.1748255.

Alvarez, S., Soto, J.R., Escobedo, F.J., Lai, J., Kibria, A.S., Adams, D.C., 2021. Heterogeneous preferences and economic values for urban forest structural and functional attributes. Landsc. Urban Plan. 215, 104234 https://doi.org/10.1016/j.landurbplan.2021.104234.

Alves, A., Gersonius, B., Kapelan, Z., Vojinovic, Z., Sanchez, A., 2019. Assessing the Co-Benefits of green-blue-grey infrastructure for sustainable urban flood risk management. J. Environ. Manag. 239, 244–254. https://doi.org/10.1016/j.jenvman.2019.03.036.

Amaya-Espinel, J.D. et al., 2021. State of the art, good practices and NBS typology. H2020 Conexus project deliverable D2.1. ⟨https://cordis.europa.eu/project/id/867564/results⟩.

Andersson-Sköld, Y., Klingberg, J., Gunnarsson, B., Cullinane, K., Gustafsson, I., Hedblom, M., Knez, I., Lindberg, F., Sang, Å.O., Pleijel, H., Thorsson, P., 2018. A framework for assessing urban greenery's effects and valuing its ecosystem services. J. Environ. Manag. 205, 274–285. https://doi.org/10.1016/j.jenvman.2017.09.071.

Ando, A.W., Cadavid, C.L., Netusil, N.R., Parthum, B., 2020. Willingness-to-volunteer and stability of preferences between cities: estimating the benefits of stormwater management. J. Environ. Econ. Manag. 99, 102274 https://doi.org/10.1016/j.jeem.2019.102274.

Angel, S., Parent, J., Civco, D.L., 2012. The fragmentation of urban landscapes: global evidence of a key attribute of the spatial structure of cities, 1990–2000. Environ. Urban. 24 (1), 249–283. https://doi.org/10.1177/0956247811433536.

Assaad, R.H., Assaf, G., Boufadel, M., 2023. Optimizing the maintenance strategies for a network of green infrastructure: an agent-based model for stormwater detention basins. J. Environ. Manag. 330, 117179 https://doi.org/10.1016/j.jenvman.2022.117179.

Augusto, B., Roebeling, P., Rafael, S., Ferreira, J., Ascenso, A., Bodilis, C., 2020. Short and medium- to long-term impacts of nature-based solutions on urban heat. Sustain. Cities Soc. 57, 102122 https://doi.org/10.1016/j.scs.2020.102122.

Balasha, A.M., Balasha, B.M., Masheka, L.H., Mulume, D.A., Mwisha, S.W., Ngabo, V.M., Amatcho, A.A., Ndele, A.B., Adrien, R.L., Bienvenu, M.S., Bahati, K., Patrick, K., Kazadi, L.K., Kalumbu, J.T., Bogaert, J., Sikuzani, Y.U., 2022. Students' willingness to plant trees and pay for their maintenance on campuses in the democratic republic of congo. Sustainability 14 (22), 15148. https://doi.org/10.3390/su142215148.

Barona, C.O., Devisscher, T., Dobbs, C., Aguilar, L.O., Baptista, M.D., Navarro, N.M., da Silva Filho, D.F., Escobedo, F.J., 2020. Trends in urban forestry research in Latin America & the Caribbean: a systematic literature review and synthesis. Urban For. Urban Green. 47, 126544 https://doi.org/10.1016/j.ufug.2019.126544.

Barona, C.O., Eleuterio, A.A., Vasquez, A., Devisscher, T., Baptista, M.D., Dobbs, C., Orozco-Aguilar, L., Meléndez-Ackerman, E., 2023. Views of government and non-government actors on urban forest management and governance in ten Latin-American capital cities. Land Use Policy 129, 106635. https://doi.org/10.1016/j.landusepol.2023.106635.

Barton, D., 2015. Monetary valuation of urban ecosystem services-operationalization or tragedy of well-intentioned valuation? An illustrated example. In: Nuss-Girona, S., Castañer, M. (Eds.), Ecosystem Services: Concepts, Methodologies and Instruments for Research and Applied Use, pp. 65–85.

Barton, D.N., 2022. Recognising institutional context in simulating and generalising exchange values for monetary ecosystem accounts. One Ecosyst. 7, e85283 https://doi.org/10.3897/oneeco.7.e85283.

Barton, D.N., Kelemen, E., Dick, J., Martin-Lopez, B., Gómez-Baggethun, E., Jacobs, S., Hendriks, C.M.A., Termansen, M., García-Llorente, M., Primmer, E., Dunford, R., 2018. Dis) integrated valuation–assessing the information gaps in ecosystem service appraisals for governance support. Ecosyst. Serv. 29, 529–541. https://doi.org/10.1016/j.ecoser.2017.10.021.

Basu, S., Nagendra, H., 2021. Perceptions of park visitors on access to urban parks and benefits of green spaces. Urban For. Urban Green. 57, 126959 https://doi.org/10.1016/j.ufug.2020.126959.

Benoliel, M.A., Manso, M., Ferreira, P.D., Silva, C.M., Cruz, C.O., 2021. Greening" and comfort conditions in transport infrastructure systems: understanding users' preferences. Build. Environ. 195, 107759 https://doi.org/10.1016/j.buildenv.2021.107759.

Bertram, C., Larondelle, N., 2017. Going to the woods is going home: recreational benefits of a larger urban forest site — a travel cost analysis for Berlin, Germany. Ecol. Econ. 132, 255–263. https://doi.org/10.1016/j.ecolecon.2016.10.017.

Bherwani, H., Banerji, T., Menon, R., 2022. Role and value of urban forests in carbon sequestration: review and assessment in Indian context. Environ., Dev. Sustain. 1–24. https://doi.org/10.1007/s10668-022-02725-5.

Bixler, T.S., Houle, J., Ballestero, T.P., Mo, W., 2020. A spatial life cycle cost assessment of stormwater management systems. Sci. Total Environ. 728, 138787 https://doi.org/10.1016/j.scitotenv.2020.138787.

Bockarjova, M., Botzen, W.J.W., 2017. Review of economic valuation of NBS in urban areas. ⟨https://naturvation.eu/sites/default/files/result/files/naturvation_review_of_economic_valuation_of_nature_based_solutions_in_urban_areas.pdf⟩. Accessed 28th March 2023.

Bockarjova, M., Botzen, W.J.W., van Schie, M.H., Koetse, M.J., 2020a. Property price effects of green interventions in cities: a meta-analysis and implications for gentrification. Environ. Sci. Policy 112, 293–304. https://doi.org/10.1016/j.envsci.2020.06.024.

Bockarjova, M., Botzen, W.J.W., Koetse, M.J., 2020b. Economic valuation of green and blue nature in cities: a meta-analysis. Ecol. Econ. 169, 106480 https://doi.org/10.1016/j.ecolecon.2019.106480.

Boguniewicz-Zabłocka, J., Capodaglio, A.G., 2020. Analysis of alternatives for sustainable stormwater management in small developments of Polish urban catchments. Sustainability 12 (23), 101891. https://doi.org/10.3390/su122310189.

Botes, C.M., Zanni, A.M., 2021. Trees, ground vegetation, sidewalks, cycleways: users' preferences and economic values for different elements of an urban street - a case study in Taipei. Environ. Econ. Policy Stud. 23, 1145–1171. https://doi.org/10.1007/s10018-020-00284-5.

Brent, D.A., Gangadharan, L., Lassiter, A., Leroux, A., Raschky, P.A., 2017. Valuing environmental services provided by local stormwater management. Water Resour. Res. 53 (6), 4907–4921. https://doi.org/10.1002/2016WR019776.

Buck, M., 2021. Considering the role of negotiated developer contributions in financing ecological mitigation and protection programs in England: a cultural perspective. Local Econ. 36 (5), 356–373. https://doi.org/10.1177/02690942211053592.

Cardinale, B.J., Duffy, J.E., Gonzalez, A., Hooper, D.U., Perrings, C., Venail, P., Narwani, A., Mace, G.M., Tilman, D., Wardle, D.A., Kinzig, A.P., 2012. Biodiversity loss and its impact on humanity. Nature 486 (7401), 59–67. https://doi.org/10.1038/nature11148.

Cetin, N.I., Bourget, G., Tezer, A., 2021. Travel-cost method for assessing the monetary value of recreational services in the Ömerli Catchment. Ecol. Econ. 190, 107192 https://doi.org/10.1016/j.ecolecon.2021.107192.

Chausson, A., Welden, E.A., Melanidis, M.S., Gray, E., Hirons, M., Seddon, N., 2023. Going beyond market-based mechanisms to finance nature-based solutions and foster sustainable futures. PLOS Clim. 2 (4), e0000169 https://doi.org/10.1371/journal.pclm.0000169.

Chen, H.-S., Lin, Y.-C., Chiueh, P.T., 2023. Nexus of ecosystem service-human health-natural resources: the nature-based solutions for urban PM2.5 pollution. Sustain. Cities Soc. 91, 104441 https://doi.org/10.1016/j.scs.2023.104441.

Chen, W.Y., 2017. Environmental externalities of urban river pollution and restoration: a hedonic analysis in Guangzhou (China). Landsc. Urban Plan. 157, 170–179. https://doi.org/10.1016/j.landurbplan.2016.06.010.

Ciasca, B.S., Klemz, C., Raepple, J., Kroeger, T., Acosta, E.A.P., Cho, S.J., Barreto, S., Bracale, H., Cesário, F., 2023. Economic cost of drought and potential benefits of investing in nature-based solutions: a case study in São Paulo, Brazil. Water 15 (3), 466. https://doi.org/10.3390/w15030466.

Claron, C., Mikou, M., Levrel, H., Tardieu, L., 2022. Mapping urban ecosystem services to design cost-effective purchase of development rights programs: the case of the Greater Paris metropolis. Land Use Policy 122, 106349. https://doi.org/10.1016/j.landusepol.2022.106349.

Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C.R., Renaud, F.G., Welling, R., 2019. Core principles for successfully implementing and upscaling Nature-based Solutions. Environ. Sci. Policy 98, 20–29. https://doi.org/10.1016/j.envsci.2019.04.014.

Collins, R., Schaafsma, M., Hudson, M.D., 2017. The value of green walls to urban biodiversity. Land Use Policy 64, 114–123. https://doi.org/10.1016/j.landusepol.2017.02.025.

Conrad, S.A., Yates, D., 2018. Coupling stated preferences with a hydrological water resource model to inform water policies for residential areas in the Okanagan Basin, Canada. J. Hydrol. 564, 846–858. https://doi.org/10.1016/j.jhydrol.2018.07.031.

CPI, 2020. An Analysis of Urban Climate Adaptation Finance. ⟨https://www.climatepolicyinitiative.org/publication/an-analysis-of-urban-climate-adaptation-finance/⟩. San Francisco, Climate Policy Initiative.

Croci, E., Lucchitta, B., Penati, T., 2021. Valuing ecosystem services at the urban level: a critical review. Sustainability 13 (3), 1129. https://doi.org/10.3390/su13031129.

Cuvi, N., Vélez, L.C.G., 2021. Los parques urbanos de Quito: distribución, accesibilidad y segregación espacial. Fronteiras 10 (2), 200–231. https://doi.org/10.21664/2238-8869.2021V10I2.P200-231.

D'Arcy, B.J., 1998. A New Scottish Approach to Urban Drainage in the Developments at Dunfermline. Proceedings of the Standing Conference on Stormwater Source Control, vol. XV. The School of the Built Environment, Coventry University. ISBN 0905949 641.

Davies, C., MacFarlane, R., McGloin, C., Roe, M., 2015. Green Infrastructure Planning Guide, v1.1.

Davies, H.J., Wu, H., Schaafsma, M., 2023. Willingness-to-pay for urban ecosystem services provision under objective and subjective uncertainty. Resour. Energy Econ. 71, 101344 https://doi.org/10.1016/j.reseneeco.2022.101344.

Dempsey, J., Suarez, D.C., 2016. Arrested development? The promises and paradoxes of "selling nature to save it. Ann. Am. Assoc. Geogr. 106 (3), 653–671.

Derkzen, M.L., van Teeffelen, A.J.A., Verburg, P.H., 2017. Green infrastructure for urban climate adaptation: How do residents' views on climate impacts and green infrastructure shape adaptation preferences? Landsc. Urban Plan. 157, 106–130. https://doi.org/10.1016/j.landurbplan.2016.05.027.

Devisscher, T., Ordóñez-Barona, C., Dobbs, C., Baptista, M.D., Navarro, N.M., Aguilar, L. A.O., Perez, J.F.C., Mancebo, Y.R., Escobedo, F.J., 2022. Urban forest management and governance in Latin America and the Caribbean: a baseline study of stakeholder views. Urban For. Urban Green. 67, 127441 https://doi.org/10.1016/j.ufug.2021.127441.

Diluiso, F., Guastella, G., Pareglio, S., 2021. Changes in urban green spaces' value perception: A meta-analytic benefit transfer function for European cities. Land Use Policy 101, 105116. https://doi.org/10.1016/j.landusepol.2020.105116.

Dobbs, C., Escobedo, F.J., Clerici, N., de la Barrera, F., Eleuterio, A.A., MacGregor-Fors, I., Reyes-Paecke, S., Vásquez, A., Zea Camaño, J.D., Hernández, H.J., 2019. Urban ecosystem Services in Latin America: mismatch between global concepts and regional realities? Urban Ecosyst. 22, 173–187. https://doi.org/10.1007/s11252-018-0805-3.

Donovan, G.H., Prestemon, J.P., Butry, D.T., Kaminski, A.R., Monleon, V.J., 2021. The politics of urban trees: tree planting is associated with gentrification in Portland, Oregon. For. Policy Econ. 124, 102387 https://doi.org/10.1016/j.forpol.2020.102387.

dos Santos, M.F.N., Barbassa, A.P., Vasconcelos, A.F., 2021. Low impact development strategies for a low-income settlement: Balancing flood protection and life cycle costs in Brazil. Sustain. Cities Soc. 65, 102650 https://doi.org/10.1016/j.scs.2020.102650.

Dubová, L., Macháč, J., 2019. Improving the quality of life in cities using community gardens: from benefits for members to benefits for all local residents. GeoScape 13 (1), 68–78. https://doi.org/10.2478/geosc-2019-0005.

Duffy, A., Jefferies, C., Waddell, G., Shanks, G., Blackwood, D., Watkins, A., 2008. A cost comparison of traditional drainage and SUDS in Scotland. Water Sci. Technol. 57 (9), 1451–1459. https://doi.org/10.2166/wst.2008.262.

Dumitru, A., Wendling, L., 2021a. Evaluating the impact of nature-based solutions: a handbook for practitioners. EU Publications Office,, Luxembourg. ⟨https://data.europa.eu/doi/10.2777/244577⟩.

Dumitru, A., Wendling, L., 2021b. Evaluating the impact of nature-based solutions: appendix of Methods. EU Publications Office,, Luxembourg. ⟨https://data.europa.eu/doi/10.2777/11361⟩.

Dyca, B., Muldoon-Smith, K., Greenhalgh, P., 2020. Common value: transferring development rights to make room for water. Environ. Sci. Policy 114, 312–320. https://doi.org/10.1016/j.envsci.2020.08.017.

EC, 2022a. The vital role of nature-based solutions in a nature positive economy. EU Publications Office, Luxembourg. ⟨https://data.europa.eu/doi/10.2777/307761⟩.

EC, 2022b. Impact assessment accompanying the proposal for a Regulation of the European Parliament and of the Council on nature restoration. European Commission,, Brussels.

EC, 2023. Nature-based solutions research policy. ⟨https://research-and-innovation.ec.europa.eu/research-area/environment/nature-based-solutions/research-policy_en⟩. Accessed 28th March 2023.

EEA, 2021. Nature-Based Solutions in Europe: Policy, Knowledge and Practice for Climate Change Adaptation and Disaster Risk Reduction. European Environment Agency, Copenhagen. ⟨https://www.eea.europa.eu/publications/nature-based-solutions-in-europe⟩.

EIB, 2023. Investing in nature-based solutions: State-of-play and way forward for public and private financial measures in Europe. European Investment Bank. Publications Office of the European Union, Luxembourg. https://doi.org/10.2867/031133.

El Harrak, M. Lemaitre, F., Decleer, K., McDonald, R., McQuaid, S., Palomo, I. Raymond, C., Wendling, L., Wilk, B. Reil, A., Berry, P., Naumann, S., MacIntyre, T., Bulkeley, H., Declerck, F., Delcroix, J., Donato, S., Eggermont, H. Freitas, T., Verheyen, K., de Vreese, R., Wild, T., 2023. European Roadmap to 2030 for research and innovation on nature-based solutions. ⟨https://networknature.eu/sites/default/files/uploads/networknatureeuropean-ri-roadmap-nbs.pdf⟩. Network Nature.

Elliot, T., Babí Almenar, J., Niza, S., Proença, V., Rugani, B., 2019. Pathways to modelling ecosystem services within an urban metabolism framework. Sustainability 11 (10), 2766. https://doi.org/10.3390/su11102766.
Engström, G., Gren, A., 2017. Capturing the value of green space in urban parks in a sustainable urban planning and design context: pros and cons of hedonic pricing. Ecol. Soc. 22 (2) https://doi.org/10.5751/ES-09365-220221.
Escobedo, F.J., Wagner, J.E., Nowak, D.J., De la Maza, C.L., Rodriguez, M., Crane, D.E., 2008. Analyzing the cost effectiveness of Santiago, Chile's policy of using urban forests to improve air quality. J. Environ. Manag. 86 (1), 148–157. https://doi.org/10.1016/j.jenvman.2006.11.029.
Escobedo, F.J., Adams, D.C., Timilsina, N., 2015a. Urban forest structure effects on property value. Ecosyst. Serv. 12, 209–217. https://doi.org/10.1016/j.ecoser.2014.05.002.
Escobedo, F.J., Clerici, N., Staudhammer, C.L., Corzo, G.T., 2015b. Socio-ecological dynamics and inequality in Bogotá, Colombia's public urban forests and their ecosystem services. Urban For. Urban Green. 14 (4), 1040–1053. https://doi.org/10.1016/j.ufug.2015.09.011.
Escobedo, F.J., Giannico, V., Jim, C.Y., Sanesi, G., Lafortezza, R., 2019. Urban forests, ecosystem services, green infrastructure and nature-based solutions: nexus or evolving metaphors? Urban For. Urban Green. 37, 3–12. https://doi.org/10.1016/j.ufug.2018.02.011.
Finance Earth, 2021. A Market Review of Nature-Based Solutions: An Emerging Institutional Asset Class (Commissioned by the Green Purposes Company). ⟨https://finance.earth/wp-content/uploads/2021/05/Finance-Earth-GPC-Market-Review-of-SbN-Report-May-2021.pdf⟩.
Flórez Yepes, G.Y., Parra, O., Ospina Parra, J.A., Álzate Álvarez, Á.Á., Chávez Marín, M. C., Gallo Cardona, C., Vidal Sierra, C.A., Serna Mendoza, C.A., Soto Vallejo, I., Castro Díaz, R., Delgado, L.E., 2020. Valoración económica de los servicios ecosistémicos de humedales Altoandinos: tres métodos de aplicación. ⟨https://repositorio.ucm.edu.co/handle/10839/2985⟩.
Fraga, J.P.R., Okumura, C.K., Guimarães, L.F., Arruda, R.N., Becker, B.R., de Oliveira, A. K.B., Veról, A.P., Miguez, M.G., 2022. Cost-benefit analysis of sustainable drainage systems considering ecosystems services benefits: case study of canal do mangue watershed in Rio de Janeiro city, Brazil. Clean. Technol. Environ. Policy 24 (2), 695–712. https://doi.org/10.1007/s10098-021-02221-w.
Franco, S.F., Macdonald, J.L., 2018. Measurement and valuation of urban greenness: remote sensing and hedonic applications to Lisbon, Portugal. Reg. Sci. Urban Econ. 72, 156–180. https://doi.org/10.1016/j.regsciurbeco.2017.03.002.
Fruth, E., Kvistad, M., Marshall, J., Pfeifer, L., Rau, L., Sagebiel, J., Soto, D., Tarpey, J., Weir, J., Winiarski, B., 2019. Economic valuation of street-level urban greening: a case study from an evolving mixed-use area in Berlin. Land Use Policy 89, 104237. https://doi.org/10.1016/j.landusepol.2019.104237.
Fruth, E., Kvistad, M., Marshall, J., Pfeifer, L., Rau, L., Sagebiel, J., Soto, D., Tarpey, J., Weir, J., Winiarski, B., 2020. Discrete choice experiment data for street-level urban greening in Berlin. Data Brief. 28, 105027 https://doi.org/10.1016/j.dib.2019.105027.
Fu, X., Hopton, M.E., Wang, X., Goddard, H., Liu, H., 2019. A runoff trading system to meet watershed-level stormwater reduction goals with parcel-level green infrastructure installation. Sci. Total Environ. 689, 1149–1159. https://doi.org/10.1016/j.scitotenv.2019.06.439.
Garbanzos, S., Maniquiz-Redillas, M., 2022. Modeling the hydrologic performance and cost-effectiveness of LID in a residential park area using a decentralized design approach. Hydrology 9 (4), 62. https://doi.org/10.3390/hydrology9040062.
García, S., 2019. Beneficios económicos de la Red Natura 2000 en España. Ministerio para la Transición Ecológica. Madrid.
García-Lamarca, M., Anguelovski, I., Cole, H.V., Connolly, J.J., Pérez-del-Pulgar, C., Shokry, G., Triguero-Mas, M., 2022. Urban green grabbing: Residential real estate developers discourse and practice in gentrifying Global North neighborhoods. Geoforum 128, 1–10. https://doi.org/10.1016/j.geoforum.2021.11.016.
GCA, 2019. Adapt now: a global call for leadership on climate resilience. Global Commission on Adaptation. ⟨https://gca.org/wp-content/uploads/2019/09/Global Commission_Report_FINAL.pdf⟩.
Glaser, B.G., 1965. The constant comparative method of qualitative analysis. Soc. Probl. 12 (4), 436–445. https://doi.org/10.2307/798843.
Godyń, I., 2022. Economic incentives in stormwater management: a study of practice gaps in Poland. Water (Switz.) 14 (23), 3817. https://doi.org/10.3390/w14233817.
Godyń, I., Grela, A., Stajno, D., Tokarska, P., 2020. Sustainable rainwater management concept in a housing estate with a financial feasibility assessment and motivational rainwater fee system efficiency analysis. Water (Switz.) 12 (1), 151. https://doi.org/10.3390/w12010151.
Gómez-Baggethun, E., Barton, D.N., 2013. Classifying and valuing ecosystem services for urban planning. Ecol. Econ. 86, 235–245. https://doi.org/10.1016/j.ecolecon.2012.08.019.
Grammatikopoulou, I., Badura, T., Johnston, R.J., Barton, D.N., Ferrini, S., Schaafsma, M., La Notte, A., 2023. Value transfer in ecosystem accounting applications. J. Environ. Manag. 326, 116784 https://doi.org/10.1016/j.jenvman.2022.116784.
Gwak, J.H., Lee, B.K., Lee, W.K., Sohn, S.Y., 2017. Optimal location selection for the installation of urban green roofs considering honeybee habitats along with socio-economic and environmental effects. J. Environ. Manag. 189, 125–133. https://doi.org/10.1016/j.jenvman.2016.12.022.
Haase, D., Kabisch, S., Haase, A., Andersson, E., Banzhaf, E., Baró, F., Brenck, M., Fischer, L.K., Frantzeskaki, N., Kabisch, N., Krellenberg, K., Kremer, P., Kronenberg, J., Larondelle, N., Mathey, J., Pauleit, S., Ring, I., Rink, D., Schwarz, N., Wolff, M., 2017. Greening cities – to be socially inclusive? About the alleged paradox of society and ecology in cities. Habitat Int. 64, 41–48. https://doi.org/10.1016/j.habitatint.2017.04.
Hagedoorn, L.C., Koetse, M.J., van Beukering, P.J.H., Brander, L.M., 2021. Reducing the finance gap for nature-based solutions with time contributions. Ecosyst. Serv. 52, 101371 https://doi.org/10.1016/j.ecoser.2021.101371.
Hardoy, J., Pandiella, G., 2009. Urban poverty and vulnerability to climate change in Latin America. Environ. Urban. 21 (1), 203–224. https://doi.org/10.1177/0956247809103019.
Hardoy, J., Motta, J.M., Kozak, D., Almansi, F., Reverter, T., Costello, M., 2022. Exploring the links between the use of NbS, mindshifts and transformative urban coalitions to promote climate resilience within an ongoing reurbanization process. The case of Villa 20, Buenos Aires. Front. Sustain. Cities 4, 962168. https://doi.org/10.3389/frsc.2022.962168.
He, Y.F., Peng, L.H., Yang, X.S., Feng, N.Y., 2021. Annual energy effects and cost-benefit analysis of green roofs in a hot summer sold winter climate. Resour. Environ. Yangtze Basin 30 (9), 2253–2263. https://doi.org/10.11870/cjlyzyyhj202109019.
Heidari, B., Schmidt, A.R., Minsker, B., 2022. Cost/benefit assessment of green infrastructure: Spatial scale effects on uncertainty and sensitivity. J. Environ. Manag. 302, 114009 https://doi.org/10.1016/j.jenvman.2021.114009.
Hekrle, M., 2022. What benefits are the most important to you, your community, and society? Perception of ecosystem services provided by nature-based solutions. Wiley Interdiscip. Rev.: Water 96e1612. https://doi.org/10.1002/wat2.1612.
Henderson, H., Bush, J., Kozak, D., 2022. Mainstreaming urban green-blue infrastructure: In R. Brears. The Palgrave Encyclopedia of Urban and Regional Futures. Springer International Publishing, Cham, pp. 1–18.
Henneberry, J., Ma, J., Privitera, R., 2020. Making a governable, value-able nature: calculative practices and eco-system services. Nat. Chall.: Contest Percept. Pract. Urban Green. Spaces 59–86. https://doi.org/10.1007/978-3-030-44480-8_4.
Hérivaux, C., Coent, P.L., 2021. Introducing nature into cities or preserving existing peri-urban ecosystems? Analysis of preferences in a rapidly urbanizing catchment. Sustain. (Switz.) 13 (2), 5871-36. https://doi.org/10.3390/su13020587.
Herwanti, S., Febryano, I.G., Yuwono, S.B., Khotimah, K., Banuwa, I.S., Harianto, S.P., Tsani, M.K., Surnayanti Damayanti, I., Prasetia, H., Rusita Fitriana, Y.R., 2021. Tourism economic value of Bukit Pangonan Urban Forest, Lampung, Indonesia. Int. J. Des. Nat. Ecodynamics 16 (5), 543–549. https://doi.org/10.18280/ijdne.160508.
Hong, S.-K., Kim, J.-M., Jo, H.-K., Lee, S.-W., 2018. Monetary valuation of urban forest attributes in highly developed urban environments: an experimental study using a conjoint choice model. Sustain. (Switz.) 10 (7), 2461. https://doi.org/10.3390/su10072461.
Hoover, F.-A., Price, J.I., Hopton, M.E., 2020. Examining the effects of green infrastructure on residential sales prices in Omaha, Nebraska. Urban For. Urban Green. 54, 126778 https://doi.org/10.1016/j.ufug.2020.126778.
Hsu, K.-W., Chao, J.C., 2020. Economic valuation of green infrastructure investments in urban renewal: the case of the station district in Taichung, Taiwan. Environ. - MDPI 7 (8), 561-12. https://doi.org/10.3390/environments7080056.
Hunter, R.F., Cleland, C., Cleary, A., Droomers, M., Wheeler, B.W., Sinnett, D., Nieuwenhuijsen, M.J., Braubach, M., 2019. Environmental, health, wellbeing, social and equity effects of urban green space interventions: a meta-narrative evidence synthesis. Environ. Int. 130, 104923 https://doi.org/10.1016/j.envint.2019.104923.
Idczak, P., Musialkowska, I., Mrozik, K., 2019. Ecosystem services in the appraisal of the economic performance of urban regeneration projects exemplified by the Jessica initiative. Ekon. i Środowisko 3, 114–129. https://doi.org/10.34659/2019/3/38.
IPBES, 2022. Methodological Assessment Report on the Diverse Values and Valuation of Nature of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. IPBES secretariat, Bonn, Germany. https://doi.org/10.5281/zenodo.6522522.
Irvine, K.N., Choy, B.H., Chua, L.H.C., Gaut, J., Ho, H.L., Tontisirin, N., 2020. A hedonic pricing approach to value ecosystem services provided by water sensitive urban design: Comparison of Geelong, Australia and Singapore. J. Environ. Des. Plan. 19, 57–78.
Irwin, N.B., Klaiber, H.A., Irwin, E.G., 2017. Do stormwater basins generate co-benefits? Evidence from Baltimore County, Maryland. Ecol. Econ. 141, 202–212. https://doi.org/10.1016/j.ecolecon.2017.05.030.
Iváncsics, V., Szendrei, Z., Iváncsics, V., Szendrei, Z., Obertik, J., Balás, G., 2019. How much is a public park worth? An ex ante methodology for impact and cost-benefit analysis on the example of Millenáris Széllkapu in Budapest. Landsc. Archit. Art. 15157-21. https://doi.org/10.22616/j.landarchart.2019.15.01.
Japelj, A., Hodges, D.G., Verlič, A., Juvančič, L., 2017. Using a latent class model to segment citizens of Ljubljana (Slovenia) according to their preferences over the recreation setting in the Golovec urban forest. Austrian J. For. Sci. 134 (1a), 41–62.
Jarvie, J., Arthur, S., Beevers, L., 2017. Valuing multiple benefits, and the public perception of SUDS ponds. Water (Switz.) 9 (2), 128. https://doi.org/10.3390/w9020128.
Jato-Espino, D., Toro-Huertas, E.I., Güereca, L.P., 2022. Lifecycle sustainability assessment for the comparison of traditional and sustainable drainage systems. Sci. Total Environ. 817, 152959 https://doi.org/10.1016/j.scitotenv.2022.152959.
Jia, J., Zhang, X., 2021. A human-scale investigation into economic benefits of urban green and blue infrastructure based on big data and machine learning: a case study of Wuhan. J. Clean. Prod. 316, 128321 https://doi.org/10.1016/j.jclepro.2021.128321.
Jiang, N., Ao, C., Xu, L., Wei, Y., Long, Y., 2023. Will information interventions affect public preferences and willingness to pay for air quality improvement? An empirical study based on deliberative choice experiment. Sci. Total Environ. 868, 161436 https://doi.org/10.1016/j.scitotenv.2023.161436.
Johnson, D., Geisendorf, S., 2019. Are neighborhood-level SUDS worth it? An assessment of the economic value of sustainable urban drainage system scenarios using cost-

benefit analyses. Ecol. Econ. 158, 194–205. https://doi.org/10.1016/j.ecolecon.2018.12.024.
Johnson, D., Geisendorf, S., 2022. Valuing ecosystem services of sustainable urban drainage systems: a discrete choice experiment to elicit preferences and willingness to pay. J. Environ. Manag. 307, 114508 https://doi.org/10.1016/j.jenvman.2022.114508.
Johnson, D., Exl, J., Geisendorf, S., 2021a. The potential of stormwater management in addressing the urban heat island effect: an economic valuation. Sustain. (Switz.) 13 (16), 8685. https://doi.org/10.3390/su13168685.
Johnson, D., See, L., Oswald, S.M., Prokop, G., Krisztin, T., 2021b. A cost–benefit analysis of implementing urban heat island adaptation measures in small- and medium-sized cities in Austria. Environ. Plan. B: Urban Anal. City Sci. 48 (8), 2326–2345. https://doi.org/10.1177/2399808320974689.
Kalfas, D., Chatzitheodoridis, F., Loizou, E., Melfou, K., 2022. Willingness to pay for urban and suburban Green. Sustain. (Switz.) 14 (4), 2332. https://doi.org/10.3390/su14042332.
Kallis, G., Gómez-Baggethun, E., Zografos, C., 2013. To value or not to value? That is not the question. Ecol. Econ. 94, 97–105.
Kauark-Fontes, B., Ortiz-Guerrero, C.E., Marchetti, L., Hernández-Garcia, J., Salbitano, F., 2023. Towards adaptive governance of urban nature-based solutions in europe and latin america—a qualitative exploratory study. Sustainability 15 (5), 4479. https://doi.org/10.3390/su15054479.
Keita, M.A., Ruan, R., An, R., 2020. Spatiotemporal change of urban sprawl patterns in Bamako District in Mali based on time series analysis. Urban Sci. 5 (1), 4. https://doi.org/10.3390/urbansci5010004.
Kenter, J.O., Reed, M.S., Fazey, I., 2016. The deliberative value formation model. Ecosyst. Serv. 21, 194–207. https://doi.org/10.1016/j.ecoser.2016.09.015.
Khan, M.P., Hubacek, K., Brubaker, K.L., Sun, L., Moglen, G.E., 2022. Stormwater management adaptation pathways under climate change and urbanization. J. Sustain. Water Built Environ. 8 (4), 4022009. https://doi.org/10.1061/JSWBAY.0000992.
Kim, H., Shoji, Y., Tsuge, T., Kubo, T., Nakamura, F., 2021a. Relational values help explain green infrastructure preferences: The case of managing crane habitat in Hokkaido, Japan. People Nat. 3 (4), 861–871. https://doi.org/10.1002/pan3.10231.
Kim, H., Shoji, Y., Tsuge, T., Aikoh, T., Kuriyama, K., 2021b. Understanding recreation demands and visitor characteristics of urban green spaces: A use of the zero-inflated negative binomial model. Urban For. Urban Green. 65, 127332 https://doi.org/10.1016/j.ufug.2021.127332.
Konijnendijk, C., Nilsson, K., Randrup, T., Schipperijn, J. (Eds.), 2005. Urban forests and trees: a reference book. Springer Berlin Heidelberg, Berlin, Heidelberg.
Kotsila, P., Anguelovski, I., Baró, F., Langemeyer, J., Sekulova, F., Connolly, J., 2021. Nature-based solutions as discursive tools and contested practices in urban nature's neoliberalisation processes. Environ. Plan. E: Nat. Space 4 (2), 252–274. https://doi.org/10.1177/2514848620901437.
Kozak, D., Henderson, H., Mazarro, A.D.C., Rotbart, D., Aradas, R., 2020. Blue-green infrastructure (BGI) in dense urban watersheds. The case of the Medrano stream basin (MSB) in Buenos Aires. Sustainability 12 (6), 2163. https://doi.org/10.3390/su12062163.
Kumar, P., Debele, S.E., Sahani, J., Rawat, N., Marti-Cardona, B., Alfieri, S.M., Basu, B., Basu, A.S., Bowyer, P., Charizopoulos, N., Jaakko, J., 2021. An overview of monitoring methods for assessing the performance of nature-based solutions against natural hazards. Earth-Sci. Rev. 217, 103603 https://doi.org/10.1016/j.earscirev.2021.103603.
Kyoi, S., 2021. People's avoidance of neighboring agricultural urban green infrastructure: evidence from a choice experiment. Sustainability 13 (12), 6930. https://doi.org/10.3390/su13126930.
Lagbas, A.J., 2019. Social valuation of regulating and cultural ecosystem services of Arroceros Forest Park: a man-made forest in the city of Manila, Philippines. J. Urban Manag. 8 (1), 59–177. https://doi.org/10.1016/j.jum.2018.09.002.
Langemeyer, J., Baró, F., Roebeling, P., Gómez-Baggethun, E., 2015. Contrasting values of cultural ecosystem services in urban areas: The case of park Montjuïc in Barcelona. Ecosyst. Serv. 12, 178–186. https://doi.org/10.1016/j.ecoser.2014.11.016.
Łaszkiewicz, E., Czembrowski, P., Kronenberg, J., 2019. Can proximity to urban green spaces be considered a luxury? Classifying a non-tradable good with the use of hedonic pricing method. Ecol. Econ. 161, 237–247. https://doi.org/10.1016/j.ecolecon.2019.03.025.
Łaszkiewicz, E., Heyman, A., Chen, X., Cimburova, Z., Nowell, M., Barton, D.N., 2022. Valuing access to urban greenspace using non-linear distance decay in hedonic property pricing. Ecosyst. Serv. 53, 101394 https://doi.org/10.1016/j.ecoser.2021.101394.
Li, X., Chen, W.Y., Hu, F.Z.Y., Cho, F.H.T., 2021. Homebuyers' heterogeneous preferences for urban green–blue spaces: a spatial multilevel autoregressive analysis. Landsc. Urban Plan. 216, 104250 https://doi.org/10.1016/j.landurbplan.2021.104250.
Liberati, A., Altman, D.G., Tetzlaff, J., Mulrow, C., Gøtzsche, P.C., Ioannidis, J.P., Clarke, M., Devereaux, P.J., Kleijnen, J., Moher, D., 2009. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. Ann. Intern. Med. 151 (4), W-65.
Lim, M., Xenarios, S., 2021. Economic assessment of urban space and blue-green infrastructure in Singapore. J. Urban Ecol. 7 (1), juab020 https://doi.org/10.1093/jue/juab020.
Liquete, C., Udias, A., Conte, G., Grizzetti, B., Masi, F., 2016. Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits. Ecosyst. Serv. 22, 392–401.
Liu, Z., Hanley, N., Campbell, D., 2020. Linking urban air pollution with residents' willingness to pay for greenspace: a choice experiment study in Beijing. J. Environ. Econ. Manag. 104, 102383 https://doi.org/10.1016/j.jeem.2020.102383.
Locatelli, L., Guerrero, M., Russo, B., Martínez-Gomariz, E., Sunyer, D., Martínez, M., 2020. Socio-economic assessment of green infrastructure for climate change adaptation in the context of urban drainage planning. Sustainability 12 (9), 3792. https://doi.org/10.3390/su12093792.
Lu, W., Xia, W., Shoemaker, C.A., 2022. Surrogate global optimization for identifying cost-effective green infrastructure for urban flood control with a computationally expensive inundation model. Water Resour. Res. 58 (4), e2021WR030928 https://doi.org/10.1029/2021WR030928.
Ma, J., Henneberry, J., Privitera, R., 2021. The challenges of valuing urban nature: accounting for urban ecosystem services within the framework of a cost-benefit analysis of nature-based investments. Lect. Notes Civ. Eng. 14681–14690. https://doi.org/10.1007/978-3-030-68824-0_9.
Manso, M., Sousa, V., Silva, C.M., Cruz, C.O., 2021. The role of green roofs in post COVID-19 confinement: an analysis of willingness to pay. J. Build. Eng. 44, 103388 https://doi.org/10.1016/j.jobe.2021.103388.
Mäntymaa, E., Jokinen, M., Juutinen, A., Lankia, T., Louhi, P., 2021. Providing ecological, cultural and commercial services in an urban park: a travel cost–contingent behavior application in Finland. Landsc. Urban Plan. 209, 104042 https://doi.org/10.1016/j.landurbplan.2021.104042.
Marques, T.H.N., Rizzi, D., Ferraz, V., Herzog, C.P. (2022). Soluções baseadas na natureza conceituação, aplicabilidade e complexidade no contexto Latino-Americano, casos do Brasil e Peru. Revista Labverde. FAUUSP. São Paulo, v. 11, n. 01, e189419, 2021. ⟨https://www.revistas.usp.br/revistalabverde/article/view/189419/178432⟩.
Marsters, L., Morales, G., Ozment, S., Silva, M., Watson, G., Netto, M., Frisari, G.L., 2021. Nature-Based Solutions in Latin America and the Caribbean: Financing Mechanisms for Regional Replication. Inter-American Development Bank and World Resources Institute, Washington, DC. https://doi.org/10.18235/0003688.
Martínez-Paz, J.M., Albaladejo-García, J.A., Barreiro-Hurle, J., Pleite, F.M.-C., Perni, Á., 2021. Spatial effects in the socioeconomic valuation of peri-urban ecosystems restoration. Land Use Policy 105, 105426. https://doi.org/10.1016/j.landusepol.2021.105426.
Masiero, M., Biasin, A., Amato, G., Malaggi, F., Pettenella, D., Nastasio, P., Anelli, S., 2022. Urban forests and green areas as nature-based solutions for brownfield redevelopment: a case study from Brescia Municipal Area (Italy). Forests 13 (3), 444. https://doi.org/10.3390/f13030444.
Matos Silva, C., Serro, J., Dinis Ferreira, P., Teotónio, I., 2019. The socioeconomic feasibility of greening rail stations: a case study in Lisbon. Eng. Econ. 64 (2), 167–190. https://doi.org/10.1080/0013791X.2018.1470272.
Mayor, B., Toxopeus, H., McQuaid, S., Croci, E., Lucchitta, B., Reddy, S.E., Egusquiza, A., Altamirano, M.A., Trumbic, T., Tuerk, A., García, G., 2021. State of the art and latest advances in exploring business models for nature-based solutions. Sustainability 13 (13), 7413. https://doi.org/10.3390/su13137413.
Medeiros, P.I.S.D., Cabral, L.C.D.S., Carvalho, A.R., 2019. Cost to restore and conserve urban forest fragment. Urban For. Urban Green. 46, 126465 https://doi.org/10.1016/j.ufug.2019.126465.
Mei, C., Liu, J., Wang, H., Yang, Z., Ding, X., Shao, W., 2018. Integrated assessments of green infrastructure for flood mitigation to support robust decision-making for sponge city construction in an urbanized watershed. Sci. Total Environ. 639, 1394–1407. https://doi.org/10.1016/j.scitotenv.2018.05.199.
Mell, I.C., Henneberry, J., Hehl-Lange, S., Keskin, B., 2013. Promoting urban greening: valuing the development of green infrastructure investments in the urban core of Manchester, UK. Urban For. Urban Green. 12 (3), 296–306.
Miyahara, A.A.L., Wild, T., Sandre, A.A., Pellegrino, P.R.M., da Silva Filho, C.A., Buckeridge, M.S., Locosselli, G.M., 2022. Developing and classifying urban biomes as a basis for nature-based solutions. Urban Clim. 45, 101251 https://doi.org/10.1016/j.uclim.2022.101251.
Moher, D., Liberati, A., Tetzlaff, J., Altman, D.G., 2009. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. J. Clin. Epidemiol. 62 (10), 1006–1012. https://doi.org/10.1016/j.jclinepi.2009.06.005.
Mok, S., Mačiulytė, E., Bult, P.H., Hawxwell, T., 2021. Valuing the Invaluable(?)—A framework to facilitate stakeholder engagement in the planning of nature-based solutions. Sustainability 13 (5), 2657. https://doi.org/10.3390/su13052657.
Molar-Cruz, A., Pöhler, L.D., Hamacher, T., Diepold, K., 2022. Who settles where? Simulating urban growth and socioeconomic level using cellular automata and random forest regression. Environ. Plan. B: Urban Anal. City Sci. 49 (6), 1697–1714. https://doi.org/10.1177/23998083211056957.
Morgenroth, J., O'Neil-Dunne, J., Apiolaza, L.A., 2017. Redevelopment and the urban forest: a study of tree removal and retention during demolition activities. Appl. Geogr. 82, 1–10. https://doi.org/10.1016/j.apgeog.2017.02.011.
NCC, 2017. Economic valuation and its applications in natural capital management. ⟨https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/957498/ncc-natural-capital-valuation.pdf⟩. Accessed 31st March 2023.
Nemitz, E., Vieno, M., Carnell, E., Fitch, A., Steadman, C., Cryle, P., Holland, M., Morton, R.D., Hall, J., Mills, G., Hayes, F., Dickie, I., Carruthers, D., Fowler, D., Reis, S., Jones, L., 2020. Potential and limitation of air pollution mitigation by vegetation and uncertainties of deposition-based evaluations: Air pollution mitigation by vegetation. Philos. Trans. R. Soc. A: Math., Phys. Eng. Sci. 378 (2183), 20190320. https://doi.org/10.1098/rsta.2019.0320.
Nesshöver, C., Assmuth, T., Irvine, K.N., Rusch, G.M., Waylen, K.A., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., 2017. The science,

policy and practice of nature-based solutions: an interdisciplinary perspective. Sci. Total Environ. 579, 1215–1227. https://doi.org/10.1016/j.scitotenv.2016.11.106.
Netusil, N.R., Lavelle, L., Dissanayake, S., Ando, A.W., 2022. Valuing the public benefits of green roofs. Landsc. Urban Plan. 224, 104426 https://doi.org/10.1016/j.landurbplan.2022.104426.
von Neumann, J., Morgenstern, O., 1953. Theory of games and economic behavior, third ed. Princeton University Press, Princeton.
Neumann, V.A., Hack, J., 2022. Revealing and assessing the costs and benefits of nature-based solutions within a real-world laboratory in Costa Rica. Environ. Impact Assess. Rev. 93, 106737 https://doi.org/10.1016/j.eiar.2022.106737.
Nordman, E.E., Isely, E., Isely, P., Denning, R., 2018. Benefit-cost analysis of stormwater green infrastructure practices for Grand Rapids, Michigan, USA. J. Clean. Prod. 200, 501–510. https://doi.org/10.1016/j.jclepro.2018.07.152.
Okada, T., Mito, Y., Tokunaga, K., Sugino, H., Kubo, T., Akiyama, Y.B., Endo, T., Otani, S., Yamochi, S., Kozuki, Y., Kusakabe, T., Otsuka, K., Yamanaka, R., Shigematsu, T., Kuwae, T., 2021. A comparative method for evaluating ecosystem services from the viewpoint of public works. Ocean Coast. Manag. 212, 105848 https://doi.org/10.1016/j.ocecoaman.2021.105848.
Oladunjoye, O., Proverbs, D., Xiao, H., 2022. Retrofitting sustainable urban drainage systems (SuDS): a cost-benefit analysis appraisal. Water (Switz.) 14 (16), 2521. https://doi.org/10.3390/w14162521.
Ossa-Moreno, J., Smith, K.M., Mijic, A., 2017. Economic analysis of wider benefits to facilitate SuDS uptake in London, UK. Sustain. Cities Soc. 28, 411–419. https://doi.org/10.1016/j.scs.2016.10.002.
Ozdemiroglu, E., Hails, R., 2016. Demystifying economic valuation, Valuing Nature paper VNP04. ⟨https://valuing-nature.net/sites/default/files/images/VNN-Demystifying%20Economic%20Valuation-Paper.pdf⟩.
Papineau Salm, J.P., Bockarjova, M., Botzen, W.J., Runhaar, H.A.C., 2023. Citizens' preferences and valuation of urban nature: Insights from two choice experiments. Ecol. Econ. 208, 107797 https://doi.org/10.1016/j.ecolecon.2023.107797.
Pareto, V., 1906. Manual of Political Economy.
Paul, C., Hanley, N., Meyer, S.T., Fürst, C., Weisser, W.W., Knoke, T., 2020. On the functional relationship between biodiversity and economic value. Sci. Adv. 6, eaax7712 https://doi.org/10.1126/sciadv.aax7712.
Pauleit, S., Zölch, T., Hansen, R., Randrup, T.B., Konijnendijk van den Bosch, C., 2017. Nature-based solutions and climate change - four shades of green. In: Kabisch, N., Korn, H., Stadler, J., Bonn, A. (Eds.), Nature-Based Solutions to Climate Change Adaptation in Urban Areas. Theory and Practice of Urban Sustainability Transitions. Springer, Cham, pp. 29–49. https://doi.org/10.1007/978-3-319-56091-5_3.
Pearce, D., Turner, R.K., 1990. Economics of natural resources and the environment. Harvester Wheatsheaf, London.
Piaggio, M., 2021. The value of public urban green spaces: measuring the effects of proximity to and size of urban green spaces on housing market values in San José, Costa Rica. Land Use Policy 109, 105656. https://doi.org/10.1016/j.landusepol.2021.105656.
Picard, P.M., Tran, T.T.H., 2021. Small urban green areas. J. Environ. Econ. Manag. 106, 102418 https://doi.org/10.1016/j.jeem.2021.102418.
Pineda-Guerrero, A., Escobedo, F.J., Carriazo, F., 2020. Governance, nature's contributions to people, and investing in conservation influence the valuation of urban green areas. Land 10 (1), 14. https://doi.org/10.3390/land10010014.
Pisani, D., Pazienza, P., Perrino, E.V., Caporale, D., De Lucia, C., 2021. The economic valuation of ecosystem services of biodiversity components in protected areas: a review for a framework of analysis for the Gargano National Park. Sustainability 13, 11726. https://doi.org/10.3390/su132111726.
Plant, L., Rambaldi, A., Sipe, N., 2017. Evaluating revealed preferences for street tree cover targets: a business case for collaborative investment in leafier streetscapes in Brisbane, Australia. Ecol. Econ. 134, 238–249. https://doi.org/10.1016/j.ecolecon.2016.12.026.
Plüddemann, A., Aronson, J.K., Onakpoya, I., Heneghan, C., Mahtani, K.R., 2018. Redefining rapid reviews: a flexible framework for restricted systematic reviews. BMJ Evid. -Based Med. 23 (6), 201–203.
Qiao, X.J., Randrup, T.B., 2022. Willingness to pay for the maintenance of green infrastructure in six Chinese pilot Sponge Cities. Water (Switz.) 14 (3), 428. https://doi.org/10.3390/w14030428.
Qiu, Y., Schertzer, D., Tchiguirinskaia, I., 2021. Assessing cost-effectiveness of nature-based solutions scenarios: integrating hydrological impacts and life cycle costs. J. Clean. Prod. 329, 129740 https://doi.org/10.1016/j.jclepro.2021.129740.
Quaranta, E., Dorati, C., Pistocchi, A., 2021. Water, energy and climate benefits of urban greening throughout Europe under different climatic scenarios. Sci. Rep. 11 (1), 12163 https://doi.org/10.1038/s41598-021-88141-7.
Quaranta, E., Fuchs, S., Liefting, H.J., Schellart, A., Pistocchi, A., 2022. Costs and benefits of combined sewer overflow management strategies at the European scale. J. Environ. Manag. 318, 115629 https://doi.org/10.1016/j.jenvman.2022.115629.
Randrup, T.B., Buijs, A., Konijnendijk, C.C., Wild, T., 2020. Moving beyond the nature-based solutions discourse: introducing nature-based thinking. Urban Ecosyst. 23, 919–926. https://doi.org/10.1007/s11252-020-00964-w.
Raymond, C.M., Kenter, J.O., Plieninger, T., Turner, N.J., Alexander, K.A., 2014. Comparing instrumental and deliberative paradigms underpinning the assessment of social values for cultural ecosystem services. Ecol. Econ. 107, 145–156. https://doi.org/10.1016/j.ecolecon.2014.07.033.
Raymond, C.M., Frantzeskaki, N., Kabisch, N., et al., 2017. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. Environ. Sci. Policy 77, 15–24. https://doi.org/10.1016/j.envsci.2017.07.008.
Reu Junqueira, J., Serrao-Neumann, S., White, I., 2022. Developing and testing a cost-effectiveness analysis to prioritize green infrastructure alternatives for climate change adaptation. Water Environ. J. 2022, 1–14. https://doi.org/10.1111/wej.12832.
Reynaud, A., Lanzanova, D., Liquete, C., Grizzetti, B., 2017. Going green? Ex-post valuation of a multipurpose water infrastructure in Northern Italy. Ecosyst. Serv. 27, 70–81. https://doi.org/10.1016/j.ecoser.2017.07.015.
Rezwan, S.M., Chowdhury, M.A.H., Rahman, S.M.M., 2022. Assessment of ecosystem services, plant diversity pattern, and water quality of an urban Water Body in Dhaka, Bangladesh. Adv. Sci., Technol. Innov. 151–163. https://doi.org/10.1007/978-3-030-86499-6_14.
Richmond, M., Upadhyaya, N., Ortega Pastor, E., 2021. An analysis of urban climate adaptation finance. San Francisco, Climate Policy Initiative. ⟨https://www.climatepolicyinitiative.org/wp-content/uploads/2021/02/An-Analysis-of-Urban-Climate-Adaptation-Finance.pdf⟩. Accessed 31st March 2023.
Riley, C.B., Herms, D.A., Gardiner, M.M., 2018. Exotic trees contribute to urban forest diversity and ecosystem services in inner-city Cleveland, OH. Urban For. Urban Green. 29, 367–376. https://doi.org/10.1016/j.ufug.2017.01.004.
Rizzo, A., Conte, G., Masi, F., 2021. Adjusted unit value transfer as a tool for raising awareness on ecosystem services provided by constructed wetlands for water pollution control: An Italian case study. Int. J. Environ. Res. Public Health 18 (4), 15311–15315. https://doi.org/10.3390/ijerph18041531.
Roebeling, P., Saraiva, M., Palla, A., Gnecco, I., Teotónio, C., Fidelis, T., Martins, F., Alves, H., Rocha, J., 2017. Assessing the socio-economic impacts of green/blue space, urban residential and road infrastructure projects in the Confluence (Lyon): a hedonic pricing simulation approach. J. Environ. Plan. Manag. 60 (3), 482–499. https://doi.org/10.1080/09640568.2016.1162138.
Ruangpan, L., Vojinovic, Z., Di Sabatino, S., Leo, L.S., Capobianco, V., Oen, A.M., McClain, M.E., Lopez-Gunn, E., 2020. Nature-based solutions for hydro-meteorological risk reduction: a state-of-the-art review of the research area. Nat. Hazards Earth Syst. Sci. 20, 243–270. https://doi.org/10.5194/nhess-20-243-2020.
Sabyrbekov, R., Dallimer, M., Navrud, S., 2020. Nature affinity and willingness to pay for urban green spaces in a developing country. Landsc. Urban Plan. 194, 103700 https://doi.org/10.1016/j.landurbplan.2019.103700.
Sachs, A.L., Boag, A.E., Troy, A., 2023. Valuing urban trees: a hedonic investigation into tree canopy influence on property values across environmental and social contexts in Baltimore, Maryland. Urban For. Urban Green. 80, 127829 https://doi.org/10.1016/j.ufug.2022.127829.
Sanderson, B.M., O'Neill, B.C., 2020. Assessing the costs of historical inaction on climate change. Sci. Rep. 10 (1), 9173 https://doi.org/10.1038/s41598-020-66275-4.
Sarvilinna, A., Lehtoranta, V., Hjerppe, T., 2017. Are urban stream restoration plans worth implementing? Environ. Manag. 59, 10–20. https://doi.org/10.1007/s00267-016-0778-z.
Schwarz, N., Haase, A., Haase, D., Kabisch, N., Kabisch, S., Liebelt, V., Rink, D., Strohbach, M.W., Welz, J., Wolff, M., 2021. How are urban green spaces and residential development related? A synopsis of multi-perspective analyses for Leipzig, Germany. Land 10 (6), 630. https://doi.org/10.3390/land10060630.
Seddon, N., Chausson, A., Berry, P., Girardin, C.A., Smith, A., Turner, B., 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. Philos. Trans. R. Soc. B 375 (1794), 20190120. https://doi.org/10.1098/rstb.2019.0120.
Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S., Turner, B., 2021. Getting the message right on nature-based solutions to climate change. Glob. Change Biol. 27 (8), 1518–1546. https://doi.org/10.1111/gcb.15513.
Shah, A.M., Liu, G., Huo, Z., Yang, Q., Zhang, W., Meng, F., Yao, L., Ulgiati, S., 2022. Assessing environmental services and disservices of urban street trees. an application of the emergy accounting. Resour., Conserv. Recycl. 186, 106563 https://doi.org/10.1016/j.resconrec.2022.106563.
Sikorska, D., Macegoniuk, S., Łaszkiewicz, E., Sikorski, P., 2020. Energy crops in urban parks as a promising alternative to traditional lawns – perceptions and a cost-benefit analysis. Urban For. Urban Green. 49, 126579 https://doi.org/10.1016/j.ufug.2019.126579.
Silvennoinen, S., Taka, M., Yli-Pelkonen, V., Koivusalo, H., Ollikainen, M., Setälä, H., 2017. Monetary value of urban green space as an ecosystem service provider: a case study of urban runoff management in Finland. Ecosyst. Serv. 28, 17–27. https://doi.org/10.1016/j.ecoser.2017.09.013.
Sinha, P., Coville, R.C., Hirabayashi, S., Lim, B., Endreny, T.A., Nowak, D.J., 2021. Modeling lives saved from extreme heat by urban tree cover. Ecol. Model. 449, 109553 https://doi.org/10.1016/j.ecolmodel.2021.109553.
Skrydstrup, J., Löwe, R., Gregersen, I.B., Koetse, M., Aerts, J.C.J.H., de Ruiter, M., Arnbjerg-Nielsen, K., 2022. Assessing the recreational value of small-scale nature-based solutions when planning urban flood adaptation. J. Environ. Manag. 320, 115724 https://doi.org/10.1016/j.jenvman.2022.115724.
Sohn, W., Kim, H.W., Kim, J.-H., Li, M.-H., 2020. The capitalized amenity of green infrastructure in single-family housing values: an application of the spatial hedonic pricing method. Urban For. Urban Green. 49, 126643 https://doi.org/10.1016/j.ufug.2020.126643.
de Souza, D.T., Torres, P.H.C., 2021. Greening and just cities: elements for fostering a south–north dialogue based on a systematic literature review. Front. Sustain. Cities 3, 669944. https://doi.org/10.3389/frsc.2021.669944.
Speak, A., Escobedo, F.J., Russo, A., Zerbe, S., 2018. An ecosystem service-disservice ratio: using composite indicators to assess the net benefits of urban trees. Ecol. Indic. 95, 544–553. https://doi.org/10.1016/j.ecolind.2018.07.048.
Stange, E.E., Barton, D.N., Andersson, E., Haase, D., 2022. Comparing the implicit valuation of ecosystem services from nature-based solutions in performance-based green area indicators across three European cities. Landsc. Urban Plan. 219, 104310 https://doi.org/10.1016/j.landurbplan.2021.104310.

Stroud, H.M., Kirshen, P.H., Timmons, D., 2023. Monetary evaluation of co-benefits of nature-based flood risk reduction infrastructure to promote climate justice. Mitig. Adapt. Strateg. Glob. Change 28 (1), 5. https://doi.org/10.1007/s11027-022-10037-2.

Suarez, A., Ruiz-Agudelo, C., Castro-Escobar, E., Flórez-Yepes, G.Y., Vargas-Marín, L.A., 2021. On the mismatches between the monetary and social values of air purification in the Colombian Andean region: a case study. Forests 12 (9), 1274. https://doi.org/10.3390/f12091274.

Swann, S., Blandford, L., Cheng, S., Cook, J., Miller, A., Barr, R., 2021. Public international funding of nature-based solutions for adaptation: a landscape assessment. World Resources Institute, Washington, DC. https://doi.org/10.46830/wriwp.20.00065.

Tanaka, K., Nelson, H., McCullar, N., Parulekar, N., 2022. Citizens' preferences on green infrastructure practices and their enhancement in Portland, Oregon. J. Environ. Manag. 318, 115415 https://doi.org/10.1016/j.jenvman.2022.115415.

Tapsuwan, S., Marcos-Martinez, R., Schandl, H., Yu, Z., 2021. Valuing ecosystem services of urban forests and open spaces: application of the SEEA framework in Australia. Aust. J. Agric. Resour. Econ. 65 (1), 37–65. https://doi.org/10.1111/1467-8489.12416.

Tavakol-Davani, H.E., Tavakol-Davani, H., Burian, S.J., McPherson, B.J., Barber, M.E., 2019. Green infrastructure optimization to achieve pre-development conditions of a semiarid urban catchment. Environ. Sci.: Water Res. Technol. 5 (6), 1157–1171. https://doi.org/10.1039/c8ew00789f.

Taylor, B., Chapron, G., Kopnina, H., Orlikowska, E., Gray, J., Piccolo, J.J., 2020. The need for ecocentrism in biodiversity conservation. Conserv. Biol. 34 (5), 1089–1096. https://doi.org/10.1111/cobi.13541.

Teotónio, I., Cruz, C.O., Silva, C.M., Morais, J., 2020. Investing in sustainable built environments: the willingness to pay for green roofs and greenwalls. Sustain. (Switz.) 12 (8), 3210. https://doi.org/10.3390/SU12083210.

Teotónio, I., Oliveira Cruz, C., Matos Silva, C., Lopes, R.F.R., 2022. Bridging CBA and MCA for evaluating green infrastructure: proposal of a new evaluation model (MAGICA). Socio-Econ. Plan. Sci. 85, 101446 https://doi.org/10.1016/j.seps.2022.101446.

Tinch, R., Beaumont, N., Sunderland, T., Ozdemiroglu, E., Barton, D., Bowe, C., Börger, T., Burgess, P., Cooper, C.N., Faccioli, M., Failler, P., 2019. Economic valuation of ecosystem goods and services: a review for decision makers. J. Environ. Econ. Policy 8 (4), 359–378. https://doi.org/10.1080/21606544.2019.1623083.

Toxopeus, H., Polzin, F., 2021. Reviewing financing barriers and strategies for urban nature-based solutions. J. Environ. Manag. 289, 112371 https://doi.org/10.1016/j.jenvman.2021.112371.

Toxopeus, H., Kotsila, P., Conde, M., Katona, A., van der Jagt, A.P., Polzin, F., 2020. How 'just' is hybrid governance of urban nature-based solutions? Cities 105, 102839. https://doi.org/10.1016/j.cities.2020.102839.

Toxopeus, H., Achterberg, E., Polzin, F., 2021. How can firms access bank finance for circular business model innovation? Bus. Strategy Environ. 30 (6), 2773–2795. https://doi.org/10.1002/bse.2893.

Tran, Y.L., Siry, J.P., Bowker, J.M., Poudyal, N.C., 2017. Atlanta households' willingness to increase urban forests to mitigate climate change. Urban For. Urban Green. 22, 84–92. https://doi.org/10.1016/j.ufug.2017.02.003.

Tudiwer, D., Hollands, J., Korjenic, A., 2019. Calculation of the cooling production costs of façade-bound greening systems in urban areas. Bauphysik 41 (2), 120–124. https://doi.org/10.1002/bapi.201800035.

Turkelboom, F., Demeyer, R., Vranken, L., De Becker, P., Raymaekers, F., De Smet, L., 2021. How does a nature-based solution for flood control compare to a technical solution? Case study evidence from Belgium. Ambio 50 (8), 1431–1445. https://doi.org/10.1007/s13280-021-01548-4.

UN, 2018. World Urbanization Prospects: The 2018 Revision. New York, UN Department of Economic and Social Affairs. Accessed 4th July 2023.

UNEA, 2022. UN Environment Assembly concludes with 14 resolutions to curb pollution, protect and restore nature worldwide, March 2. Available from: ⟨https://www.unep.org/news-and-stories/press-release/un-environment-assembly-concludes-14-resolutions-curb-pollution⟩. Accessed 8th June 2022.

van der Jagt, A.P., Buijs, A., Dobbs, C., van Lierop, M., Pauleit, S., Randrup, T.B., Wild, T., 2023. An action framework for the participatory assessment of nature-based solutions in cities. Ambio 52 (1), 54–67. https://doi.org/10.1007/s13280-022-01772-6.

Vanstockem, J., Vranken, L., Bleys, B., Somers, B., Hermy, M., 2018. Do looks matter? A case study on extensive green roofs using discrete choice experiments. Sustain. (Switz.) 10 (2), 309. https://doi.org/10.3390/su10020309.

Vásquez, A., Dobbs, C., 2020. Ensuring equitable greenspace to deprived social groups. In: Douglas, et al. (Eds.), The Routledge Handbook of Urban Ecology. Routledge, London, pp. 817–825. ⟨https://doi.org/10.4324/9780429506758⟩.

Velasco-Muñoz, J.F., Aznar-Sánchez, J.A., Schoenemann, M., López-Felices, B., 2022. The economic valuation of ecosystem services: bibliometric analysis. Oeconomia Copernic. 13 (4), 977–1014. https://doi.org/10.24136/oc.2022.028.

Venter, Z.S., Barton, D.N., Martinez-Izquierdo, L., Langemeyer, J., Baró, F., McPhearson, T., 2021. Interactive spatial planning of urban green infrastructure–Retrofitting green roofs where ecosystem services are most needed in Oslo. Ecosyst. Serv. 50, 101314 https://doi.org/10.1016/j.ecoser.2021.101314.

Vincent, S.U., Radhakrishnan, M., Hayde, L., Pathirana, A., 2017. Enhancing the economic value of large investments in Sustainable Drainage Systems (SuDS) through inclusion of ecosystems services benefits. Water (Switz.) 9 (11), 841. https://doi.org/10.3390/w9110841.

Viti, M., Löwe, R., Sørup, H.J.D., Rasmussen, M., Arnbjerg-Nielsen, K., McKnight, U.S., 2022. Knowledge gaps and future research needs for assessing the non-market benefits of Nature-Based Solutions and Nature-Based Solution-like strategies. Sci. Total Environ., 156636 https://doi.org/10.1016/j.scitotenv.2022.156636.

Walras, L., 1877. Elements of Pure Economics. Irwin,. ISBN 0-678-06028-2.

Wan, N.-F., Cai, Y.-M., Shen, Y.-J., Ji, X.-Y., Wu, X.-W., Zheng, X.-R., Cheng, W., Li, J., Jiang, Y.-P., Chen, X., Weiner, J., Jiang, J.-X., Nie, M., Ju, R.-T., Yuan, T., Tang, J.-J., Tian, W.-D., Zhang, H., Li, B., 2018. Increasing plant diversity with border crops reduces insecticide use and increases crop yield in urban agriculture. eLife 7, e35103. https://doi.org/10.7554/eLife.35103.

Wang, M., Wang, X., Yi, C., Ge, X., 2022a. Cost-effectiveness analysis of a Sponge City construction based on the Life Cycle Cost theory - a case study of the Yanshan South Road area of Qian'an City, China. Water (Switz.) 14 (17), 2647. https://doi.org/10.3390/w14172647.

Wang, Y., An, X., van Roon, M., Li, P., 2022b. The residents' perceptions on and willingness to pay for water sensitive industrial development: evidence from New Zealand. Int. J. Sustain. Dev. World Ecol. 29 (3), 230–245. https://doi.org/10.1080/13504509.2021.1951393.

Whiteoak, K., 2020. Market challenges and opportunities for NBS. In: Wild, T., et al. (Eds.), Nature-based solutions: State of the art in EU-funded projects. EU Publications Office, Luxembourg, pp. 203–222. ⟨https://data.europa.eu/doi/10.2777/236007⟩.

Wilbers, G.J., de Bruin, K., Seifert-Dähnn, I., Lekkerkerk, W., Li, H., Budding-Polo Ballinas, M., 2022. Investing in urban blue–green infrastructure—assessing the costs and benefits of stormwater management in a peri-urban catchment in Oslo, Norway. Sustain. (Switz.) 14 (3), 1934. https://doi.org/10.3390/su14031934.

Wild, T.C., Wilker, J., Tack, B., Rymsa-Fitschen, C., Moore, T., van de Steene, S., Henneberry, J.M., Rusche, K., Timmermans, W., 2015. Policy lessons and recommendations. VALUE+ Final Report. South Yorkshire Forest Partnership, Sheffield.

Wild, T.C., Henneberry, J., Gill, L., 2017. Comprehending the multiple 'values' of green infrastructure – valuing nature-based solutions for urban water management from multiple perspectives. Environ. Res. 158, 179–187. https://doi.org/10.1016/j.envres.2017.05.043.

Wilker, J., Rusche, K., 2013. Economic valuation as a tool to support decision-making in strategic green infrastructure planning? Local Environ. 19 (6), 702–713.

Wilkerson, B., Romanenko, E., Barton, D.N., 2022. Modeling reverse auction-based subsidies and stormwater fee policies for Low Impact Development (LID) adoption: a system dynamics analysis. Sustain. Cities Soc. 79, 103602 https://doi.org/10.1016/j.scs.2021.103602.

Wong, C.P., Jiang, B., Bohn, T.J., Lee, K.N., Lettenmaier, D.P., Ma, D., Ouyang, Z., 2017. Lake and wetland ecosystem services measuring water storage and local climate regulation. Water Resour. Res. 534, 3197–3223. https://doi.org/10.1002/2016WR019445.

Wong, C.P., Jiang, B., Kinzig, A.P., Ouyang, Z., 2018. Quantifying multiple ecosystem services for adaptive management of green infrastructure. Ecosphere 911, e02495. https://doi.org/10.1002/ecs2.2495.

Wu, J., Kauhanen, P.G., Hunt, J.A., Senn, D.B., Hale, T., McKee, L.J., 2019. Optimal selection and placement of green infrastructure in urban watersheds for PCB control. J. Sustain. Water Built Environ. 524, 018–019. https://doi.org/10.1061/JSWBAY.0000876.

Wu, L., Rowe, P., 2022. Green space progress or paradox: identifying green space associated gentrification in Beijing. Landsc. Urban Plan. 219, 104321 https://doi.org/10.1016/j.landurbplan.2021.104321.

Xu, H., Fu, F., Miao, M., 2022. What is the effect of Cultural Greenway Projects in high-density urban municipalities? Assessing the public living desire near the Cultural Greenway in Central Beijing. Int. J. Environ. Res. Public Health 19 (4), 2147. https://doi.org/10.3390/ijerph19042147.

Xu, X., Zhang, Q., 2019. Sustainable configuration of bioretention systems for nutrient management through Life-Cycle Assessment and Cost Analysis. J. Environ. Eng. (U. S.) 145 (5), 4019016. https://doi.org/10.1061/(ASCE)EE.1943-7870.0001526.

Yaacovi, Y., Gasith, A., Becker, N., 2021. How much is an urban stream worth? Using land senses and economic assessment of an urban stream restoration. Int. J. Sustain. Dev. World Ecol. 287, 602–611. https://doi.org/10.1080/13504509.2021.1929546.

Young, J.C., Rose, D.C., Mumby, H.S., Benitez-Capistros, F., Derrick, C.J., Finch, T., Garcia, C., Home, C., Marwaha, E., Morgans, C., Parkinson, S., 2018. A methodological guide to using and reporting on interviews in conservation science research. Methods Ecol. Evol. 9 (1), 10–19. https://doi.org/10.1111/2041-210X.12828.

Zhang, L., Fukuda, H., Liu, Z., 2019. Households' willingness to pay for green roof for mitigating heat island effects in Beijing (China). Build. Environ. 150, 13–20. https://doi.org/10.1016/j.buildenv.2018.12.048.

Zhang, X., Ni, Z., Wang, Y., Chen, S., Xia, B., 2020. Public perception and preferences of small urban green infrastructures: a case study in Guangzhou, China. Urban For. Urban Green. 53, 126700 https://doi.org/10.1016/j.ufug.2020.126700.

Zhang, Y., Dong, R., 2018. Impacts of street-visible greenery on housing prices: Evidence from a hedonic price model and a massive street view image dataset in Beijing. ISPRS Int. J. Geo-Inf. 7 (3), 104. https://doi.org/10.3390/ijgi7030104.

Zhao, C., Sander, H.A., 2018. Assessing the sensitivity of urban ecosystem service maps to input spatial data resolution and method choice. Landsc. Urban Plan. 175, 11–22. https://doi.org/10.1016/j.landurbplan.2018.03.007.

Zhi-Ying, H., Yeo-Chang, Y., 2021. Beijing resident's preferences of ecosystem services of urban forests. Forests 12 (1), 14–23. https://doi.org/10.3390/f12010014.

Zhong, Q., Zhang, L., Zhu, Y., Konijnendijk van den Bosch, C., Han, J., Zhang, G., Li, Y., 2020. A conceptual framework for ex ante valuation of ecosystem services of

brownfield greening from a systematic perspective. Ecosyst. Health Sustain. 6 (1), 1743206 https://doi.org/10.1080/20964129.2020.1743206.
Zidar, K., Belliveau-Nance, M., Cucchi, A., Denk, D., Kricun, A., O'Rourke, S., Rahman, S., Rangarajan, S., Rothstein, E., Shih, J., Montalto, F., 2017. A framework for multifunctional green infrastructure investment in Camden, NJ. Urban Plan. 2, 56–73. https://doi.org/10.17645/up.v2i3.1038.
Zubelzu, S., Rodríguez-Sinobas, L., Andrés-Domenech, I., Castillo-Rodríguez, J.T., Perales-Momparler, S., 2019. Design of water reuse storage facilities in Sustainable Urban Drainage Systems from a volumetric water balance perspective. Sci. Total Environ. 663, 133–143. https://doi.org/10.1016/j.scitotenv.2019.01.342.