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Ecosystem Services Analysis and Design through Nature-Based Solutions in Urban Planning at a Neighbourhood Scale

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Abstract: The new frontiers of sustainable cities should focus on urban planning tools and strategies that are able to integrate ecosystem services in urban development. An important step could include the design of nature-based solutions (NbSs) for introducing important ecological functions aiding human well-being and mitigating the loss of soil. In this study, we propose a methodology to analyse, in a spatial way, the effect of land use scenarios generated by urban planning in the provision of ecosystem services. The methodology analyses the variation of ecosystem services, considering the ecosystem services of the study area and their potential roles in changing the functions of planned urban actions as the starting point. One scenario of analysis includes the integration of NbSs into urban planning. The case study is that of a peri-urban area, characterized by an agroecosystem, which is intended for urban development in the municipality of Gallipoli, Southern Italy. The analysis highlights a low provision of ecosystem services by the agroecosystem, which has had the effect of important olive trees being destroyed by *Xylella fastidiosa* bacteria. Thus, the integration of NbSs and reducing the construction of buildings in the urban neighbourhood plan could improve the quantity of ecosystem services in the area. Moreover, the ecological design of ecosystem services could improve the typology of ecosystem services provision in the area in consideration of the starting points. Therefore, the analysis of the capacity to integrate ecosystem services in urban planning at the neighbourhood scale could be a tool of ecological urban design, useful to support the decision-making processes.

Keywords: ecosystem services; nature-based solutions; land use and land cover; urban planning

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1. Introduction

Urbanization has led to land use change from agroecosystems or natural land to impermeable surfaces and biodiversity loss [1,2], causing ecosystem degradation and fragmentation, which leads to a loss of ecosystem services [3–5]. Ecosystem services (ESs) represent the human benefits derived by combinations of biophysical structures and ecological functions [6,7]. Moreover, the conservation and sustainable supply of ecosystem services is essential to safeguard human well-being [7]. For example, urban development, leading to a loss of agroecosystems, has huge implications for social–ecological systems due to the loss of ESs [8,9]. Therefore, the integration of ESs into the strategic decision-making processes of urban development is important in order to achieve the goals of the 2030 Sustainable Development Goals (SDGs): notably, SDG 3, "Good health and well-being"; SDG 11, "Make cities and human settlements inclusive, safe, resilient and sustainable"; and SDG 13, "Take urgent action to combat climate change and its impacts" [10,11]. However, in spite of the above, the integration of ESs is not an intrinsic part of urban planning, but one that remains in its exploratory phase [9,12–15] due to a lack of understanding surrounding how the concept of ecosystem services should be integrated into urban development [9,16].

The integration can be achieved by the contextualization of ESs in synchronization with the objectives of urban planning [9,16–18].

Nature-based solutions (NbSs), a technique which facilitates both climate change adaptation and mitigation measures, are green elements integrated within "grey" infrastructures and constituting an emerging concept for urban planners for fostering sustainable development [7]. Moreover, in an urban context, mitigation actions should harmonize with economic activities without compromising the ecological function and provision of ESs [7–9,16]. In consideration of this, the European Commission promoted the "Connecting Nature" project, financed by Horizon 2020, an innovation action programme with the aim of achieving the SDGs in urban areas through the integration of NbSs in cooperation with the public and private sectors [19].

NbSs reduce the negative environmental impacts of soil impermeabilization, as well as improve the quality of human life [20,21] by providing multiple ecological functions that are useful for supporting human well-being [7,16,22]. For example, NbSs provide ecosystem services which improve our quality of life, such as microclimate regulation, gas regulation, rainwater drainage, carbon sequestration, sewage and waste treatment, biodiversity conservation, recreational activities, and educational values [7,23–26]. Therefore, NbSs are important measures and can be used to develop urban land use with land cover structures that promote ecological functions and social benefits [27,28]. Land use represents how and why humans use land [29], and is linked to the specific benefits that some might, or would like, to obtain from the land. Land cover is one of the many biophysical attributes of the vegetations that affect ecosystem functions [29,30], which can influence the capacity of the land to produce ecosystem services. Therefore, in urban planning processes, NbSs can be included and evaluated in synergy with the new land cover/land use scenarios, as per planning choices to increase ESs [31].

Different typologies of urban plans at different scales can have different socioeconomic and environmental requirements and impacts, and therefore the ES assessment should be based on these criteria [9,16]. Many examples of applications of ES analysis have been realized for regional- and local-scale planning; however, there is a lack of applications at the neighbourhood scale that manage urbanization in single portions of the urban area [15,16]. Specifically, urban neighbourhood plans are important as they are based on the evolution of an urban area which is integrated as a single unit of the city [7,16,32]. Therefore, in a holistic vision of urban development, the urban neighbourhood is the base for a sustainable urban development process [5,33]. Therefore, the aim of this study was to apply an ES-based analysis for the development of an urban neighbourhood plan by harmonizing different approaches and leading to improved urban decision processes.

The methodology is focused on the provision of ecosystem services under land cover/land use scenarios in the new neighbourhood development of the peri-urban area of the city of Gallipoli. The urban development plan at the neighbourhood scale in the city is a result of a panarchy approach of planning processes, whereby the municipal urban plan fixes the typologies of development, the dimensions of the building area, and the correlated services, such as public parks, roads, and schools (top–down effects), whereas the landowners are the promotors of urban development (bottom–up actions) [3,34–36]. Precisely, the current planning procedure does not consider ecosystem services. Therefore, the present study attempted to evaluate the integration of the design of NbSs into urban planning processes through bottom–up actions along, accounting for their potential provisioning of ESs.

Therefore, the objectives of the present research were the identification of land cover/land use scenarios at the neighbourhood scale for the integration of NbSs in an urban development plan, along with an estimate of the ecosystem services provisioning of the NbSs under different land cover/land use scenarios.

2. Materials and Methods

2.1. Study Area

The study focus was a peri-urban area of Gallipoli in the province of Lecce, Italy, characterized by agroecosystems mixed with the sprawled houses, where a new residential area has been planned by the municipality for urban development (Figure 1). The agroecosystem is characterized by olive groves affected by *Xylella fastidiosa*, a microorganism that desiccate the plant [3]. Land in the study area is owned by numerous landowners and the agricultural activities are primarily for self-consumption. The municipality planned and designed the area as a new area for urban sprawl, and the landowners wish to implement the planned urban transformations. The urban transformation of the area comprises three urban development plans at a neighbourhood scale, called Sacramento, Giardini, and San Leonardo (Figure 1).

Figure 1. Study area under the urban neighbourhood plan.

2.2. Ecosystem Services Analysis

The methodology includes four phases (Figure 2). The first phase attempted to characterize the land use of the study area, while considering the infestation of *Xylella fastidiosa*—the driving force destroying the olive trees in the area.

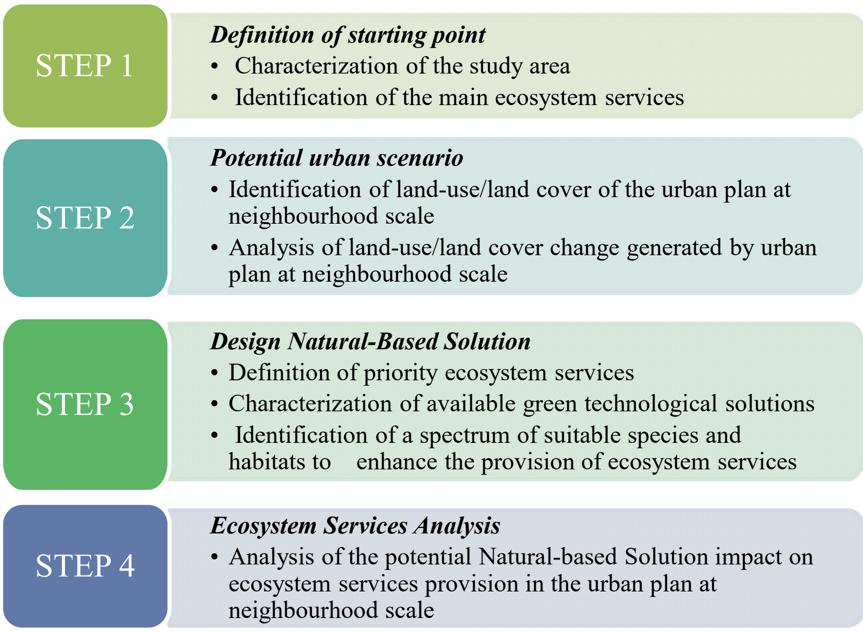

Figure 2. The methodology applied to analyse the ecosystem services for the neighbourhood-scale plans in a peri-urban area.

The first phase of analysis revolved around the olive trees, involving an evaluation of disease severity, identification of cultural value, and identification of land uses, along with their ESs. Disease severity in the olive groves was estimated by visual inspection through evaluation of symptoms of *X. fastidiosa* related to leaf scorching and wilting of the canopy [3,37,38]. The cultural value of the monumental olive groves was analysed objectively by measuring diameter of the trunk and through a visual analysis of the shape of the plants' trunk, as established by the regional law 14/2007 (B.U.R. PUGLIA—N. 83, 7 June 2007) [3,38,39]. Land use classes were characterized by considering the main bibliography and involving specific experts, along with their capacity to provide ecosystem services [16,38,40–44].

The second phase aimed to define the urban neighbourhood plan. Land use/land cover change analysis was performed in comparison with the initial status of the land use/land cover of the study area. Vectorial overlaps of different land use/land cover scenarios using QGIS software was applied for the analysis of land use/land cover. The analysis highlighted and quantified the typologies of spatial transformations promoted by the urban plan [3,45].

The third phase of analysis attempted to evaluate the main ecosystem services that were important for human well-being in the urban context, and attempted to identify potential NbSs to adopt for urban planning. This phase was carried out coherently with the developed urban neighbourhood plan, and the landscape and environmental conditions of the study area [46]. Moreover, the perceptions shared by the experts involved in the planning activities and the bibliography were important to define the relations between the NbSs and the priority ESs.

In the end, the main effect of the NbSs on the provisioning of ESs was analysed. The quantification of CO_2 sequestration was made for four scenarios, as the starting point scenarios with healthy olive trees (past scenario), the starting point scenario with dry olive trees (scenario 0), the urban plan scenario (scenario 1), and the scenario that integrates the NbSs in the urban plan (scenario 2). CO_2 sequestration was chosen as indicator of ESs, linked with the air quality conditions and climate regulation that have environmental impacts in urban development [47–55]. The CO_2 sequestration was estimated considering the main ecological and biophysical functions generated by the land use of each scenario and using the literature-defined values [56].

Moreover, in this phase, the variation of the cultural value of the land use change was also analysed qualitatively by considering the conversion of the olive groves due to *Xylella fastidiosa*, and proposed NbSs through considering the context of the study area, the expert involved, and the bibliography.

3. Results

3.1. Land Use Characterization of Different Scenarios

The land use of the area (Figure 1) was mainly characterized by "Arable land" (33% of the total surface) and "Olive grove" (28% of the total surface) (Table 1 and Figure 3).

Table 1. Composition of the land use of the study area.

Land Use	ha	%
Arable lands	12.8	33%
Artificial surfaces	6.2	16%
Fruit trees	0.2	0%
Green urban areas	1.2	3%
Herbaceous vegetation	6.6	17%
Olive Groves	10.9	28%
Shrub	0.3	1%
Vineyards	0.9	2%
Total	39.0	

There were artificial surfaces (roads and buildings) that covered 16% of the study area. The presence of natural vegetation was very low (shrub with 0.3 ha) and characterized 1% of the total area. The herbaceous vegetation was nitrous, comprising ruderal flora with a low ecological value, and was conditioned by present and past anthropogenic activities. Though 63% of the area was characterized by agricultural use, this use was scarce and poorly productive. The arable land was characterized by strong fragmentation by the owners and, in many cases, was represented by small plots used as vegetable gardens.

The main ecosystem services were provided by the olive groves (Table 2). The olive groves land use was characterized by the presence of many olive trees with cultural value, as defined by regional law (LR 14/2007, B.U.R. PUGLIA—N. 83, 7 June 2007). Out of 350 olive trees analysed, 200 had a monumental character, 66 of which had a diameter larger than 70–100 cm, with a sculptural shape, representing important cultural and aesthetic value in the landscape. However, the area of the olive groves was severely infected by *X. fastidiosa*, and almost all the trees have a canopy with desiccated branches. Due to the heavy infestation of the now desiccated olive groves, these plants were considered dead. The presence of *X. fastidiosa* had a strong ecological impact; therefore, the olive groves have lost their ecological function in the landscape (Figure 4).

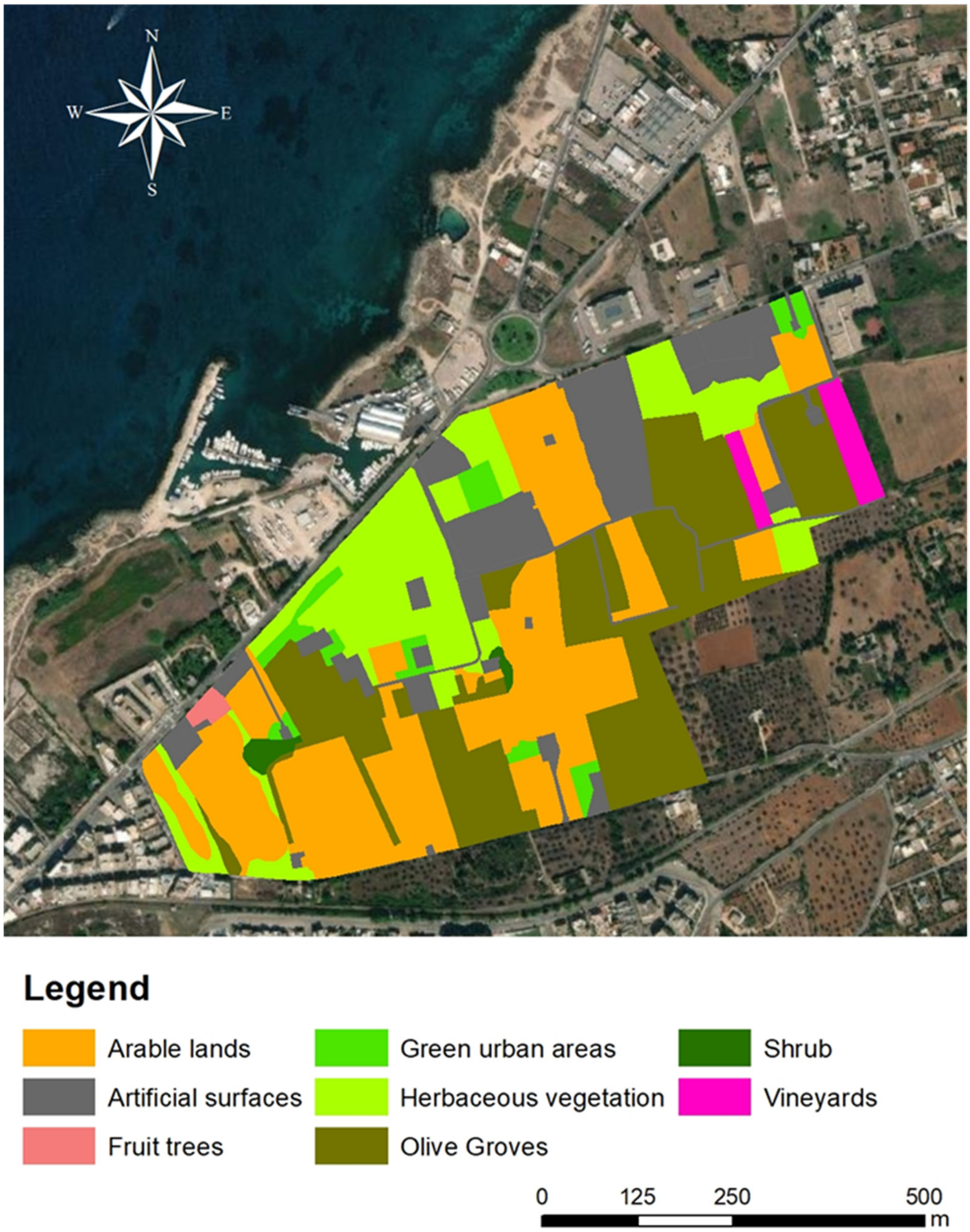

Figure 3. Spatial configuration of the land uses of the study area.

Table 2. Qualitative characterization of the ecosystem services provision capacity, linked with the land uses of the study area. Symbols: "-"—no relevant capacity; ☺—low capacity; ☺☺—medium capacity; ☺☺☺—high capacity [16,31,38,40–44,57,58].

Service	Olive Groves Pre-Xyella Fastidiosa	Olive Groves Affected by *X. fastidiosa*	Arable Lands	Herbaceous Vegetation	Fruit Trees	Shrub	Artificial Surfaces (Building; Roads; Parking Areas)	Green Urban Areas	Vineyards
1—Food	☺☺	-	☺☺	-	☺☺	-	-	-	☺☺
2—Water	-	-	-	-			-	-	-
3—Raw Materials	☺☺	☺☺☺	☺	-	☺☺	-	-	-	☺
4—Genetic resources	☺☺	☺	☺	☺	☺☺	☺	-	☺	☺
5—Medicinal resources	☺	-	-	-	☺☺	☺	-	-	☺
6—Ornamental resources	-	-	-	-		-	-	☺	-
7—Air quality regulation	☺☺☺	☺	☺	☺	☺☺	☺	-	☺	-
8—Climate regulation	☺☺☺	☺	☺	☺	☺☺	☺	-	☺	☺
9—Moderation of extreme events	☺☺	☺	☺	☺	☺☺	☺	-	☺	-
10—Regulation of water flows	☺	☺	☺	☺	☺	☺	-	☺	☺
11—Waste treatment	☺	-	☺	-	☺	-	-	-	-
12—Erosion prevention	☺☺	☺	-	☺	☺☺	☺	-	☺	-
13—Maintenance of soil fertility	☺☺	☺;	☺	☺	☺☺	☺	-	☺	-
14—Pollination	☺	☺	☺	☺	☺☺	☺	-	☺	-
15—Biological control	☺	☺	☺	☺	☺	☺	-	☺	-
16—Maintenance of life cycles of migratory species	☺☺	☺	☺	☺	☺☺	☺	-	☺	☺
17—Maintenance of genetic diversity	☺	☺	☺	☺	☺	☺	-	☺	☺
18—Aesthetic information	☺☺☺	-	☺	-	☺☺	☺☺	-	☺	☺☺
19—Opportunities for recreation and tourism	☺☺☺	-	☺		☺☺	☺☺	-	☺	☺☺
20—Inspiration for culture, art, and design	☺☺☺	-	-	-	☺☺	☺☺	-	☺	☺☺
21—Spiritual experience	☺☺☺	-	-	-	☺☺	☺☺	-	☺	☺☺
22—Information for cognitive development	☺☺☺	-	-	-	☺☺	☺☺		☺	☺☺

Figure 4. Example of dry olive trees desiccated by *X. fastidiosa* in the study area.

The removal of the infected monumental olive trees would cause the loss of an identity element of the landscape of Gallipoli, which would never be restored. In addition, the olive grove was an important carbon sink and therefore had an important role in mitigating the local microclimate and the improved air quality of the local area. Paradoxically, the olive trees that were previously a valuable element of the landscape now represent an element of degradation in the landscape (Table 2).

The olive groves were characterized by nitrophilous ruderal vegetations, which had low interest from the landowner, due to the loss of productivity. Earlier, the main ecosystem services produced from these groves was raw material, derived by the utilization of the wood.

Hence, the provision of ecosystem services of the olive trees affected by *X. fastidiosa* was almost comparable to uncultivated areas characterized by herbaceous ruderal vegetation [42].

The urban neighbourhood plan was developed, reducing the potential artificial surface planned in the municipal urban plan of Gallipoli. The total artificial surface planned was about 15 ha of the area, corresponding to 38% of the total area, about double the original artificial surface during the starting scenario (Table 3 and Figure 5).

Table 3. Land use/land cover generated by urban development plan at neighbourhood scale.

Land Urban Plan	ha	%
Area not included in the urban plan	2.1	5%
Artificial surfaces	14.9	38%
Fruit trees	0.8	2%
Green urban areas	21.1	54%
Total	39.0	

Figure 5. Land use/land cover planned by the urban neighbourhood plan.

The increase in the artificial surface at later phases was mainly from the arable land (5.9 ha), in the olive groves, 3.2 ha, and in the herbaceous vegetation, 2.7 ha (Table 4). The arable land was mainly developed in the form of the new building and connected areas, whereas the olive groves were used for the realization of new roads (Figure 6). So, accounting of ES lost due to the new building in arable land was limited. However, considering the health status of olive groves, the ecosystem services which were lost due to their conversion to artificial surfaces were also minimal, and comparable to the ecosystem services lost from the conversion of herbaceous vegetation into building areas.

Table 4. Transition status under the land use/land cover change from starting point scenario to urban neighbourhood plan scenario. The yellow color indicates the surfaces that have remained unchanged.

Class		Urban Neighbourhood Plan Scenario (ha)			
		Area Not Included in the Urban Plan	**Artificial Surfaces**	**Fruit Trees**	**Green Urban Areas**
Land Use starting scenario (ha)	Arable lands	0.1	5.9		6.7
	Artificial surfaces	1.4	2.2		2.5
	Fruit trees	0.1	0.1	0.0	0.0
	Green urban areas	0.1	0.3		0.8
	Herbaceous vegetation	0.3	2.7		3.6
	Olive Groves	0.0	3.2	0.8	6.8
	Shrub	0.0	0.2		0.0
	Vineyards		0.3		0.5

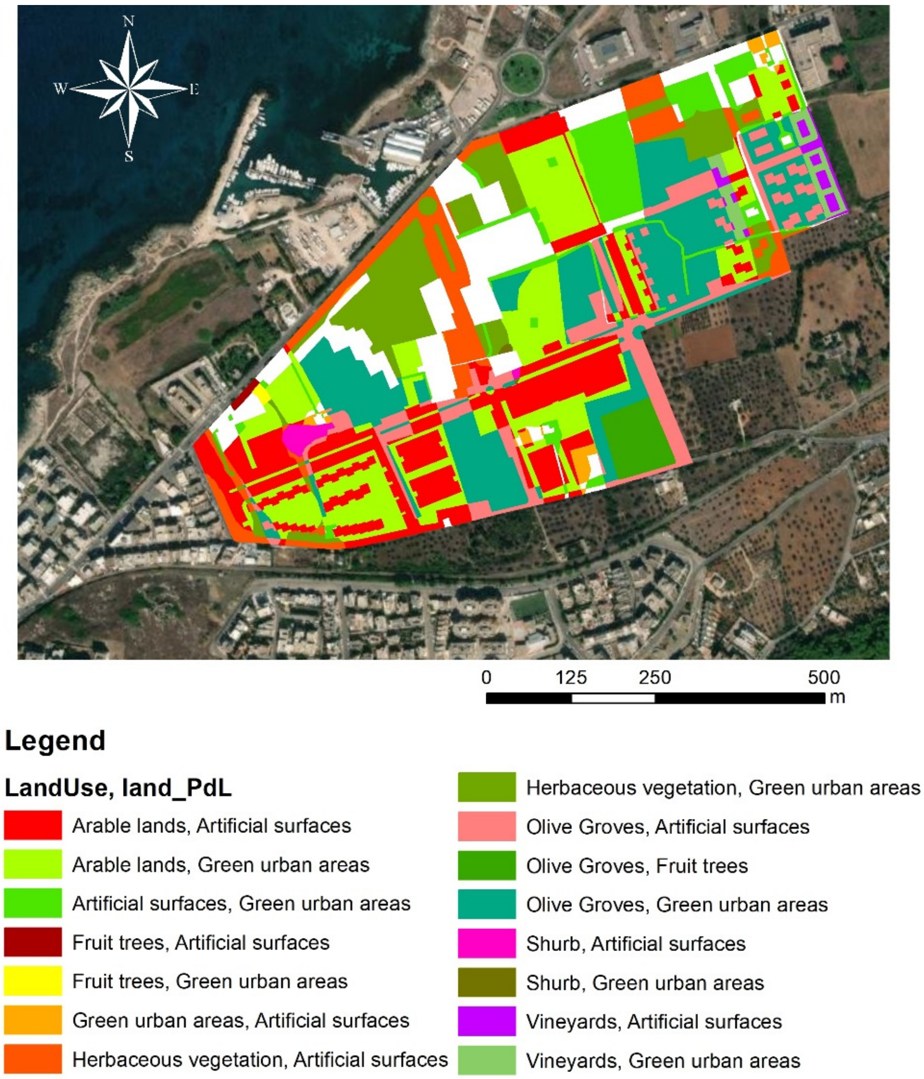

Figure 6. Land use/land cover change from past scenario to urban neighbourhood plan scenario.

The urban neighbourhood plan could produce an increase in ecosystem services from the conversion of the "arable lands" and "herbaceous vegetation" in "urban green areas". The important aspect, in this case, was the way of the ecological design of the green area that has to be realized in an active manner to develop important ecological functions for human well-being.

3.2. Proposed Nature-Based Solutions

As the urban plan was developed at a local scale, it is possible to prioritize the ESs that can be developed considering the specific environmental issues that characterize the urban area, such as the quality of the air and microclimate, that can be altered due to the built environmental and human activities.

Regulating services, defined as "air quality regulation" and "climate regulations", were classified as prioritized ESs, and can be planned in the area for mitigative purposes [59,60]. In the area occupied by dead olive groves, the mitigation actions of the urban neighbourhood plan have to focus various opportunities—recovering aesthetic information; building opportunities for recreation and tourism; inspiration for culture, art, and design; spiritual experience (P); information for cognitive development (P)—provided by the monumental olive trees (Table 5) [38,42]. This is important for restoring the original cultural value of the area where many monumental olive trees were located, which are now dry/dead due to *Xylella fastidiosa*. So, while developing the urban plan, the cultural and amenity services can be considered as priority ecosystem services.

Table 5. Ecological functions generated with NbSs which can be useful to increase priority ecosystem services (P) and potential co-benefits (C).

Ecosystem Service	Ecological Benefits	Ecological Function	NbSs	References
1—Food production (C)	Provision of natural resources: hunting, game, fruits, etc. Small-scale subsistence.	Production functions (Provision of natural resources).	Intensive and extensive green rooves for big buildings. EIGR. Grasslands; IGR: Sclerophyllous vegetation. Green Wall: Grasslands. The use of endemic vegetations with germplasm derivate from the local context. Creation microhabitat and structure able support local insects and animal using Melliferous, Aromatic Flora (MAF: Sclerophyllous vegetation). Creation of Urban Forest Habitat (UFH: Broad-leaved forests). Urban community gardens with an attempt to Graft Monumental Olive Trees infected with resistant essences (UG-OT: olive trees). Urban community gardens with Reforestation: mixed shrub and arboreal agricultural essences and natural flora (UG-R: Fruit trees and berry plantations). Squares, streets, and parking lots with Grassy Floors (GF: Grasslands). Using Flora for Environmental Monitoring (FEM: Sclerophyllous vegetation).	[7,21,41,42,46,56,61–83]
2—Raw Materials ©				
3—Genetic resourc© (C)				
4—Medicinal reso©es (C)				
6—Ornamental r©urces (C)				
7—Air quality regulation (P)	Role of ecosystems in bio-geochemical cycles (e.g., CO_2/O_2 balance, ozone layer, etc.).	Regulation functions Maintenance of essential ecological processes and life-support systems.		
8—Climate regulation (P)	Maintenance of a favourable local climate (temp., humidity, etc.) for human habitation and health.			
9—Moderation of ext©e events (C)	Influence of ecosystem structure on Dampening env. disturbances. Role of vegetation root matrix and soil biota in soil retention. Role of land cover in regulating runoff and river discharge.			
10—Regulation ©water flows (C)	Role of land cover in regulating runoff and river discharge.			
11©aste treatment (C)	Filtering, retention, and storage of fresh water (e.g., in aquifers). Role of the vegetation in removal or breakdown of xenic nutrients.			
12©osion prevention (C)	Prevention of damage from erosion/silt.			
13—Maintenance of soil fertility	Maintenance of healthy soils and productive ecosystems.			

Table 5. *Cont.*

Ecosystem Service	Ecological Benefits	Ecological Function	NbSs	References
14—Pollination (C)	Role of biota in movement of floral gametes thus pollination of crops.	Habitat functions (Providing habitat (suitable living space) for wild plant and animal species).		
15—Biological control (C)	Population control through trophic–dynamic relations.			
17—Maintenance of genetic diversity (C)	Suitable living space for wild plants and animals. Suitable reproduction habitat. Genetic material and evolution in wild plants and animals.			
18—Aesthetic information (P)	Attractive landscape features. Variety in landscapes with (potential) recreational uses. Variety in natural features with cultural and artistic value. Variety in natural features with spiritual and historic value. Variety in nature with scientific and educational value. Living space (ranging from small settlements to urban areas). Social activities (outdoor sports, beach tourism, etc.).	**Information and carrier functions:** Providing opportunities for cognitive development; providing a suitable substrate or medium for human activities and infrastructure.		
19—Opportunities for recreation and tourism (P)				
20—Inspiration for culture, art, and design (P)				
21—Spiritual experience (P)				
22—Information for cognitive development (P)				

Of course, the definitions of priority ecosystem services do not exclude the possibility of introducing other ecosystem services. The design of priority ecosystem services can also support to the development of various indirect ecosystem services producing other co-benefits. For instance, the locations, dimensions, and typologies of the public spaces might not be suitable for obtaining new habitats with income generation for the local population; however, they can develop the social activities linked with food production, raw materials, medicinal resources, and ornamental resources, i.e., these ecosystem services can be considered and classified as co-benefits.

This phase was developed by considering the NbSs that can be developed in the urban areas to support ecosystem services. The main solutions are highlighted in Table 5 and Figure 7.

Mainly, the solutions reported in the literature have been adopted [20,40,52–59] for the study area.

These infrastructures cannot represent a large natural area; however, they can improve specific ecological functions, increase human health, and enhance local biodiversity. In an urban context, where ecological land use is in competition with social and economic land use, it is necessary to implement whatever measures are possible, independently of the dimensions.

The NbSs are proposed by considering the priority ecosystem services in relation with land use and land cover in the urban plan at the neighbourhood scale, the experiences of the experts involved in urban processes, and bibliography research.

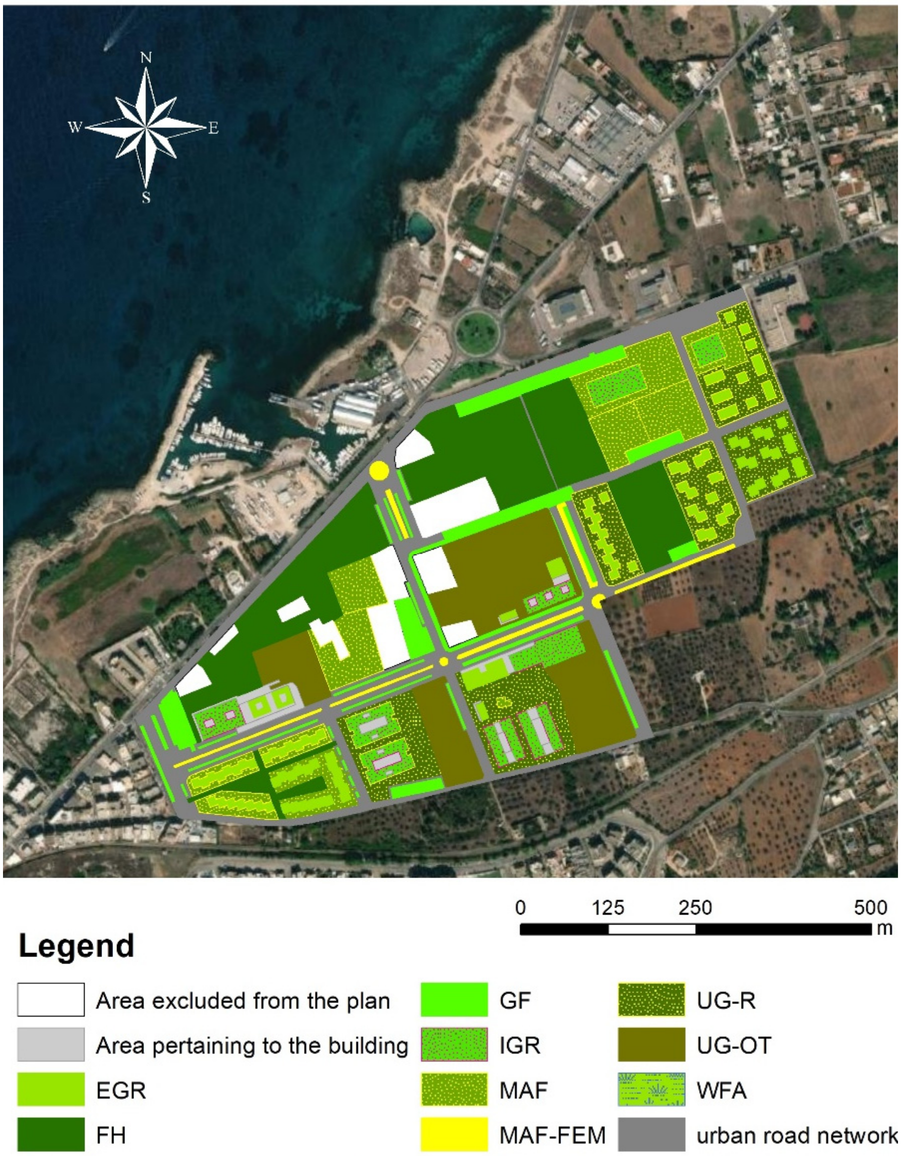

Figure 7. Spatial localizations of NbSs considering the urban neighbourhood plan.

In this study area, it was decided to assign equal importance to cultural value and the regulation services—"air quality regulation" and "climate regulations" [84]. Therefore, the application of the fruit crops and the replacement of dead olive trees is seen as fundamental. Other priorities could produce different solutions. For example, by giving more importance to CO_2 sequestrations, it is possible to set up the green area with species with high carbon sequestration potential, independently of fruit production, or to reduce the extension of the community gardens to allow for forest areas.

3.3. Ecosystem Services Impact Assessment

The study area is a private urban area; therefore, the land cover and land use transformations are conditioned by both public and private choices. The urban land use is conditioned by the municipal urban plan of Gallipoli city, which defines this area as a residential urban sprawl zone of the city. However, the urban land cover transformations are defined by the choices of private landowners, by planning urban structures, such as buildings, parking areas, urban gardens, etc., in order to obtain their own economic profit. Therefore, in this phase, the future urban development of the neighbourhood is linked to local private initiatives and economic investment, and not to public actions and funding. In this way, it is important to highlight the potential ecosystem services provided by the land cover land use generated by new urban development plans at a neighbourhood scale. The bottom–up actions for NbSs require practical application of the international policies, and require sustainability to be addressed.

In the study area, the transition from "Past Scenario" (pre-*X. fastidiosa*) to "Scenario 0" (post-*X. fastidiosa*) produces a loss of ecosystem services, such as "Air quality regulation" and "Climate regulation", due to the loss of the thick crown of the dead olive trees (Figure 3; Table 5). This situation persisted from 2017, and has produced a loss of 74% of the capacity to absorb CO_2 in this area (Table 6).

Table 6. Analysis of CO_2 sequestration considering the land use/land cover under different scenarios. We have considered the land use/land cover scenarios by including olive groves in good status (past scenario), olive groves affected by *X. fastidiosa* (current situation—scenario 0), actions foreseen by the urban plan (scenario 1), and the urban plan integrated with NbSs (scenario 2).

CO_2 sequestration (Past scenario)			
Land Use pre *X. fastidiosa*	**ha**	**t/ha**	**t**
Arable lands	12.8	5.00	63.8
Artificial surfaces	6.2	0.00	0.0
Fruit trees	0.2	21	3.5
Green urban areas	1.2	6.60	7.9
Herbaceous vegetation	6.6	0.00	0.0
Olive Groves	10.9	51.50	560.3
Shrub	0.3	17.74	3.0
Vineyards	0.9	21.00	18.0
Total	39.0		679.8

CO_2 sequestration (Scenario 0)			
Land Use post *X. fastidiosa*	**ha**	**t/ha**	**t**
Arable lands	12.8	5.00	63.8
Artificial surfaces	6.2	0.00	0.0
Fruit trees	0.2	21	3.5
Green urban areas	1.2	6.60	7.9
Herbaceous vegetation	6.6	0.00	0.0
Olive Groves (*Xyella fastidiosa*)	10.9	6.60	71.8
Shrub	0.3	17.74	3.0
Vineyards	0.9	21.00	18.0
Total	39.0		170.30

CO_2 sequestration (Scenario 1)			
Land Urban Plan	**ha**	**t/ha**	**t**
Area not included in the urban plan	2.1	0	0.0
Artificial surfaces	14.9	0	0.0
Fruit trees	0.8	21	17.6
Green urban areas	21.1	6.6	139.4
Total	39.0		157.0

CO_2 sequestration (Scenario 2)			
Land Urban Plan	**ha**	**t/ha**	**t**
Area excluded from the plan	2.3	0	0
Area pertaining to the building	0.8	0	0
EGR (Grasslands)	2.1	3.04	6.52
FH (Broad-leaved forests)	7.4	28.24	209
GF (Grasslands)	2.9	3.04	8.74
IGR (Sclerophyllous vegetation)	2.1	17.74	37.4
MAF (Sclerophyllous vegetation)	4.2	17.74	74.5
MAF-FEM (Sclerophyllous vegetation)	0.7	17.74	11.9
UG-R (Fruit trees and berry plantations)	4.7	21	98.9
UG-OT (Olive trees)	4.8	51.5	246
urban road network	7.0	0	0
Total	39		693

The important losses of ESs were the following: "Aesthetic information"; "Opportunities for recreation and tourism"; "Inspiration for culture", "Art and design"; "Spiritual experience"; "Information for cognitive development". These can be considered irreversible transformations. In addition, the presence of dry olive trees and of uncultivated trees can give the vision of a degraded and abandoned landscape, where the improvisation of the individual persists, without a vision of uniform urban development.

Passing from "Scenario 0" to "Scenario 1", the land use capacity of the "Air quality regulation" and the capacity to absorb CO_2 may not be different. However, the increase in the impermeable surface is likely compensated by the increase in the urban green areas.

The development of NbSs (Scenario 2) may cover the capacity to absorb CO_2 of the scenario pre-*X. fastidiosa*. The dead olive trees will be replaced with new trees, promoting biophysical structure, able to support pollution absorbance as CO_2. Therefore, compared with "Scenario 0", the NbSs could quadruple the capacity to absorb CO_2 due to the general expansion of wooded surfaces with the replacement of the dead olive trees and the conversion of arable lands in urban community gardens characterized by tree fruits. Therefore, the transition from "Scenario 1" to "Scenario 2" is favourable and should be sponsored (Table 6).

Moreover, the NbS can reduce the emission of CO_2. For example, the green roofs can increase energy-saving capacity in the buildings by reducing the greenhouse gases emissions, with positive effect on carbon footprints [7]. Therefore, the bottom–up action of the private stakeholders at the neighbourhood scale has a key role in their following sustainable policies, as promoted by the international initiative—"Climate Neutral and Smart Cities"—where cities are committed to a new form of sustainable urban transformation towards climate neutrality by 2030 [85].

NbSs measures increase the permeable surface of the area due to the realization of green roofs. This can improve ecosystem services, such as "Climate regulation", "Moderation of extreme events", and "Regulation of water flows". The presence of forest habitats and creation of microhabitats are able to support local insects and animals, and also the biodiversity of the area. These areas were designed to try to create a continuous habitat between private green urban areas and public green urban areas.

The NbSs provide the use of endemic vegetations with germplasms derived from the local context, with particular attention to the melliferous and aromatic flora essences. Therefore, this can reduce the water input and management actions for the vegetation, by reducing the use of natural resources [82].

The urban community gardens can improve the cultural aspect of the area linked to the agricultural landscape. Of course, these cannot introduce the same cultural aspect as the monumental olive groves, but they can contribute to cultural functionality of the area. Moreover, using agricultural melliferous, aromatic flora could be important to increase pollination functions.

The community gardens are important nature-based solutions planned in the urban plan, sponsored by smart city strategies, promoted by Horizon 2020, to foster social aspects, such as psychological well-being, and reinforce the sense of community, if compared with the actual status. The community gardens have great potential to build personal relationships and social cohesion; therefore, they represent an important meeting place to create a sense of community in new urban areas [7,67]. In fact, in a social–ecological system, along with the presence of the cultural elements, the accessibility and possibility for the stakeholders to use them is also important [46,86]. The foreseen NbSs strive to implement the fruition in the area, maintaining the cultural agricultural value. Additionally, in this case, the choice of agricultural vegetation for implementing social and educational values is important.

The NbSs can be linked to the concept of serendipity and hence the possibility of such interventions to obtain benefits that was unforeseen in the initial design goal, without the need of quantifying or evaluating them [38]. Thus, the development of community gardens could be followed by extreme and experimental actions to preserve the historical value linked to the presence of monumental olive trees as much as possible. For example, there is possibility for the development of artistic elements or street furniture, starting from the use of olive tree trunks along the dry-stone wall in the area, or in a small portion of the area pertaining to the plan.

The olive trees affected by *Xylella fastidiosa* that have not been eradicated could be experimentally preserved in place (avoiding their eradication) in order to transform them into artistic works of furniture for the community gardens that will be built. An art competition could be organized in order to encourage participation from more artists and to have a greater number of proposed solutions, along with increased creativity of the solutions.

The trunks of the non-eradicated olive trees can be used as support for the development of ornamental plants and can be covered with climbing plants (Figure 8A—artistic drawing as an example of what can be achieved). In this case, the chosen olive tree would not be eradicated, but rather left to provide support for the development of ornamental plants. Alternatively, other plants can be allowed to grow on the olive tree trunk, as shown in the example in Figure 8B (oak plant spontaneously developing its roots within the dry trunk). After all, if nature does not act by chance, but according to the logic dictated by the opportunities that arise, we can stimulate and create these opportunities.

Figure 8. (**A**) Example of artistic expression of recovery of a dry olive grove; (**B**) oak plant grown spontaneously inside a dry olive tree trunk.

4. Discussion

The development of NbSs in the urban neighbourhood plan should contribute to reducing the negative effects of urban land use and land cover transformation from conversion of part of the arable land into building elements and road networks. The ecosystem services analysis provides indications on how NbSs can have positive effects in urban sprawl in terms of typologies and level of ecological functions developed between different land use and land cover options. In this case, both the amount of green space and the typologies of the greens spaces and the vegetation used are important factors. This is the main difference between scenario 1 and scenario 2 (Table 6).

In the case of Gallipoli, the diffusion of the *Xylella fastidiosa* has produced an irreversible loss of cultural ecosystem services and provision of ecosystem services (production of olive oil), mainly connected with the monumental olive groves that cannot be recovered in the short time. In the current state, the low value of the area for agricultural production, and the land owners' interest in urban transformation in agreement with the municipal urban plan, can push them not to apply any actions for vegetation recovery, which might have negative effects on the ecosystem services and landscape value. This is mainly appliable to socioecological systems, where the interest in human well-being is high, and changes in land use and ecosystem services can be caused by human choices that may prefer to abandon the land instead of using it [36]. Every action is important to shape the landscape, and simple abandonment due to the scarce economic interest presented by the landscape can produce negative effects.

The urban planning at the neighbourhood scale can have a role in aggregating all stakeholders by developing a unique vision of landscape development. Instead, in the current state, the individual owners (with an average of 0.5 ha each) could develop heterogeneous actions leading to a worsening of the situation, or even decide to do not act, due to the low economic interest in the investment of money.

Therefore, in the peri-urban area, characterized by landscape degradation and urban development, the urban development plan could represent an opportunity to increase the resilience of the landscape. The urban neighbourhood plan can develop the interest and economic support of the companies to apply landscape transformation. The ecosystem services analysis in the urban planning process can be useful to increase the social and ecological resilience of some ecosystem services, such as CO_2 sequestrations of the area recovering important ecological functions, and structure lost for *X. fastidiosa* spread.

The strategies of NbSs represent new ecological elements that could reduce the impact of the urban land use change and the increases in the priority ecosystem services to achieve the environmental objectives of the urban plan at a neighbourhood scale. This approach could be applied at municipal and regional scales to determine the provision of ecosystem services by the land use/land cover, where the NbSs become specific patches of the land use/land cover pattern. However, at municipal and regional scales, the priorities of ecosystem services could change, and other factors have to be considered and analysed, such as creating and analysing an ecological network between the nature-based solutions and natural areas. In this way, the introduction of NbS and ecosystem services analysis should be developed in terms of green infrastructure, defined as a "strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services . . . " [27,28,87].

However, the analysis of ecosystem services is not a substitute for evaluations of the effects caused by waste production, mobility, quality of the area, and use of water resources, etc. An ES approach should be considered as a tool to better arrange the relationships between biodiversity, ecological functions, and urban land use/land cover. Therefore, the analysis of ecosystem services in the urban planning process should be considered complementary to other approaches and not preponderant or exclusive. For example, in this case, the analysis of ecosystem services should be weighed with other social and economic factors, such as the need of houses, especially in communities with economically deprived populations.

The impacts of NbSs on ecosystem services provision in the new urban area can be tested when the urban plan is realized. Therefore, the present study represents a prevision analysis, derived considering objective data by a bibliography analysis and studies already tested, expert contributions, and the landscape context. Moreover, the use of ecosystem services within the urban neighbourhood plan can be considered as an additional tool to bring designers closer to ecological and social issues for local planning. Above all, it helps to perceive the actions aimed at sustainability as important for obtaining a higher quality and more attractive plan, without any additional costs for planners.

Another important element is the temporal projection of the mitigation strategies that are developed. In this study, "the cultural amenity services" have been considered priority ecosystem services for the past characteristics of the study areas, where beautiful monumental olive trees were present, now destroyed by the *Xylella fastidiosa*. The cultural value regeneration was focused on both new agricultural practices in respect to the past scenarios to introduce new fruit plants, or the reestablishment of old olive groves using species resistant to *Xylella fastidiosa*. Indeed, the sustainable concept of ecosystem services analysis is focused on future generations; therefore, it is intrinsic that the cultural strategies should promote the transformation developed from the urban plan considering long-term visions. Therefore, the cultural strategies should be developed not only considering how the area is in the present, but how this area would be in the future. Only in this way we can realize the future cultural landscape, as well as acknowledging the contributions of past generations. Therefore, in this study, we might obtain a landscape structure that can partially recover the cultural value of the olive trees, considering the adopted mitigation actions over a long period. For example, by proposing again the techniques used in the past to grow olive groves in the community gardens, in about 50–100 years we can produce olive trees with huge trunk diameters and heights. Indeed, the monumental olive trees shapes are the result of past human agricultural practices that, in current economic productions, are not feasible [3,38,43]. So, if we want to repropose the cultural structure of olive groves, then it is necessary to repropose the past cultural systems of production in synergy with the olive tree plants. This is a hard application, but it is not impossible in the community garden, where social activity and maintenance of cultural values are priorities in respect to agricultural economic productions.

5. Conclusions

In this paper, we focused on the application of an ecosystem services analysis in urban planning at a neighbourhood scale. This methodology represents a cultural leap in the use of the concept of ecosystem services in urban planning at a neighbourhood scale. It combines an assessment and mapping of the actions of ES, with the ability to plan and design them using NbSs, which are too often developed in isolation.

The approach applied emphasis on the capacity to design mitigation measures with NbSs to improve ecosystem services, which are useful in satisfying environmental goals and human well-being. In this case, the analysis of ecosystem services in the urban neighbourhood plan does not represent an integrative study developed separately in the context of urban planning process, but rather it represents an element that merges with the urban planning development to produce a new vision related to the sustainability of urban planning.

In this study, we develop an overview of how the concept of ecosystem services can be integrated into the workflow of the urban planning process, concerning the positive effect of the integration of vegetation into the urban infrastructure, with the possibility of developing specific NbSs. However, in the specific urban contexts and plan, it is necessary to consider the potential ecosystem disservices that the vegetation can produce, such as the absorbance of heavy metals in the fruit or the allergenic matters of production [61]. For example, the green roof and the urban community gardens may have negative ecological effects or create ecosystem disservices. Nitrogen, phosphorus, and potassium, for example, may accumulate in high concentrations in garden soils [88] due to the indiscriminate application of fertilizers or compost, polluting urban stormwater runoff or groundwater [89]. Therefore, the consideration of the ecosystem services concept in the urban planning process needs a transdisciplinary approach to account for all the potential effects on the relationships and interactions that can be developed between the urban ecosystem and human benefits. Mainly, in the urban context, where different social and economic interests coexist, stakeholder consultation is crucial to obtain existing information and to confirm the values, interests, and dependencies on priority ecosystem services with the people who need and use them.

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