ASSESSING THE PERFORMANCE OF URBAN GREEN INFRASTRUCTURE: THE CASE STUDY OF BENICALAP DISTRICT, VALENCIA, SPAIN

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ABSTRACT
During the last few years, the number of cities which are making efforts in improving urban greenery as a measure to strengthen urban resilience and citizen's wellbeing is increasing. The assessment of the implementation of urban green infrastructure actions, as any other type of intervention, involves the use of indicators to measure the effects of these actions. These indicators are understood as parameters that allow assessing the impact and the temporary monitoring of the effects of human actions carried out on the territory. Drawing on the literature of ecosystem/landscape services and green infrastructure, this study proposes a set of indicators which are able to analyse the performance of urban green infrastructure in terms of structure and functionality. A selection of the proposed indicators connected to structural properties, regulation and cultural landscape services are tested at the street level in Valencia City, Spain. Indicators are applied in two pilot actions which are being developed in Benicalap District, Valencia, in the context of a broader project which aims to give evidence about the benefits of nature-based solutions. This research contributes to a better understanding of how indicators can be used as an effective tool to assess the landscape services provided by urban green infrastructure. This information can be useful to communicate the benefits of urban green infrastructure and to make decisions about the development of sustainable strategies based on urban greenery.
Keywords: nature-based solutions, sustainability, urban greenery, landscape services, Valencia.

1 INTRODUCTION

Green areas deliver a wide range of landscape services (LS) to face city's challenges and reach resilience and sustainability. Nowadays, there is an increasing concern of the relevance of giving evidences of the benefits offered by green infrastructure [1]–[4], in order to prove that an increase of urban green spaces would provide a proportionally larger number of ecological, economic and social benefits and services. Urban green infrastructure (UGI) includes green, partly green and blue spaces (e.g. wetlands). It also includes green spaces which can be located close to the city or within the city itself, like agricultural land [2].

During the last years, European Commission has shown a growing concern in the role of green infrastructure (GI) and many reports have been developed to help find solutions to urban challenges through the implementation of GI. The Commission has started to pay attention to the need of efficient tools to map GI components, which are thought to support the future landscape services' assessment. Some examples of physical mapping methods are available (e.g. Guidos Toolbox, Conefor software package, Linkage Mapper, Quickscan) and have been deployed to city case studies from the local to pan-European scales [5]. Despite the benefits associated with UGI, implementation is far from straightforward or to be incorporated in applied urban planning and management [6], [7].

Sustainable strategies could be successfully designed and implemented through guiding current and hypothetical results of UGI improvements with the aid of a set of green performance indicators. This research brings knowledge of the impacts of nature-based

solutions (NBS) related to three urban challenges, which were proposed by EKLIPSE experts [3] to guide the design, development, implementation and assessment of NBS pilot projects in urban and in the climate mitigation context [4].

The main goal of this work is to propose a set of green performance indicators and show how to practically assess the landscape services provided by urban green infrastructure. These examples of urban green infrastructure indicators, adapted to landscape services classification, are applied for the evaluation of environmental and cultural benefits provided by pilot actions in open spaces in Benicalap District, Valencia. Key performance indicators (KPIs) are applied to pre-greening and post-greening stages of Grow Green NBS pilot projects. In particular, this work focuses on the monitoring of two of these actions: a sustainable small forest and a green-blue corridor.

2 METHODOLOGY

2.1 Proposal of urban green indicators

Considering the relevance of green indicators and urban green infrastructure for urban planning [7], [8], a set of the most mentioned UGI indicators is proposed (Table 1) to be applied at urban level to assess UGI performance.

The proposal of indicators is structured in two parts following the structure–function–value chain model proposed by Termorshuizen and Opdam [9]. First, the structure indicators are related to spatially explicit landscape characteristics, which may be connected to more than one landscape service. For instance, large tree diameter generally involves a large tree canopy that promotes stormwater interception, reduction of local temperature and habitat for nesting birds and small mammals. Secondly, the function and value indicators are proposed for assessing the principal regulation and cultural landscape services delivered by UGI. The function indicators refer to the potential or capacity to deliver a service (e.g. runoff coefficient in relation to precipitation quantities or recreation potential) and the value indicators are connected to the benefit, economic or non-economic, for people (e.g. economic benefit of reduction of storm water to be treated in public sewerage system). The functional and value indicators are arranged according to the LS and their subcategories following previous work on indicators, for example, Pakzad and Osmond [8] and Valls-Donderis et al. [10]. LS are classified according to the framework established by Vallés-Planells et al. [11], which was based in the Common International Classification of Ecosystem Services (CICES) [12].

2.2 Location of nature-based solutions in city of Valencia: Grow Green projects study area

Benicalap District has 2,216,000 m^2 of surface of which 367,038 m^2 are urban green infrastructure. The resident population reaches 46,699 inhabitants, around 8 m^2 of green spaces per inhabitant [13]. The shortest distance between green spaces is 228 m, which facilitates 62.5% of inhabitants have access to urban green infrastructure in the very nearby (at 50 m from their house) and 100% of Benicalap population further (at 300 m, 500 m distance).

Grow Green project (GG) embeds five NBS-actions [4] in Ciutat Fallera neighbourhood, whose objective is to make citizens aware of the need of sustainability in the cities. Ciutat Fallera and Benicalap are neighbourhoods within Benicalap District (Fig. 1) northwest of the city. These actions seek to restore the ancestral connections and ensure the transition between

Table 1: Collection of landscape services and green indicators (KPIs) at urban level.

GI indicators linked to structural characterization			
	Theme		UGI indicators
Structure	Spatial structure		Green area/inhabitant, proximity to green spaces, total area of green space, accessibility of urban green, structural and functional connectivity, impervious surface, facilities
	Urban vegetation structure		Density of trees by street section, percent of street trees of top most abundant genus, family and order, tree diameter classes, tree crown coverage

GI indicators linked to regulation and maintenance landscape services			
Class	Group	Subgroup	UGI indicators
Function and value Flow regulation	Water flow regulation	Runoff regulation	Runoff coefficient in relation to precipitation quantities, economic benefit of reduction of storm water to be treated in public sewerage system, flood peak reduction
Regulation of physical environment	Atmospheric regulation	Climate regulation	Temperature reduction in urban areas, reduced building energy use for heating and cooling
		Climate change mitigation	Total amount/yearly carbon sequestration and stored in vegetation
		Air quality regulation	Annual amount of pollutants (O_3, NO_2, SO_2, PM_{10}, $PM_{2.5}$) captured by vegetation
		Noise regulation	Noise level attenuation
Regulation of biotic environment	Lifecycle maintenance and habitat protection	Biodiversity maintenance and pest and disease control	Vegetation and wildlife diversity, habitat heterogeneity, species suitability

GI indicators linked to cultural landscape services			
Class	Group	Subgroup	UGI indicators
Function and value Health	Physical health		Walkability, increase of physical outdoor activity
	Mental health		Reduced depression and anxiety, attention restoration, recovery from stress
Enjoyment			Recreation potential, green space quality, green space attractiveness, green space visitation
Self-fulfilment	Didactic resources		Outdoor educational activities
Social fulfilment	Social relationship		Social interactions, community activities, social cohesion
	Place identity		Neighborhood attachment

the rural and the urban ecosystems. In Valencia, the urban orchard, Huerta de Valencia, is a unique agroecosystem, declared World Heritage by the UN, and a fundamental component of UGI and maybe a sustainable strategy to tackle climate mitigation. The target actions of

Figure 1:   The urban green infrastructure and the location of Benicalap District in Valencia, Spain.

this study are: a green-blue corridor (GG action 3) and a sustainable small forest (GG action 2).

   Two sites of Benicalap District are selected for practical assessments (Fig. 2). A street connected to a small square as a part of a corridor and a poor in vegetation-vacant lot of Ciutat Fallera were selected for the location of NBS pilot projects. Four alternatives were assessed to choose the most suitable location for the green-blue corridor (Fig. 2). The sustainable small forest was decided to be created in the neighbourhood of Benicalap park and two farmhouses (Alquería del Moro and Alquería de La Torre).

Figure 2:   The current state of UGI of Ciutat Fallera, Benicalap, the locations of NBS pilot projects: Sustainable small forest (Action 2) and green-blue corridor (Action 3); Alternative 1: Carrer del Foc and Plaza Regino Mas, Alternative 2: Carrer Emili Camps Gallego (north) and Plaza Regino Mas, Alternative 3: Carrer Emili Camps Gallego (south) and Plaza Regino Mas, Alternative 4: Carrer Amadeo Desfilis and Plaza Regino Mas.

2.3 UGI classification: Selection of landscape services provided by UGI to assess

The most relevant green indicators found in literature are applied to street elements of urban green infrastructure. For this purpose, UGI map is developed with the aid of GIS and fieldwork (Fig. 2). Table 2 shows the UGI street elements included in Nature-based solution pilot projects which were proposed in the context of Grow Green H2020 European project.

Table 2: UGI elements found in pilot projects in Benicalap neighbourhood according to European Union [2], Clément [14] and Valencia City Council [15].

Vegetation cover	UGI	Description
1. Ruderal vegetation	Abandoned, ruderal areas	Recently abandoned areas, construction sites, etc. with spontaneously occurring pioneer or ruderal vegetation.
2. Green street, avenues and boulevards	Tree alleys and street trees, hedges	Trees having or not having tree pits, planted along roads and paths either solitary or in rows, trees surrounding hedges along roads or paths.
	Green verge	Stripes of green, e.g. flowers, along a built or natural element.
	Street green	Non-tree, mostly shrubby or grassy road verges or areas between the opposite roadways.
	Green island	Sustainable green roundabout, which can contain flowers, shrubs and trees.

2.4 Analysis blocks and UGI indicators used for pilot projects assessment

The sequence of urban green infrastructure indicators is shown according to their utility to achieve study's objectives and is structured in three blocks (Table 3):

A. Selection of the most suitable alternative for the green corridor. Four vegetation plan alternatives (Fig. 2) are assessed as possible locations of a green-blue corridor according to UGI biodiversity indicators.
B. Assessment of the impact of the green-blue corridor and the sustainable small forest on regulation and maintenance LS: biodiversity. This block includes current evaluations (pre-greening stage) and future (post-greening stage) of indicators connected to plant community structure and biodiversity to demonstrate the effectiveness of UGI implementation and green indicators' validity.
C. Assessment of the impact of the green-blue corridor and the sustainable small forest on cultural LS. Social interactions and physical activity level are assessed before the implementation of NBS through cultural UGI indicators.

2.5 Urban vegetation structure indicators description

The density of trees by street section is a value that relates the number of trees per meter of transverse section. Some minimum criterion of tree density per section are used, so the optimum density for big size trees should be 0.2 [16]. Longitudinal transects along pilot

projects were done in June 2019. Considering the length of project actions, street section

Table 3:   Proposed indicators to assess the performance of the green infrastructure of Benicalap District, Valencia, Spain. The division of indicators is according to their utility case.

Subgroup	UGI indicators	Utility
Urban vegetation structure	Density of trees by street section, Percent of street trees of top most abundant genus, family and order, Tree diameter classes, Crown coverage of the tree (large) Index of abundance of street trees in pilot projects	B
Biodiversity maintenance and pest and disease control	Diversity of trees, shrubs and bushes, diversity of vegetation strata, Species suitability	A, B
Increase of physical activity	Percentage of people undertaking forms of physical activity	C
Community cohesion	Percentage of people interacting with each other in an outdoor space	C

measures 50 m. Tree diameter classes indicator is used to classify green infrastructure trees according to their size class distribution. It is desirable for cities to manage and reach standard values of street trees distribution in UGI elements. Street trees are classified in size classes according to tree diameter breast height (DBH) [17].

Crown coverage is the projected surface of the tree canopy cover that was used to calculate habitat diversity. Performance indicators are proposed to obtain a desirable percentage of existing urban tree canopy by using street trees canopy desired values as proposed by Leff [18].

Index of abundance of street trees is used to evaluate street trees species taxonomic order present in the urban ecosystem. Current species richness of street trees of pilot projects is assessed with UGI map. Information about street trees species is found on the website of Statistical Office of Valencia municipality.

2.6 Biodiversity

In order to calculate the biodiversity of trees, shrubs and bushes, Shannon–Wiener Index (H') is used, with the aid of Braun-Blanquet scale [19]. According to Krebs [20], evenness (E) oscillates between 0 (species are not equally distributed) and 1 (there is equal species distribution, complete evenness). Urban green infrastructure diversity of vegetation strata is also estimated with Shannon–Wiener Index based on five different proportions of habitat proposed by Handley [21] to measure the heterogeneity of a habitat: bare ground and turf grass, rough grassland and herbs, shrubs, trees (tree canopy) and built (impervious) environment. Diversity strata index of post-greening moment is an estimation since the real surface covered by new introduced vegetation is uncertain.

Protective tree diversity can be measured with the aid of three indicators: age diversity or age classes considering diameter classes, species diversity and species suitability [18]. Species suitability is understood as their level of adaptation to local climate, fulfil soil, humidity and management's requisites and are not invasive.

2.7 Physical activity and social interactions: Mohawk

Method for observing physical activity and wellbeing, on short Mohawk, proposed by Benton et al. [22] was designed to measure physical activity and social interactions in small urban green space such as: pocket parks, tree-lined streets and green corridors along waterways. In this study, we apply these cultural indicators to assess present situation of pilot projects.

Social interactions were measured with behavioural observations of individuals who are interacting with the people around them. The same person can be coded as engaging in multiple behaviours. Physical health of Ciutat Fallera's inhabitants was assessed with indicators of physical activity level. Physical activity is more than physical exercise [23]. Regarding the adequacy of field observations, data are collected about inhabitants "age and gender and ruled hours" intervals. Pre-greening assessment of neighbourhood wellbeing indicators was carried out during one week on November 2019.

3 RESULTS AND DISCUSSION

3.1 Selection of the most suitable alternative for the green corridor

The analysis of the four green corridor alternatives (Fig. 2) in terms of biodiversity indicates that alternatives 1 and 2 are the best locations according to biodiversity. This information was used together with data on indicators related to other regulation services (runoff regulation, climate regulation and climate change mitigation), cultural services (recreation potential and place identity) and other factors connected to gender issues in order to decide the best alternative. After this process, alternative 1, Carrer del Foc street and Plaza Regino Mas square, was selected as the best location to build green-blue corridor (Table 4).

Table 4: Results of diversity indices applied to vegetation species and habitat types of proposed alternatives for selecting green-blue corridor emplacement.

	Diversity indices	Alternatives			
		1	**2**	**3**	**4**
	Shannon–Wiener Index	*1.93*	1.98	1.76	1.71
Vegetation	Maximum diversity	*3.78*	3.66	3.76	3.76
	Evenness	*0.51*	0.54	0.47	0.45
	Shannon–Wiener Index	*0.99*	1.07	0.94	0.98
Strata	Maximum diversity	*1.61*	1.61	1.61	1.61
	Evenness	*0.61*	0.66	0.59	0.61
	Bare ground/turf grass	*9.18*	12.67	9.93	9.35
	Rough grassland/herb	*0.41*	0.64	0.24	0.17
% Habitat cover	Shrub, bush, creeper	*5.10*	6.52	3.69	3.26
	Tree	*65.85*	62.74	67.53	62.64
	Built environment	*19.45*	17.43	18.61	24.57

3.2 Assessment of the impact of the green-blue corridor and the sustainable
      small forest on regulation and maintenance LS: biodiversity

3.2.1 Structural indicators
There are 8,899 individuals of 113 species spread all over Benicalap District and 122 individuals of 11 species of street trees in the pilot projects. Within street trees species of

NBS pilots there are 88.52% deciduous trees and 11.48% perennial trees. The area of pilot projects represents 0.57% of Benicalap District, where 11 species of seven families and six orders are concentrated (Table 5).

Table 5: Number of individuals, species, index of abundance (I_{TREES}) and percentage of street trees species at district, street and pilot projects (actions) level.

Order	District	Street	I_{trees}	Species	District %	Street %	Pilot %
Arecales	1689	1	0.00	*Phoenyx dactylifera*	3.78	0.30	0.85
Asparagales	71	1	0.01	*Yucca elephantipes*	2.86	2.38	0.85
Fabales	790	9	0.01	*Ceratonia siliqua*	0.54	12.50	0.85
				Cercis siliquastrum	25.68	1.59	5.93
				Robinia pseudoacacia	4.63	1.47	0.85
Lamiales	1366	48	0.04	*Jacaranda mimosifolia*	27.72	9.58	33.05
				Olea europaea	2.59	23.68	7.63
Malpighiales	52	1	0.02	*Populus sp.*	3.54	1.92	0.85
Sapindales	1825	35	0.02	*Ailanthus altissima*	0.20	100.00	2.54
				Melia azedarach	29.97	7.27	27.12
Urticales	33	23	0.70	*Ulmus pumila*	2.25	72.73	19.49

Density of trees by street section is 0.1, which means that the recommended distances [16] are not always respected (Table 5). Present number of street trees is two times smaller than it should be. Recommended indicator has value of 0.2 for 100 m longitudinal transect, which means one tree at every five meters.

Size class distribution is applied specifically to street trees. In both pilot projects, semi-mature trees dominate (68.12%, 50.00%), while senescent trees are very poor represented (1.45%) or are missing (0.00%) (Table 6). The other two age classes are also unbalanced. According to Leff [18], the ideal percentages of street trees distribution are not respected (40% juvenile, 30% semi-mature, 20% mature and 10% senescent trees). In the pilot projects, there are almost double and more than double semi-mature trees than it should be (30%). More juvenile trees are needed in both cases, as they revitalize the urban ecosystem. In the corridor, the percentage of mature trees reaches around 20%. However, in the forest, the existing proportion (29.17%) overpasses the recommendation (20%). Our study results are opposite to McPherson et al. findings of cities of Inland Valley, California, where street inventories were characterized by higher percentage of young trees populations (55%) [24]. The similitude appears for lower than ideal percentages of mature (18%) and old (5%) trees.

Present relative tree canopy cover of the corridor represents 69.20% of total area (7,352 m^2), which is qualified as fair [18]. Present forest tree canopy cover is estimated as low (24.40% of total surface (5,356 m^2)) (Table 6). Low status sites investigated by Pauleit et al. [25] presented around 3% of tree cover of 0.25 km^2. Considering Ciutat Fallera's financial situation [13], we could it classify as low status neighbourhood.

3.2.2 Biodiversity indicators

The estimation of the values of post greening vegetation diversity shows a significant rise of these indicators in both actions. In the case of the green-blue corridor, Shannon–Wiener Index increases from 1.15 to 1.93, which means that goes from an initial poor biodiversity level (0.5 < H' < 1.5) to almost a good level (2 < H' < 3) according to Agencia d'Ecologia

Table 6:   Community structure indicators of the current situation of street trees within project actions.

Indicators		Green-blue corridor	Sustainable small forest
Street trees density (N. trees/50 m)	Canopy width (m)		
	Small size	8	0
	Medium size	2	0
	Big size	0	5
Age diversity (%)	Juvenile	14.49	20.83
	Semi-mature	68.12	50.00
	Mature	15.94	29.17
	Senescent	1.45	00.00
Relative tree canopy (%)		69.20	24.40

Urbana de Barcelona [16] and evenness raises in 50% (Table 7). Regarding the forest which, at present time, contains just one species (*Ulmus pumila*), post greening stage involves reaching a very good level of biodiversity (3 < H' < 4) and a more equal species distribution (closer to value 1). According to Barker et al. [6], community's accessible green spaces, street trees and hedgerows are very likely to enhance biodiversity at micro scale.

Table 7:   Diversity of vegetation species, strata diversity and habitats proportions before and after selecting the pilot projects to construct the green-blue corridor (action 3) and small sustainable forest (action 2).

	Diversity indices	Action 3		Action 2	
		Pre-greening	Post-greening	Pre-greening	Post-greening
Vegetation	Shannon–Wiener Index	1.15	1.93	*	3.07
	Maximum diversity	3.40	3.78	*	4.13
	Evenness	0.34	0.51	0	0.74
Strata	Shannon–Wiener Index	0.97	0.99	0.56	0.69
	Maximum diversity	1.61	1.61	1.61	1.61
	Evenness	0.60	0.61	0.35	0.43
% Habitat cover	Bare ground/turf grass	7.43	9.18	74.60	
	Rough grassland/herb	0.04	0.41	–	80.00
	Shrub, bush, creeper	2.44	5.10	–	
	Tree	57.99	65.85	25.40*	20.00
	Built environment	32.09	19.45	–	0

*At pre-greening stadia there is only a set of decrepit *Ulmus pumila.*

When comparing the diversity of vegetation strata for pre and post greening stages, the increase in Shannon–Wiener Index (from 0.97 to 0.99) and evenness (from 0.60 to 0.61) is slight in the case of the corridor. Regarding forest, similar values are found (Shannon–Wiener Index rises from 0.56 to 0.69 and evenness from 0.35 to 0.43). This result can be explained by the fact that in the pre-greening stage, only two out of five types of habitats were identified (trees, 25.4% and bare ground/turf grass, 74.6%), while, after the implementation of NBS, three categories of habitats, such as: bare ground and turf grass, rough grassland and herbs and shrubs, bushes and creeper plants are expected to increase around 80%. This result is the

estimation of the first year post greening. When trees reach their maturity, crown coverage is expected to be more than 70%. In 2000, all sites of Merseyside, UK, the structural diversity (Shannon–Wiener Index) is 1.09 for a vegetation area which covers 8.31 ha [25].

Among the species of pilot project, five street tree species out of ten are identified as being suitable for the area. According to Leff [18], this means a fair degree of adaptability (50%) to Valencia's climate and soil conditions. These species are: Mediterranean native species (*Cercias siliquastrum*, *Ceratonia siliqua, Olea europaea*), naturalized species, useful for inhabitants e.g. date palm (*Phoenix dactylifera*) and ornamental species cultivated for decorative purpose e.g. blue jacaranda (*Jacaranda mimosifolia*). All of them are present in the location of the corridor in the pre-greening stage.

3.3 Assessment of the impact of the green-blue corridor and the sustainable small forest on cultural LS

Fig. 3 shows the results of behavioural indicators of social interactions and physical activity measured before the implementations of NBS with Mohawk tool. Results on social interactions reveal that 34.77% of people were talking with each other or having other types of physical contact e.g. holding hands in the street part of corridor, 28.89% in the square part. And 29.93% persons interacted in the forest area. This can be explained by the fact that Carrer del Foc street and Plaza Regino Mas is four times smaller than forest area. Also, corridor's square presents some facilities, such as: bus stop, bars, restaurants, playgrounds and school, which leaded to casual encounters, reflected by the big percentage of neighborhood community who was passing through and having contact in the green-blue corridor. Also, Plaza Regino Mas has a smaller surface than forest. The small surface of forest was used mostly to walk dogs and pass through. According to Barker et al. [6], neighbourhood green spaces are likely to improve social interactions and enhance physical health of inhabitants. Regarding indicators of physical activity level, it can be seen that more than 80% of people were walking in the corridor's arena, while in the forest area were estimated almost 72%. A percentage of 10.51% of vigorous people were crossing the forest area, while 2.65% were walking fast or running in corridor's street and 12.28% in the square part. Forest pilot project is a calmer open space, an isolated one with lower traffic than corridor, which is more dynamic and characterized by a big number of passing cars and noise. The creation of green-blue corridor and sustainable forest are expected to increase both social interactions and level of physical activity.
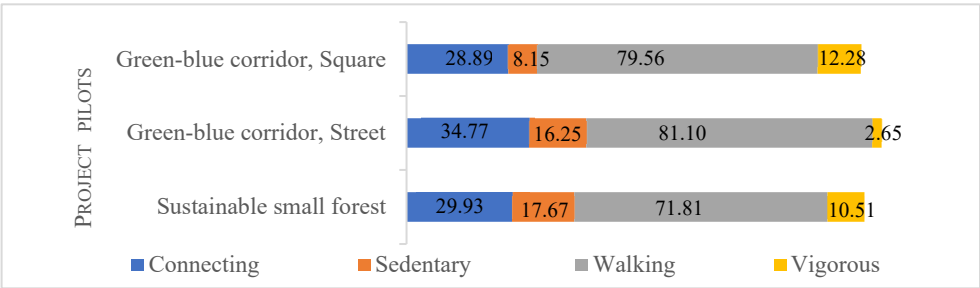

Figure 3:   Values of behavioural KPIs for one week at sustainable small forest action and green-blue corridor action (street and square). Bar chart numbers represent percentages of people who are connecting and undertaking forms of physical activity.

The indicators applied in this work are limited to the pre-greening stage of two small scale pilot projects with poor impact at district scale. Further studies should consider the whole range of UGI elements, including agriculture land which was not part of the analysed case studies.

4 CONCLUSIONS

The article reviews the applicability of green infrastructure indicators at micro scale or street scale and tests the usefulness of a set of these indicators to design and evaluate the effects of NBS implementation and the improvement of green infrastructure. Not only structure indicators are used to assess UGI condition, but also indicators linked to regulation and cultural landscape services, especially to biodiversity and people behaviour.

The assessment of regulation services, in terms of structural indicators, suggests that none of the sites where the pilot projects will be developed meet the recommended density of street trees and tree age diversity. Tree canopy is fair in the green-blue corridor and low in the sustainable small forest for the pre-greening stage. Concerning biodiversity indicators, they allow the prediction of the post-greening stage situation, showing an increase in Shannon–Wiener Index and evenness, which is especially significant for the sustainable small forest. The assessment of the cultural services connected to social interactions and physical activity indicates that the green-blue corridor shows slightly higher values than the sustainable small forest does at the pre-greening stage.

This paper demonstrates that UGI indicators are a helpful method, complementary to cartography, in order to assess design alternatives and select the most sustainable future strategies to be implemented at urban scale. By unifying green infrastructure indicators and methods of measurement from three complementary domains, such as ecology, forestry and social-cultural sciences, this work contributes to a better understanding of UGI as a sustainable tool and to make better informed decisions regarding its implementation in urban planning and management.

The results of this study show how urban green infrastructure elements can be used to integrate urban and agroecosystems. Working in a space of opportunity in its transition between city and orchard, new elements of the urban green infrastructure can be integrated and used to extend the network and solve the interface between agriculture and city, contributing thus to deliver a wide range of ecosystem services' in both rural and urban settings, the purpose of the green infrastructure.

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