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REPORT ON ESA MONETARY EVALUATION FOR NBS

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0 Executive summary

Task 7.1 of WP7 aims to valuate ex-ante the impacts generated by NBS in Front-runner cities involved in Urban GreenUP project. NBS have been using the benefit transfer technique based on the ecosystem services approach (see deliverable 7.3).

The benefit transfer is a procedure for taking the estimates of economic benefits (or values in general) gathered from one site and applying them to another. Benefit transfer can potentially be used to estimate values for any ecosystem service, if there are primary valuations of that ecosystem service from which to transfer values.

This technique is particularly indicated for the case of URBAN GreenUP cities since the valuation performed has been carried out before the implementation of the NBS in cities. The ex-ante economic valuation is the first step for the identification of the value generated by nature in Front-runner cities. After the implementation of NBS and the monitoring process, an ex-post valuation will be carried out based on the ecosystem services provided and measured through a set of KPIs previously defined with the support of cites.

The deliverable is composed by different blocks:

1. Description of the methodologies and tools for the economic valuation of the ecosystem services;
2. Explanation of the benefit transfer technique adopted for the ex-ante valuation performance of NBS in Front-runner cities;
3. Literature review of case studies of NBS economic valuation at urban level;
4. Definition of a matrix used for the ex-ante economic valuation and association of the values detected in the case studies review to the NBS planned in Front-runner cities;
5. Ex-ante economic valuation in Valladolid, Liverpool, and Izmir.

1 Introduction

1.1 Purpose and targets groups

WP7 of Urban GreenUP project is focused on exploitation and market deployment as well as on the ex-ante economic valuation of NBS in Front-runner cities: Valladolid, Liverpool, and Izmir. Specifically, Task 7.1 aims to define the methodology for the economic valuation performance of NBS based on the ecosystem services approach and to adopt this approach to perform the ex-ante economic valuation of NBS. This deliverable (7.2) describes:

- the methodology used for the ex-ante valuation performance of NBS;
- the ex-ante economic valuation performance of NBS in front-runner cities: Valladolid, Liverpool, and Izmir.

The main target groups of this deliverable are the partners of the Urban GreenUP project, front-runner and follower cities. The deliverable can also be of interest for other cities, their technical and business partners, who wish to acquire information on economic valuation of NBS impact generated in cities and on Urban GreenUP specific approach on this.

1.2 Contributions from other partners

The following Table describes the main contributions from participant partners in the development of this deliverable.

Partner	Contribution
UB	Research activities on NBS projects, criteria & dimensions for NBS economic valuation Analysis of the NBS and identification of the ecosystem services provided by them Literature review on case studies for the economic valuation of NBS Benefit transfer technique performance
VAL and city technical partner	Front-runner cities and their technical partners have contributed in the definition and population of the set of KPI for NBS.
LIV and city technical partner	Front-runner cities and their technical partners have contributed in the definition and population of the set of KPI for NBS.
IZM and city technical partner	Front-runner cities and their technical partners have contributed in the definition and population of the set of KPI for NBS.
RMIT	Revision of overall deliverable

Table 1: Contribution form project partners

1.3 Connection with other project activities

The following table summarises the main relationship of this deliverable to other activities (or deliverables) developed within Urban GreenUP Project and that should be considered along with this document for further understanding of its contents.

Partner	WP	Relation
ACC	WP1	Definition of the NBS catalogue
VAL	WP2	Definition and implementation of NBS. Monitoring and analysis of the performances.
LIV	WP3	Definition and implementation of NBS. Monitoring and analysis of the performances.
IZM	WP4	Definition and implementation of NBS. Monitoring and analysis of the performances.
GMV	WP5	Definition of the KPI for the NBS monitoring program

Table 2: Relation to other project activities

2 Ecosystem services valuation

2.1 Methodologies for the ecosystem services valuation

The valuation of ecosystem services provided by NBS in urban areas can be performed through the application of the Total Economic Value methodology. As explained in D 7.3 Guidelines for the use of ESA in different contexts, the TEV is defined as "the sum of the values of all service flows that natural capital generates both now and, in the future, – appropriately discounted" (Pascal, et al., 2010). Through a standard unit of account – money or any market-based unit of measurement, TEV can capture all elements of utility and disutility obtained from ecosystem services. Hence, this framework considers both the value that humans receive when they make use of the natural environment and the value they attribute to it that does not originate from any exploitation. The methodologies for the ecosystem services valuation can be dived in three groups:

1. Direct market valuation - use of data from real markets, which reflect actual preferences or costs for individuals;
2. Revealed preferences - based on the observation of individual choices in existing markets, in this case, it is said that economic agents "reveal" their preferences through options;
3. Stated preferences - simulation of the market and demand for ES using surveys on hypothetical variations used to estimate both the value of use and non-use;

King & Mazotta (2001), Wilson & Carpenter (1999), de Groot et al. (2006).

Through the analyses carried out in D 7.3, 15 methodologies have been analysed:

1. Direct market valuation - Market prices, Replacement costs & damage, cost avoided, Production function approaches;
2. Revealed preferences: travel costs and hedonic prices;
3. Stated preferences - Contingent valuation, Choice modelling, Deliberative monetary valuation, Questionnaire, In-depth interview, Focus group, Citizens' juries, Health-based valuation method, Q-Methodology.

The methodologies can be used to measure "use value" and "non-use value" and the related ecosystem services associated. An interpretative framework has been created to clarify the linkages between the TEV approach, the related ecosystem services, and the economic valuation approaches that can be adopted (see figure 1).

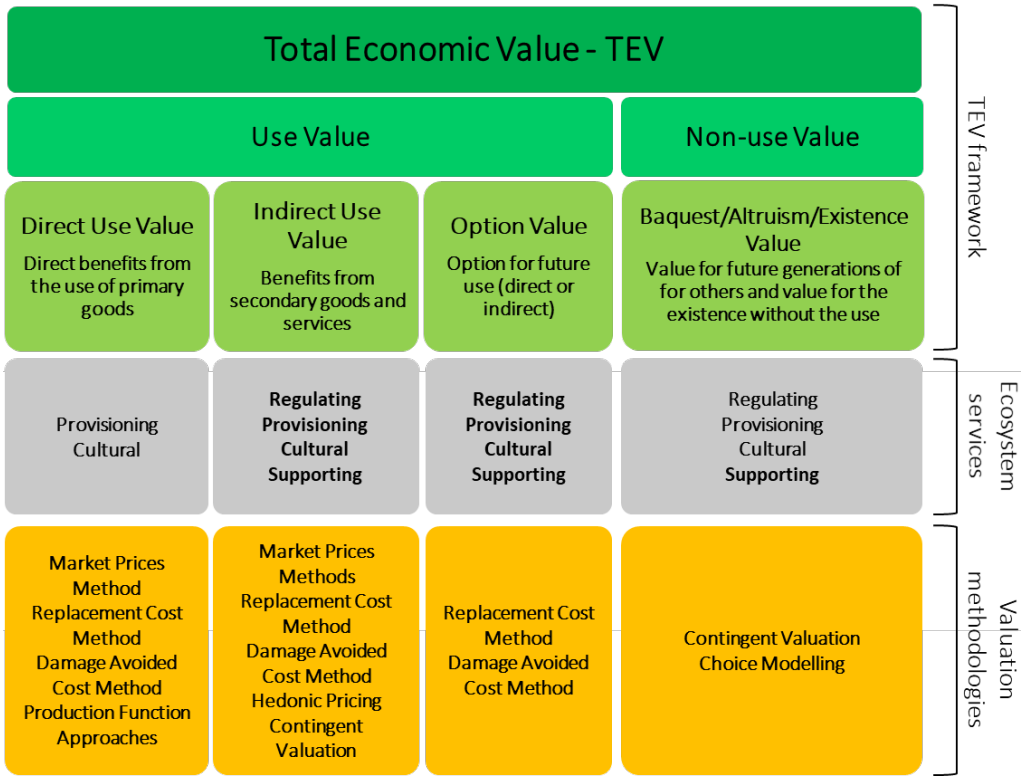

Figure 1: Methodologies for the estimation of the different types of values. Adapted from Pascual, U. et al., 2010 and EC, 2013.

More detailed information about the methodologies for the ecosystem services valuation, can be found in the deliverable 7.3 “Guidelines for the application of the ESA methodology”.

2.2 Tools for the ecosystem services valuation

There is a range of tools available to assist decision-makers in the integration of ecosystems and their services into policy and planning decisions. In fact, following the increased awareness and acknowledgment of nature's role in supporting human well-being, a plethora of tools for measuring, modelling, and valuing ecosystem services have been developed in recent years. For practitioners, selecting an appropriate tool or suite of tools for measuring and modelling ecosystem services can be confusing. Tools are created for different purposes, produce various outputs, have different requirements in terms of time, data, and specialised expertise. Based on the literature review, a repository of the existing tools for the economic valuation of ecosystem services has been structured. The tools for the economic valuation of ecosystem services have been listed in the table below (for more detailed information, consult the deliverable 7.3 "Guidelines for the application of the ESA methodology").

2.3 Methodologies and tools for the ecosystem services valuation at urban level

The valuation of ecosystem services at the urban level can be performed through the direct application of methodologies or using tools that are able to catch the value generated by NBS at the urban scale. In light of this, an extensive review of the literature and of the case studies has been performed to identify the principal methodologies and tools used for the ecosystem services valuation at urban level. In total more than 130 papers and case studies have been analysed to individuate the ad hoc methodologies and tools for the ecosystem services valuation. The analysis results are reported in figure 2 and figure 3 (for more detailed consult the D7.3 "Guidelines for the ESA approach application in different contests"). Figure 2 represents the interpretative framework linking ecosystem services and the various methodologies available to evaluate them at the urban level. Methodologies in green boxes belong to the direct market valuation approaches, those in purple boxes to the revealed preferences category, and those in light blue boxes to the stated preferences methods.

Figure 3 summarises the findings of the ecosystem services valuation tools review: the ecosystem services have been associated to the tools used for the economic valuation (for more detailed consult the D7.3 "Guidelines for the ESA approach application in different contests").

Values derived by the economic valuation of ecosystem services individuated through the case studies analysed have been used to perform the ex-ante valuation of the NBS in front-runner cities: Valladolid, Izmir, and Liverpool. The ex-ante valuation has been performed using the benefit transfer technique based on the ecosystem services provided by NBS.

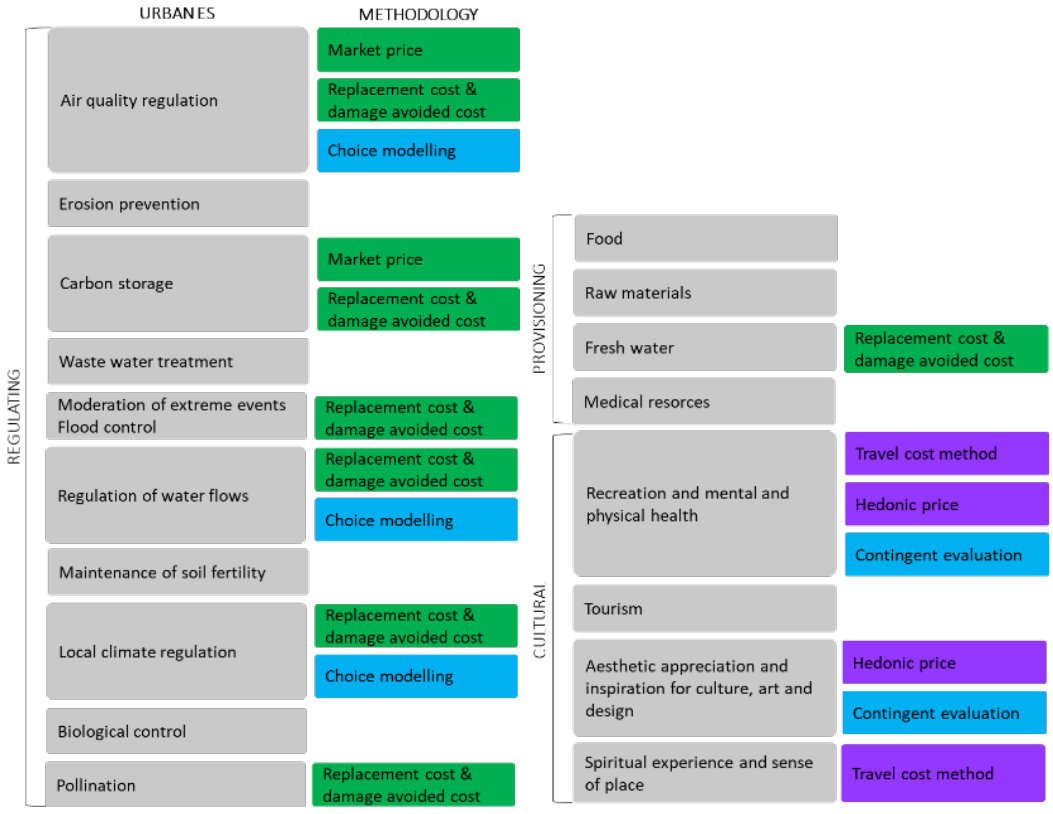

Figure 2: Ecosystem services and valuation methodologies

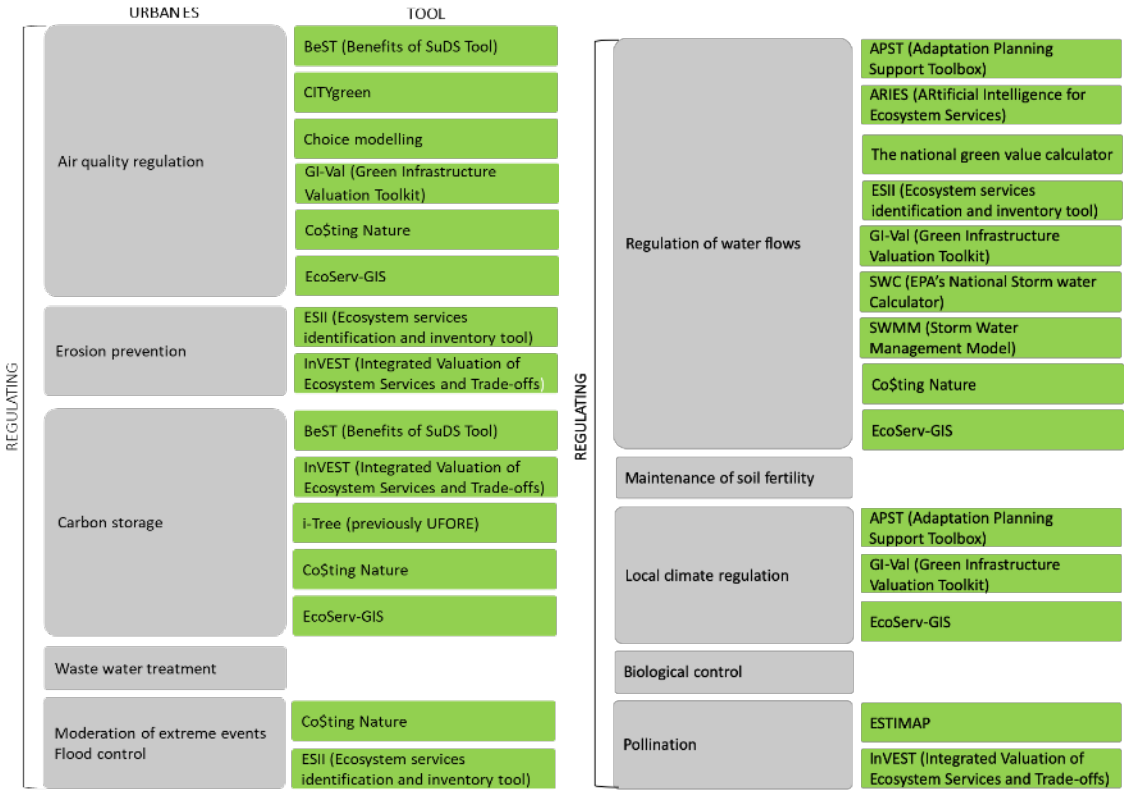

Figure 3: Ecosystem services and valuation tools

3 Ex-ante valuation of ecosystem services in Urban GreenUP project

3.1 Benefit transfer

As highlighted in the previous paragraph, alternative approaches to economic valuation are available for quantifying and communicating information on impacts on ecosystem services (see deliverable 7.2). For example, bio-physical indicators for ecosystem services may also be used to convey impacts directly to decision-makers. The advantage of economic valuation is that impacts are expressed in common units (i.e. money) that can be directly compared and reflect impacts in terms of human well-being. There are many contexts in which the economic valuation of ecosystem services may be useful, including:

- Raise awareness of the value of the environment
- Reveal the distribution of costs and benefits
- Design the most effective tools for environmental management
- Design appropriate fees for the use of ecosystem services
- Calculate potential returns on investment for projects that impact the environment
- Compare the costs and benefits of different uses of the environment
- Calculate environmental damages and set compensation

The valuation methods are designed to span the range of valuation challenges raised by the application of economic analyses to the complexity of the natural environment. The selection of appropriate valuation methods is, in part, determined by the type of ecosystem service being valued. In the ex-ante valuation of NBS that has been performed in front-runner cities (Valladolid, Liverpool, and Izmir) the technique adopted is the “benefit transfer” and the values used derive from the review of the ecosystem services valuation at the urban level..

Benefit transfer is a procedure for taking the estimates of economic benefits (or values in general) gathered from one site and applying them to another. The site from which the estimates are taken is called the study site, in that it is a site that has already been studied in some way. The site to which the estimates are applied is called the policy site because benefit transfer is usually part of an economic analysis of proposed policy action (Rosenberger and Loomis 2001; NRC 2005).

Benefit transfer can potentially be used to estimate values for any ecosystem service, provided that there are primary valuations of that ecosystem service from which to transfer values. Benefit transfer have been employed widely in national and global ecosystem assessments (e.g., the UK NEA, 2011; EEA, 2010; TEEB, 2010), value mapping applications (see Schaegner et al., 2013) and policy appraisals (e.g., World Bank, 2002). The use of benefit transfer is widespread but requires a careful application.

This technique is particularly indicated for the case of URBAN GreenUP cities since the valuation that has to be performed will be carried out before the implementation of the NBS in cities. The ex-ante economic valuation is the first step for the identification of the value generated by nature in Front-runner cities.

After the implementation of NBS and the monitoring process, an ex-post valuation will be carried out based on the ecosystem services provided and measured through a set of KPIs previously defined with the support of cites.

Figure 4 represents the steps that have been followed for the performance of the ex-ante valuation based on the benefit transfer technique.

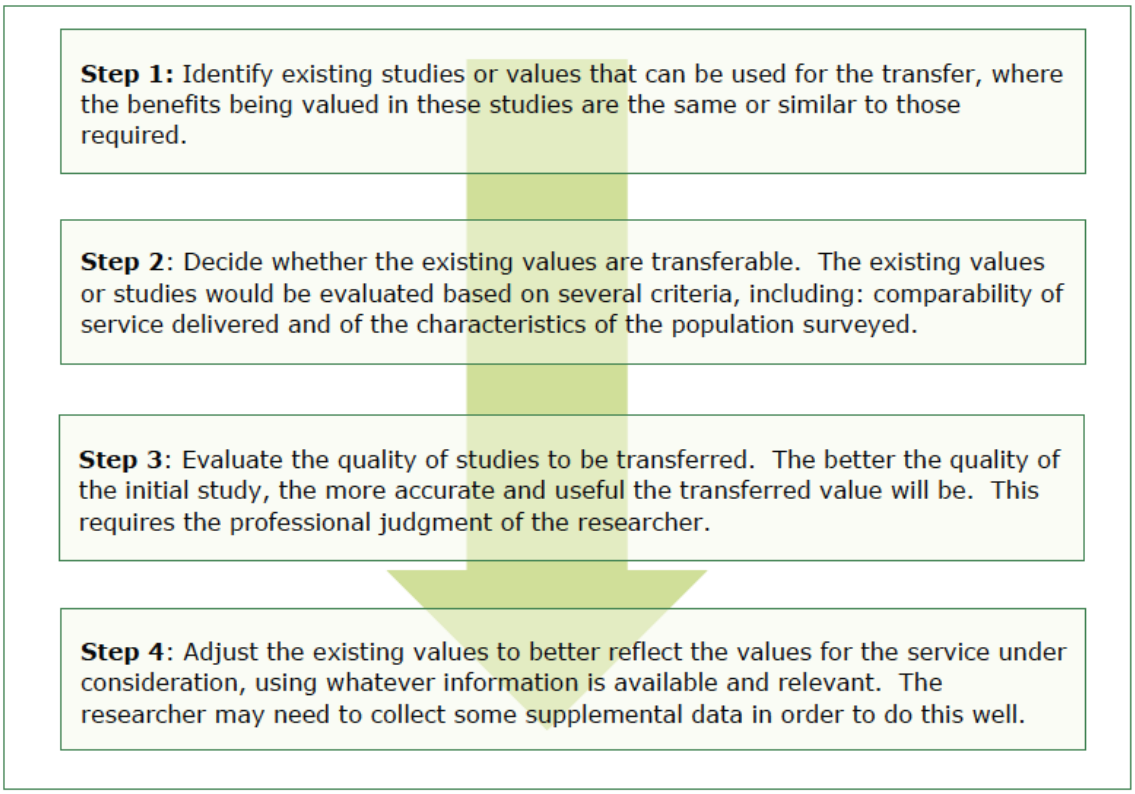

Figure 4: Application of the benefits transfer method (LIFE N2K Wales, 2015)

Different papers and case studies have been analysed in order to individuate the values needed for the benefit transfer performance. The process adopted for the values individuation and selection is outlined in the next paragraph.

3.2 Data set for the benefit transfer valuation

The values for the benefit transfer have been collected through an extensive literature review. The literature review regarding the application of the methodologies and tools for the valuation of ecosystem services at urban level has been performed to identify the values associated with different ecosystem services provided by NBS.

The review has been performed by using Scopus. The following keywords have been used for the methodologies case studies: first, the methodology or tool name, followed by “ecosystem service”, “[economic] valuation”, “urban”. In total, 130 papers have been analysed, but only 37 of them reported quantitative values. These case studies have been used for the ex-ante valuation of the NBS implemented in the Front-runner cities. In the case studies analysed 22 NBS have been considered:

- Cycle path
- Green roof
- Greening of the bypass
- Municipal trees
- Vegetated swale
- Rain garden
- Green roof
- Permeable pavement
- Street trees
- Technological green
- Urban Farming
- Urban forest
- Urban green (street and park trees)
- Urban green spaces
- Urban park
- Urban trees
- Urban Wetland Parks
- Green noise barriers
- Green walls
- Vertical gardens
- Vertical greening systems

The 37 case studies individuated considered one or more than one ecosystem services, for 13 ecosystem services valuated. The case studies collected have been classified based on several elements:

1. NBS considered;
2. Ecosystem services generated by the considered NBS;
3. Location;
4. Values of the ecosystem services reported;
5. Literature references.

The table below summarises all the **case studies selected** to perform the economic valuation, and the literature references. The values associated at each **ecosystem service valuated** are reported in Table 7.

NBS	ES	Location	Source
Eurasian Jays	Pollination	Stockholm national urban park	Hougner, et al., 2006
Bioretention cells/rain gardens	Cultural (health, education, amenity); regulating (climate, carbon, flooding); and supporting (biodiversity)	Zwolle	Ashley, et al., 2017
Fluvial floodable parks; green roofs	Moderation of extreme events	Rio de Janeiro	Miguez, et al., 2017
Green building development	Regulation of water flows; Local climate regulation; Air quality regulation	Yuen Long and Eastern district	Chau et al., 2010
Green roof	Climate regulation	Southwestern region	McRae, 2016
	Air quality maintenance (Avoided CO_2 emissions; Avoided emissions of air pollutants; CO_2 sequestration; Air pollutants removal); Climate regulation (thermal insulation; UHI mitigation)	Hong Kong	Peng, & Jim, 2015
	Climate regulation	Beijing	Zhang et al., 2019

Greening of the bypass	Climate change adaptation & mitigation; Water management & flood alleviation; Health & well-being; Labour productivity; Tourism; Recreation & leisure; Biodiversity; Land management	St Helens	The Mersey Forest, 2010
Modular green walls; green facade	Biodiversity	Southampton	Collins et al., 2017
Municipal trees	Carbon storage and sequestration	New York	Peper et al., 2007
	Air quality regulation	New York	
	Regulation of water flows	New York	
	Local climate regulation	New York	
	Aesthetic appreciation and inspiration for culture, art and design	New York	
Parks, green enclaves, pocket gardens, road side green corridor	Recreation and mental and physical health	Guangzhou	Jim and Chen, 2006
Permeable pavement; vegetated swale; Rain garden; Green roof	Run off reduction	Houston	Thiagarajan et al., 2018
Rural park and periurban rural areas	Inclusive of all ES	N.A.	Neonato et al., 2019
Street trees	Aesthetic appreciation and inspiration for culture, art and design	Portland	Donovan & Butry, 2010
SUDs	Water regulation	Hong Kong	Chui et al., 2016
Urban Farming	Food production	Boston	Goldstein et al., 2017
Urban forest	Carbon storage and sequestration	Beijing	Leng et al., 2004
	Air quality regulation	Lanzhou	Zhang, et al., 2006
	Local climate regulation	Sacramento	Simpson, 1998
	Local climate regulation	Beijing	Leng, et al., 2004
	Air quality regulation	Rome	Capotorti, et al., 2017
	Air quality regulation	Chicago	McPherson et al., 2004
	Air quality regulation	Sacramento	Scott et al., 1998
	Air quality regulation	Philadelphia	Nowak, et al., 2007
	Carbon storage and sequestration	Philadelphia	Nowak, et al., 2007

	Local climate regulation	Chicago	McPherson et al., 1997
	Aesthetic appreciation and inspiration for culture, art and design	Joensuu	Tyrväinen, 1997
	Recreation and mental and physical health	Guangzhou	Jim and Chen, 2007
	Aesthetic appreciation and inspiration for culture, art and design	Joensuu	Tyrväinen and Väänänen, 1998
	Climate regulation (UHI)	7 cities	Kim et al., 2016
	Air quality regulation	Barcelona	Chaparro & Terradas, 2009
Urban gardens	N.A	Barcelona	Camps-Calvet et al., 2016
	N.A	Barcelona	Camps-Calvet et al., 2016
Urban green (street and park trees)	Local climate regulation	Modesto	McPherson et al., 1999
	Carbon storage and sequestration	Modesto	McPherson et al., 1999
	Air quality regulation	Modesto	McPherson et al., 1999
Urban green areas	N.A	Tzaneen and Bela-Bela	Shackleton et al., 2015
	N.A	Tzaneen and Bela-Bela	Shackleton et al., 2015
Urban green spaces	Spiritual experience and sense of place	Bulawayo	Ngulani and Shackleton, 2019
	Aesthetic appreciation and inspiration for culture, art and design	Aalborg	Panduro and Veie, 2013
Urban park	Recreational value	West Norwich	Day and Smith
	N.A	Guangzhou	Jim and Chen, 2006
	N.A	Rotterdam	Buchel and Frantzeskaki, 2015
Urban trees	Air pollution removal; Water quality (runoff)	Manchester/Wellington	Kingston et al., 2019
	Carbon sequestration	10 cities	Nowak and Crane, 2002
Urban Wetland Parks	Recreation and mental and physical health	Guiyang	Wang et al., 2019
Vertical gardens, green noise barriers and green walls	Aesthetic value; noise reduction	N.A.	Veisten et al*, 2012*
Vertical greening systems	Energy performance; Aesthetic values	Genoa	Rosasco & Perini, 2018
Technological green	Inclusive of all ES	N.A.	Neonato et al., 2019
Therapeutic gardens	Inclusive of all ES	N.A.	Neonato et al., 2019
Tree-lined street and green traffic islands	Inclusive of all ES	N.A.	Neonato et al., 2019

Periurban parks	Inclusive of all ES	N.A.	Neonato et al., 2019
Monumental cemeteries and memorial parks	Inclusive of all ES	N.A.	Neonato et al., 2019
Green walls and green roofs	Inclusive of all ES	N.A.	Neonato et al., 2019
Urban parks and historic gardens	Inclusive of all ES	N.A.	Neonato et al., 2019
Urban neighbourhood green space	Inclusive of all ES	N.A.	Neonato et al., 2019

Table 3: case studies of NBS ecosystem services valuation at urban level

As already said, in total 13 ecosystem services have been valuated in the case studies considered. The table below shows the recurrences of the different typologies of ES in the case studies used for the benefit transfer and the related NBS.

	PROVISIONING	REGULATION									CULTURAL			ALL
NBS	food production	carbon sequestration and storage	air quality regulation	water regulation	climate regulation	pollination	storm water protection	energy saivings	UIH effect reduction	noise reduction	recreation and tourism	aesthetic value	sense of place	all
Eurasian jays						1								
Green roof		1	1	1				2	2					
Green walls and green roofs														1
Monumental cemeteries and memorial parks														1
Municipal trees		1	1	1	1							1		
Parks, green enclaves, pocket gardens, road side green corridor											1			
Periurban parks														1
Permeable pavement				1										
Rain garden				1										
Rural parks and peri-urban areas														1
Technological green														1
Therapeutic gardens														1
Tree-lined street and green traffic islands														1
Urban farming	1													
Urban forest		4	8		3			1	1					
Urban green spaces													1	
Urban neighborhood green space														1
Urban park											1			1
Urban parks and historic gardens														1
Urban trees			1				1							
Urban Wetland Parks											1			
Vegetated swale				1										
Vertical gardens, gre										1		1		
Vertical greening systems								1				1		

Table 4: ecosystem services valuation recurrences in literature

Some of the ecosystem service listed above have not been considered for the benefit transfer since there were no correspondence with the NBS planned in Urban GreenUP cities. These are: pollination since the ecosystem services is referred at a particular case study related with the Eurasian Jays, the aesthetic value related with the analysis of the Urban Wetland Parks and the aesthetic value provided by the cycle path since it is not possible to calculate the value per single unit of measure.

The methodologies and tools adopted for the economic valuation performance in the case studies are different. The table below reports the list of the methodologies and tools used in the case studies individuated and the number of recurrence of each of them.

Methodology or tool adopted for the economic valuation in case studies	Number of recurrences
Replacement cost	5
Contingent valuation	4
Choice modelling	3
Damage cost avoided	12
Hedonic prices	5
In-depth interviews	2
Market prices	3
Travel costs	2
Questionnaires	3
Q methodology	1
BeST (Benefits of SuDS Tool)	2
CITYgreen	1
GI-Val (Green Infrastructure Valuation Toolkit)	1
HEAT (Health Economic Assessment Tools)	1
i-Tree (previously UFORE)	3
ORVal	1
The National Green Value Calculator	1

Table 5: methodologies or tools adopted for the economic valuation in the case studies and number of recurrences

In total 10 methodologies and 6 tools have been used in the 37 case studies individuated. The most used methodology is “damage and avoided cost” (12), followed by the “replacement cost and “hedonic prices” (5) and finally by the “contingent valuation” (4). The tools that have been used more than once in the case studies are: i-Tree (3) and BeST. The variability in the methodologies and tools applied for the valuation of ecosystem services generate different values individuated per each ecosystem services. For this reason, when possible a range of values has been defined per each ecosystem services by using the minimum and the maximum value detected.

The economic values have been converted in euros, the value of the ecosystem services generated per single unit of measure have been calculated. The values are expressed either in *euro/m2/year* or *euro/tree/year*. In some cases, values with different units of measure have been individuated for a single ecosystem service based on the results of the case studies review. The table summarises the unit of measures used for each ecosystems service.

Ecosystem service	Unit of measure
Carbon storage and sequestration	€/tree
Air quality regulation	
Regulation of water flows	
Local climate regulation	
Aesthetic appreciation and inspiration for culture, art and design	
Spiritual experience and sense of place	
Local climate regulation	€/m2
Carbon storage and sequestration	
Air quality regulation	
Local climate regulation	
Recreation and mental and physical health	
Spiritual experience and sense of place	
Run off reduction	
Noise reduction	
Energy performance	
Aesthetic value	
Air pollution removal	
Food production	
Water quality	

Table 6: ecosystem services and unit of measures

Based on this analysis, a matrix has been created to associate the NBS planned in Front-runner cities with the ecosystems provided and their values. The matrix is reported in table 7. The different colour of the cells represent the unit of measure per each ecosystem service: purple - m^2/year; green - tree/year.

	PROVISIONING	REGULATION									CULTURAL		
NBS	food production	carbon sequestration and storage	air quality regulation	water regulation	climate regulation	storm water protection	energy saivings	UIH effect reduction	noise reduction	recreation and tourism	aesthetic value	sense of place	all
Urban gardens and parks		^1,11 €	0,05 - 0,39 €	^ 11 €	^ 0,07 €	^ 0,167 €				0,95 €	81,50 €		
												0,003 - 0,022 €	
										4,90 €			
Urban forest		1,17 €	8,17 €	55,20 €	3,12 €					0,95 €	81,50 €		
			0,05 €			0,17 €						0,003 - 0,022 €	
			^ 0,05 - 0,39							4,90 €			
					3,00 €								
		1,11 €	*11,98		0,07 €			51,3 - 69,34 €					
		4,53 - 14,25 €	1,68 - 14,50		9,05 - 22,6								
Rain garden				13,76 €		^ 0,167 €							
Permeable pavement				11,00 €		^ 0,167 €							
Vegetated swale				11,00 €		^ 0,167 €							
Green roof		0,56 - 0,98 €	0,57 - 0,94 €	8,25 €			1,24 - 7,97 €	3,00 - 6,73 €			^ 2,74 €		
Green walls		^ 0,56 - 0,98 €	^ 0,57 - 0,94 €					^ 3,00 - 6,73 €	2,65 €		2,74 €		
							15,83 €						
Urban orchards	4,06 €			^ 11 €		^ 0,167 €				^ 0,95 - 4,90 €			
Technological green													0,50 - 14,92 €
Cycle path										^ 0,95 - 4,90 €			

m2/year	* the value has been excluded from the valuation since the case study is located in China and the air pollution levels are extremely different from EU cities
tree/year	^ the value refers to the ecosystem provided by another NBS, but it has been transferred given the characteristics of the NBS considered and the ecosystem provided

Table 7: NBS and ecosystem services values for the benefit transfer

The matrix includes the values detected in the literature. In some cases, the value of a specific ecosystem service is represented by a single value since only a case study was found for that particular ecosystem service and NBS. In other cases, the values of the ecosystems are represented by ranges since more than one value has been found in the literature. For some NBS (Urban forest and Urban gardens and parks) the values individuated have different units of measurement: m2/year and tree/year. In those cases, to avoid the double counting issue, only the value referred at the trees has been used to perform the ex-ante valuation, since the value is more reliable. Furthermore, the values of some ecosystem services related at a particular NBS have also been associated with other NBS given their similar structure. Here is the list of the NBS and ecosystem services association:

1. The carbon sequestration value related to the NBS “Urban forest” has been associated with the NBS “Urban gardens and parks”;

2. The air quality regulation value related to the NBS “Urban forest” has been associated with the NBS “Urban gardens and parks”;
3. The climate regulation value related to the NBS “Urban forest” has been associated with the NBS “Urban gardens and parks”;
4. The storm water protection value related to the NBS “Urban forest” has been associated at the NBS “Urban gardens and parks”, “Rain garden”, “Permeable pavement”, “Vegetated swale” and “Urban orchards”;
5. The water regulation value related to the “Permeable pavement” has been associated with the NBS “Urban gardens and parks” and “Urban orchards”;
6. The carbon sequestration, air quality regulation and UIH effect values related to the NBS “green roofs” have been associated with the “green walls”;
7. The aesthetic value related to the “green walls” has been associated with the NBS “green walls”;
8. The recreational and tourism value related to the “Urban gardens and parks” has been associated with the NBS “Urban orchards” and “Cycle path”.

Finally, for a specific category of NBS referred at the “technological green” the value associated with the benefit transfer application relates to the Neonato et al. study (Neonato et al., 2019). The value individuated by Neonato et al. includes all the ecosystem services provided by the NBS and it has been calculated through the benefit transfer technique. This value has been used to valuate the most innovative NBS planned in Urban GreenUP since no case studies have been found in the literature.

To perform the ex-ante valuation, it has been necessary to individuate the correspondences between the NBS (and ecosystem services) detected through the literature review and the NBS planned in Valladolid, Liverpool, and Izmir. The NBS planned in Front-runner cities have been analysed to understand their characteristics and to individuate the ecosystem services provided by them. In this way, it has been possible to associate the values detected from the literature review and to perform the economic valuation. In almost all of the NBS considered it has not been possible to attribute a value at all the ecosystem services provided given the limited number of case studies available. The table below summaries the associations between the NBS detected in the case studies, the NBS planned in Front-runner cities and the ecosystem services that have been considered. The correspondence between the NBS individuated in the literature review case studies and the NBS planned in Urban GreenUP cities have been performed though the accurate analysis of the NBS description to understand and detect which are the ecosystem services provided.

NBS in literature review	Corresponding Urban GreenUP NBS	ES considered
Cycle path	Cycle and pedestrian green route	Recreation and tourism
Green roof	Green roof and green covering shelters	Energy savings
Green roof	Green roof and green covering shelters	Energy savings; Climate regulation (UHI); Air quality regulation; Carbon sequestration and storage

Green walls	Vertical gardens and green walls	Noise reduction; Aesthetic values
Green walls	Vertical gardens and green walls	Energy savings; Aesthetic values
Permeable pavement	Cool pavement	Water regulation
Vegetated swale	Grassed swales and water retention ponds	Water regulation
Green roof	Green roof and green covering shelters	Water regulation
Rain garden	Rain gardens; SUDs	Water regulation
Technological green	Electro wetland	All
Technological green	Floating gardens	All
Technological green	Green noise barriers	All
Technological green	Floating reed beds	All
Technological green	Green shady structures	All
Technological green	Mobile gardens (forest)	All
Technological green	Urban garden bio-filter	All
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Climate regulation; Air quality regulation; Carbon sequestration and storage; Water regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air quality regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air quality regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Climate regulation (UHI)

Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Climate regulation; Air quality regulation ; Carbon sequestration and storage
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Energy savings
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air quality regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air quality regulation; Carbon sequestration and storage
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air quality regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Climate regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air pollutant removal
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Climate regulation; Carbon sequestration and storage; Air quality regulation
Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Air pollution removal; Storm water protection

Urban forest	Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Carbon sequestration and storage
Urban gardens and parks	Green resting areas and parklets; Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Recreation and tourism
Urban gardens and parks	Green resting areas and parklets; Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Sense of place
Urban gardens and parks	Green resting areas and parklets; Cooling and shade trees; Planting and renewal urban trees (including urban catchment forestry); Urban carbon sink; Trees re-naturing parking; Natural wastewater treatment (including green filter area)	Recreation and tourism
Urban orchards	Urban farming	Food production
Urban orchards	Establishment of fruit walls	Food production

Table 8: Associations between the NBS detected in the case studies, the NBS planned in Front-runner cities and the ecosystem services

After that, the values have been associated to each ecosystem service provided by NBS planned in Valladolid, Liverpool, and Izmir and the ex-ante valuation based on the benefit transfer technique has been performed.

The valuation performed allowed identifying the values generated through the implementation of NBS. Nonetheless, the benefit transfer technique adopted is characterise by some limitations in the results obtained. In particular, the limited number of case studies individuated represents a shortcoming for the ex-ante economic valuation performed. In, fact, in several cases it has not been possible to attribute a value to each ecosystem service provided by the NBS considered. Finally, the values identified were not discounted to the current year and refer to different countries with different purchasing power. The table below represent the NBS planned in Front-runner cities, the ecosystem services provided by them and those that have been possible to evaluate.

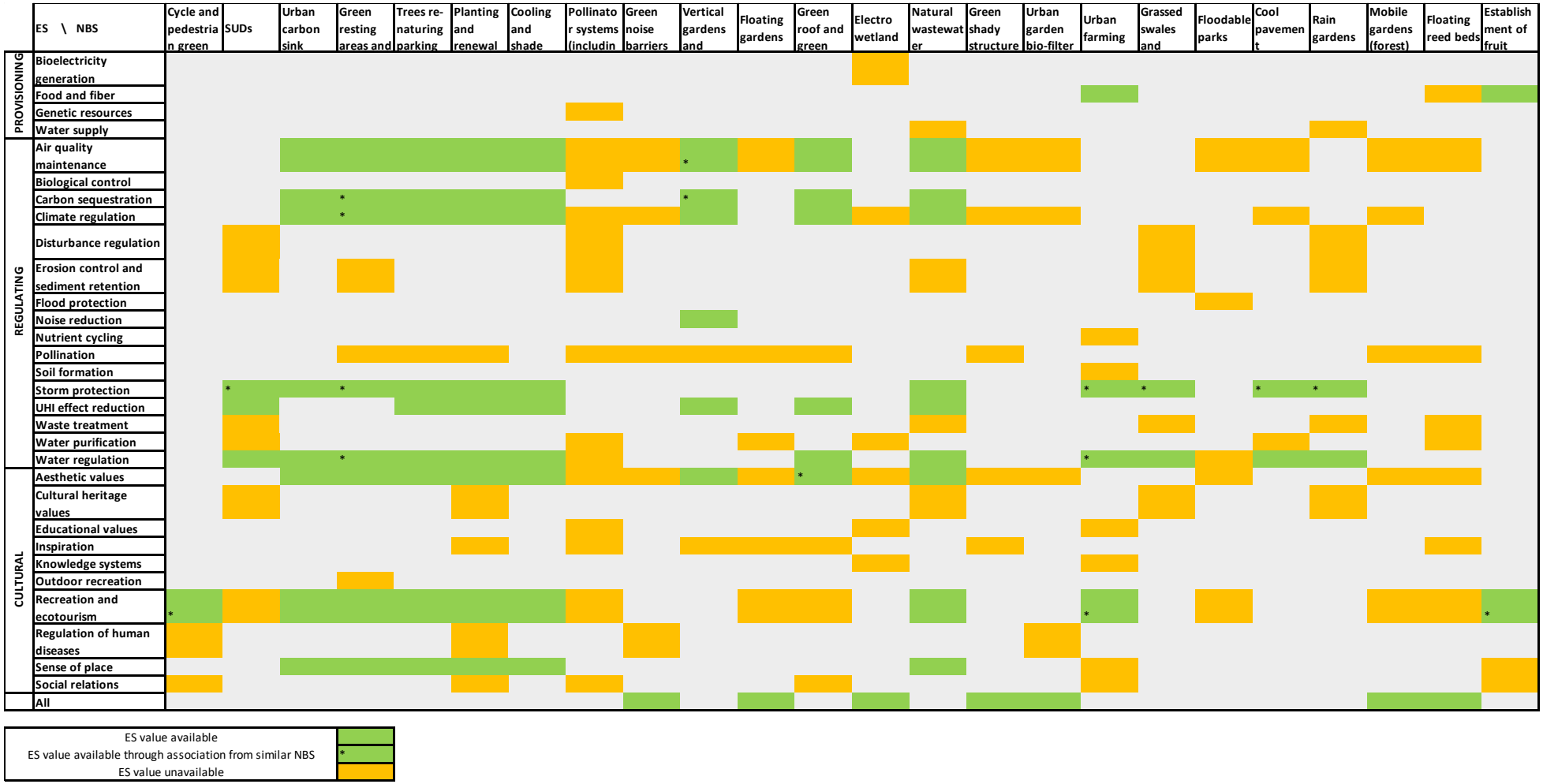

Table 9: Ecosystem services valuated through the benefit transfer approach

In the next chapters, the ex-ante economic valuation results have been reported per each city.

4 Ecosystem services monetary valuation in Valladolid

4.1 NBS and ecosystem services

The NBS planned by Valladolid will be implemented in three different demo sites: SubDemo site A, SubDemo site B, SubDemo site C. Furthermore, the NBS have been grouped based on the typology of intervention: renaturing urban areas, water interventions, singular green infrastructure, and non-technical interventions. The figure below summarized all the 42 interventions Valladolid commit to implementing within the URBAN GreenUP project. Every intervention is identified by a unique key (VAcX).

	RE-NATURING URBANIZATION	WATER INTERVENTIONS	SINGULAR GI	NON TECHNICAL INTERVENTIONS
SubDemo A	VAc1- New green cycle lane	VAc8- SUDs for green bike lane	VAc15 - Cycle-pedestrian green paths	Common non-technical interventions: VAc37, 38, 39, 40, 41 & 42
	VAc2- Planting 1,000 trees		VAc16- Smarts soils as substrate	
	VAc3- Tree shady places		VAc19- Natural pollinator's mod.	
	VAc6- Green Resting areas		VAc22 - Green Noise Barriers	
Sub-Demo B	VAc4- Shade and cooling trees		VAc17- Smarts soils as substrate.	Common non-technical interventions: VAc37, 38, 39, 40, 41 & VAc42
			VAc20- Compacted Pollinator's m.	
			VAc23 - Green Noise Barriers	
			VAc24 - Vertical mobile garden	
			VAc25 - Green Façade	
			VAc26 - Electro wetland Roof	
			VAc27 - Green Covering Shelter	
			VAc28 - Green Roof	
			VAc29 - Green Shady Structures	
			VAc30 - Urban Garden Bio-Filter	
Sub-Demo C	VAc5- Re-naturing parking trees	VAc9- SUDs for re-naturing parking	VAc18 - Smarts soils as substrate	VAc34: Educational path in VAc13
		VAc13- Natural wastewater treatment Plant	VAc19, VAc21-Natural pollinator's modules	VAc35: Educational path in VAc11
		VAc10- Rain gardens	VAc20 - Compacted Pollinator's modules	VAc36 - Farming Educational active.
		VAc12– Green filter area		
	VAc7- Urban Carbon Sink	VAc11- Floodable Park	VAc31 - Urban orchards	Non-technical interventions: VAc37, 38, 39, 40, 41 & VAc42
		VAc14- Parking Green Pavement	VAc32 - Community composting.	
			VAc33 - Small-scale urban livestock	

Figure 5: Demo Valladolid interventions in the URBAN GreenUP project

Not all the solutions individuated by Valladolid have been included in the ex-ante economic valuation. The interventions classified under the category "non-technical interventions" have been excluded since are actions related to the social acceptance of the NBS planned or with the communication and raising awareness activities. The remaining NBS (29) have been analysed in order to individuate the ecosystem services provided by them. The table below summarised the NBS included in the economic valuation and the related ecosystem services that have been associated to them. Some of the NBS have been grouped based on the typology of intervention and on the ecosystem services provided. The ecosystem services have been associated through the review of the literature and the NBS catalogue previously developed in D 1.1 with the involvement of all project partners.

NBS	Ecosystem services generated
Cycle and pedestrian green route/green paths	Regulation of human diseases; Social relations; Recreation and tourism
Urban carbon sink	Climate regulation; Air quality maintenance; Aesthetic values; Recreation and ecotourism; Water regulation; Storm protection; Sense of place; Carbon sequestration
Green resting areas	Air quality maintenance; Climate regulation; Water regulation; Erosion control; Pollination; Aesthetic values; Recreation and tourism; Outdoor recreation; Storm protection; Carbon sequestration
Trees re-naturing parking	Air quality maintenance; Climate regulation; Water regulation; Pollination; Storm protection; Aesthetic values; UHI effect reduction; Sense of place; Recreation and tourism; Carbon sequestration
Planting and renewal urban trees	Air quality maintenance; Climate regulation; Water regulation; Pollination; Storm protection; Inspiration; Aesthetic values; Social relations; Sense of place; Cultural heritage values; Recreation and tourism; Regulation of human diseases; UHI effect reduction; Carbon sequestration
Mobile gardens	Air quality maintenance; Climate regulation; Pollination; Recreation and tourism; Aesthetic values
Cooling and shade trees	Climate regulation; Aesthetic values; Recreation and tourism; UHI effect reduction; Storm protection; Water regulation; Sense of place; Air quality maintenance; Carbon sequestration
Natural pollinator's modules	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values; Social relations; Recreation and tourism; Educational values; Disturbance regulation; Biological control; Genetic resources; Water regulation; Erosion control; Water purification and waste treatment
Fruit walls	Food and fiber; Social relations; Sense of place; Recreation and tourism
Vertical mobile garden/green noise barrier and green walls	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values; UHI effect reduction; Noise reduction; Carbon sequestration
Green roofs/ Green covering shelters	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values; Social relations; Recreation and tourism; UHI effect reduction; Water regulation; Carbon sequestration
Electro wetland	Water purification and waste treatment; Climate regulation; Knowledge systems; Educational values; Aesthetic values; Bioelectricity generation
Green shady structures	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values
Urban garden bio-filter	Air quality maintenance; Climate regulation; Regulation of human diseases; Aesthetic values
Urban orchards/ Small-scale urban livestock	Food and fiber; Water regulation; Social relations; Sense of place; Recreation and ecotourism; Knowledge systems;

	Educational values; Soil formation; Nutrient cycling; Storm protection
Floodable parks	Flood protection; Water regulation; Air quality maintenance; Aesthetic and recreation values
Natural wastewater treatment/ Green filter area (water intervention)	Water regulation; Water supply; Erosion control and sediment retention; Waste treatment; Recreation; Cultural; UHI effect reduction; Storm protection; Sense of place; Climate regulation; Air quality maintenance; Aesthetic values; Carbon sequestration
SUDs	Disturbance regulation; Water regulation; Erosion control and sediment retention; Water purification and waste treatment; Recreation and ecotourism; Cultural; UHI effect reduction; Storm protection
Rain gardens	Disturbance regulation; Water regulation; Water supply; Erosion control and sediment retention; Waste treatment; Cultural; Storm protection

Table 10: NBS implemented in Valladolid and ecosystem services provided

4.2 Ex-ante economic valuation

The benefit transfer technique has been performed to identify ex-ante the economic value generated through the implementation of the NBS in Valladolid. As already explained the values of NBS found through the literature review have been associated to the NBS planned in Valladolid. After that, the NBS values have been calculated based on their characteristics. The table below summarises the results obtained for the Valladolid case study taking into account the following elements:

1. NBS to be implemented;
2. Ecosystem services valuated;
3. Value generated per year.

NBS	ES	Economic value per year
Cycle and pedestrian green route	Recreation and tourism	3.173 € - 16.366 €
Urban carbon sink	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	1.245.140 € - 1.737.521 €
Green resting areas	Recreation and tourism, sense of place	286 € - 1.477 €
Trees re-naturing parking	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, recreation and tourism, aesthetic value, sense of place	8.780 € - 13.875 €

Planting and renewal urban trees (including urban catchment forestry)	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, recreation and tourism, aesthetic value, sense of place	74.520 € - 94.115 €
Mobile gardens (forest)	All	500 € - 14.920 €
Cooling and shade trees	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	44.712 € - 56.469 €
Pollinator systems (including smart soil and green fences)	N.A	N.A.
Vertical gardens, green noise barriers and green walls	Energy savings, noise reduction, aesthetic value	10.546 € - 12.426 €
Green roof and green covering shelters	Carbon sequestration, air quality, water regulation, climate regulation, storm water protection, energy savings, UIH effect reduction, aesthetic value	21.257 € - 25.949 €
Electro wetland	All	25 € - 746 €
Green shady structures	All	119 € - 3.536 €
Urban garden bio-filter	All	5 € - 149 €
Urban farming	Food production, water regulation, storm water protection, recreation and tourism	1.618 € - 2.013 €
Floodable parks	N.A.	N.A.
Natural wastewater treatment (including green filter area)	All	158.011 € - 222.014 €
SUDs	Water regulation, storm water protection	18.620 €
Rain gardens	Water regulation, storm water protection	13.760 €

Table 11: Economic valuation of the NBS implemented din Valladolid

The table summarises the economic value that can be generated though the implementation of NBS in Valladolid. Through the analysis performed it has been possible to calculate also the total value generated per each ecosystem service. The table below summarises the results obtained.

	ES value
Regulating	1.394.474 € - 1.898.510 €
Provisioning	406 €
Cultural	218.810 € - 338.451 €

Table 12: Ecosystem services value in Valladolid

The total economic value generated through the implementation of the NBS in Valladolid is in the range of 1.599.453 € and 2.238.657 € based on the results obtained through the application of the ex-ante valuation approach.

5 Ecosystem services monetary valuation in Liverpool

5.1 NBS and ecosystem services

The NBS planned by Liverpool will be implemented in three different demo sites: SubDemo site A, SubDemo site B, SubDemo site C. Furthermore, the NBS have been grouped based on the typology of intervention: renaturing urban areas, water interventions, singular green infrastructure, and non-technical interventions. The figure below summarized all the 30 interventions Liverpool commit to implementing within the URBAN GreenUP project. Every intervention is identified by a unique key (LAcX).

Re-naturing urbanization	Water interventions	Singular Green Infrastructures	Non-technical interventions
LAc1 – New pedestrian and cycleway green route	**LAc4- Urban catchment forestry**	**LAc12 – Pollinator verges**	**LAc22 – Green art/engagement**
LAc5 – Shade trees	**LAC8 – SUDS raingarden**	**LAc13 – Pollinator walls vertical**	**LAc23 – Forest Church**
LAc6 – Cooling trees	**LAc10 – Hard drainage pavements**	**LAc add2 – Green screens**	**LAc25 – GI for Physical Health**
LAc add1 – Green Resting Areas	**LAc16 – Floating gardens**		***Common non-technical interventions**

Figure 6: Demo Liverpool interventions in SubDemo A

Re-naturing urbanization	Water interventions	Singular Green Infrastructures	Non-technical interventions
LAc2- Green travel route	LAc4- Urban Catchment forestry	LAc13- Pollinator walls/vertical	LAc19- GI For Education
LAc5- Shade trees. Species to spread canopies		LAc14- Pollinator roofs	Lac21` - Engagement Portal for citizens*
LAc6- Cooling trees. Species to maximise cooling effect		LAc15- Mobile gardens	Lac24 – Engagement app for citizens*
			Lac25 - GI for physical health*
			Lac26 - GI for mental health
			Lac27 - Promotion of ecological reasoning*
			Lac28 - Single window/desk for RUP deployment*
			Lac29 - Support to citizen project of NBS*
			Lac30 - City mentoring strategy*

Figure 7: Demo Liverpool interventions in SubDemo B

Re-naturing urbanization	Water interventions	Singular Green Infrastructures	Non-technical interventions
LAc1 New pedestrian and cycle way green route	LAc8 – SUDS	LAc11- Enhanced nutrient managing and releasing soil	LAc18- Wood allotments
LAc3 Road junction pedestrian improvements	LAnew- Floating reed beds	LAc12- Pollinator verges and spaces	LAc19- GI for Education
LAC7 – Urban Carbon		LAc13 Pollinator walls	LAc20- Forest School
			LAc20 Forest School
			LAc21- Engagement Portal for citizens
			LAc 21 – Engagement Portal for citizens
			LAc 23 Forest Church
			LAc24 – Bioapp
			LAc25- GI for physical Health
			LAc26 – GI for Mental Health
			LAc27- Promotion of Ecological Reasoning/Intelligence
			LAc28 – Single window/desk for RUP deployment
			LAc 29- Support to citizen project of NBS
			LAc30 – City mentoring strategy

Figure 8: Demo Liverpool interventions in SubDemo C

Not all the solutions individuated by Liverpool have been included in the economic ex-ante valuation. In fact, the interventions classified under the category "non-technical interventions" have been excluded since are actions that are related with the social acceptance of the NBS planned or with the communication and raising awareness activities[1]. The remaining NBS (18) have been analysed in order to individuate the ecosystem services provided by them. The table below summarised the NBS included in the economic valuation and the related ecosystem services that have been associated to them. Some of the NBS have been grouped based on the typology of intervention and on the ecosystem services provided. The ecosystem services have been associated through the review of the literature and the NBS catalogue previously developed in D 1.1 with the involvement of all project partners.

NBS	Ecosystem services generated
Cycle and pedestrian green route	Regulation of human diseases; Social relations; Recreation and tourism

[1] The methodologies described are able to catch and measure the impacts generated by actions that are related with environmental goods and services.

Urban carbon sink	Climate regulation; Air quality maintenance; Aesthetic values; Recreation and ecotourism; Water regulation; Storm protection; Sense of place; Carbon sequestration
Green resting areas	Air quality maintenance; Climate regulation; Water regulation; Erosion control; Pollination; Aesthetic values; Recreation and tourism; Outdoor recreation; Storm protection; Carbon sequestration
Urban catchment forestry	Air quality maintenance; Climate regulation; Water regulation; Pollination; Storm protection; Inspiration; Aesthetic values; Social relations; Sense of place; Cultural heritage values; Recreation and ecotourism; Regulation of human diseases; UHI effect reduction; Carbon sequestration
Cooling and shade trees	Climate regulation; Aesthetic values; Recreation and ecotourism; UHI effect reduction; Storm protection; Water regulation; Sense of place; Air quality maintenance; Carbon sequestration
Pollinators	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values; Social relations; Recreation and ecotourism; Educational values; Disturbance regulation; Biological control; Genetic resources; Water regulation; Erosion control; Water purification and waste treatment
Floating gardens	Air quality maintenance; Water purification and waste treatment; Pollination; Inspiration; Aesthetic values; Recreation and tourism
SUDs	Disturbance regulation; Water regulation; Erosion control and sediment retention; Water purification and waste treatment; Recreation and ecotourism; Cultural; UHI effect reduction; Storm protection
Rain gardens	Disturbance regulation; Water regulation; Water supply; Erosion control and sediment retention; Waste treatment; Cultural; Storm protection
Mobile gardens (forest)	Air quality maintenance; Climate regulation; Pollination; Recreation and tourism; Aesthetic values
Floating reed beds	Air quality maintenance; Water purification and waste treatment; Pollination; Inspiration; Aesthetic values; Recreation and tourism

Table 13: NBS implemented in Liverpool and ecosystem services provided

This information and the data collected regarding the value of ecosystems services collected through the case studies analyses have been used to perform the ex-ante economic valuation of the NBS.

5.2 Ex-ante economic valuation

The benefit transfer technique has been performed to identify ex-ante the economic value generated through the implementation of the NBS in Liverpool. As already explained the values of NBS found through the literature review have been associated to the NBS planned in Izmir. After that, the NBS values have been calculated based on their characteristics. The table below

summarises the results obtained for the Valladolid case study taking into account the following elements:

1. NBS to be implemented;
2. Ecosystem services valuated;
3. Value generated per year.

NBS	ES valuated	Economic value per year
Cycle and pedestrian green route	Recreation and tourism	380 € - 1.960 €
Urban carbon sink	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	3.875 € - 4.894 €
Green resting areas	Recreation and tourism	N.A.
Urban catchment forestry	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	61.660 € - 82.204 €
Cooling and shade trees	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	175.037 € - 235.933 €
Pollinators	N.A.	N.A.
Fruit walls	Food production, recreation and tourism	481 € - 860 €
Floating gardens	All	30 € - 895 €
SUDs	Water regulation, storm water protection	9.749 €
Rain gardens	Water regulation, storm water protection	696 €
Mobile gardens (forest)	All	25 € - 746 €
Floating reed beds	All	6 € - 179 €

Table 14: Economic valuation of the NBS implemented in Liverpool

The table summarises the economic value that can be generated though the implementation of NBS in Liverpool. Through the analysis performed it has been possible to calculate also the total value generated per each ecosystem service. The table below summarises the results obtained.

	ES value
Regulating	235.725 € - 315.382 €
Provisioning	390 €
Cultural	13.380 € - 15.487 €

Table 15: Ecosystem services value in Liverpool

The total economic value generated through the implementation of the NBS in Liverpool is in the range of 249.074 € - 333.620 € based on the results obtained through the application of the ex-ante valuation approach.

6 Ecosystem services monetary valuation in Izmir

6.1 NBS and ecosystem services

The NBS planned by Izmir will be implemented in three different demo sites: SubDemo site A, SubDemo site B, SubDemo site C. Furthermore, the NBS have been grouped based on the typology of intervention: renaturing urban areas, water interventions, singular green infrastructure, and non-technical interventions. The figure below summarized all the 20 interventions Izmir commit to implementing within the URBAN GreenUP project.

Re-naturing urbanization	Water interventions	Singular Green Infrastructures
Arboreal areas around Car Park Areas		Smart Soil (Biochar) into Green Shady Structures
Installation of parklets		Green Covering Shelter for car parking area
		Green Permeable Pavement Around Car Parking Area
		Green Shady Structures for car parking area

Figure 9: Demo Izmir interventions in SubDemo A

Re-naturing urbanization	Water interventions	Singular Green Infrastructures
	Grassed swales and Water Retention Ponds around Bio-boulevard	Smart soil production in climate-smart urban farming precinct
		Natural pollinator's modules
		Climate-smart greenhouse in urban farming precinct
		Biofuel production unit
		Development of Smart soils from mud plant, to use in urban farming

Figure 10: Demo Izmir interventions in SubDemo B

Re-naturing urbanization	Water interventions	Singular Green Infrastructures	Non-technical interventions
Cycle and pedestrian route in new Green Corridor	Culvert works for Peynircioğlu Stream	Green fences	Industrial Heritage Route along the Izmir Urban Green Corridor
Planting 4800 Cool & Shady Trees	Green pavements for Peynircioğlu Stream	Fruit walls	
Urban Carbon Sink			

Figure 11: Demo Izmir interventions in SubDemo C

Not all the solutions individuated by Izmir have been included in the ex-ante economic valuation. The interventions classified under the category "non-technical interventions" have been excluded since are actions that are related to the social acceptance of the NBS planned or with the communication and raising awareness activities. The remaining NBS (19) have been analysed in order to individuate the ecosystem services provided by them. The table below summarised the NBS included in the economic valuation and the related ecosystem services that have been associated to them. Some of the NBS have been grouped based on the typology of intervention and on the ecosystem services provided. The ecosystem services have been associated through the review of the literature and the NBS catalogue previously developed in D 1.1 with the involvement of all project partners.

NBS	Ecosystem services generated
Cycle and pedestrian green route	Regulation of human diseases; Social relations; Recreation and tourism
Urban carbon sink	Climate regulation; Air quality maintenance; Aesthetic values; Recreation and ecotourism; Water regulation; Storm protection; Sense of place; Carbon sequestration
Parklets	Air quality maintenance; Climate regulation; Water regulation; Erosion control; Pollination; Aesthetic values; Recreation and ecotourism; Outdoor recreation; Storm protection; Carbon sequestration
Planting and renewal urban trees	Air quality maintenance; Climate regulation; Water regulation; Pollination; Storm protection; Inspiration; Aesthetic values; Social relations; Sense of place; Cultural heritage values; Recreation and ecotourism; Regulation of human diseases; UHI effect reduction; Carbon sequestration
Cooling and shade trees	Climate regulation; Aesthetic values; Recreation and ecotourism; UHI effect reduction; Storm protection; Water regulation; Sense of place; Air quality maintenance; Carbon sequestration
Natural pollinator's modules Green fences/screens	Air quality maintenance; Climate regulation; Pollination; Inspiration; Aesthetic values; Social relations; Recreation and ecotourism; Educational values; Disturbance regulation; Biological control; Genetic resources; Water regulation; Erosion control; Water purification and waste treatment
Grassed swales and water retention ponds	Disturbance regulation; Water regulation; Erosion control and sediment retention; Waste treatment; Cultural; Storm protection
Cool pavement/green pavement	Air quality maintenance; Climate regulation; Water regulation; Water purification and waste treatment; Storm protection
Urban farming	Food and fiber; Water regulation; Social relations; Sense of place; Recreation and ecotourism; Knowledge systems; Educational values; Soil formation; Nutrient cycling; Storm protection

Table 16: NBS implemented in Izmir and ecosystem services provided

This information and the data collected regarding the value of ecosystems services collected through the case studies analyses have been used to perform the ex-ante economic valuation of the NBS.

6.2 Ex-ante economic valuation

The benefit transfer technique has been performed to identify ex-ante the economic value generated through the implementation of the NBS in Izmir. As already explained the values of NBS found through the literature review have been associated to the NBS planned in Izmir. After that, the NBS values have been calculated based on their characteristics. The table below summarises the results obtained for the Valladolid case study taking into account the following elements:

1. NBS to be implemented;
2. Ecosystem services valuated;
3. Value generated per year.

NBS	ES valuated	Economic value per year
Cycle and pedestrian green route	Recreation and tourism	11.400 € - 58.800 €
Urban carbon sink	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	535.870 € - 759.360 €
Parklets	Recreation and tourism, sense of place	48 € - 246 €
Planting and renewal urban trees	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, recreation and tourism, aesthetic value, sense of place	3.875 € - 4.894 €
Cooling and shade trees	Carbon sequestration and storage, air quality regulation, water regulation, climate regulation, storm water protection, UIH effect reduction, recreation and tourism, aesthetic value, sense of place	709.803 € - 765.051 €
Natural pollinator's modules Green fences/screens	N.A.	N.A.
Grassed swales and water retention ponds	Water regulation, storm water protection	7.817 €
Cool pavement/green pavement	Water regulation, storm water protection	8.509 €
Urban farming	Food production, recreation and tourism	14.883 € - 18.517 €

Table 17: Economic valuation of the NBS implemented in Izmir

The table summarises the economic value that can be generated though the implementation of NBS in Izmir. Through the analysis performed it has been possible to calculate also the total value generated per each ecosystem service. The table below summarises the results obtained.

	ES value
Regulating	873.299 € - 1.113.366 €
Provisioning	3.735 €
Cultural	415.171 € - 506.093 €

Table 18: Ecosystem services value in Izmir

The total economic value generated through the implementation of the NBS in Izmir is in the range of 1.260.996 € and 1.604.677 € based on the results obtained through the application of the ex-ante valuation approach.

7 Conclusions and next steps

The ex-ante valuation has been performed using the benefit transfer technique to quantify the economic value that will be generated through the implementation of the NBS in the three front-runner cities: Valladolid, Liverpool, and Izmir.

To perform the ex-ante valuation, it has been necessary to:

1. Analyse several case studies in which the ecosystem services have been valuated at urban level;
2. Create a repository of economic values related to the services provided to different NBS;
3. Analyse the NBS planned in the three Front-runner cities;
4. Identify the ecosystem services provided by the NBS in Front-runner cities;
5. Associate the values individuated to each ecosystem service provided by each NBS;
6. Perform the ex-ante valuation.

The results show that the NBS planned can generate several impacts at the urban level and at the same time can help the cities to cope with the significant challenges that are affecting their territories. The table below summaries the ecosystem services values generated by the NBS implementation in the three cities.

	VALLADOLID	LIVERPOOL	IZMIR
Regulating	1.394.474 € - 1.898.510 €	235.725 € - 315.382 €	873.299 € - 1.113.366 €
Provisioning	406 €	390 €	3.735 €
Cultural	218.810 € - 338.451 €	13.380 € - 15.487 €	415.171 € - 506.093 €

Table 19: ecosystem services values in the Front-runner cities of Urban GreenUP

In Valladolid, the value generated through the implementation of NBS is in the range of 1.599.453 € and 2.238.657 €. Based on the results, the NBS that will generate more value are: the cycle and pedestrian route, the urban carbon sink and the natural waste-water treatment. In Liverpool, the value generated through the implementation of NBS is in the range of 249.074 € and 333.620 €. Based on the results, the NBS that will generate more value are: the cycle and pedestrian route, the urban catchment forest and the cooling and shade trees. In Izmir, the value generated through the implementation of NBS is in the range of 1.260.996 € and 1.604.677 € Based on the results, the NBS that will generate more value are: the cycle and pedestrian route, the urban carbon sink and the cooling and shade trees.

The ex-ante valuation performed has two main limits:

- it has not being possible to valuate all the ecosystem services provided by NBS planned in Front-runner cities given the lack of data in literature;
- the case studies individuated have used different tools and methodologies to perform the economic valuation generating different values per ecosystem service.

It should be noted that the calculation of the value of the NBS planned in Front-runner cities requires to multiply the annual estimated value per the duration of the solution (which is pecific

for each NBS considered in relation to its life span). The values generated each year for the whole duration of the solutions should be discounted to calculate the actual value. This operation has not been performed as the duration of a single solutions have not been estimated yet, and it will be performed in the ex-post valuation.

Through the ex-post valuation it will be also possible to improve the valuation taking into account the specific characteristics (economic, social and cultural) of the three Front-runner cities. The ex-post valuation will make use of the KPI defined in the first stage of the project (see deliverable 5.1). Finally, for the performance of a city-based ex-post valuation, different methodologies able to measure the willingness to pay – such as contingent valuation and surveys - could be adopted.

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