Review of Economic Valuation of Nature Based Solutions in Urban Areas

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1. Introduction

Following the European Commission (2015, p.24), nature-based solutions (NBS) can be defined as actions inspired by, supported by, or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions. They are positive responses to societal challenges, and can have the potential to simultaneously meet environmental, social and economic objectives.

Nesshover (2017) positions NBS as an overarching concept that builds on, and supports, other closely related concepts, such as the ecosystem approach, ecosystem services, ecosystem-based adaptation and mitigation, green engineering and green and blue infrastructure. All of these concepts recognise the importance of nature and imply that a systematic approach is needed to environmental management that considers human actions and their consequences. A key feature of NBS is through its focus on intervention tackling a societal problem, together with the impact such an intervention brings along. By building upon these existing concepts, a common framework has been established in the NATURVATION project to categorise NBS in various domains (ecological and landscape domains), and in accordance with an ecosystem service classification. See the Appendix for the respective lists of NBS domains and indicators. This framework is also used in this review of economic values of NBS, which aims to link values to these classifications and service indicators as much as possible.

A recent report on NBS to climate change adaptation and mitigation (Kabisch et al., 2016b) highlights the usefulness of applying NBS in an urban context. NBS are becoming more important in the presence of growing urbanisation worldwide. At the same time, the high level of interconnectedness between climate change, biodiversity and human health and well-being makes NBS more promising for addressing urban challenges of today and the future. Important effects of urban green reported by Kabisch et al. (2016b) are directly related to the regulating services of urban ecosystems, for example, they may be responsible for temperature cooling effects between 0.5 and 7°C, with an average of 1°C (Bowler et al., 2010). In particular, the cooling effects of green roofs on ambient air temperatures may be up to 0.4 and 1.8°C depending on local circumstances, which can bring important economic benefits to cities by limiting impacts from climate change (Naumann et al. 2011; Estrada et al., 2017).

Additional benefits of urban green surfaces pertain to ecosystem regulating as well as cultural services, and include, among others, providing habitat for wildlife, retaining stormwater, improving air quality, and providing space for urban agriculture and recreation. However there are also disadvantages of urban green. Some of those may be found in the domain of socio-environmental realm, and include ecological disservices such as allergic potential of plant pollens, increased amount of insects and perceived unsafety of poorly illuminated urban green areas, as well as social inequality and (increased) gentrification. The latter may be triggered by higher housing prices (both in terms of purchase and rent) that reflect the value of natural amenities in urban areas (Brander en Koetse, 2011), which in turn cause a chain of endogenous effects such as self-selection of urban residents and concentration of higher-income residents near greener areas. This may hamper access of lower-income groups to natural amenities, and thus social inequality in the ecological domain.

An assessment of the economic values of the potential advantages and disadvantages of particular NBS can provide relevant insights into possible economic trade-offs that arise in implementing NBS in cities as well as the economic feasibility of policies aimed at expanding NBS. However as Naumann et al. (2011) pointed out, there is a lack of a systematic quantification of ecosystem service benefits in projects involving ecosystem solutions, such as NBS for climate change. In particular, there exists a large discrepancy between the quantification of costs and benefits of ecosystem service projects. On the one hand, project costs generally appear to be well-defined and directly expressed in monetary terms. On the other hand, project benefits of NBS are less clearly defined; often such benefits are not assessed and if they are then benefits are often expressed in qualitative terms.

Multiple functions and benefits offered by NBS are of a long-term character and stretch to the social and ecological domains (e.g. habitat protection, recreational opportunities). Creating awareness and developing an evidence base of quantitative estimates of benefits connected to the introduction of natural amenities remain critical issues for the assessment of policy and practical solutions aimed at implementing NBS. A lack of monetary values for natural amenities prevents a comprehensive assessment of project costs and benefits which may lead to sub-optimal policy decisions. This highlights the need for assessing the benefits associated with natural solutions in a comprehensive manner. For example, Raymond et al. (2017) provides an attempt at setting out a comprehensive framework for the assessment of NBS interventions and their impacts.

The NATURVATION project aims at developing a comprehensive NBS assessment tool for urban areas. Monetary values of NBS can be an important input for the development of such a tool in order to enable assessment of the economic implications of NBS in relation to ecological and societal effects. This deliverable report describes the review of economic values of NBS, for which the European Commission's definition of NBS was adopted. Economic valuation of natural ecosystems and their services or goods has proven to be relevant for a number of reasons. To mention a few, economic valuation can be used to make trade-offs comparable and therefore enable well-informed decisions concerning nature and the creation of NBS. Moreover, assessing monetary values of NBS allows for comparing different stocks of natural infrastructure and their services. Finally, a monetary value can be used for communicating the importance of natural resources relative to other costs and benefits of intended interventions. This report adds to the evidence base of NBS values on the junction of nature and man-made infrastructure, economy and society.

In particular, the report describes a database on economic values of NBS which has been created on the basis of a literature review (and is available online at www.naturvation.eu). This database addresses existing knowledge gaps (Kabisch et al. 2016a) by linking reported economic values to ecosystem services, ecological domains, landscape types and other relevant classifications. It can therefore be used to inform science, policy and practice on various facets of NBS, for example the economic values of particular ecosystem services and functions which NBS can fulfil. See Appendix for summary tables describing the database. A next step in the NATURVATION project is a comprehensive assessment of NBS impacts (see for example Raymond et al., 2017), for which the review in this report provides input for the assessment of the economic values of these impacts.

2. Method

2.1 Literature search

The review of economic values of NBS focusses on both values of existing nature in cities and values of particular NBS interventions, such as installing green roofs. There exists ample literature offering various approaches to the assessment of economic values of services provided by natural ecosystems or natural infrastructure. As a first step, we have reviewed qualitative and quantitative overview publications, such as literature review articles and meta-analyses, respectively (see the literature list below). Next, the search continued by looking into primary economic valuation studies of nature at particular case study sites (listed separately below). We chose to search for papers that applied the most commonly used methods for economic value assessment of environmental goods: namely, (i) the revealed preference method, (ii) the stated preference method and (iii) the benefit transfer method. The revealed preference method allows us to induce values of nature from observed data which is based on market transactions and prices (which are housing prices in this case). The stated preference method allows to elicit values of nature that are not directly traded on the market, but can be asked for in a semi-experimental setting, which in turn permits collecting latent information on individual preferences that otherwise would not be available. The benefit transfer method uses assessments and values from other studies and applies them to a specific situation or object of valuation. Including all these methods in our review thus allows us to obtain comprehensive insights into economic values of nature and its services.

A selection of terms was used in order to search the body of literature for relevant publications on economic valuation of nature and its services in cities, which included 3 main components: valuation method, location, and the type of nature / service. The list of search terms used is shown in Table 1 below. The contents of the terms was selected on the basis of the concepts listed in overview papers (such as Nesshover et al., 2017) as well as in individual publications. Combinations of these three types of terms were used to search articles in publicly accessible databases, such as EVRI, ENVALUE, and the search engines Google Scholar and Scopus. Moreover, articles for the review were selected by checking cross-references in relevant articles. The database lists all papers that were found except a few in which no monetary values were stated, and finally contains 105 papers and 255 value entries/observations.

The review of economic values of NBS for the NATURVATION project consists of two phases. The current report deals with the first phase, which consists of creating an open-access database of Financial and Economic Values of NBS (FEVD), and an accompanying description of the database with a qualitative literature review. In the second phase, the database will be refined for a quantitative analysis of values in primary valuation papers, which will be carried out as a meta-analysis.

TABLE 1. SEARCH TERMS FOR THE LITERATURE REVIEW

Method	Location	Type of nature / service
Value	Urban	Natural infrastructure
Valuation	City / cities	Green infrastructure
Economic value	Local	Blue infrastructure
Stated preferences	Community	Blue amenities
Contingent valuation		Terrestrial water
Dichotomous choice		Watershed
Choice experiment		Wetlands
Stated choice		Open space
Revealed preferences		Water assets
Hedonic pricing		Water bodies
Housing prices		Canals
		Lakes
		Green
		Greenbelt
		Green roof
		Garden
		Park
		Forest
		Natural
		Nature
		Water
		Water quality
		Ecosystem
		Ecosystem services

2.2 Structure of the database

The database is constructed as follows. It consists of three major blocks that describe: (i) bibliographic reference variables, (ii) type of nature valued and coding according to variables relevant to the NATURVATION project, and (iii) economic value, its units and the applied estimation method. As identifications, FEVD contains an observation number and a paper number. Because some papers reported multiple values, there are more observations in the database (n=255) than papers (n=105). Bibliographic information entails author name(s) and year of publication. Full references to the included studies are found in the list of literature below. Furthermore the database includes the time span of data used in a particular study, and its geographical location (see Table 2). Where applicable, the database also records the nearest town of data collection.

In the second block, the database includes text descriptions of the type of valued nature and its coding following a conceptual framework developed within the NATURVATION project. Nature types were thus coded in 9 categories from ecological domains (see Table A1), and 14 types of landscapes (see Table A2). Next, each entry to the database is characterised by the type of ecosystem service that it provides. 4 main ecosystem service types are coded (provisioning, regulating, cultural, and habitat and supporting services), as well as their sub-categories (see Table A3). Connected to ecosystem services is the typology of economic values that distinguishes direct use value, indirect use value, non-use value and option value (see Section 2.3 of this paper). FEVD also contains a coding of valued nature and its services according to NBS goals that are derived from sustainability-related goals (see Table A4). Other indicators that are included, where applicable, are the temporal and spatial scales of the valuation study (see Table A5), as well as the agent type for which the valuation was conducted (see Table A6).

The final block of the database lists the values of nature and its services extracted from the collected studies and their units. If a monetary unit was used, it also states the valuation year. For the units valued, the database records its metrics (e.g. per ha, per ton, per entry) and payment frequency (per month, per year, one-time payment). Average study housing prices and their monetary unit and year are reported for values obtained with hedonic pricing models. Finally, the applied methods to obtain the value of nature or its service are listed.

2.3 Economic typology of valuation of nature

The economic discipline uses a different typology of valuation when approaching value assessment than ecology. In particular, this typology is different from functions such as the provisioning, regulating and cultural functions typology used in ecology when natural resources or their benefits are assessed. In connection to valuation of nature, Hein et al. (2006) provide a link between the ecological and economic typologies of values and functions, as shown in Figure 1. While the three ecosystem services as presented by Hein et al. (2006) do not coincide with the four ecosystem functions as used in this project, it provides a useful framework for linking ecological services to economic value types. As an aside, habitat and supporting services that are separately presented in our project framework, are part of provisioning services as presented by Hein et al. (2006).

Figure 1 tells us that the economic value typology cuts a different cross-section when compared to ecological function types. In value assessments the major distinction in economics is made between use values, non-use values and option values (an explanation follows below). First, whereas the economic value typology hinges on the utilitarian or usability principle of goods and services, the ecological typology is directly related to the function types offered by natural ecosystems. Second, all ecosystem functions have various economic values, be it direct use values, indirect use values, non-use values or option values:

- ***Direct use values*** arise from human direct utilization of ecosystems, through the sale or consumption of a good, such as a piece of fruit or clean water. All production services, and some cultural services (such as recreation) have direct use values.

- ***Indirect use values*** stem from the indirect utilization of ecosystems, in particular through the positive externalities that ecosystems bring. This reflects the type of benefits that regulation services provide to society. For example, these are decreased flood risk or better climate conditions.

- ***Option values*** arise because even when people are unsure about their future demand for a service, they are willing to pay to keep open the option of using a resource in the future, or to avoid irreversible negative impacts on the resource (the latter is sometimes referred to as quasioption value). This reflects some degree of risk aversion. Option values may be attributed to all use and non-use values, and thus to all services supplied by an ecosystem. I.e. an option value may presume the preservation of the service to be used in the future, be it a provisioning, regulatory, cultural or habitat service, and it is independent of whether this service is being utilised at present or not.

Non-use values are derived from attributes inherent to the ecosystem itself and can be anthropocentric (like aesthetic beauty), as well as ecocentric (i.e. related to the notion that animal and plant species may have a certain right to exist). Three sub-types of non-use value are distinguished and reflect various motivations of stakeholders involved: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility gained from future improvements in the well-being of one’s descendants).

While the different categories of economic value typology may sometimes be difficult to separate, both conceptually and empirically, the above list is helpful because it can serve as a roadmap for reviewing economic literature on nature assessment. Hence the FEVD also contains a coding of the economic typology of the values included in the database.

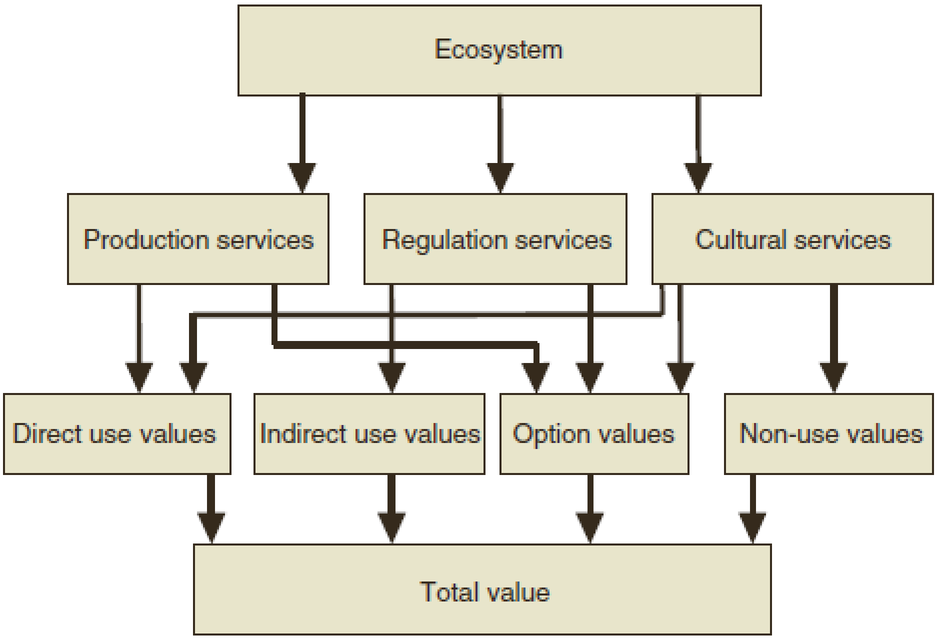

Figure 1. Connection between ecosystem service types and economic values in value assessments. Source: Hein et al. (2006)

2.4 Valuation method

With regards to methods that were selected for this review, it is important to reflect upon which values each method can measure. Revealed preference studies, and hedonic pricing in particular1, are based on actual observations of market exchanges, which are in this case housing prices based on sale transactions. From these prices, and based on econometric inference, one aims to extract information about household preferences towards the nature component of a house or its location. In particular, for the purpose of this overview and the value of NBS, studies were selected that estimated the relation between housing prices and natural amenities present in the vicinity of houses, while controlling for other variables of influence on housing prices. Values of nature obtained by means of this method reflect direct and indirect use values which are capitalized in the housing prices.

Methods that belong to the stated preferences domain are the contingent valuation method and the (discrete) choice modelling method. These methods are particularly suitable for valuing goods and services that are not directly traded on the market. They are based on willingness-to-pay or willingness-to-accept measures, and usually ask individuals to state their preference (e.g. a maximum willingness-

[1] The revealed preference method includes an array of methods such as market prices (direct valuation method) and travel costs, avoided costs and hedonic pricing (indirect valuation methods). The hedonic pricing method is mainly used in academic studies in recent decennia and is considered a state-of-the-art revealed preference method.

to-pay amount) in a hypothetical situation that involves such non-traded goods or services. For example, individual preferences for an increase in municipal taxes that are expected to lead to better water quality in public water bodies, or to more green on the streets. Such choices in turn reflect personal preferences from which monetary values of nature and its services can be derived. Such methods can elicit all economic values connected to NBS, namely direct and indirect use values, and non-use and option values. However, in some settings, only a specific value can be elicited, such as conservation of a natural park or a species, which would correspond to an option value. The benefit transfer method borrows or applies values from existing studies to a particular situation or object of valuation. Because original studies may differ in the applied assessment methods, benefit transfer methods depend on the values and approaches used in the original studies.

In summary, an advantage of the stated preference techniques is that they can elicit a total value of NBS, i.e. combined use, non-use and option value. A disadvantage is that they are based on hypothetical choices, which may result in uncertainty of the value estimate. At the same time, while hedonic price modelling can elicit a more refined estimate of only the direct and indirect use values of NBS, its advantage is that it is based on real transactions. Given the particular advantages and disadvantages of each method, we decided to include NBS values elicited by both methods in the database and to record the method that was used in the original valuation study. Moreover, a number of studies using the benefit transfer method are included.

3. Main Findings

3.1 Meta-analysis studies

First of all it has become clear from the review that a good basis exists of studies that elicited values of a variety of ecosystem services and NBS in cities. An example is the meta-analyses of values of green and blue open spaces in urban areas conducted by Brander & Koetse (2011). In a meta-analytic setting, researchers collect studies that provide value estimates of the same good or service, and attempt at explaining differences between studies based on a number of explanatory variables. For example, Brander & Koetse (2011) examined the value of distance to the open space in urban areas expressed in US dollars per 10m, and estimated how this value is dependent on study characteristics (type of open space, functional form of estimated regression, distance at which and for which the estimate was done) as well socio-economic and geographical characteristics (price level, population density and location). Results of a meta-analysis can be used for benefit transfer purposes in which representative values from the broader literature are applied to a particular case study site in cases where no good location-specific value exists.

A great variety of values have already been collected by meta studies that report meta-values based on multiple studies from multiple contexts and locations.. Just to name a few, a value of a hectare of an urban forest is found to be about 1500 USD (Brander and Koetse, 2011), the recreational value of 1 hectare of coastal ecosystem is 4700 USD (Ghermandi and Nunes, 2013), a ton of sequestrated carbon is at least 125 USD (van der Bergh and Botzen, 2014), and 1 m2 of green roofs is valued between 290 USD and 700 USD (Bianchini and Hewage, 2012). In some cases, the unit value of nature decreases with its size and distance to the nature. Higher population density causes nature to be valued higher, probably due to its relative scarcity. Interestingly, while studies which value solely blue amenities are not great in number, the reviewed studies reveal that the presence of blue infrastructure per se has a relatively high value. This is, for example, shown by Luttik (2000) who finds that property prices are highest for houses located in the vicinity of, or overviewing water bodies; and by Brander et al. (2006) who found that water quality improvements are valued the highest in wetland valuation studies.

Brander et al. (2013) analyse values for wetland ecosystems in a meta-analysis, and present a list of values, depending on the service valued, and region. Overall, mean values are found to be 7,000 USD per ha per year for flood control, 3,400 USD per ha per year for water supply and 5,800 USD per ha per year for water quality services. It is important to notice here, that values found by Brander et al. (2013) have a wide range, which implies caution should be taken in applying benefit transfer. As an illustration, their own attempt at valuing wetland services worldwide resulted in a figure of 26.5 billion USD per year, with a confidence interval between 20.2 and 4.7 billion USD on a yearly basis.

However, while meta-analyses can be very useful, most existing reviews and meta-analyses are limited in that they report aggregated values for a certain size of blue or green nature, but do not satisfactorily cover particular ecosystem functions. This hampers linking values of nature to its specific functions which are useful for valuing specific NBS types in the framework of the NATURVATION project. Our database aims to fill this gap, by trying to better link values to specific functions and NBS types.

3.2 Primary valuation studies

Geographical coverage

The literature on economic valuation of urban nature is great in number and highly diverse in methods used, purpose served, and geographical focus. For example, a large majority of studies comes from (Western) Europe, North America and Asia. To be more specific, most papers in our database originate from North America (39%), followed by Asia (24%) and Europe (22%). Only a small part of studies are carried out in Australia (n=4), South America (n=3) or Africa (n=2). 7 studies in the FEVD are overview papers which include a mix of locations, thus they are bundled under the caption “Other / worldwide”. In terms of values recorded from the studies in the database, most values come from European studies (39%), followed by North American estimates (34%) and Asian ones (15%).

TABLE 2. GEGRAPHICAL SPREAD OF PAPERS AND VALUES IN THE DATABASE

Continent	**PAPERS**		**VALUES**	
	N	%	N	%
North America	41	39,05%	86	33,73%
South America	3	2,86%	4	1,57%
Europe	23	21,90%	99	38,82%
Asia	25	23,81%	39	15,29%
Africa	2	1,90%	2	0,78%
Australia	4	3,81%	7	2,75%
Other / worldwide	7	6,67%	18	7,06%
TOTAL	**105**	**100%**	**255**	**100%**

Variables defining NBS type and services

A next cluster of indicators in the database belongs to the ecological domain, landscape type and ecosystem services. We have coded the studies in the database according to the main 9 categories of natural space in the ecological domain; subcategories however can easily be coded if necessary due to the presence of textual descriptions of type of space. The full list of ecological domain categories and FEVD frequencies are found in Table A1 in the Appendix.

Almost a half of recorded values in the database fall under the category of parks and other (semi)natural urban green spaces (49%). This category includes large and small urban parks and forests, botanical gardens, green corridors and other open green spaces. The second most populated category of the ecological domain is blue areas (22%), which includes various types of blue urban areas, such as lakes, rivers, streams, canals, but also sea coast, delta, or wetland, fen or marsh areas. The third most sizeable category of recorded values is open green spaces directly adjacent to urban areas (16%), which provide urban areas with various services, like recreation, aesthetics and tourism. Such areas may include farm- or agricultural land, woodlands, fields, golf courses and other sizeable areas of nature in the direct vicinity of urban areas. The fourth biggest category is external building greens (6%) mainly consisting of values connected to green roofs in our database. Other categories are green areas for water management (3%) including watersheds and urban drainage systems; urban green areas connected to grey infrastructure (2%), including alleys and street trees, green parking lots or riverbank green space; and derelict areas (1%).

According to the landscape classification (see the corresponding definitions and statistics in Table A2), 4 types that are most frequent in our database of valued nature are woodscape (37%), parkscape (18%), waterscape (13%) and farmscape (12%). These are followed by riverscape (9%) and coastalscape (7%). Note, that landscape categories are not exclusive. For example mixed blue and green landscapes are coded in two categories; also areas with multiple landscapes like a national park received multiple coding entries according to their constituent parts.

Ecosystem services were mostly coded in multiple categories, because most of the NBS valued offer multiple services to the urban areas. Note here, that in most, but not all studies, valued or presumed services were explicitly listed. If that was not the case, then the coding was left to the discretion of the researcher, and the coding was done and checked by two researchers. In 41% of valued NBS, provisioning services were present, in 87% of the cases regulating services and cultural services (not necessarily the same cases) were present, and in 60% of the cases the ecosystem services were habitat and supporting services.

The classification of NBS goals also often included multiple goals per valuation unit, because a single kind of NBS may target multiple goals. This coding, in most cases, was to the discretion of the researcher as few original studies mention such goals explicitly. Most frequently occurring goals in our database are environmental quality, including air quality and waste management (62%), health and well-being (59%), green space, habitat and biodiversity (54%), cultural heritage and cultural diversity (39%), and water management (29%).

Furthermore, where possible, we have coded the spatial and temporal scales of NBS valuation. Concerning the spatial scale, most (82%) of the valuations took place on a meso-level (metropolitan / urban), and substantially less studies were conducted on the micro level (district / neighbourhood) or sub-micro level (street / house), with 12% each. A few (5%) of the valuations were carried out on a macro-level (national / global), which are mainly meta-analyses or similar kinds of valuations.

Various methods use various temporal scales to assess the value of nature. In most cases, methods applied were using either immediate time frame (19%) or long-term time frame referring to values in terms of periods of longer than 3 years (21%). The latter is due to studies that evaluated the total (or discounted) value of a natural asset or its services by expressing it in present value terms. 7% and 9% of the valuations, respectively, were valued in the short-term (weeks / months) or medium term period (1-3 years).

Moreover, we have attempted to code the agent types for which the NBS valuation was conducted. 3 broad categories were identified, i.e. individuals (19%), households (57%) and groups / population of a specified area (24%). The type of agent was to a large degree connected to the valuation method used. So, hedonic pricing relates to household agents because such valuations are based on housing prices. On the other hand, the stated preference method is mostly associated with individual agents since most willingness-to-pay survey questions are asked to individuals. All of the identified agent types belong to the private sector on a more aggregated level of categorisation.

Values of NBS in the database

A great variety of values have been collected and recorded in the database. The values are however highly heterogeneous both in their magnitude and the unit of measurement. The latter applies to the currency, the base year of measurement, the physical unit (e.g. per hectare, per tree, per meter of distance), and the time unit (i.e. a recurring payment such as per year, or a one-time payment such as total value of an asset or an entry price). This makes it difficult to provide a simple overview of the values collected in the database. Nevertheless, we shall attempt to reflect on some values, per ecological category.

Studies that apply hedonic price modelling (revealed preference method) use relatively homogeneous and easily comparable value units, which are often expressed in % value change of property depending on the presence of, or distance from, urban nature. We will first discuss these studies. In particular we find that housing prices decrease on average by 2.11% as the distance to parks and natural green urban areas (which make up a half of observations in the database) increases by 100m. An increase in distance to urban blue areas is valued at about the same level, namely on average at 1.91% of a house price. However, distance to peri-urban open space in our database is valued at about the half of the latter, namely on average at 0.82% of the property price. Specific absolute monetary values depend on the local currency and the level of local property prices. In most cases, the unit value of nature decreases with its size and distance to the nature. Higher population density causes nature to be valued higher, which is due to its higher relative scarcity.

Values of external building greens are presented in various units. For example, the discounted present value of 1 m2 of green roofs is valued at between 290 USD and 700 USD (Bianchini and Hewage, 2012). Other recorded values include discounted values per 1 m2 of various ecosystem services that green roofs provide (ibid), such as air purification and recreation; or yearly values of ecosystem services per 1 m2, such as flood reduction and mitigation of the urban heat island effect.

Furthermore, a number of values of urban blue are estimated with the value or benefit transfer method, and also resemble similar measurement units. Brander et al. (2006) estimate the value of wetlands at 2800 USD per ha per year; Brander et al. (2007) estimate the recreational value of a coral reef at 3725 USD per ha per year; and Ghermandi and Nunes (2013) estimate the recreational value of a coastal area at 4700 USD per ha per year. Moreover, Brenner et al. (2010) estimate an array of values of coastal areas, split by ecosystem service, which range from 20 USD per ha per year for soil formation to 77000 USD per ha per year for disturbance regulation.

In sum, while the current overview of economic valuation studies on urban nature is by no means complete and offers a selection of studies, it reveals a great variability in services valued and metrics used in expressing the values. This is mainly due to differences in the valuation methods used and goals of a particular study. It makes a simple comparison of values between and across studies difficult. Nevertheless, the database presents a useful overview of the palette of values attached to urban nature, valued at various circumstances, and for different purposes.

The meta-analysis to be conducted later on in the project for WP3 will aim to create consistent value metrics for specific NBS types and functions. We are confident that this will be possible with a more detailed categorization of studies in the current database in terms of aggregated NBS domains, like green and blue. However, it remains to be seen whether sufficient individual estimates per function exist for making a reliable more detailed link between values and functions for several NBS types.

4. Conclusions: Challenges and Perspectives

The current literature review of economic valuation studies on urban nature and the constructed database offer an evidence base for deriving economic values of NBS based on a selection of studies of economic values of nature in urban areas. These values were estimated with methods that are widely used in the discipline of environmental economics which encompass the broad range of economic value typologies from use and non-use values.

This overview and database fill the gap in the NBS-related literature in so far that we have gathered academic studies focusing on a quantification and monetisation of nature and its benefits in an urban context in relation to specific NBS domains and functions. Our selection reveals a large variability in services valued and metrics used in expressing the values of nature and its services. This is mainly due to differences in the valuation methods used and purposes served by a particular study. This heterogeneity hampers making a congruent comparison of collected values between and across studies. Notwithstanding, this review report and database aim to present a useful overview of a palette of values attached to urban nature, valued at various circumstances, and for different purposes, which can subsequently be used for benefit transfer purposes.

Economic values of urban nature present in the database cover a variety of landscapes, goals and services. In terms of landscapes, most values are attributes to parkscape, woodscape and farmscape, as well as to water surfaces such as waterscape, riverscape and coastalscape. Ecological domains include urban parks and (semi)natural urban green areas, blue areas, peri-urban open space areas and external building greens. Valued services are mainly (i) regulating services, including local climate regulation, air quality regulation, noise reduction, carbon storage and water purification; and (ii) cultural services, including recreation, tourism and aesthetics. Goals (to be) targeted by interventions include environmental quality; green spaces; and health and well-being. Agents involved in nature valuation are individuals, households and a group or population of a specified area.

The meta-analysis to be conducted later on in the NATURVATION project for WP3 will try to create consistent value metrics for selected NBS types and functions. We are confident that this will be possible in terms of aggregated NBS domains like green and blue, but a potential obstacle is that perhaps insufficient individual estimates per function exists for making a reliable more detailed link between values and functions for several NBS types.

Literature List

Estrada, F., Botzen, W.J.W., Tol, R. (2017). A global economic assessment of city policies to reduce climate change impacts. Nature Climate Change (In press).

European Commission (2015) Towards an EU Research and Innovation policy agenda for Nature-Based Solutions & Re-Naturing Cities. Final Report of the Horizon 2020 Expert Group on 'Nature-Based Solutions' and Re-Naturing Cities. Directorate-General for Research and Innovation

Meta and Review Studies:

Bergh J. C. J. M. van den & W. J. W. Botzen (2014) A lower bound to the social cost of CO2 emissions. Nature Climate Change 4: 253–258.

Bianchini F., Kasun Hewage (2012) Probabilistic social cost-benefit analysis for green roofs: A lifecycle approach. Building and Environment 58: 152-162.

Bowler, D.E., Lisette Buyung-Ali, Teri M. Knight, Andrew S. Pullin (2010) Urban greening to cool towns and cities: A systematic review of the empirical evidence. Landscape and Urban Planning 97(3): 147-155.

Brander L., Roy Brouwer, Alfred Wagtendonk (2013) Economic valuation of regulating services provided by wetlands in agricultural landscapes: A meta-analysis, Ecological Engineering 56: 89-96.

Brander LM, Koetse MJ. (2011) The value of urban open space: meta-analyses of contingent valuation and hedonic pricing results. Journal of Environmental Management 92(10):2763-73.

Brander, L.M., Beukering van, P.,Cesar, H.S.J. (2007) The recreational value of coral reefs: a meta-analysis. Ecological Economics 63: 209-218.

Brander, L.M., Florax, R.J.G.M. & Vermaat, J.E. (2006) The Empirics of Wetland Valuation: A Comprehensive Summary and a Meta-Analysis of the Literature. Environmental and Resource Economics 33: 223.

Ghermandi A., Paulo A.L.D. Nunes (2013) A global map of coastal recreation values: Results from a spatially explicit meta-analysis, Ecological Economics 86: 1-15.

Gómez-Baggethun E., Barton D.N. (2013) Classifying and valuing ecosystem services for urban planning. Ecological Economics 86: 235-245.

Haase, D., Larondelle, N., Andersson, E. et al. (2014) A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. AMBIO 43:413.

Hein, L., Kris van Koppen, Rudolf S. de Groot, Ekko C. van Ierland (2006) Spatial scales, stakeholders and the valuation of ecosystem services. Ecological Economics 57(2): 209-228.

Kabisch N., Jutta Stadler, Horst Korn and Aletta Bonn (2016b) Nature-based solutions to climate change mitigation and adaptation in urban areas. German Federal Agency for Nature Conservation. BfN Report 446.

Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, H. Korn, J. Stadler, K. Zaunberger, and A. Bonn (2016a) Nature-based solutions to climate change mitigation and adaptation in urban areas: perspectives on indicators, knowledge gaps, barriers, and opportunities for action. Ecology and Society 21(2):39

Naumann, S., G. Anzaldua, P. Berry, S. Burch, M. Davis, A. Frelih-Larsen, H. Sanders, and M. Gerdes. (2011) Assessment of the potential of ecosystem-based approaches to climate change adaptation and mitigation in Europe. Final report to the European Commission. Ecologic Institute, Berlin, Germany and Environmental Change Institute, Oxford University Centre for the Environment, Oxford, UK.

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., Külvik M., Rey F., van Dijk J., Vistad O.I., Wilkinson M.E., Wittmer H. (2017) The science, policy and practice of nature-based solutions: An interdisciplinary perspective. Science of the Total Environment 579: 1215–1227.

Raymond, C.M., Berry, P., Breil, M., Nita, M.R., Kabisch, N., de Bel, M., Enzi, V., Frantzeskaki, N., Geneletti, D., Cardinaletti, M., Lovinger, L., Basnou, C., Monteiro, A., Robrecht, H., Sgrigna, G., Munari, L. and Calfapietra, C. (2017) An Impact Evaluation Framework to Support Planning and Evaluation of Nature-based Solutions Projects. Report prepared by the EKLIPSE Expert Working Group on Nature-based Solutions to Promote Climate Resilience in Urban Areas. Centre for Ecology & Hydrology, Wallingford, United Kingdom. 82p.

Primary Economic Valuation Studies:

Alvarez, S.; Asci, S.; Vorotnikova, E. (2016) Valuing the Potential Benefits of Water Quality Improvements in Watersheds Affected by Non-Point Source Pollution. Water 8: 112.

Anderson, S.T., West, S.E. (2006) Open space, residential property values, and spatial context. Regional Science and Urban Economics 36: 773-789.

Anthon, S., Thorsen, B.J., Helles, F. (2005) Urban-fringe afforestation projects and taxable hedonic values. Urban Forestry & Urban Greening 3(2): 79-91.

Barton D.N. (2002) The transferability of benefit transfer: contingent valuation of water quality improvements in Costa Rica. Ecological Economics 42(1–2): 147-164.

Been, V., Voicu I. (2006) The Effect of Community Gardens on Neighboring Property Values, New York University Law and Economics Working Papers. Paper 46.

Bengochea-Morancho, A. (2003) A hedonic valuation of urban green areas. Landscape and Urban Planning 66: 35-41.

Bergstrom, J.C., Dillman, B.L., Stoll, J.R. (1985) Public environmental amenity benefits of private land: the case of prime agricultural land. Southern Journal of Agricultural Economics 17: 139-149.

Bishop, K. (1992) Assessing the benefits of community forests: an evaluation of recreational use benefits of two urban fringe woodlands. Journal of Environmental Planning and Management 35: 63-76.

Bolitzer, B., Netusil, N.R. (2000) The impact of open spaces on property values in Portland, Oregon. Journal of Environmental Management 59: 185-193.

Bowker, J.M., Diychuck, D.D. (1994) Estimating the nonmarket benefits of agricultural land retention in eastern Canada. Agricultural and Resource Economic Review 23: 218-225.

Breffle, W.S., Morey, E.R., Lodder, T.S. (1998) Using contingent valuation to estimate a neighbourhood's willingness to pay to preserve undeveloped urban land. Urban Studies 35: 715-727. Brenner, J. Jimenez, J.Sarda, R.Garola, A. (2010) An assessment of the non-market value of the ecosystem services provided by the Catalan coastal zone. Ocean & Coastal Management 53: 27-38.

Bueno, E.A., Ancog, R., Obalan, E. et al. (2016) Measuring Households' Willingness to Pay for Water Quality Restoration of a Natural Urban Lake in the Philippines. Environmental Processes 3(4): 875-894.

Chau, C.K., M.S. Tse, K.Y. Chung (2010) A choice experiment to estimate the effect of green experience on preferences and willingness-to-pay for green building attributes. Building and Environment 45(11): 2553-2561.

Chaudhry, P., Tewari, V.P., Singh, B. (2008) WTP vs WTA for assessing the recreational benefits of urban forests: a case from a modern and planned city of a developing country. Forests, Trees and Livelihoods 18(3): 215-231.

Chen W.Y. (2017) Environmental externalities of urban river pollution and restoration: A hedonic analysis in Guangzhou (China). Landscape and Urban Planning 157: 170-179.

Chen, M. (2005) Evaluation of Environmental Services of Agriculture in Taiwan. National Taiwan University, Taipei, Taiwan

Chen, W.Y., J Aertsens, I. Liekens, S. Broekx, L. de Nocker (2014) Impact of Perceived Importance of Ecosystem Services and Stated Financial Constraints on Willingness to Pay for Riparian Meadow Restoration in Flanders (Belgium). Environmental Management 54(2): 346-359

Chen, W.Y., Jim C.Y. (2012) Contingent valuation of ecotourism development in country parks in the urban shadow. International Journal of Sustainable Development & World Ecology 19(1): 44-53.

Cho, Seong-Hoon, Neelam C. Poudyal, Roland K. Roberts (2008) Spatial analysis of the amenity value of green open space. Ecological Economics 66: 403–416.

Chui, T.F.M., W.Y. Ngai (2016) Willingness to Pay for Sustainable Drainage Systems in a Highly Urbanised City: a Contingent Valuation Study in Hong Kong. Water and Environment Journal 30(1-2): 62-69.

Correll, M.R., Lillydahl, J.H., Singell, L.D. (1978) The effects of greenbelts on residential property values: some findings on the political economy of open space. Land Economics 54: 207-217.

Czembrowski, P., Kronenberg J. (2016) Hedonic pricing and different urban green space types and sizes: Insights into the discussion on valuing ecosystem services. Landscape and Urban Planning 146: 11-19.

Dare, A.M., Ayinde, I.A., Shittu, A.M. (2015) Urban trees forest management in Abeokuta Metropolis, Ogun State, Nigeria: An application of contingent valuation method. Management of Environmental Quality: An International Journal 26(1): 72-83.

Dumenu, W.K. (2013) What are we missing? Economic value of an urban forest in Ghana. Ecosystem Services 5: 137-142.

Ezebilo E. (2016) Willingness to Pay for Maintenance of a Nature Conservation Area: A Case of Mount Wilhelm, Papua New Guinea. Asian Social Science 12(9): 149-161.

Fleischer, A., Tsur, Y. (2000) Measuring the recreational value of agricultural landscape. European Review of Agricultural Economics 27, 385-398.

Fleischer, A., Tsur, Y. (2004) The Amenity Value of Agricultural Landscape and Rural/Urban Land Allocation. Discussion Paper No. 5.04. The Center for Agricultural Economic Research, The Hebrew University of Jerusalem, Jerusalem.

Frey, E., Palin, M., Walsh, P., Whitcraft, C. (2013). Spatial Hedonic Valuation of a Multi-use Urban Wetland in Southern California. Agricultural and Resource Economics Review 42(2): 387-402.

Giergiczny, M., Jakub Kronenberg (2014) From Valuation to Governance: Using Choice Experiment to Value Street Trees. AMBIO 43: 492–501.

Hanley, N.D., Wright, J.L. (1992) Valuing the environment: recent UK experience and an application to Green Belt land. Journal of Environmental Planning and Management 35: 145-160.

Herath, S., Choumert, J. & Maier, G. (2015) The value of the greenbelt in Vienna: a spatial hedonic analysis. The Annals of Regional Science 54: 349.

Ichihara, K., Cohen, J.P. (2011) New York City property values: what is the impact of green roofs on rental pricing? Letters in Spatial and Resource Science 4: 21.

Jim, C.Y., Chen, W.Y. (2006) Recreation-amenity use and contingent valuation of urban greenspaces in Guangzhou, China. Landscape and Urban Planning 75: 81-96.

Jin, J., Jiang, C., and LI, L. (2013) The economic valuation of cultivated land protection: A contingent valuation study in Wenling City, China. Landscape and Urban Planning 119: 158-164.

Kenney, M. A., Wilcock, P. R., Hobbs, B. F., Flores, N. E. Martínez, D. C. (2012) Is Urban Stream Restoration Worth It? Journal of the American Water Resources Association 48: 603–615.

Kim D-H, Ahn B-I, Kim E-G. (2016) Metropolitan Residents' Preferences and Willingness to Pay for a Life Zone Forest for Mitigating Heat Island Effects during Summer Season in Korea. Sustainability 8(11): 1155.

Kim, J.H., Kim, SN., Doh, S. (2015) The distance decay of willingness to pay and the spatial distribution of benefits and costs for the ecological restoration of an urban branch stream in Ulsan, South Korea. The Annals of Regional Science 54(3): 835-853.

Kim, Y., Johnson, R.L. (2002) The Impact of forests and forest management on neighboring property values. Society and Natural Resources 15: 887-901.

Krieger, D. (1999) Saving Open Spaces: Public Support for Farmland Protection. Working Paper Series WP 99e1. Center for Agriculture in the Environment, Northern Illinois University, Chicago.

Kwak, S.J., Yoo, S.H., Han, S.Y. (2003) Estimating the public's value for urban forest in the Seoul metropolitan area of Korea: a contingent valuation study. Urban Studies 40: 2207-2221.

Lantz, Peter v., C. Boxall, M. Kennedy, J. Wilson (2013) The Valuation of Wetland Conservation in an Urban/peri Urban Watershed. Regional Environmental Change 13(5): 939-953

Larson, E.K., Perrings, C. (2013) The value of water-related amenities in an arid city: The case of the Phoenix metropolitan area. Landscape and Urban Planning 109(1): 45-55.

Latinopoulos, D., Mallios, Z., Latinopoulos, P. (2016) Valuing the benefits of an urban park project: A contingent valuation study in Thessaloniki, Greece. Land Use Policy 55: 130-141.

Leggett, C.G., Bockstael, N.E. (2000) Evidence of the Effects of Water Quality on Residential Land Prices. Journal of Environmental Economics and Management 39(2): 121-144.

Leng, Z., Lei Y. (2011) Estimate the Forest Recreational Values of Zhangjiajie in China Using a Contingent Valuation Method. Low Carbon Economy (2): 99-106.

Li, Y., He, L., Xu, W., Wang, H., He, Z. (2013) Using GIS and Hedonic in the modelling of spatial variation of housing price in Xiamen city. International Review for Spatial Planning and Sustainable Development 1(4): 29-42.

Lin, I.-H., Wu, C., De Sousa, C. (2013) Examining the economic impact of park facilities on neighboring residential property values. Applied Geography 45: 322–331.

Lindsey, G., Knaap, G. (1999) Willingness to pay for urban greenway projects. Journal of the American Planning Association 65, 297-313.

Lo, A.Y., Jim, C.Y. (2010) Willingness of residents to pay and motives for conservation of urban green spaces in the compact city of Hong Kong. Urban Forestry & Urban Greening 9(2): 113-120.

Lockwood, M., Tracy, K. (1995) Nonmarket economic valuation of an urban recreation park. Journal of Leisure Research 27: 155-167.

Luttik, J. (2000) The value of trees, water and open space as reflected by house prices in the Netherlands. Landscape and urban planning 48(3): 161-167.

Lutzenhiser, M., Netusil, N.R. (2001) The effect of open spaces on a home's sale price. Contemporary Economic Policy 19: 291-298.

Machado, F.H., L.F. Silva, F.A. Dupas, A.P. Mattedi, F.E. Vergara (2014) Economic Assessment of Urban Watersheds: Developing Mechanisms for Environmental Protection of the Feijão river, São Carlos - SP, Brazil. Brazilian Journal of Biology 74(3).

Mahmoudi, P., Darla Hatton MacDonald, Neville D. Crossman, David M. Summers, John van der Hoek (2012) Space matters: the importance of amenity in planning metropolitan growth. The Australian Journal of Agricultural and Resource Economics 57: 38–59.

Majumdar, S., Deng, J., Zhang, Y., Pierskalla, C. (2011) Using contingent valuation to estimate the willingness of tourists to pay for urban forests: A study in Savannah, Georgia. Urban Forestry & Urban Greening 10(4): 275-280.

Mansfield, C., Pattanayak, S.K., McDow, W., McDonald, R., Halpin, P. (2005) Shades of green: measuring the value of urban forests in the housing market. Journal of Forest Economics 11, 177-199.

Maxwell, S. (1994) Valuation of Rural Environmental Improvements using Contingent Valuation Methodology: a Case Study of the Marston Vale Community Forest Project. Journal of Environmental Management 41(4): 385-399.

McPherson, E.G., Simpson, J.R., Pepper, P.J., Xiao, Q. (1999) Benefit-cost analysis of Modesto's municipal urban forest. Journal of Arboriculture 25 (5): 235–248.

Melichar, J., Kaprová K. (2012) Revealing preferences of Prague's homebuyers toward greenery amenities: The empirical evidence of distance–size effect. Landscape and Urban Planning 109(1): 56-66.

Mell I.C., John Henneberry, Sigrid Hehl-Lange, Berna Keskin (2013) Promoting urban greening: Valuing the development of green infrastructure investments in the urban core of Manchester, UK. Urban Forestry & Urban Greening 12(3): 296–306.

Mohamed N., M.N. Shamsudin, A.N.A. Ghani, A. Radam, S. Kaffashi, N.N.R.N.A. Rahim, N.H. Bin Hassin (2012) Willingness to Pay for Watershed Conservation at Hulu Langat, Selangor. Journal of Applied Sciences 12: 1859-1864.

Mueller, J. M., W. Swaffar, E. A. Nielsen, A. E. Springer, S. M. Lopez (2013) Estimating the value of watershed services following forest restoration Water Resources Research 49: 1773–1781.

Netusil, N. R., M. Kincaid, H. Chang (2014) Valuing water quality in urban watersheds: A comparative analysis of Johnson Creek, Oregon, and Burnt Bridge Creek, Washington. Water Resources Research 50: 4254–4268.

Nilsson, P. (2015) The influence of urban and natural amenities on second home prices. Journal Housing and the Built Environment 30(3): 427-450.

Palmquist, R.B. (1992) Valuing localized externalities. Journal of Urban Economics 31: 59-68.

Panduro, T.E., Veie, K.L. (2013) Classification and valuation of urban green spaces—A hedonic house price valuation. Landscape and Urban Planning 120: 119-128.

Phaneuf, D., Smith, V., Palmquist, R., Pope, J. (2008) Integrating Property Value and Local Recreation Models to Value Ecosystem Services in Urban Watersheds. Land Economics 84(3): 361-381.

Polyakov, M., J. Fogarty F. Zhang, R. Pandit, D.J. Pannell (2017) The Value of Restoring Urban Drains to Living Streams. Water Resources and Economics 17: 42-55.

Ready, R.C., Berger, M.C., Blomquist, G.C. (1997) Measuring amenity benefits from farmland: hedonic pricing vs. contingent valuation. Growth and Change 28 (4): 438-458.

Rosenberger, R.S., Needham, M.D., Morzillo, A.T., Moehrke, C. (2012) Attitudes, willingness to pay, and stated values for recreation use fees at an urban proximate forest. Journal of Forest Economics 18(4): 271-281.

Rosenberger, R.S., Walsch, R.G. (1997) Nonmarket value of western valley Ranchland using contingent valuation. Journal of Agricultural and Resource Economics 22: 296-309.

Sander H., Polasky, S., Haight R.G. (2010) The value of urban tree cover: A hedonic property price model in Ramsey and Dakota Counties, Minnesota, USA. Ecological Economics 69(8): 1646-1656.

Sander, H.A., Polasky, S. (2009) The value of views and open space: Estimates from a hedonic pricing model for Ramsey County, Minnesota, USA. Land Use Policy 26(3): 837-845.

Sander, H.A., Haight R.G. (2012) Estimating the economic value of cultural ecosystem services in an urbanizing area using hedonic pricing. Journal of Environmental Management 113: 194–205.

Sander, H.A., Zhao, C. (2015) Urban Green and Blue: Who Values What and Where? Land Use Policy 42: 194-209.

Saphores, J.-D., Li, W. (2012) Estimating the value of urban green areas: A hedonic pricing analysis of the single family housing market in Los Angeles, CA. Landscape and Urban Planning 104(3–4): 373-387.

Sarvilinna, A., V. Lehtoranta, T. Hjerppe (2017) Are Urban Stream Restoration Plans Worth Implementing? Environmental Management 59(1): 10-20

Sattout, E.J., Talhouk, S.N., Caligari, P.D.S. (2007) Economic value of cedar relics in Lebanon: An application of contingent valuation method for conservation. Ecological Economics 61(2–3): 315-322.

Scarpa, R., Hutchinson, W.G., Chilton, S.M., Buongiorno, J. (2000) Importance of forest attributes in the willingness to pay for recreation: a contingent valuation study of Irish forests. Forest Policy and Economics 1: 315-329.

Schläpfer F., Waltert F., Segura L., Kienast F. (2015) Valuation of landscape amenities: A hedonic pricing analysis of housing rents in urban, suburban and periurban Switzerland. Landscape and Urban Planning 141: 24-40.

Shang, Z., Che, Y., Yang, K., Jiang, Y. (2012) Assessing Local Communities' Willingness to Pay for River Network Protection: A Contingent Valuation Study of Shanghai, China. Int. J. Environ. Res. Public Health 9: 3866-3882.

Smith, V.K., Poulos, C., Kim, H. (2002) Treating open space as an urban amenity. Resource and Energy Economics 24: 107-129.

Stetler, K.M., Venn, T.J., Calkin, David E. (2010) The effects of wildfire and environmental amenities on property values in northwest Montana, USA. Ecological Economics 69(11): 2233-2243.

Tajima, K. (2003) New estimates of the demand for urban green space: implications for valuing the environmental benefits of Boston's big dig project. Journal of Urban Affairs 25, 641-655.

Tao Z., Yan H., Zhan J. (2012) Economic Valuation of Forest Ecosystem Services in Heshui Watershed using Contingent Valuation Method. Procedia Environmental Sciences 13: 2445-2450.

Tapsuwan, S., Ingram, G., Burton, M., Brennan, D. (2009) Capitalized amenity value of urban wetlands: a hedonic property price approach to urban wetlands in Perth, Western Australia. Australian Journal of Agricultural and Resource Economics 53: 527–545.

Tu, G., Abildtrup, J., Garcia, S. (2016) Preferences for urban green spaces and peri-urban forests: An analysis of stated residential choices. Landscape and Urban Planning 148: 120-131.

Tyrvainen, L. (2001) Economic valuation of urban forest benefits in Finland. Journal of Environmental Management 62: 75-92.

Tyrvainen, L., Vaananen, H. (1998) The economic value of urban forest amenities: an application of the contingent valuation method. Landscape and Urban Planning 43: 105-118.

Vaughan, R.J. (1981) The value of urban open space. Research in Urban Economics 1: 103-130.

Votsis, A. (2017) Planning for green infrastructure: The spatial effects of parks, forests, and fields on Helsinki's apartment prices. Ecological Economics, 132: 279-289.

Walsh P.J., Milon J.W., Scrogin D.O. (2011) The Spatial Extent of Water Quality Benefits in Urban Housing Markets. Land Economics 87(4): 628-644.

Wang H., He J., Kim Y., Kamata T. (2013) Willingness-to-pay for water quality improvements in Chinese rivers: An empirical test on the ordering effects of multiple-bounded discrete choices. Journal of Environmental Management 131: 256-269.

Willis, K.G., Whitby, M.C. (1985) The value of Green Belt Land. Journal of Rural Studies 1: 147-162.

Windle, J., Cramb, R.A. (1993) Contingent Valuation as a Guide to Environmental Policy: An Application to the Conservation of Natural Bushland in Brisbane. Economic Analysis and Policy 23(2): 139-149.

Xiao, Y., Li, Z., Webster C. (2016) Estimating the mediating effect of privately-supplied green space on the relationship between urban public green space and property value: Evidence from Shanghai, China. Land Use Policy 54: 439-447.

Zhao J., Liu Q., Lin L., Lv H., Wang Y. (2013) Assessing the comprehensive restoration of an urban river: An integrated application of contingent valuation in Shanghai, China. Science of The Total Environment 458–460: 517-526.

APPENDIX

Table A1: Ecological domains and how often they are valued in the database in absolute frequency (N) and as a percentage of total recorded values (%)

CATEGORY	Subcategories	Explanation	Frequency (N)	Frequency (%)
(External) building greens	ALL		**16**	**6.30%**
	Green roofs	Roof vegetation on thin substrate either with varying degrees of irrigation and management; vegetation established either artificially or by seeding or planning or naturally; can include perennials, grasses, small trees, rooftop farming, mosses, succulents, few herbs and grasses		
	Green walls or facades	Including e.g. ground-based climbing plants intended for ornamental purposes or plants growing in façade-bound substrate (e.g. containers or textile-systems)		
	Balcony green	Plants on balconies and terraces which are planted mostly in pots		
Urban green areas connected to grey infrastructure	ALL		**5**	**1.97%**
	Alley and street trees/hedges/greens	Trees planted in alleys or along roads and paths, either solitary or in rows. Hedges along roads or paths. Non-tree, mostly shrubby or grassy verges along roads.		
	Railroad bank and tracks	Green space along railroads		
	House gardens	Areas in the immediate vicinity of private houses cultivated mainly for ornamental purposes and/or non-commercial food production		
	Green playground/ school grounds	Green areas intended for playing or outdoor learning		
	Institutional green space	Green spaces surrounding public and private institutions and corporation buildings		
	Green parking lots	Parking lots which are surrounded by or interspersed with trees, grass patches, flower beds, bushes, or other vegetation		
	Riverbank greens	Green space sideways the rivers, streams and canals, usually with foot or bike paths		
Parks and (semi)natural urban green areas	ALL		**125**	**49.21%**
	Large urban park or forest	Larger green (forested) area within a city intended for recreational use by urban population; can include different features such as trees, grassy areas, playgrounds, water bodies, ornamental beds, etc.		
	Pocket parks / neighbourhood green spaces	Small green areas around and between buildings which are vegetated by ornamental trees, shrubs, grass; often in residential areas, but also between other building types		

	Botanical garden	Educational and ornamental areas planted with large diversity of plant species.		
	Green corridor	Networks of linked landscape elements that provide ecological, recreational, and cultural benefits to the community		
Allotments and community gardens	ALL		**0**	**0.00%**
	Allotments	Small garden parcels cultivated by different people, intended for non-commercial food production		
	Community gardens	Areas which are collectively gardened by a community for food and recreation		
	Horticulture	Land devoted to growing vegetables, flowers, berries, etc		
Green indoor areas	ALL		**0**	**0.00%**
	Indoor vertical greeneries (walls and ceilings)	Including e.g. ground-based climbing plants intended for ornamental purposes or plants growing in façade-bound substrate (e.g. containers or textile-systems) inside of a building		
	Atrium	Green area surround/enclosed in a building, planted mostly with ornamental plants		
Blue areas	ALL		**56**	**22.05%**
	Lake/pond	Natural and artificial standing water bodies containing freshwater with (semi)natural aquatic communities; banks are artificial/managed or natural		
	River/stream/canal/ estuary	Natural and artificial running water bodies containing freshwater (or in the case of estuaries, mixed fresh and saltwater) with (semi)natural aquatic communities; banks are artificial/managed or natural		
	Delta	Landform at the mouth of a river formed by sediment deposits		
	Sea coast	Contact areas between the sea and the land of different characteristics (e.g. sand beaches, cliffs, coastal dunes)		
	Wetland/bog/fen/ marsh	Areas with soil permanently or periodically saturated with water and characteristic flora and fauna		
Green areas for water management	ALL		**8**	**3.15%**
	Rain gardens	Shallow, vegetated basins that collect and temporarily store rainwater runoff from rooftops, sidewalks, and streets or allow for its infiltration		
	Swales / filter strips	Vegetated and gently sloped pit or shallow drainage channels for filtering surface runoff		
	Sustainable urban drainage systems	Systemic approach to manage drainage in and around properties, often combining green and grey components; can include e.g. green roofs, permeable surfaces, infiltration trenches, swales, detention basins, etc.		
Derelict areas	Abandoned and derelict spaces with growth of	Recently abandoned areas, construction sites, former industrial areas, etc. with spontaneously occurring pioneer or ruderal vegetation	**3**	**1.18%**

	wilderness or green features			
Open green (and blue) space directly adjacent to urban areas	Farmland, agricultural land, fields, woodlands, golf courses	Various sizeable plots of green (and blue) space that are directly adjacent to urban areas and can provide urban areas with various services, a.o. recreation, aesthetics and tourism.	**41**	**16.14%**
TOTAL			**254**	**100%**

Source: Adapted from Braquinho et al. 2015, Xing et al. 2017, Ecologic studies on GI and EbA/EbM, US EPA website on Green Infrastructure, and Ndubisi et al 1995[2]; Please refer to Braquinho et al. (2015) and the US EPA website on GI[3] for photos to illustrate the majority of the subcategories listed in Table

[2] F.Ndubisi, D.M.Terry, D.D.Niels, Environmentally sensitive areas: a template for developing greenway corridors. In: J.Fabos, J.Ahern (Eds.), Greenways: The Beginning of an International Movement, 1995, Elsevier, Amsterdam.

[3] https://www.epa.gov/green-infrastructure/what-green-infrastructure

Table A2: Landscape domains and how often they are valued in the database in absolute frequency (N) and as a percentage of total recorded values (%)

Landscape	Definition	Frequency (N)	Frequency (%)
Coastalscape	Coastal areas (built and wild)	**18**	**7,06%**
Riverscape	River areas (natural and managed), riverbanks	**22**	**8,63%**
Waterscape	Lakes, ponds, fountains, wetland (natural/managed/artificial)	**32**	**12,55%**
Soilscape	Surface and subsurface soil	**4**	**1,57%**
Underscape	Underground water bodies, bedrock	**0**	**0,00%**
Gardenscape	Private gardens (domestic & commercial)	**9**	**3,53%**
Parkscape	Public parks (may contain wooded areas, formally managed as public parks) and allotment gardens	**47**	**18,43%**
Woodscape	Forested and wooded land (public and private land consisting entirely of forest area)	**94**	**36,86%**
Farmscape	Farmland areas within or on boundaries of urban	**31**	**12,16%**
Roofscape	Roof space – public, private, commercial (a sub-set of the builtscape, but critical for NBS which compete with other sustainability interventions , e.g. solar, white coatings, so kept separate)	**11**	**4,31%**
Builtscape	Built fabric – walls/facades, paving, car parks, indoor green	**7**	**2,75%**
Streetscape	Road infrastructure (including hedges, marginal land, roundabouts)	**8**	**3,14%**
Railscape	Rail infrastructure (including marginal land, embankments)	**0**	**0,00%**
Barescape	Abandoned and derelict land, buildings, infrastructure	**5**	**1,96%**

Table A3: Ecosystem services for NBS and their percentage frequency of occurrence in the database

Type of ecosystem service	Ecosystem service category	Frequency of occurrence in the database (FEVD)
Provisioning Services	**ANY provisioning services**	**41,57%**
	Food	18,82%
	Raw Materials	12,94%
	Fresh Water quantity	20,78%
	Medicinal resources	1,18%
Regulating services	**ANY regulating services**	**86,67%**
	Local climate regulation (temperature reduction)	45,10%
	Air quality regulation	51,76%
	Coastal protection	3,14%
	Noise reduction	52,94%
	Carbon storage/sequestration	49,41%
	Flood regulation	57,65%
	Water purification	20,78%
	Pollination	2,75%
Habitat and supporting services	**ANY habitat & supporting services**	**59,61%**
	Habitats for species	58,04%
	Maintenance of genetic diversity	41,96%
Cultural services	**ANY cultural services**	**87,06%**
	Recreation and mental and physical health	78,43%
	Tourism	37,65%
	Aesthetic appreciation	76,47%
	Inspiration for culture, art & design	37,65%

Table A4: NBS goals and their percentage frequency of occurrence in the database

NBS Goal	Description	Frequency of occurrence in the database (FEVD)
1	Climate action for adaptation, resilience and mitigation	22,35%
2	Water management	29,02%
3	Coastal resilience and marine protection	3,53%
4	Green space, habitats and biodiversity	53,73%
5	Environmental quality, including air quality and waste management	61,96%
6	Regeneration, land-use and urban development	11,37%
7	Inclusive and effective governance	2,75%
8	Social justice, inequality and social cohesion	29,41%
9	Health and well-being	58,82%
10	Economic development and decent employment	21,96%
11	Cultural heritage and cultural diversity	39,22%
12	Sustainable consumption and production	17,65%

Table A5: Spatial and temporal scales of NBS valuation and their absolute and percentage frequency of occurrence in the database.

Indicators		**N**	**%**
SPATIAL SCALE			
Macro	Global/national	13	5,10%
Meso	Metropolitan/urban	208	81,57%
Micro	District/neighbourhood	31	12,16%
Sub-Micro	Street/house	30	11,76%
TEMPORAL SCALE			
Imediate	Days/weeks	49	19,22%
Short-term	Weeks/months	20	7,84%
Medium term	1-3 years	22	8,63%
Long-term	Longer than 3 years	54	21,18%

Table A6: Agents for which the valuation is applied valuation and their absolute and percentage frequency of occurrence in the database.

AGENTS	**N**	**%**
individuals	48	18,82%
households	145	56,86%
group / population	62	24,31%
TOTAL	**255**	**100%**