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Valuing Ecosystem Services at the Urban Level: A Critical Review

Edoardo Croci *, Benedetta Lucchitta * and Tommaso Penati

GREEN Research Center, Bocconi University, 20100 Milano, Italy; tommaso.penati@unibocconi.it
* Correspondence: edoardo.croci@unibocconi.it (E.C.); benedetta.lucchitta@unibocconi.it (B.L.)

Abstract: This paper critically analyses the methodologies that can be adopted to value ecosystem services (ESs) at the urban level through a literature review. While literature on ES valuation has grown in recent years, its application to urban contexts is still limited. Twenty-five papers, which include 29 different case studies, carry out an economic valuation and have undergone an in-depth analysis. The papers have been selected out of 80 papers detected through keywords. Six different valuation methodologies have been employed in the case studies. The most common ESs valued at the urban level are air quality regulation, local climate regulation, carbon sequestration and storage, and aesthetic appreciation and inspiration for culture, art, and design. The methodologies recur with different frequencies in the valuation of ESs at the urban level. Choice modeling and contingent valuation methodologies are used to value a variety of ESs, including regulating, cultural, and supporting services. Other methodologies are used to value only specific ESs. The replacement cost and damage cost avoided methodologies are used for the assessment of regulation services only; the travel cost method and contingent valuation are used for cultural services only. The results indicate that the considered valuation methodologies show different levels of appropriateness with respect to specific ES categories. Therefore, there is a need to expand the application of valuation methodologies to capture the value of all ESs provided by natural resources, in order to protect and enhance them.

Keywords: urban ecosystem services valuation; nature-based solutions; economic valuation

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1. Introduction

The protection and enhancement of natural resources and nature-based solutions (NBSs) [1] are fundamental to ensure the correct functioning of ecosystems at different scales, from global to local, as ecosystem services (ESs) are the "direct and indirect contributions of ecosystems to human wellbeing" [2]. A better understanding of the economic value generated by NBSs, and the ESs they provide, can facilitate the adoption of efficient policies and measures to preserve and enhance them [3,4]. The monetary valuation of an ES is traditionally absent from economic accounting and so their production ordinarily fails to reach optimum social conditions. As a result, their critical contributions are not considered in public, corporate, and individual decision-making [5].

Public goods, such as water and air, are characterized by non-excludability and non-rivalry. The former signifies that it is not possible to selectively exclude some individuals from their use, while the latter signifies that consumption by one individual does not reduce its availability to others. Other environmental goods such as urban parks are closer to the category of common goods. Unlike public goods, common goods are non-excludable but rivalrous. Therefore, individuals cannot be excluded from their use, but consumption by one individual does reduce its availability to others.

In traditional environmental economic theory, this is the cause of market failure and justifies state intervention to avoid underproduction and the depletion of natural resources [6]. Coase [7] argues that this kind of market failure depends on the incomplete attribution of property rights on natural resources and the services they provide. Other authors argue that neither the state nor the market ensures that individuals sustain a long-term, productive use of natural resource systems and so innovative collaborative governance systems are needed [8].

When it comes to NBSs, assessing costs is usually quite straightforward. For example, planting a tree requires investments for the actual purchase, transport, site preparation, equipment, miscellaneous supplies, and labor costs [9]. However, valuing its benefits is more complicated. The ESs provided by trees in an urban context include climate regulation through shading, carbon sequestration, recreation, etc. [10]. The valuation of ES benefits allows the pricing of the impacts generated by human actions on the environment, thus disclosing the complexity of human–environment relationships and highlighting how human decisions affect the flows and the values of ESs [11]. It is important to note that the economic valuation is very unlikely to reveal the effective value of such goods or services, and an underestimation of such value is bound to occur. In particular, capturing the non-use value component of ESs can be cumbersome, as it is usually measured based on the preferences of individuals who do not often have complete knowledge about the issue with which they are presented. The presence of biases in some valuation methodologies also affects the estimation of the economic value of a good [12]. Measuring the monetary value of environmental goods and services still poses a problem, in particular at the urban level. The choice of the proper methodology to apply is linked to the ESs to be valued [13]. ESs are multi-functional, that is, they provide several benefits such as the improvement of air quality, climate regulation, flood risk reduction, urban heat island effect reduction, and cultural and recreational services, thus helping cities to cope simultaneously with the significant social, economic, and environmental challenges they face [14–17]. To capture the multi-functionality of an ES, it is necessary to select and adopt the appropriate valuation methodology which can fully capture the hidden values of the ES. This would foster the introduction of policies and actions which protect and enhance ESs though the implementation of NBSs. Attaching a value to environmental goods would make it easier for their inclusion in economic choices and public decision-making processes. Eventually, this will lead to the creation of stronger conservation policies, and to the adoption of economic instruments that would result in better safeguarding of the environment, such as payment for ecosystem services (PESs) [18–20].

The paper aims to identify, analyze, and describe the methodologies that can be used to gauge the economic value of the ES generated by the NBS at the urban level. Features and pros and cons of different valuation methodologies are assessed and a framework that highlights the linkages between specific economic valuation methodologies, ES categories, and the NBSs providing these ESs is created. To this purpose, a literature review of papers focused on the economic analysis of the ES provided at the urban level has been performed to detect the most frequently adopted methodologies for each category of ES. The methodologies analyzed have been categorized and associated with the ES valued. Moreover, the NBS providing the ES—e.g., urban forest, green roofs, etc.—have been considered as well. The paper contributes to (i) identifying a set of case studies which carried out a monetary valuation of ESs, (ii) detecting the most common methodologies for the valuation of ESs at the urban level and illustrating the strengths and weaknesses, (iii) creating a framework that matches ESs with valuation methodologies, and (iv) identifying existing gaps in valuation approaches. The paper is structured as follows: Section 2 describes the paper methodology; Section 3 provides a classification of ESs based on international frameworks; Section 4, analyses the case studies and the valuation methodologies found in literature; a discussion of the results is dealt with in Section 5; and finally conclusions are drawn in Section 6.

2. Methodology

The following steps of analysis were performed: (i) a literature review of case studies on ES valuation at the urban level, (ii) an analysis of the methodologies adopted in the literature (description, pros, and cons), and (iii) definition of a framework linking valuation methodologies with ESs at the urban level.

As a first step, a literature review of the case studies of ES valuation at the urban level has been performed using Scopus and Google Scholar. Research articles have been searched in English using combinations of words related to urban ESs and their economic value. In particular, the following keywords have been used: first, the methodology name, followed by "ecosystem service", "urban", and "(economic) valuation". The term "(economic) valuation" has been added only when the previous search did not return any relevant results. Besides the database search of scientific literature, bibliographic references were also drawn from the relevant articles and included in the present literature review. In total, the initial search yielded over 200 articles, 80 of which were considered for inclusion in the study after a screening of their abstracts. Given the purposes of this paper, only 25 of them were eventually selected for analysis: the ones which carry out a quantitative valuation of the economic benefits provided by ESs at the urban level. On the contrary, the ones which carry out only a qualitative analysis, in absence of an economic valuation, as well as those articles gauging ESs outside the urban context, have been excluded. The selected papers include 29 selected cases ranging from 1984 to 2018. The case studies collected through the literature review have been categorized based on (i) the methodological category (direct market valuation, revealed preferences, and stated preferences), (ii) the valuation methodology adopted, (iii) the location and year of valuation, (iv) the NBS that provides the ES, and (v) the ES valued.

The second step includes the analysis of the methodologies used to measure the economic value generated by the ES in the selected case studies. The methodologies have been analyzed and described taking into consideration three main elements: (i) the description of the methodology, (ii) the ES valued through each methodology, and (iii) the pros and the cons of the use of a methodology concerning specific ES categories. The third step capitalizes on the previous ones: pros and cons have been defined by taking into account the intrinsic properties of the valuation methodologies, the outcome of the case studies on the valuation of ESs, and the drivers that affect the implementation of such methodologies during the valuation process.

Finally, a framework that identifies the relations between specific economic valuation methodologies, ES categories, and the NBSs providing these ESs has been developed. The framework is composed of three elements: ES category, specific ES valued, and the methodology adopted for the economic valuation. The framework has been defined capitalizing on the results obtained through the previous methodological steps.

3. Ecosystem Services Categorization

ESs at the urban level contribute in several ways to human wellbeing. They ensure a better quality of life in cities by providing a myriad of benefits such as air and water purification, flood mitigation, noise reduction, local climate regulation, CO_2 sequestration, water and food provision, renewable energy supply, and higher physical and psychological wellbeing [14–16]. Several classifications of ESs have been provided, including those presented by the Millennium Ecosystem Assessment (MA) [2], the Economics of Ecosystems and Biodiversity (TEEB) [21], the Common International Classification of ES (CICES) [22], and the Mapping and Assessment of Ecosystems and their Services (MAES)—Urban ecosystems, 4th report [23].

The MA individuates four categories of ES: (i) regulating—"benefits obtained from the regulation of ecosystem processes, including, for example, the regulation of the climate, water, and some human diseases"; (ii) provisioning—"goods directly produced by ecosystems, such as food, freshwater, timber, and fibers"; (iii) cultural—"intangible benefits derived from ecosystems such as spiritual enrichment, recreation, and aesthetic experience, and aesthetic values"; and (iv) supporting—"the services that ensure the flow of the other ESs". Since the CICES and TEEB focus on different contexts, a correspondence framework between these two different classification approaches is provided hereby.

Figure 1 summarizes in detail the correspondence between the ESs identified by the CICES and the ones considered by TEEB. The first column refers to the classification of ESs made by the CICES. The second column refers to the name adopted by TEEB. Finally, the last column shows the definitions of each service identified according to TEEB, except for noise reduction and the regulation of water flows, the definitions of which are taken from the CICES since they are absent from TEEB classification. In order to have the full picture, the authors have included them as well. To define a complete framework of correspondence between the different classifications, ESs included in the MAES Urban classification have also been highlighted (boxes outlined in black in the second column).

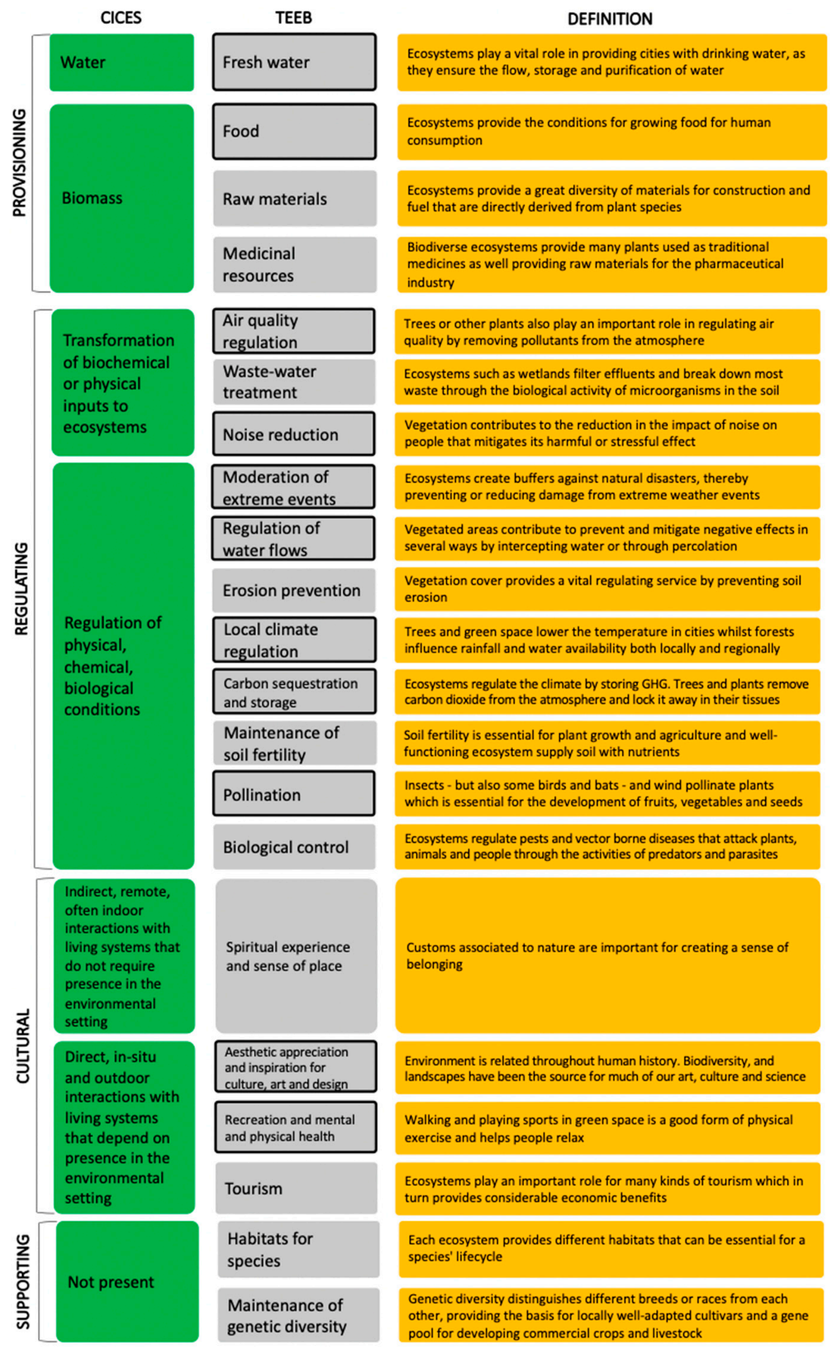

Figure 1. Ecosystem service (ES) classification. Bocconi University elaboration adapted from the Common International Classification of ES (CICES) and the Economics of Ecosystems and Biodiversity (TEEB).

The ES classification according to the MAES Urban is limited to only 11 out of the 21 ESs presented in Figure 1. That is because the MAES Urban only considers those ESs which are relevant to and occur in urban ecosystems, defined as socio-ecological systems composed of green infrastructure and built infrastructure [23]. For this study, only the ESs included in the MAES Urban are taken into account. According to the MAES Urban, freshwater and food are the main provisioning services in cities; noise reduction, air quality regulation, moderation of extreme events, regulation of water flows, local climate regulation, climate sequestration and storage, and pollination are the main regulating services; and finally, recreation, mental and physical health, and aesthetic appreciation and inspiration are the main cultural services. The only ESs that have been included in our study, despite being left out of both the MAES Urban and the CICES, are supporting services, namely habitats for species and maintenance of genetic diversity. In literature, these kinds of ESs are defined as intermediate ESs. Even if ESs do not produce direct benefits to human wellbeing [24], through a cascade model the linkages between intermediate ESs and final ESs can be put in evidence by investigating their indirect contribution to human wellbeing (e.g., urban parks create habitat for pollinators, which in turn provide pollination, beneficial to society) [25]. Moreover, several studies claim that urban parks constitute biodiversity hotspots and thus provide habitats for wildlife [26]. Since the interaction with biodiversity is among the activities of park visitors [27], the provision of habitats for species in urban contexts does contribute directly to human wellbeing. Thus, as a habitat for species, the ES is deemed as a final service and not only as an intermediate one in this study. Indeed, whether ESs have an intermediate or final role depends on the context [28].

4. Classification of Methodologies for Ecosystems Services Valuation at the Urban Level

4.1. Valuation of Ecosystem Services

Different approaches have been defined for the valuation of ESs such as the System of Environmental–Economic Accounting Central Framework (SEEA) adopted by the United Nations Statistical Commission [29], and the Mapping and Assessment of Ecosystems and their Services (MAES) developed by the European Commission Joint Research Centre (JRC) [30]. The former hinges around asset accounts, which record both the opening and closing stock of assets and changes over the accounting period, whereas the latter proposes a set of indicators to measure ESs at the national level. A third approach has been proposed by the Economics of Ecosystem and Biodiversity [21], which requires considering the Total Economic Value (TEV) generated by the ES. The TEV is "the sum of the values of all service flows that natural capital generates both now and, in the future—appropriately discounted" [19]. Hence, the TEV considers also the "hidden" components of environmental goods that markets fail to account for. The value is measured in terms of marginal changes of the natural capital stock, that is, by assessing the quality and quantity of environmental goods and services [31]. Therefore, through a standard unit of account, the TEV can capture all of the elements of utility and disutility obtained from the ES, taking into consideration all the services and disservices produced by nature. This framework considers both the value that humans receive when they make use of the natural capital and the value they attribute to it that does not originate from any exploitation. In particular, the TEV distinguishes between use-value and non-use value [21,31], and both of them are classified in different typologies.

Use-value is created when individuals interact with nature, either directly or indirectly. It includes: (i) the direct use-value, generated when individuals in a consumptive or a non-consumptive way use nature; (ii) the indirect use-value, which indicates the benefits to individuals who are not actually making use of the ESs, supported by nature [32–34]; and (iii) the option value, which is the benefit from the possibility of using a resource in the future, without any imminent intention of using it at the current time. The existence of such value is due to the uncertainty concerning future preferences and/or the availability of the good.

Non-use value is the value attributed to economic goods even if these have never been and never will be used. Non-use value consists of three components: (i) the altruistic value, stemming from the awareness that contemporaries get to enjoy the natural environment; (ii) the bequest value, given by the fact environmental goods and services are preserved for future generations; and (iii) the existence value, consisting of the satisfaction coming from the existence of the natural environment [31,35].

The TEV identifies three main approaches to valuate ESs. In the first one, values are derived from the market transactions directly related to the ES considered; in the second one, values are derived from parallel market transactions that are associated indirectly with the ES considered; in the third one, information on the ES value is gauged through the creation of hypothetical markets [21].

Based on this, the corresponding monetary valuation methodological categories have been identified: (i) the direct market valuation (market price methods, replacement cost and damage cost avoided, and production function approaches)—based on the use of data from real markets, which reflect actual preferences or costs for individuals, to estimate use-value; (ii) the revealed preferences (hedonic pricing and travel cost methods)—based on individual choices in existing markets linked to the use of the considered natural resource; and (iii) the stated preferences (contingent valuation, choice modeling, and deliberative monetary valuation)—based on the simulation of market demand for ESs using surveys on hypothetical variations used for the value of use and non-use [33,36,37]. Although these methodologies can be adopted at various scales, the study focuses on those that can be used at the urban level only. Through the literature review, it has been possible to determine which methodologies have been adopted so far at the scale of interest.

4.2. Valuation of Ecosystem Services at the Urban Level

The choice of the methodology to apply is tightly linked to the ESs to be valued. ESs can vary in scale, from the local, regional, national, to global level, and in scope, being terrestrial or marine, inland or coastal, rural or urban [13], and in their presence or absence in a specific ecosystem which affects the choice of the methodologies to be adopted at that level. In fact, different spatiotemporal features including habitats, geographic contexts, and political and socio-economic characteristics affect how ESs are provided and experienced [38]. It is therefore necessary to understand the magnitude of the bio-physical conditions in order to properly carry out an economic valuation of the ESs found at a certain scale. An ES cascade model links ecological and biophysical structures to elements of human wellbeing through a series of intermediate steps, thus shedding light on questions such as what the limits to the capacity of supply of ESs are in different situations, and how to value the contributions that ESs make to human wellbeing [39]. Hence, it is important to map ESs as a way to analyze their spatial distribution in a territory, which determinates both their supply and demand [40,41]. Mapping ESs is also essential to make localization choices regarding new NBSs. Indeed, mapping ESs can either drive an increase in the presence of NBSs in areas where they are scarce, following distributional equity criteria, or it may accrue the concentration of NBSs in areas where the number of potential users of NBSs and their willingness to pay for them is higher, following economic maximization criteria [38].

This paper, by focusing on ESs within cities, makes a step forward in assessing the valuation methodologies adopted at the urban level. Through the literature review, 25 papers (for a total of 29 case studies and 36 observations of ES valuations) have been found to carry out an economic valuation of ESs at the urban level. In total 11 ESs—9 of which considered by the MAES Urban were found within cities, plus 2 others—have been valued in 10 countries. Those services have been provided by nine different NBSs. The selected case studies refer to different years, ranging from 1984 to 2018.

The case studies have been summarized in Table 1 and have been categorized based on the following elements: (i) the valuation methodology adopted, (ii) the location, (iii) the year of valuation, (iv) the natural resource providing the ES, and (v) the ES valued.

Table 1. ESs valued at the urban level.

Method	Location	Year	Nature-Based Solution (NBS)	ES Valued	Reference
Market Price Methods	Beijing	N.A.	Urban forest	Carbon storage and sequestration	Leng et al., 2004 [42]
	Lanzhou	N.A.	Urban forest	Air quality regulation	Zhang et al., 2006 [43]
	Hong Kong	N.A.	Green roof	Air quality regulation; carbon storage and sequestration	Peng and Jim, 2015 [44]
	Boston	2015	Urban orchards	Food	Goldstein et al., 2017 [45]
Replacement Cost & Damage Cost Avoided	Stockholm national urban park	N.A.	Eurasian jays	Pollination	Hougner et al., 2006 [46]
	Sacramento	N.A.	Urban forest	Local climate regulation	Simpson, 1998 [14]
	Beijing	N.A.	Urban forest	Local climate regulation	Leng et al., 2004 [42]
	Lanzhou	N.A.	Urban forest	Air quality regulation	Zhang et al., 2006 [43]
	Southwest USA	2013	Green roof	Local climate regulation	McRae, 2016 [47]
	Hong Kong	N.A.	Green roof	Local climate regulation	Peng and Jim, 2015 [44]
	Rio de Janeiro	N.A.	Fluvial floodable park; green roof	Moderation of extreme events	Miguez et al., 2018 [48]
	Rome	2005	Urban forest	Air quality regulation	Capotorti et al., 2017 [49]
	Chicago	1991	Urban forest	Air quality regulation	McPherson et al., 1994 [50]
	Sacramento	1990	Urban forest	Air quality regulation	Scott et al., 1998 [51]
	Philadelphia	N.A.	Urban forest	Air quality regulation; carbon storage and sequestration	Nowak et al., 2007 [52]
	Chicago	1991	Urban forest	Local climate regulation	McPherson et al., 1997 [53]
	Modesto	1998	Urban forest	Local climate regulation; carbon storage and sequestration	McPherson et al. 1999 [54]
	New York	2005	Urban forest	Carbon storage and sequestration; regulation of water flows; air quality regulation	Peper et al., 2007 [55]
Hedonic Pricing	New York	2005	Urban forest	Aesthetic appreciation and inspiration for culture, art, and design	Peper et al., 2007 [55]
	Joensuu	1984–1986	Urban forest	Aesthetic appreciation and inspiration for culture, art, and design	Tyrväinen, 1997 [56]
	Portland	2007	Urban forest	Aesthetic appreciation and inspiration for culture, art, and design	Donovan and Butry, 2010 [57]
Travel Cost	Bulawayo	2015	Urban green spaces	Spiritual experience and sense of place	Ngulani and Shackleton, 2019 [58]
	Guiyang	2015	Urban wetland park	Recreation and mental and physical health	Wang et al., 2019 [59]
Contingent Valuation	Joensuu	1995	Urban forest	Aesthetic appreciation and inspiration for culture, art, and design	Tyrväinen and Väänänen, 1998 [60]
	Guangzhou	2003	Urban forest	Recreation and mental and physical health	Jim and Chen, 2006 [61]
	Beijing	2018	Green roof	Local climate regulation	Zhang et al., 2019 [62]
Choice Modelling	Hong Kong	N.A.	Green building development	Regulation of water flows; local climate regulation; air quality regulation	Chau et al., 2010 [63]
	South Korea	2010	Urban forest	Local climate regulation	Kim et al., 2016 [64]
	Southampton	2014/15	Green wall	Habitats for species	Collins et al., 2017 [65]

Based on the analysis of the cases studies, some ESs gauged at the urban level are more often compared to others: the most considered ESs for valuation are air quality regulation (nine observations), local climate regulation (nine observations), carbon sequestration and storage (five observations), and aesthetic appreciation and inspiration for culture, art, and design (four observations). The ES fresh water and noise reduction, both among the 11 ESs to be found within urban ecosystems according to the MAES Urban, are not present in current literature. On the contrary, two other ESs that are not included in the MAES Urban classification—spiritual experience and sense of place, and habitats for species—have been gauged. Table 2 summarizes the results drawn by the literature review analysis.

Table 2. ESs valued at the urban level.

ES Category	ES Typology	No. of Observations
Regulating	Carbon storage and sequestration	5
	Air quality regulation	9
	Local climate regulation	9
	Moderation of extreme events	1
	Regulation of water flows	2
	Pollination	1
Provisionng	Food	1
Cultural	Aesthetic appreciation and inspiration for culture, art, and design	4
	Spiritual experience and sense of place	1
	Recreation and mental and physical health	2
Supporting	Habitat for species	1

Moving on to ES valuation methodologies, not all of them are used in literature at the urban level: for example, production function approaches and deliberative monetary valuations have not been found. There are several reasons why some methodologies are not used at the urban level, such as lack of data needed to perform the valuation, impossibility to identify the impacts generated by the ES, underestimation of some ESs, or because a specific methodology is used to value ESs that are not present at the urban level. In more detail, Table 3 summarizes the methodologies that have been adopted in the considered papers.

Table 3. Methodologies adopted for ES valuation at the urban level.

Methodology	No. of Observations
Market price methods	4
Replacement cost & damage cost avoided	14
Hedonic prices	3
Travel costs	2
Contingent valuation	3
Choice modelling	3

In fact, the selection of a methodology depends on several factors, and in particular, the presence of NBSs that provide specific ESs at a given scale, as well as the availability and ability to retrieve the necessary data to perform the valuation. In some cases, a specific ES is absent at the urban level and consequently some methodologies cannot be adopted. For example, production function approaches are used to determine the value of inputs affecting agriculture, forestry, and fisheries, and the ES supporting them. However, in the urban context agriculture is barely present, let alone forestry and fisheries. Another factor that determines whether a methodology is suitable to be implemented at a certain scale is the availability and the quality of data. For instance, hedonic pricing is adopted mostly in urban contexts, as it relies on house pricing data. This methodology uses the price change of a good as a benchmark; at the urban level, this good is real estate property. The methodologies pro and cons and the possibility to adopt them at the urban level have been analyzed in further detail and reported in Table 4. This table summarizes the six methodologies that have been used in the analyzed case studies. The structure of the methodology assessment includes: (i) the methodology name; (ii) the definition of the methodology; (iii) the kinds of values considered; (iv) the ES categories included; and

(v) the pros, and (vi) cons. The pros and cons have been defined based on the strengths and weaknesses of the valuation methodology referred to by authors in the case studies analyzed in the literature review.

Table 4. Methodologies adopted for ES valuation at the urban level.

	Methodology	Definition	Values	ES	Pros	Cons
Direct market valuation	Market Price methods [66]	"Market-price methods utilize directly observed prices and/or costs from actual markets related to the provision of an environmental good or service as a proxy to the value of those goods."	Direct and indirect use-value	Provisioning, regulating, and cultural services	Price data are easy to obtain.	The value of goods and services can be underestimated due to market imperfections. The value of the natural resource can be underestimated, considering the inability to capture non-use values.
	Replacement cost & damage cost avoided [32]	"The replacement cost method measures the potential expenditures in replacing/restoring the function that is lost. The damage cost avoided method measures the costs that would be incurred if a specific environmental function were not present."	Direct and indirect use-value	Regulating services	Straightforward and time- and resource- saving nature, thus allowing for an application even in countries where resources and technical skills are limited.	The methodology relies on the quality of data available, since inaccurate values can lead to a misleading appraisal of the natural resource.
Revealed preferences	Travel cost method [31]	"The travel cost method is a survey-based technique that uses the cost incurred by individuals travelling to and gaining access to a recreation site as a proxy for the recreational value of that site."	Use-value	Cultural services	It allows computing of the recreational value of any location and is quite easy to implement.	It tends to underestimate the recreational value of the site since it only considers the time and money spent on getting there. The method cannot be applied in case of multifunctional trips, in which the visit to the site is not the only destination. It is not applicable to studies in the poorest countries, where the majority of people cannot afford to travel.
	Hedonic pricing [32]	"Hedonic pricing attempts to (i) identify how much of a property differential is due to a particular environmental difference between properties and (ii) infer how much people are willing to pay for an improvement in the environmental quality that they face and what the social value of the improvement is."	Direct and indirect use-value	Cultural services	It can isolate the effects of ESs on land value, under the assumption that those services are fully reflected in land prices.	It relies on a large amount of high-quality data on property price.
Stated preferences	Contingent valuation [67]	"Environmental evaluations are obtained by using surveys to ask people directly their willingness to pay or willingness to accept a given gain or loss of a specified good."	Use-value and non-use value	Any services	It allows for a high degree of flexibility in the formulation of the questions, including the valuation of scenarios that are yet to happen.	Respondents' valuation can be influenced by their prior knowledge and by what they are told in the questionnaire. Hence, bias issues in survey design should be taken into account. It is based on hypothetical behavior.
	Choice modelling [66]	"The choice modelling technique estimates economic values by constructing a hypothetical market for the non-market environmental good."	Use-value and non-use value	Any services	Respondents do not have to give a price valuation of the natural resource, but just need to select their preferred policy option, thus ruling out any sort of bias related to respondents' lack of knowledge about monetary economy.	It is more complex to analyze and to explain to the respondents, who may not look at the policy characteristics as a bundle but focus only on one attribute.

The analysis performed highlights the relations between the valuation methodologies and the ES. The same ES can be valued through a plurality of approaches: three methodologies in the case of provisioning services, four in the case of regulating services, and five in the case of cultural services. Furthermore, it has been possible to identify the main pros and cons of each methodology. When considering the pros, they can be summed up as follows: (i) easy-to-obtain data for market price methods; (ii) easy-to-use methodology, hence time and resource-saving for replacement cost and damage cost avoided, and travel cost methods; (iii) flexible and adaptable methodological structure for contingent valuation; and (iv) no previous knowledge required from respondents for choice modelling. Instead, the cons can be grouped into: (i) ES value underestimation for market price methods and travel cost methods; (ii) high-quality data requirement for market price methods, and replacement cost and damage cost avoided methods; and (iii) bias problems in survey design for contingent valuation, and choice modelling.

5. Discussion

The relationships between valuation methodologies, ESs considered, and the NBSs providing the service have been identified through the analysis. These relationships are graphically represented through a framework linking the ES considered, the methodologies adopted to value them, and the NBS that provided the specific ES valued. The methodologies are illustrated in Figure 2. The ESs are divided according to the category they belong to—namely, provisioning, regulating, cultural, and supporting.

The framework shows that direct market valuation methodologies are the most adopted in the case studies detected through the literature review. In particular, the market price methodology has been applied for the valuation of three different ESs (food, air quality regulation, and carbon sequestration and storage), while replacement costs and damage cost avoided have been applied for the valuation of six ESs (air quality regulation, carbon sequestration and storage, moderation of extreme events, regulation of water flows, local climate regulation, and pollination). The direct market valuation category is followed by the stated preference category: choice modelling gauges four different ESs (erosion prevention, regulation of water flows, local climate regulation, and habitat for species), while contingent valuation gauges three ESs (local climate regulation, recreation and physical and mental health, and aesthetic appreciation and inspiration for culture, art, and design). Finally, the least adopted category is revealed preference: the travel cost method measures two ESs (recreation and physical and mental health, and spiritual experience and sense of place), while hedonic pricing only measures one (aesthetic appreciation and inspiration for culture, art and design). In total, seven ESs are valued by direct market valuation methods, six by stated preference methods, and three by revealed preference methods. It is also possible to observe that, based on the literature review performed, a few ESs have not been valued at all: out of the 11 ESs identified in the MAES Urban, 9 have been valued in literature so far.

The framework shows how some methodologies are used only for some categories of ESs. Direct market valuation has been used to value provisioning and regulating services and revealed preferences to assess cultural services, while stated preferences has gauged regulating, cultural, and supporting services.

In more detail, the ES category with the most observations is by far that of regulating services (27 out of 36 observations): air quality regulation and local climate regulation have been valued the most, with nine valuations each, followed by carbon sequestration and storage, with five valuations. It is not surprising that these ESs are the most studied, given their capacity to deliver positive impacts on environmental, social, and economic dimensions at the same time [68]. For example, a local climate regulation ES, which is tightly linked with urban heat island effect, generates benefits that copes with all of the three challenges: through a decrease in temperature, it improve citizens wellbeing (social effect), diminishes the impact of climate change (environmental effect), and finally, reduces households' energy expenses (economic effect). Specific methodologies have been used for the valuation of the ESs for each of the following categories: provisioning, regulating, cultural, and supporting. In some cases, the same ES category can be valued through different methodologies belonging to different methodological categories.

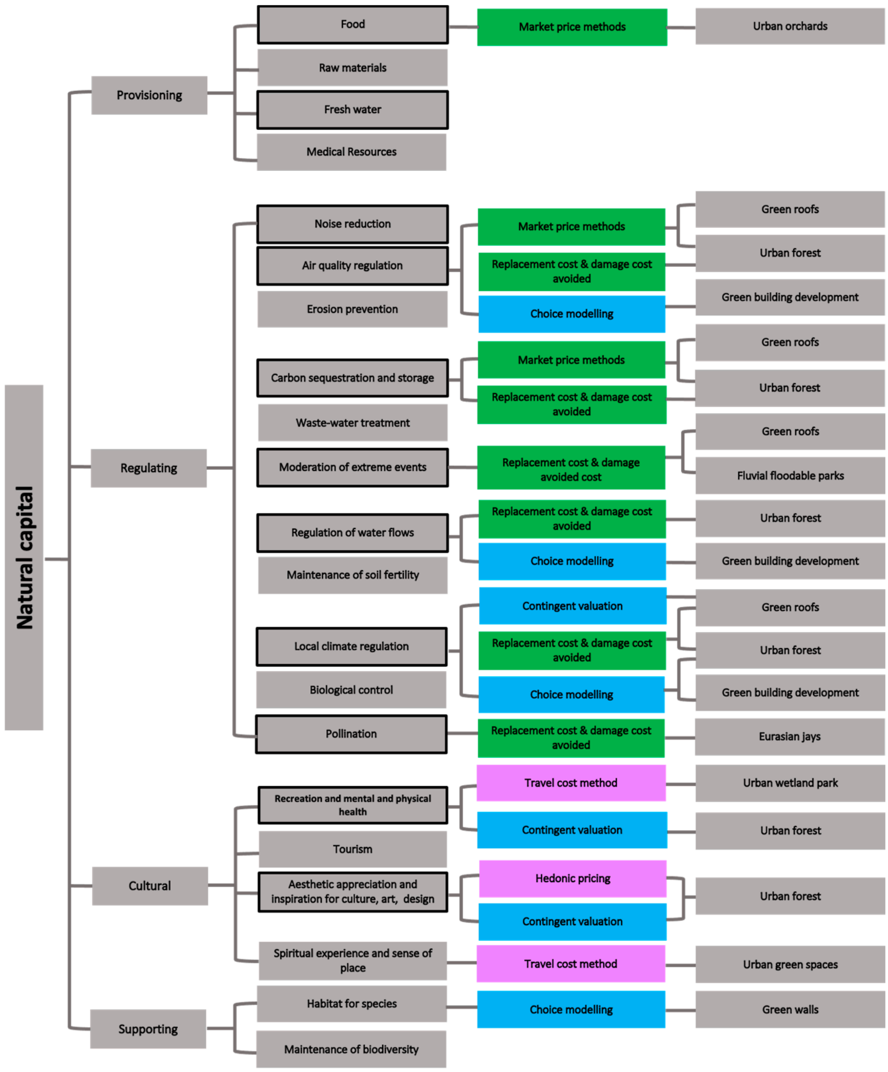

Figure 2. Framework linking NBSs, ESs, and the methodologies used to value them. ES boxes outlined in black indicate ESs found at the urban level according to the MAES Urban classification. Methodologies in green boxes belong to the direct market valuation approach, those in purple boxes to the revealed preference approach, and those in light blue boxes to the stated preference approach.

For the provisioning category, only the market price methodology has been adopted to value the provisioning of food at the urban level. In total it has been possible to detect the valuation of one out of four ESs included in the provisioning category through the case study literature review, although markets exist for most provisioning services in particular those linked with water. Although, as suggested by Koetse [69], provisioning services can also be valued through contingent valuation and choice modelling valuation. For the regulating category, different methodologies have been applied: market price methods, replacement costs and damage cost avoided, choice modelling, and contingent valuation, and in total it has been possible to detect the valuation of six out of eleven ESs included in the regulating category through the case study literature review. Even in the case of regulation services other methodologies can be applied: hedonic prices, contingent valuation, and choice modelling valuation [69,70]. For the valuation of the services under the cultural category, the methodologies adopted are the travel cost method, hedonic pricing, and contingent valuation (in total it has been possible to detect the valuation of three out of four ESs included in the cultural category through the case study literature review). Finally, for the supporting category, habitat for species has been valued through the choice modelling methodology (in total it has been possible to detect the valuation of one out of two ESs included in the supporting category through the case study literature review).

Besides this, as previously described, various methodologies can be used to measure the use-value and non-use value of NBSs and the related ES associated. In particular, direct use-value is usually estimated through direct market valuation approaches such as market-price based, cost-based, and production function approaches, which rely on data from actual markets to carry out the economic valuation [42–45]. For indirect use-value, along with direct market valuation approaches, revealed preferences (hedonic pricing and travel cost methods) [55–58], and stated preferences (contingent valuation and choice modelling) can also be adopted [60–65]. Since it is based on future scenarios that are yet to happen, option value can only be measured through stated preference methods, that is contingent valuation and choice modelling. Indeed, contingent valuation and choice modelling are the only methodologies able to value non-use values of ESs. Even if these methodologies can be applied to all ES categories [69,70], in the case studies analyzed these methods have been used to value only 6 out of 21 ESs considered.

First of all, the results highlight that not all the ESs provided by an NBS are valuated in literature. In fact, in the majority of the detected case studied only one ES per each NBS considered is valued (only 3 case studies out of 25 value more than one ES). So, even if NBSs are by definition multifunctional and can provide different ESs at the same time, the economic valuation carried out is able to catch only part of the generated benefits [38].

Secondly, non-use values are often not considered in the valuation of the ES. In fact, they can be detected through the adoption of the contingent valuation and choice modelling methodologies, which are scarcely adopted (in the case studies analyzed these methodologies have been used only 7 times out of 29). Non-use values are particularly important at the urban level as they are linked with aspects such as scenery and landscape, community identity, and sense of place, which significantly affect wellbeing in cities.

So, it can be said that the value generated by ESs at the urban level is generally underestimated. The lack of considerations of the full economic value of ESs generated by NBSs at the urban level can incentivize the undesirable conversion of ecosystems into built infrastructures, with an associated loss of ES. A critical aspect refers to the difference in values estimated through the use of the different methodologies. A possibility to provide more reliable values of NBSs is to use a combination of valuation models [70,71].

Moreover, values of ESs are often site-specific, as societal and economic conditions of each context, including the characteristics of urban residents and in particular their economic status, affect the values of ESs following several methodologies, especially the ones based on the willingness to pay (e.g., contingent valuation) [72]. In some case the economic valuation "can fail to reflect the plurality of values across different stakeholder groups within complex socio-ecological systems" [73]. This can lead to a different attribution of values to the ES produced by a NBS based on their location. This can potentially lead to unequal distribution of NBSs in cities and raise social divide issues. For example, land use planning for climate change adaptation has often been found to exacerbate socio-spatial inequalities [74] by concentrating the implementation of NBSs in higher-wealth neighborhoods [41].

Other approaches can be adopted to assess the benefits generated by ESs, such as the mapping of the status of ESs [75–77] helping to overcome some of the barriers and biases encountered in the economic valuation of ESs. In fact, ES mapping can be used to investigate how ES values vary across space and identify spatial areas with high or low provision and high or low demand for ESs [78]. This can lead to policies targeted to reduce gaps and differences. Furthermore, mapping ESs makes it possible to analyze their spatial configuration, highlighting which the inter-connections and dependencies are between ES provisioning at different scales. Mapping ESs can be linked to economic valuation to compare the relation between ES demand and supply [40,79], and to measure the economic value of the benefits derived from ES conservation and enhancement [38,80]. Mapping ESs and in particular presenting data at finer resolution can support the management of

ESs also at smaller scales and can contribute to (i) providing more relevant information for specific management interventions, (ii) facilitating the engagement of other relevant scientific disciplines [40], and (iii) guiding land use planning and land management at large scales, where multiple sectors, such as agriculture, urban areas, water resources, conservation, and forestry intersect [81]. This can help to take into account the urban-rural area interactions that are essential to ensure the flow of ESs. Even if the majority of the ES mapping studies are focused on a wider scale, studies in urban areas are increasing [82].

In fact, one of the main barriers encountered in valuation is the lack of bio-physical data, so the creation of a dataset on the state of ESs over time, based on the mapping of ESs, can support the application of several economic valuation methodologies.

Overall, the economic valuation of ESs should be further developed and experimented upon at the urban level also with the support of other approaches and interactions with other disciplines. In fact, economic valuation can contribute to improved urban planning and management of NBSs by informing decisions makers about the full social cost and benefits provided by ESs, leading to more efficient public choices and an increase of social wellbeing.

6. Conclusions

The paper assesses the economic valuation methodologies adopted to measure the monetary value of ESs generated by NBSs at the urban level, through an analysis based on a literature review. It finds that six different valuation methodologies have been employed in the 29 case studies found within 25 papers. Although several studies on the methodologies of the economic valuation of ESs already exist, the literature review brought to light some characteristics of the valuation methodologies when adopted specifically at the urban level.

The economic valuation of NBSs and the ESs generated by them is not trivial since in most cases markets fail to price these goods properly. Due to their nature as public or common goods, these goods are difficult to value and thus difficult to protect and enhance. That is why attaching a value to nature would make it easier to include them in private and public decision-making processes. Indeed, such inclusion of public goods would lead to the social optimization of ESs, because it would allow their regulation along with their supply, thus guaranteeing they are safeguarded. This is especially true at the urban level, where ES benefits are of the utmost importance. The economic valuation can shed light on the multifunctionality of ESs at the urban level, thus allowing the capture of their overall value. For example, a single ES could provide not only environmental but also social and economic benefits: the extensive application of the methodologies for the economic valuation of ESs within cities could lead to a better estimation of such benefits, also taking into account the hidden values that markets are not able to catch. Therefore, thanks to the adoption of economic valuation methodologies, it is possible to avoid underestimating the benefits generated by ESs. With a clear picture of their value and contribution to human wellbeing, governments would promote the definition of adequate policies and measures to protect and enhance ESs through the implementation of NBSs.

The analysis carried out in the paper is affected by some limitations—mainly, it has been developed based on limited available literature. Furthermore, the selection of relevant case studies has been furtherly hindered by the scarcity of economic valuations in literature. Nevertheless, the paper represents a step forward in understanding the value of nature at the urban level and in assessing the main methodologies to value the different typologies of ESs. It sets the stage for the development of further investigations aimed standardizing the valuation methodologies that can be applied at the urban level to value ESs and to define the ranges of values provided by each ES when they are considered depending on specific local conditions. This could provide a better estimation of the impacts generated by natural resources at the urban level, thus supporting the improvement of policies for the enhancement of natural resources.

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References

1. IEEP. *Workshop on Mobilizing Up-Scaling of Nature-Based Solutions for Climate Change throughout 2020 and Beyond*; IEEP: Brussels, Belgium, 2020.
2. Reid, W.; Mooney, H.; Cropper, A.; Capistrano, D.; Carpenter, S.; Chopra, K. *Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Synthesis*; Island Press: Washington, DC, USA, 2005.
3. Keyzer, M.; Sonneveld, B.; Veen, W. Valuation of Natural Resources: Efficiency and Equity. *Dev. Pract.* **2009**, *19*, 233–239. [CrossRef]
4. Hailu, F. *The Economic Value of Natural and Environmental Resource*; GRIN Verlag: München, Germany, 2013.
5. Kumar, P.; Esen, S.E.; Yashiro, M. Linking Ecosystem Services to Strategic Environmental Assessment in Development Policies. *Environ. Impact Assess. Rev.* **2013**, *40*, 75–81. [CrossRef]
6. Dasgupta, P. The Economics of the Environment. *Environ. Dev. Econ.* **1996**, *1*, 387–428. [CrossRef]
7. Coase, R.H. The Problem of Social Cost. In *Classic Papers in Natural Resource Economics*; Gopalakrishnan, C., Ed.; Palgrave Macmillan UK: London, UK, 1960; pp. 87–137, ISBN 978-0-230-52321-0.
8. Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*; Political Economy of Institutions and Decisions; Cambridge University Press: Cambridge, UK, 1990.
9. McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Gardner, S.L.; Vargas, K.E.; Maco, S.E.; Xiao, Q. *Piedmont Community Tree Guide: Benefits, Costs, and Strategic Planting*; PSW-GTR-200; U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station: Albany, CA, USA, 2006.
10. Dobbs, C.; Kendal, D.; Nitschke, C.R. Multiple Ecosystem Services and Disservices of the Urban Forest Establishing Their Connections with Landscape Structure and Sociodemographics. *Ecol. Indic.* **2014**, *43*, 44–55. [CrossRef]
11. Mooney, H.; Cropper, A.; Reid, W. Confronting the Human Dilemma. *Nature* **2005**, *434*, 561–562. [CrossRef]
12. Graves, P.E. *Chapter 15: Environmental Valuation: The Travel Cost Method*; Social Science Research Network: Rochester, NY, USA, 2013.
13. DEFRA. *An Introductory Guide to Valuing Ecosystem Services*; DEFRA—Department for Environment Food and Rural Affairs: London, UK, 2007.
14. Simpson, J.R. Urban Forest Impacts on Regional Cooling and Heating Energy Use: Sacramento County Case Study. *J. Arboric.* **1998**, *24*, 201–214.
15. Carter, J.G. Climate Change Adaptation in European Cities. *Curr. Opin. Environ. Sustain.* **2011**, *3*, 193–198. [CrossRef]
16. Camps-Calvet, M.; Langemeyer, J.; Calvet-Mir, L.; Gómez-Baggethun, E. Ecosystem Services Provided by Urban Gardens in Barcelona, Spain: Insights for Policy and Planning. *Environ. Sci. Policy* **2016**, *62*, 14–23. [CrossRef]
17. Majidi, A.N.; Vojinovic, Z.; Alves, A.; Weesakul, S.; Sanchez, A.; Boogaard, F.; Kluck, J. Planning Nature-Based Solutions for Urban Flood Reduction and Thermal Comfort Enhancement. *Sustainability* **2019**, *11*, 6361. [CrossRef]
18. Engel, S.; Pagiola, S.; Wunder, S. Designing Payments for Environmental Services in Theory and Practice: An Overview of the Issues. *Ecol. Econ.* **2008**, *65*, 663–674. [CrossRef]
19. Muradian, R.; Corbera, E.; Pascual, U.; Kosoy, N.; May, P.H. Reconciling Theory and Practice: An Alternative Conceptual Framework for Understanding Payments for Environmental Services. *Ecol. Econ.* **2010**, *69*, 1202–1208. [CrossRef]
20. Croci, E.; Lucchitta, B. Nature-Based Solutions (NBSs) for Urban Resilience. Introduction. *Econ. Policy Energy Environ.* **2019**, 31–42. [CrossRef]
21. Sukhdev, P.; Wittmer, H.; Schröter-Schlaack, C.; Neßhöver, C.; Bishop, J.; Ten Brink, P.; Gundimeda, H.; Kumar, P.; Simmons, B. *Mainstreaming the Economics of Nature: A Synthesis of the Approach, Conclusions and Recommendations of TEEB*; UNEP: Nairobi, Kenya, 2010.
22. Haines-Young, R.; Potschin, M. *CICES Version 4: Response to Consultation*; Centre for Environmental Management, School of Geography, University of Nottingham: Nottingham, UK, 2012; p. 17.
23. European Commission. Directorate General for the Environment. In *Mapping and Assessment of Ecosystems and Their Services*; Urban Ecosystems, 4th Report; Publications Office: Luxembourg, 2016.

24. Lamothe, K.; Sutherland, I. Intermediate Ecosystem Services: The Origin and Meanings behind an Unsettled Concept. *Int. J. Biodivers. Sci. Ecosyst. Serv. Manag.* **2018**, *14*, 179–187. [CrossRef]
25. Saarikoski, H.; Jax, K.; Harrison, P.A.; Primmer, E.; Barton, D.N.; Mononen, L.; Vihervaara, P.; Furman, E. Exploring Operational Ecosystem Service Definitions: The Case of Boreal Forests. *Ecosyst. Serv.* **2015**, *14*, 144–157. [CrossRef]
26. Nielsen, A.B.; van den Bosch, M.; Maruthaveeran, S.; van den Bosch, C.K. Species Richness in Urban Parks and Its Drivers: A Review of Empirical Evidence. *Urban Ecosyst* **2014**, *17*, 305–327. [CrossRef]
27. Palliwoda, J.; Kowarik, I.; von der Lippe, M. Human-Biodiversity Interactions in Urban Parks: The Species Level Matters. *Landsc. Urban Plan.* **2017**, *157*, 394–406. [CrossRef]
28. Potschin-Young, M.; Czúcz, B.; Liquete, C.; Maes, J.; Rusch, G.; Haines-Young, R. Intermediate Ecosystem Services: An Empty Concept? *Ecosyst. Serv.* **2017**, *27*, 124–126. [CrossRef]
29. United Nations. *System of Environmental-Economic Accounting 2012—Central Framework*; United Nations: New, York, NY, USA, 2014.
30. European Commission. Directorate General for the Environment. In *Mapping and Assessment of Ecosystems and Their Services: An Analytical Framework for Ecosystem Assessments under Action 5 of the EU Biodiversity Strategy to 2020*; Publications Office: Luxembourg, 2013.
31. Ozdemiroglu, E.; Tinch, R.; Johns, H.; Provins, A.; Powell, J.C.; Twigger-Ross, C. *Valuing Our Natural Environment—Final Report*; EFTEC: London, UK, 2006.
32. Pearce, D.; Turner, R. Economics of Natural Resources and the Environment/D.W. Pearce, R.K. Turner. *Am. J. Agric. Econ.* **1991**, *73*, 100–101. [CrossRef]
33. De Groot, R.; Stuip, M.A.M.; Finlayson, M.; Davidson, N. *Valuing Wetlands: Guidance for Valuing the Benefits Derived from Wetland Ecosystem Services*; International Water Management Institute: Colombo, Sri Lanka, 2006.
34. Balmford, A.; Rodrigues, A.S.L.; Walpole, M.; Brink, P.; Kettunen, M.; Braat, L.; de Groot, R. *The Economics of Ecosystems and Biodiversity: Scoping the Science*; European Commission: Cambridge, UK, 2008.
35. Randall, A.; Stoll, J. Existence Value in a Total Valuation Framework. In *Managing Air Quality and Science Resources at National Parks and Wilderness Areas*; CRC Press: Boca Raton, FL, USA, 1983; pp. 265–274.
36. Ecosystem Valuation. Available online: http://www.ecosystemvaluation.org (accessed on 15 November 2019).
37. Wilson, M.A.; Carpenter, S.R. Economic Valuation of Freshwater Ecosystem Services in the United States: 1971–1997. *Ecol. Appl.* **1999**, *9*, 772–783. [CrossRef]
38. Pulighe, G.; Fava, F.; Lupia, F. Insights and Opportunities from Mapping Ecosystem Services of Urban Green Spaces and Potentials in Planning. *Ecosyst. Serv.* **2016**, *22*, 1–10. [CrossRef]
39. Potschin, M.B.; Haines-Young, R.H. Ecosystem Services: Exploring a Geographical Perspective. *Prog. Phys. Geogr.* **2011**, *35*, 575–594. [CrossRef]
40. Malinga, R.; Gordon, L.J.; Jewitt, G.; Lindborg, R. Mapping Ecosystem Services across Scales and Continents—A Review. *Ecosyst. Serv.* **2015**, *13*, 57–63. [CrossRef]
41. Grêt-Regamey, A.; Weibel, B.; Kienast, F.; Rabe, S.-E.; Zulian, G. A Tiered Approach for Mapping Ecosystem Services. *Ecosyst. Serv.* **2015**, *13*, 16–27. [CrossRef]
42. Leng, P.; Yang, X. Economic valuation of urban greenspace ecological benefits in Beijin city. *J. Beijing Agric. Coll.* **2004**, *19*, 25–28.
43. Zhang, W. Initial analysis on the ecological service value of the greening land in Lanzhou city. *Pratacultural Sci.* **2006**, *23*, 98–102.
44. Peng, L.L.H.; Jim, C.Y. Economic Evaluation of Green-Roof Environmental Benefits in the Context of Climate Change: The Case of Hong Kong. *Urban For. Urban Green.* **2015**, *14*, 554–561. [CrossRef]
45. Goldstein, B.; Hauschild, M.; Fernández, J.; Birkved, M. Contributions of Local Farming to Urban Sustainability in the Northeast United States. *Environ. Sci. Technol.* **2017**, *51*. [CrossRef]
46. Hougner, C.; Colding, J.; Söderqvist, T. Economic Valuation of a Seed Dispersal Service in the Stockholm National Urban Park, Sweden. *Ecol. Econ.* **2006**, *59*, 364–374. [CrossRef]
47. McRae, A. Case Study: A Conservative Approach to Green Roof Benefit Quantification and Valuation for Public Buildings. *Eng. Econ.* **2016**, *61*, 190–206. [CrossRef]
48. Miguez, M.; Raupp, I.; Verol, A. An Integrated Quantitative Framework to Support Design of Resilient Alternatives to Manage Urban Flood Risks. *J. Flood Risk Manag.* **2018**, *12*, e12514. [CrossRef]
49. Capotorti, G.; Alós Ortí, M.M.; Copiz, R.; Fusaro, L.; Mollo, B.; Salvatori, E.; Zavattero, L. Biodiversity and Ecosystem Services in Urban Green Infrastructure Planning: A Case Study from the Metropolitan Area of Rome (Italy). *Urban For. Urban Green.* **2019**, *37*, 87–96. [CrossRef]
50. Mcpherson, E.; Nowak, D.; Heisler, G.; Grimmond, C.; Souch, C.; Grant, R.; Rowntree, R. *Chicago's Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project*; US Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: Newtown Square, PA, USA, 1994.
51. Scott, K.; Mcpherson, E.; Simpson, J. Air Pollutant Uptake by Sacrameto's Urban Forest. *J. Arboric.* **1998**, *24*, 224–234.
52. Nowak, D.J.; Hoehn, R.E.I.; Crane, D.E.; Stevens, J.C.; Walton, J.T. *Assessing Urban Forest Effects and Values, Philadelphia's Urban Forest*; U.S. Department of Agriculture, Forest Service, Northern Research Station: Newtown Square, PA, USA, 2007; p. 22.
53. Mcpherson, E.; Nowak, D.; Heisler, G.; Grimmond, C.; Souch, C.; Grant, R.; Rowntree, R. Quantifying Urban Forest Structure, Function, and Value: The Chicago Urban Forest Climate Project. *Urban Ecosyst.* **1997**, *1*, 49–61. [CrossRef]

54. McPherson, E.G.; Simpson, J.R.; Peper, P.J.; Xiao, Q. Benefit-Cost Analysis of Modesto's Municipal Urban Forest. *J. Arboric.* **1999**, *25*, 235–248.
55. Peper, P.J.; McPherson, E.G.; Simpson, J.R.; Gardner, S.L.; Vargas, K.E.; Xiao, Q. *New York City, New York Municipal Forest Resource Analysis*; U.S. Department of Agriculture, Forest Service, Pacific Southwest Research Station, Center for Urban Forest Research: Newtown Square, PA, USA, 2007.
56. Tyrväinen, L. The Amenity Value of the Urban Forest: An Application of the Hedonic Pricing Method. *Landsc. Urban Plan.* **1997**, *37*, 211–222. [CrossRef]
57. Donovan, G.H.; Butry, D.T. Trees in the City: Valuing Street Trees in Portland, Oregon. *Landsc. Urban Plan.* **2010**, *94*, 77–83. [CrossRef]
58. Ngulani, T.; Shackleton, C.M. Use of Public Urban Green Spaces for Spiritual Services in Bulawayo, Zimbabwe. *Urban For. Urban Green.* **2019**, *38*, 97–104. [CrossRef]
59. Wang, Y.; He, C.; Wang, L.; Liu, Y.; Ye, K.; Yang, X.; Kong, Z.; Su, Y. Framework for Valuating Urban Wetland Park Ecosystem Services Based on the Cascade Approach. *Pol. J. Environ. Stud.* **2019**, 28. [CrossRef]
60. Tyrväinen, L.; Väänänen, H. The Economic Value of Urban Forest Amenities: An Application of the Contingent Valuation Method. *Landsc. Urban Plan.* **1998**, *43*, 105–118. [CrossRef]
61. Jim, C.Y.; Chen, W.Y. Recreation–Amenity Use and Contingent Valuation of Urban Greenspaces in Guangzhou, China. *Landsc. Urban Plan.* **2006**, *75*, 81–96. [CrossRef]
62. Zhang, L.; Fukuda, H.; Liu, Z. Households' Willingness to Pay for Green Roof for Mitigating Heat Island Effects in Beijing (China). *Build. Environ.* **2019**, *150*, 13–20. [CrossRef]
63. Chau, C.K.; Tse, M.S.; Chung, K.Y. A Choice Experiment to Estimate the Effect of Green Experience on Preferences and Willingness-to-Pay for Green Building Attributes. *Build. Environ.* **2010**, *45*, 2553–2561. [CrossRef]
64. Kim, D.-H.; Ahn, B.-I.; Kim, E.-G. Metropolitan Residents' Preferences and Willingness to Pay for a Life Zone Forest for Mitigating Heat Island Effects during Summer Season in Korea. *Sustainability* **2016**, *8*, 1155. [CrossRef]
65. Collins, R.; Schaafsma, M.; Hudson, M.D. The Value of Green Walls to Urban Biodiversity. *Land Use Policy* **2017**, *64*, 114–123. [CrossRef]
66. Christie, M.; Fazey, I.; Cooper, R.; Hyde, T.; Kenter, J.O. An Evaluation of Monetary and Non-Monetary Techniques for Assessing the Importance of Biodiversity and Ecosystem Services to People in Countries with Developing Economies. *Ecol. Econ.* **2012**, *83*, 67–78. [CrossRef]
67. Bateman, I.; Turner, R. Valuation of the Environment, Methods and Techniques: The Contingent Valuation Method. In *Sustainable Environmental Economics and Management: Principles and Practice*; Belhaven Press: London, UK, 1993; pp. 120–191, ISBN 978-1-85293-205-3.
68. Raymond, C.M.; Frantzeskaki, N.; Kabisch, N.; Berry, P.; Breil, M.; Nita, M.R.; Calfapietra, C. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ. Sci. Policy* **2017**, *77*, 15–24. [CrossRef]
69. Koetse, M.J.; Brouwer, R.; van Beukering, P.J.H. Economic valuation methods for ecosystem services. *Ecosyst. Serv.* **2015**, 108–131. [CrossRef]
70. Gómez-Baggethun, E.; Barton, D.N. Classifying and valuing ecosystem services for urban planning. *Ecol. Econ.* **2013**, *86*, 235–245. [CrossRef]
71. Costanza, R.; Wilson, M.; Troy, A.; Voinov, A.; Liu, S.; D'Agostino, J. *The Value of New Jersey's Ecosystem Services and Natural Capital*; Gund Institute for Ecological Economics, University of Vermont for New Jersey Department of Environmental Protection: Trenton, NJ, USA, 2006.
72. Brzoska, P.; Spāģe, A. From City- to Site-Dimension: Assessing the Urban Ecosystem Services of Different Types of Green Infrastructure. *Land* **2020**, *9*, 150. [CrossRef]
73. Haase, D.; Larondelle, N.; Andersson, E.; Artmann, M.; Borgström, S.; Breuste, J.; Gomez-Baggethun, E.; Gren, A.; Hamstead, Z.; Hansen, R.; et al. A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. *Ambio* **2014**, *43*, 413–433. [CrossRef]
74. Pandeya, B.; Buytaert, W.; Zulkafli, Z.; Karpouzoglou, T.; Mao, F.; Hannah, D.M. A Comparative Analysis of Ecosystem Services Valuation Approaches for Application at the Local Scale and in Data Scarce Regions. *Ecosyst. Serv.* **2016**, *22*, 250–259. [CrossRef]
75. Bastian, O.; Syrbe, R.-U.; Rosenberg, M.; Rahe, D.; Grunewald, K. The five pillar EPPS framework for quantifying, mapping and managing ecosystem services. *Ecosyst. Serv.* **2013**, *4*, 15–24. [CrossRef]
76. Kroll, F.; Müller, F.; Haase, D.; Fohrer, N. Rural–urban gradient analysis of ecosystem services supply and demand dynamics. *Land Use Policy* **2012**, *29*, 521–535. [CrossRef]
77. Liu, S.; Costanza, R.; Troy, A.; D'Aagostino, J.; Mates, W. Valuing New Jersey's ecosystem services and natural capital: A spatially explicit benefit transfer approach. *Environ. Manag.* **2010**, *45*, 1271–1285. [CrossRef]
78. Palomo, I.; Martín-López, B.; Potschin, M.; Haines-Young, R.; Montes, C. National Parks, buffer zones and surrounding lands: Mapping ecosystem service flows. *Ecosyst. Serv.* **2013**, *4*, 104–116. [CrossRef]
79. Crossman, N.D.; Burkhard, B.; Nedkov, S.; Willemen, L.; Petz, K.; Palamo, I.; Drakou, E.G.; Martín-López, B.; McPhearson, T.; Boyanova, K.; et al. A blueprint for mapping and modeling ecosystem services. *Ecosyst. Serv.* **2013**, *4*, 4–14. [CrossRef]
80. Costanza, R.; de Groot, R.; Sutton, P.; van der Ploeg, S.; Anderson, S.J.; Kubiszewski, I.; Farber, S.; Turner, R.K. Changes in the Global Value of Ecosystem Services. *Glob. Environ. Chang.* **2014**, *26*, 152–158. [CrossRef]
81. Chan, K.; Shaw, M.; Cameron, D.R.; Underwood, E.; Daily, G. Conservation Planning for Ecosystem Services. *PLoS Biol.* **2006**, *4*, e379. [CrossRef]
82. Burkhard, B.; Kroll, F.; Nedkov, S.; Müller, F. Mapping Ecosystem Service Supply, Demand and Budgets. *Ecol. Indic.* **2012**, *21*, 17–29. [CrossRef]