Ecosystem Services in Strategic Environmental Assessment: a Case Study of an Urban Development Plan in Gallipoli City

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Abstract. The growth of urban populations leads to cities and their suburbs to spread, expand, and replace agricultural and natural lands. Indeed, urbanization brings to land-use change, altering the relationship between human societies and environmental resources with loss of important natural and rural ecosystem goods and services. In urban areas, the elements that provide ecosystem services are defined as ‘green infrastructure’. The Strategic Environmental Assessment (SEA) is an appraisal process introduced in the EU regulation with Directive 2001/42/CE to assess the effect of the Plans and Programmes on the environment and human well-being. An important part of SEA processes is represented by the analysis of different scenarios of the urban development with mitigation measures: actions must be implemented in order to avoid and reduce the expected adverse environmental impacts. Currently, among these measures, few or none takes into consideration the assessment of ecosystem services, and therefore, the concept of ecosystem services in urban planning is purely conceptual than practical. Starting from a case study in the Gallipoli municipality, South Italy, we propose a methodological analysis to evaluate ecosystem services in a SEA process. In particular, we have analyzed different urban scenarios in synergy with the mitigation measures proposed. The results show a decrease in ecosystem services passing from the current agricultural land use to an urban development forecast with the enhancement of ecosystem services if we apply specific mitigation actions to the original urban plan. Authors believe that a correct and profitable assessment of ecosystem services in SEA strategy allows passing from an approach mainly oriented towards a conservation purpose to an approach aimed also to the improvement of ecosystem services within the territory transformation processes. In accordance with the spontaneous vegetation and the typical crops of the area, the mitigation measures developed are mainly focalized on green infrastructures that can increase the ecological functions.

1. Introduction
Currently, about 55 percent of the world’s population lives in urban areas, with projection indicating a growth of up to 68 percent by 2050 [1]. The growth of urban populations causes cities and their suburbs to spread, expand and replace agricultural and natural lands [2,3]. Urbanization brings land-use change, altering the relationship between human societies and environmental resources [4-6]. It produces land erosion, energy flows, biogeochemical cycles, climatic conditions, habitat fragmentation with related biodiversity loss, and decline of ecological functions fundamental for the provision of important ecosystem goods and services, defined as ecosystem services [4, 7, 8]. Therefore, the management of...
land use connected to urban expansion has become one of the most important challenges to sustainable landscape [9-11].

Managing and building sustainable urban areas has become one of the most critical development challenges and one of the main concerns to answer the apparent discrepancy between proper land use management and both rapid urbanization growth and productive activities [12].

Today, we have to face new challenges about improving urban ecosystem services availability in response to land-use change and soil degradation using available urban spaces in a multifunctional way. This problem must be solved in a sustainable way using innovative Green Infrastructure (GI) that combines technology with landscape design by enhancing ecosystem services provision of goods and ecological process supporting life on earth, like pollination, water purification, climate regulation [13]. The concept of GI emphasizes the quality as well as the quantity of urban, peri-urban greens spaces and natural areas, their multifunctional role, and the importance of interconnections between habitats [14-16] as they could improve environmental quality, reducing fragmentation and then biodiversity loss. If a GI is proactively planned, developed, and maintained it has the potential to guide urban development by providing a framework for economic growth and nature conservation [17-19]. GIs include parks and reserves, sporting fields, riparian areas like stream and riverbanks, greenways and trails, community gardens, street trees, and nature conservation areas, as well as less conventional spaces such as green walls, green alleyways, and cemeteries [20].

Decision making on resource management and environmental conservation received worldwide attention in urban development given the urgent need to preserve ecosystems and find a sustainable balance between long- and short-term costs/benefits of human activities. Strategic decisions, policies, and actions aimed at limiting human intervention within the carrying capacity of ecosystems, preserving their vitality and resilience, and maintaining the capacity to provide goods and services in the long-term are required. Only in this way, technological progress and productivity growth will be directed towards increasing efficiency in the use of natural resources rather than the flow of energy and raw materials [21, 22].

In this context, The Strategic Environmental Assessment (SEA) is an appraisal process introduced in the EU regulation with Directive 2001/42/CE to assess the effect of the plans and strategies of the land-use change on human well-being. An important part of SEA processes is represented by the analysis of different scenarios of urban development with mitigation measures: actions must be implemented in order to avoid and reduce the expected adverse environmental impacts [23]. Currently, among these measures, few or none takes into consideration the assessment of ecosystem services. Therefore, the concept of ecosystem services in urban planning is purely conceptual than practical.

As above discussed, starting from a case study in the Gallipoli municipality, South Italy, we propose a methodological analysis to evaluate how ecosystem services change with the urban plan development in a SEA process. In particular, we have analyzed how the ecosystem services provision could be affected by the different urban scenarios and how the enhancement or realization of green infrastructures, proposed like mitigation measures to urban development in the SEA report, can deliver important ecosystem services. The proposed mitigation measures are not theoretical but will become an integral part of the new urban design and therefore mandatory during the construction of urban buildings and infrastructures [23]. Authors believe that a correct and profitable assessment of ecosystem services in SEA strategy allows passing from an approach mainly oriented towards a conservation purpose to an approach able to deliver the optimal quality and quantity of basic ecosystem services within the territory transformation processes. This methodology can be useful to better integrate the SEA into ‘real’ decision making giving evidence about efficiency in land use to increase the ecological functions reducing the ecological footprint and increasing the carrying capacity of an urban system [24].
2. Methodology proposed

The study was carried out following the scheme reported in Figure 1. It adopts a multidisciplinary approach in order to develop a methodology of the ecosystem services assessment for urban development that allows economic, ecological and social aspects to coexist creating trade-off and synergies among them.

![Figure 1. Scheme of the methodology proposed](image)

The engineering and architectural skills were integrated with sustainable and environmental sciences related to landscape enhancement, biodiversity conservation, and urban planning development. The land planner, assisted by a group of experts (i.e. an ecologist, a botanist, a geologist, a forest agronomist, and a zoologist), has taken into account how the green infrastructures can combine the issue of ecosystem services with the development of the urban area.

In order to evaluate the ecosystem service changes caused by planning urban sprawl in peri-urban areas, we applied a scenario analysis according to the SEA procedure as indicated by the Directive 2001/42/EC. The changes which occurred in the provision of ecosystem services considering the different urban development scenarios (for example the land use change from olive groves to uncultivated soil) were selected from the literature (see Table 1 caption later in the text) and from the consideration of the experts. The experts have considered the characterization of the study area; a multiscale study of the context of reference; the identification of the main environmental and ecological issues; the identification of a spectrum of suitable species and habitats to enhance biodiversity and consequently reduce habitat/landscape fragmentation [25, 26].

3. Results and discussions

3.1. Step 1

The study area is located in the peri-urban area of the municipality of Gallipoli where urban and rural characters are interconnected, and a net separation is not evident. Gallipoli has a core urban area that is mainly surrounded by peri-urban areas characterized mainly by agroecosystems (Figure 2A).

The study area interested by the urban sprawl has an area of 12.7 ha and it is characterized by individual buildings immersed in arable lands and olive groves. This area is a cultural landscape, which
is the result of strong historical interactions between ecological, economic, and social components. Many olive groves are monumental trees (following also the definition given by Apulian L.R. 14/07) but, unfortunately, they have been infected by *Xylella fastidiosa* causing the desiccation and the death of all the infected plants. The destructive consequence caused by this pathogen on olive trees is compromising the economic and ecological (and landscaping) purposes of olive groves with a direct and indirect effect on ecosystem services and on psycho-physical well-being of citizens; moreover, from a floristic point of view, the study area was characterized by ruderal, nitrophilous and alien species with a low ecological value.

![Figure 2.](image-url) The study area of the Urban Sprawl Plan. The figure was developed using Base Map in QGIS software.

With these assumptions (i.e. loss of economic, ecological and ecosystem services, caused by *Xylella fastidiosa* and low biodiversity values of the area) now, the private owners of this area are developing urban sprawl designs to implement the urban planning forecasts of the Gallipoli municipality according to the urban and environmental law. The urban sprawl design includes the realization of (Figure 3):

- non-intensive residential (10,609 m²); residential integrated with other activities (39,663 m²);
- structures of public interest (15,200 m²);
- green areas (16,850 m²);
- public parking (7,549 m²);
- urban road network (25,766 m²);
- other (5,031 m²).

The area occupied by the historic monumental olive trees is 7,281 m². The urban plan initially provided for the protection of all the historic olive trees by not occupying this area for the building construction and using it as “urban monumental olive park”. The urban sprawl plan only provided for the movement of about 13-17 olive trees and their repositioning within both public and private green areas of the new urban area.
The progress of *Xylella fastidiosa* has caused the drying of monumental historic olive trees causing the loss of ecosystem services provided by the monumental olive grove (Table 1). Dried olive trees will need to be eradicated [27]. However, the urban plan foresees to use the area of monumental olive trees for the creation of an urban park with native vegetation trying to restore the ecological value of the area associated with the presence of olive trees.

**Table 1.** Variation of ecosystem services provision of monumental olive groves to dry olive grove because of a *Xylella fastidiosa*. The emoticon 😊😊 indicates positive alteration, ☹️ indicates negative alteration. The number of emoticons gives an estimation of the intensity of the alteration: 1: low alteration; 2: medium alteration; 3: strong alteration. [25]

| Functions | Ecosystem Services | Variation from Old Olive to Dry olive grove |
|-----------|--------------------|------------------------------------------|
| **Regulation functions** (Maintenance of essential ecological processes and life support systems) | | |
| Gas regulation | UVB-protection by O₃ (preventing disease); Maintenance of (good) air quality; Influence on climate | 😊😊😊 |
| Climate regulation | Maintenance of a favorable climate (temp., precipitation, etc.) for human habitation, health, cultivation. | 😊😊 |
| Soil retention | Maintenance of arable land; Prevention of damage from erosion/siltation. | 😊 |
| Soil formation | Maintenance of productivity on arable land; Maintenance of natural productive soils; | 😊 |
| Nutrient regulation | Maintenance of healthy soils and productive ecosystems | 😊 |
| **Habitat functions** | | |
| Refugium function | Maintenance of biological and genetic diversity (and, thus, the basis for most other functions) | 😊 |
| Providing habitat (suitable living space) for wild plant and animal species | Nursery function | Maintenance of commercially harvested species |
|-------------------------------------------------|----------------|-----------------------------------------------|
| Production functions (Provision of natural resources) | Food | Hunting, game, fruits, etc. |
| | | Small-scale subsistence |
| Information functions (Providing opportunities for cognitive development) | Aesthetic information | Enjoyment of scenery (scenic roads, housing, etc.) |
| | Re-creation | Travel to natural ecosystems for eco-tourism and (re-creational) nature study |
| | Cultural and artistic information | Use of nature as a motive in books, film, painting, folklore, national symbols, architect |
| | Spiritual and historic information | Use of nature for religious or historic purposes (i.e., the heritage value of natural ecosystems and features) |
| Carrier functions (Providing a suitable substrate or medium for human activities and infrastructure) | Habitation | Living space (ranging from small settlements to urban areas) |
| | Urban-facilities | Social-activities (outdoor sports, beach-tourism, etc.) |

3.2. Step 2
One of the main issues connected with the urban sprawl is the soil consumption that produces direct impacts, such as soils waterproofing and the reduction of agricultural or natural vegetation, and indirect impacts, for instance, the worsening of the microclimate and the quality of the air and the depletion of the quality of human life. For this reason, in the planning of urban sprawl, actions to mitigate environmental issues have been envisaged, such as the construction of a realization of a green infrastructure integrated with anthropic elements.

Green infrastructures are based on the principle that the need to protect nature must be integrated into spatial planning with references to the concepts of ecological connectivity, conservation, and multifunctionality of ecosystems. Examples are natural parks, peri-urban farmland, forests, and urban gardens. The "green roofs" and "vertical walls" could be useful to increase the biodiversity present on the site through the use of spontaneous plant species and the structuring of natural habitats envisaged by the HABITAT DIRECTIVE 92/43/EEC.

The green roof represents an essential tool for environmental mitigation and compensation within the urban area, where the high building density and high anthropic disturbance allow little space for natural dynamics. The "green roofs" can be designed as real gardens that can be enjoyed by the inhabitants to spend their free time. These green roofs could also be used as "urban gardens" that can combine social well-being with small productive activities. The basic idea for the construction of green roofs for biodiversity consists of creating mosaics of different and contiguous microhabitats that can host plant species with different morpho-functional characteristics. Of course, all this depends on the type of green roof that will be developed: extensive (mainly characterized by a lawn); Intensive (characterized by shrubs). The type of technology will be developed in the design phase also according to other needs, such as the installation of technologies for the production of renewable energy. These two needs must not act in opposition but in synergy: for example, it is possible to use plants capable of developing in low light conditions such as Crepis Bursifolia, a perennial herbaceous plant that is compatible with the installation of photovoltaic panels, can be used.

With the same principle, "green vertical walls" can be created, the external cladding of buildings that can host plant species, which not only improve biodiversity but also the landscape insertion of buildings and environmental quality.

In this way, the development of a greater green area would be ensured with the possibility of increasing ecosystem services for the population by enhancing the ecological value of the area.
In green urban areas, the creation of "temporary artificial filtering basins" could be proposed to act as an infrastructure for the dispersion of rainwater during heavy rainfall, guaranteeing normal infiltration into the aquifer. Thanks to specific engineering works, these systems could develop some valuable hygrophilous natural habitats in support of biodiversity.

At the same time, to expand the presence of tree species and diversify agricultural biodiversity, a "traditional agricultural park" will be created where a large part of the arboreal germplasm of the local agricultural tradition will be inserted. For example, it is possible to insert different cultivars: *Ficus carica* L.; *Malus domestica* L.; *Mespilus germanica* L.; *Punica granatum* L.; *Zyziphus sativus* L.; *Cydonia oblonga* L.; *Morus alba* L. and *Morus nigra* L.

The spectrum of suitable species and possible habitats had been identified taking account of the risk of *Xylella fastidiosa* infection, present in Apulia throughout the Salento peninsula. The host range of the sequence type ST53 that was found in Salento includes several species of the Mediterranean vegetation. Therefore, it is necessary to take into account any restrictions arising from norms designed to contain *Xylella fastidiosa* in areas where it has been detected (Table 2).

Table 2. Selection of vegetation potentially suitable for the development of urban greenery.

| Tree                          | Shrub                    | Bush                        | Grass                        |
|-------------------------------|--------------------------|-----------------------------|------------------------------|
| *Celtis australis*            | *Arbutus unedo*          | *Cistus creticus*           | *Crepis bursifolia*          |
| *Ceratonia siliqua*           | *Crataegus monogyna*     | *Cistus monspeliensis*      | *Cynodon dactylon*           |
| *Ligustrum vulgare*           | *Viburnum tinus*         | *Cistus salvifolius*        | *Dactylis hyspanica*         |
| *Laurus nobilis*              | *Myrtus communis*        | *Daphne gnidium*            | *Plantago serraria*          |
| *Olea europaea*               | *Paliurus spinosa-christi* | *Phlomis fruticosa*       | *Lotus corniculatus*         |
| *Quercus ilex*                | *Phillyrea media*        | *Ruscus aculeatus*          | *Poa bulbosa*                |
| *Quercus ithaburensis*        | *Pistacia lentiscus*     | *Salvia officinalis*        | *Trifolium nigrescens*       |
| *Quercus virginiana*          | *Pyrus amigdaliformis*   | *Thymus capitatus*          | *Trigonella esculenta*       |

To try to keep the cultural value of monumental olive groves, we proposed to select the best monumental olive groves kept and try to graft them with resistant olive at *Xylella fastidiosa*. In this case, the olive trees would have an ecologic ornamental aesthetic role to save the cultural and non-productive aspects. This action is palliative and the result is uncertain and will also depend on the progress of the infection.

3.3. Step 3-4
The change in the provision of ecosystem services was carried out considering the scenario of evolution from the current land use to the planned urban development and taking into account mitigation actions. Mainly, we considered how the supply of goods and services for natural and semi-natural ecosystems can vary from areas characterized by monumental dry olive groves and herbaceous vegetation with a low ecological value or uncultivated land to planned green infrastructures (Table 3).

Table 3. Functions, goods and services identified for natural and semi-natural ecosystems introduced by the Urban Sprawl Plan. The emotion😊 indicates positive alteration, ☹ indicates negative alteration. The number of emoticons gives an estimate of the intensity of the alteration: 1: low alteration; 2: medium alteration; 3: strong alteration [27].

| Functions                          | Ecosystem Services                              | From current land use to Urban Sprawl | Urban element                |
|------------------------------------|------------------------------------------------|---------------------------------------|------------------------------|
| Regulation functions (Maintenance of essential ecological) | Gas regulation | UVB-protection by O₃ (preventing disease); Maintenance of (good) air quality; Influence on climate |😊😊😊😊😊😊 | Green Urban Area |
| Processes and Life Support Systems | Climate Regulation | Disturbance Prevention | Water Regulation | Water Supply | Soil Retention | Soil Formation | Nutrient Regulation | Waste Treatment | Pollination | Biological Control | Habitat Functions | Production Functions | Information Functions | Carrier Functions |
|----------------------------------|-------------------|-----------------------|------------------|-------------|---------------|---------------|-------------------|----------------|-------------|-------------------|------------------|-----------------|------------------|-------------------|
| Climate regulation               | Maintenance of a favorable climate (temp., precipitation, etc.) for human habitation, health, cultivation. | Storm protection (e.g., by coral reefs); Flood prevention (e.g., by wetlands and forests) | Drainage and natural irrigation | Provision of water for consumptive use (e.g., drinking, irrigation and industrial use) | Maintenance of arable land; Prevention of damage from erosion/siltation. | Maintenance of productivity on arable land; Maintenance of natural productive soils; | Maintenance of healthy soils and productive ecosystems | Pollution control/detoxification; Filtering of dust particles (air quality) | Pollination of wild plant species; Pollination of crops. | Control of pests and diseases; Reduction of herbivory (crop damage). | Pollination of wild plant species; Pollination of crops. | Food | Enjoyment of scenery (scenic roads, housing, etc.) | Travel to natural ecosystems for eco-tourism and (re-creational) nature study | Living space (ranging from small settlements to urban areas) |
| Maintenance of a favorable climate (temp., precipitation, etc.) for human habitation, health, cultivation. | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof | Green Roof |
| Storm protection (e.g., by coral reefs); Flood prevention (e.g., by wetlands and forests) | Green Roof | Green Roof | Green Urban Area | Green Roof | Green Urban Area | Green Urban Area |
| Drainage and natural irrigation | Green Roof | Green Roof | Green Urban Area |
| Provision of water for consumptive use (e.g., drinking, irrigation and industrial use) | Green Roof | Green Roof | Green Urban Area |
| Maintenance of arable land; Prevention of damage from erosion/siltation. | Green Roof | Green Roof | Green Urban Area |
| Maintenance of productivity on arable land; Maintenance of natural productive soils; | Green Roof | Green Roof | Green Urban Area |
| Maintenance of healthy soils and productive ecosystems | Green Roof | Green Roof | Green Urban Area |
| Pollution control/detoxification; Filtering of dust particles (air quality) | Green Roof | Green Roof | Green Urban Area |
| Abatement of noise pollution | Green Roof | Green Roof | Green Urban Area |
| Pollination of wild plant species; Pollination of crops. | Green Roof | Green Roof | Green Urban Area |
| Control of pests and diseases; Reduction of herbivory (crop damage). | Green Roof | Green Roof | Green Urban Area |
| Pollination of wild plant species; Pollination of crops. | Green Roof | Green Roof | Green Urban Area |
| Control of pests and diseases; Reduction of herbivory (crop damage). | Green Roof | Green Roof | Green Urban Area |
| Pollution control/detoxification; Filtering of dust particles (air quality) | Green Roof | Green Roof | Green Urban Area |
| Abatement of noise pollution | Green Roof | Green Roof | Green Urban Area |
| Pollination of wild plant species; Pollination of crops. | Green Roof | Green Roof | Green Urban Area |
| Control of pests and diseases; Reduction of herbivory (crop damage). | Green Roof | Green Roof | Green Urban Area |
| Food | Hunting, game, fruits, etc. | Small-scale subsistence | Green Roof | Green Roof | Green Urban Area |
| Enjoyment of scenery (scenic roads, housing, etc.) | Green Roof | Green Roof | Green Urban Area |
| Travel to natural ecosystems for eco-tourism and (re-creational) nature study | Green Roof | Green Roof | Green Urban Area |
| Use of nature as a motive in books, film, painting, folklore, national symbols, architect | not evaluated |
| Use of nature for religious or historic purposes (i.e., the heritage value of natural ecosystems and features) | not evaluated |
| Use of natural systems for school excursions, etc. | not evaluated |
| Use of nature for scientific research | not evaluated |
| Living space (ranging from small settlements to urban areas) | Green Roof | Green Roof | Green Urban Area |
| Tourism-activities (outdoor sports, beach-tourism, etc.) | Green Roof | Green Roof | Green Urban Area |

Figure 4 represents a spatialization of the change of ecosystem services considering the table 3. The main loss of ecosystem services is linked with the road network of the urban area and urban parking. However, this study is not considered some mitigation actions like permeable flooring that can reduce the loss of ecosystem services. These elements can be considered in the future. The main gains are linked with the realization of the new urban green area.
4. Conclusion
This approach is useful in the SEA procedure (Directive 2001/42/CE) and Environmental Impact Assessment (EIA: Directive 2014/52/EU) because it allows linking the land use changes caused by urban sprawl planning with social, ecological and economic benefits. The enhancement of ecosystem services provided with the plan of green infrastructures can lead to review, rethink and planning urban vegetation, not only to raise the esthetic value of an area but also to improve the ecological urban functions useful for human well-being. This approach can be applied at various spatial scales: single buildings, blocks, neighborhoods, the entire cities or metropolitan areas. In this study, the advantages of implementing green infrastructure solutions are multiple, both in environmental and economic terms, and for the quality of life. Economic improvements include the following: energy saving; public economic incentives; additional thermal insulation; increase in property value; water retention. Among the benefits addressed to the livability of the internal environments and the surrounding territory, we can mention soundproofing; improvement of the external microclimate and positive influence on the internal one; a qualitative and quantitative increase of spontaneous flora and natural habitats; filtering of pollutants; positive influence on people's psycho-physical state. The use of this approach allows estimating, from a qualitative point of view, how the provision of ecosystem services changes with the use of the land over time. The assessment of ecosystem services is carried out in a relative sense to highlight the socio-ecological effects from the past land use to the new urban planning expansion.

According to Beker et al, 2013 [28], integrating ecosystem services within environmental assessment has potential value to help address some of the common problems with current environmental
assessment practices, but it requires context specific consideration that will not be appropriate in all cases. In this study, we tried to identify the importance of different ecosystems that provide distinct goods and services and to value how they could be affected by policy choices relevant to the urban development plan. We conclude that the incorporation of the concept of ecosystem service within the assessment of an urban development plan has helped us to compare different land-use scenarios and alternative management strategies (e.g. introducing green infrastructures like mitigation actions) in terms of their benefit or risk to the ecosystem services provision, and it has provided a potentially valuable contribution to improving the environmental assessment process.

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