Integrating Ecosystem Services Value in the Economic Assessment of Urban Projects. Proposal of an Analytical-Operative Approach

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Abstract. Urban project evaluation methods frequently rely on the assessment of costs and benefits that are directly tied to monetary measurement. They do not account for the additional advantages to society and economy that ecosystems, depending on their conditions and in response to rising community need, might provide. What might therefore be developed to support the inclusion of the ecosystem services assessment within the framework of economic evaluation procedures in urban system?

The work attempts to offer a viable and adaptable framework capable of guiding private and/or public entities' actions while also taking into consideration the ecosystem's advantages, more specifically the ecosystem services. The proposed workflow is constituted by series of steps that support the development of decision-making processes that can assess a single intervention from several perspectives, from environmental to economic in nature. It can support the implementation of economic evaluation strategies that take into account the importance of ecosystem services provided by urban habitats. The research highlights how different land use patterns, socioeconomic systems, and environmental conditions can change the project's potential to deliver ecosystem services.

The conclusions outline the practical implications and the limits of the developed assessment framework.

Keywords: Economic evaluation · Ecosystem services · Urban · Analytical framework

1 Introduction

Cities and towns have the biggest and most significant influence on ecological processes and biological variety (biodiversity) of all land uses because to their structures, transportation infrastructure, parks, and demands for goods and services. This effect is expected to persist given the ongoing trend of urbanization and the production needed to feed it [1, 2].

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The definition of biodiversity given by the 2005 Millennium Ecosystem Assessment [3], which was based on the 1992 Convention on Biological Diversity [4], consists in the variety of life on Earth, which is made up of many components, including genes, species, populations, and ecosystems, on a variety of geographical scales, from local to global [5–7].

Although though cities and their surrounding areas might pose a danger to biodiversity, they also offer a variety of chances for various species to coexist in various ecosystems and with various land uses. Cities are frequently situated near areas with high biodiversity, such estuaries, coasts, ecotones, and fertile plains [8, 9]. The following ways that they can sustain biodiversity if they are well-managed:

- cities serve as refuges for animals whose habitats have been devastated by intense agriculture and forestry;
- cities are socio-ecological systems where new species communities and habitats can emerge;
- urban green spaces give cities advantages (ecosystem services) that cannot be imported, such noise reduction and pollution absorption [10].

Ecosystem services refer to the products and services that nature offers. Together with the life necessities like food and water, they also offer other services like water filtration and cultural and therapeutic advantages. The yearly value of ecosystem services worldwide was tentatively estimated in 1997 to be USD 32 trillion, or nearly twice the world's GDP [11–14].

The following categories of ecosystem services were established by the Millennium Ecosystem Assessment in 2005:

- Provisioning service, provide food, water, raw materials, biofuels, and medicinal resources;
- Regulating services regulate the quality of air, soil and water, provide flood and disease control, provide pollination services and regulate pests and prevent disease;
- Habitat or supporting services provide living spaces for plants or animals; they also maintain a diversity of different breeds of plants and animals;
- Cultural services include the non-material benefits people obtain from contact with ecosystems, including aesthetic, spiritual, educational and psychological benefits; public health and recreational opportunities [3].

The Economic of Ecosystems and Biodiversity (TEEB) program seeks to highlight the benefits of biodiversity to the global economy. During their conference in Germany in 2007, the G8 + 5 environment ministers decided to "start the process of examining the global economic value of biological variety, the costs of the loss of biodiversity, and the failure to adopt protective measures versus the costs of successful conservation." To help decision-makers manage the planet's limited ecological resources wisely, the TEEB method approaches environmental challenges from an economic viewpoint [15, 16].

This emphasizes the significance of cities for biodiversity on a global scale, as well as the significance of urban green spaces and biodiversity for the sustainability of cities and the welfare of its inhabitants in sustainable economy perspective. As cities expand and the line separating urban and rural regions becomes less distinct, plants and animals adapt

to the shifting urban environment, reflecting the ongoing evolution of the connection between humans and nature. With rising city growth come more habitats, and both purposefully and accidentally introduced species may be found in cities [17].

Because the society and the economy depend on the ecosystem products and services that the environment provides, protecting biodiversity is essential to ensuring a healthy local economy. Ecosystem services, which comprise both natural resources (products) and activities that offer a service, such as clean air, fuel, and water purification, are supported by biodiversity. Conserving the ecosystem and taking advantage of the clean water it produces is less expensive than replacing an ecosystem function, for as by constructing and operating a water treatment facility [18, 19].

When a species that may offer medical services or other benefits becomes extinct and cannot be replaced, the loss of biodiversity has an even bigger negative impact.

The current governmental-territorial scenario, both international and domestic, calls for a shift in the transformation processes of human settlements on the territory toward the reduction of biodiversity loss, the enhancement of value-adding practices related to it (biodiversity), and the definition of trajectories of social, economic, and environmental integration. In order to define and identify those settlement transformation interventions that, from the perspective of a sustainable economy, are able to produce the least impacts on human and natural ecosystems, environmental, economic, and social, and preserve and/or increase natural capital, it is necessary to encourage the adoption of an integrated, multidimensional, multiscale approach. What tools and techniques, though?

2 Aims

It is critical to highlight how various strategies and tools are employed in practice to aid in the incorporation of environmental value into decision-making processes for land use and/or urban planning. Some of them are based on multi-criteria logic, in which several indicators are considered and meant to express distinct impacts both numerically and qualitatively.

To progress toward an integrated strategy that protects and advances the environmental component, decision-makers, educators, and land development professionals must change their perspectives. It is crucial to encourage information-sharing throughout collaborative decision-making procedures.

Based on these fundamental assumptions, the work makes an attempt to provide a framework for assessing in eco-systemic terms the consequences that settlement transformation processes may have in the urban environments of cities. This methodology enables the evaluation of projects in urban environments using the socioeconomic and ecological conditions of the reference environment.

The work is articulated as follows. Section 3 describes the techniques, and assessment tools that support interventions that protect the biotic component. Section 4 describes the economic evaluation approach proposed for urban initiatives, together with its supporting documentation. Section 5 shows the work's results, and the application potential of the suggested analytical scheme is analysed, as a complement to the acknowledged evaluation processes that are increasingly used in contemporary practice.

3 Mainstreaming Economic-Environmental Assessment: Main Approaches and Methods

With a preference for a integration logic among many elements, it is aimed to suggest a multi-criteria evaluation technique in which several considerations are concurrently incorporated, among them the ecological and environmental features of the relevant urban system with that concern social and economic nature. It is conceivable to enable co-participatory processes of identifying the kinds of interventions to be carried out on the existing, favoring an integrated ecosystem approach, by supporting an assessment workflow through the suggested methodological framework [20]. Figure 1 depicts the articulation of one of the key worldwide standards for environmental-economic accounting of reference, the System of Environmental Economic Accounting-Central Framework (SEEA-CF) by the United Nations, in conjunction with various methodologies and instruments for assistance [20].

To concern the SEEA-CF, it is based on quantifying the stocks of assets and flows of ecosystem services that habitats offer to the economy, particularly to the regional production system. Operationally, it consists of successive steps starting with the accounting of the extension and condition regarding the kind of ecosystem, followed by the assessment of the ecosystem service that it generates. It immediately moves to the economic accounting of ecosystem services from the biophysical measurement [20]. You can read the structure of SEEA-CF flowchart in Fig. 1.a.

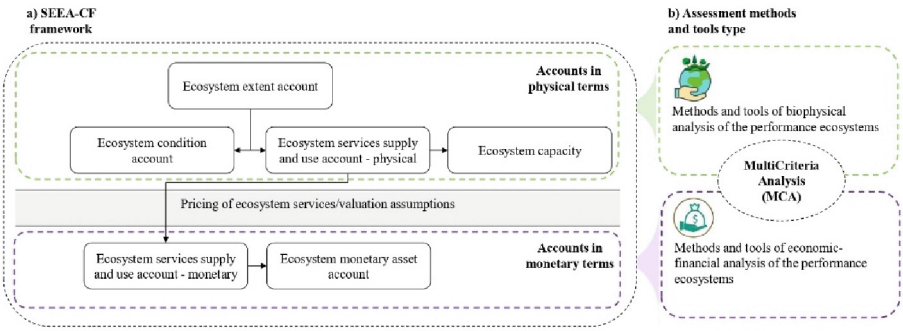

Fig. 1. SEEA-CF framework with methods/tools clusters.

Depending on the type of evaluation problem to be solved, the evaluation methodology and tool to be used, and the potential application of participatory processes for gathering stakeholder expressions of interest, different methodologies for evaluating urban-territorial projects from an ecosystem perspective may be used. It is possible to categorize three distinct types of approaches and tools of assistance in line with the phase relating to the biophysical accounting and the economic-based one (Fig. 1.b). They are: *i*) multi-criteria, *ii*) biophysical, and *iii*) economic-financial in nature. In particular, biophysical techniques are used to characterize ecosystems' contributions to the provision of ecosystem services for the community through the enhancement of natural processes. The measurement of several biotic and abiotic configurational aspects

of existing ecosystems serves as their theoretical underpinning. Some examples of biophysical approaches include direct measurements, such as field observations and surveys, indirect measurements, such as remote sensing techniques, the use of analysis-tools (such as i-Tree software), and analytical-mathematical modeling tools, such as ecological and statistical analysis tools [21–23]. Economic-financial strategies explore how a habitat's generation of ecosystem services influences land development economically, as assessed just in monetary terms. These strategies include creating an assessment framework that integrates the costs and benefits of the proposed activity. The direct and indirect costs and benefits of eco-system conservation, restoration, and service supply for biodiversity protection may be assessed. Costs for ecosystem restoration, particularly those that promote the provision of habitat for biodiversity, are included. Because the installation of ecosystem restoration can also reduce the effects of urban heat islands, the phenomena being examined may have a direct economic impact. There are references for estimating the equivalent economic value for the natural assets, water resource, and atmospheric carbon dioxide concentration to be put into the valuation frameworks supporting the economic-financial approaches. Otherwise, the multi-criteria assessment approaches allow economic, environmental, and socio-cultural factors to be considered independently or together within the same domain of research. This is accomplished using suitable evaluation methods and associated instruments that enable comprehensive analyses and investigations of several elements of various kinds, represented in monetary and/or nonmonetary terms [21, 24–26]. There are several noteworthy ones among them, including the Benefit-Transfer (BT) method [22], or even the tools implementing the Analytic Hierarchy Process (AHP) [27], Techniques for Order of Preference Based on Similarity to the Ideal Solution (TOPSIS) [21], Natural-Capital Accounting (NCPT), and optimization algorithms specific to operations research [27]. By designing multi-objective mathematical optimization models according to the multidimensional nature of SEEA-CF, they may be used to answer a large number of multi-criteria matrix assessment issues. It is feasible to define and select the kind of settlement transformation intervention to be implemented using a sustainable economy strategy by cultivating an integrated, multidimensional, multiscale evaluative logic that takes into account the usage of various evaluation instruments and methodologies [28, 29].

4 Proposal of an Economic-Environmental Accounting System for Urban Projects

4.1 Methodological Framework Approach for Integrated Economic-Environmental Assessments

The structuring of the proposed evaluation approach can be succinctly described methodologically (Fig. 2) as an interactive and integrated process consisting of the following stages, based on the logical-functional links of SEEA-CF in Fig. 1:

– Stage 1 (Identification of Objectives): definition of the objectives, general and specific to be achieved and identification of potential tactics for achieving the ecological targets related to the bioclimatic, environmental, human settlement, infrastructural and socio-economic conditions of the urban reference context;

– Stage 2 (Evaluation criteria and performance indicators): identification of the main direct and indirect drivers of ecosystem service provision in terms of suitable indicators to be used in the evaluation procedure, both biophysical and economic;
– Stage 3 (Assessment methods and tools): identification of the appropriate evaluation models to support the decision-making systems of public and private entities when evaluating the cost-effectiveness of the process.

In particular, the proposed economic-environmental evaluation scheme can be taken as the framework that substantiates the operational framework outlined next. The identification of sustainability goals to be pursued (Stage 1) is necessary to ensure the production of services aimed at: regulating the natural and climatic conditions of the place; socially and culturally educating the population; and sustaining the local economy through supply enhancement and/or new commercial-recreational activities (cultural and recreational services). Each goal, or type of ecosystem service, can be articulated using appropriate evaluation criteria and particular performance indicators (Stage 2). The indicators that can be used concern both the conditions that represent the urban ecosystem in its naturalistic and biodiversity characteristics and the performance in terms of the impact that the intervention solution is able to express with respect to the economic, social, and environmental characteristics of the urban environment and the area in which it is located. The identification (and implementation in the operational framework) of appropriate multi-criteria matrix techniques for the study and evaluation of interventions (Stage 3), is aimed at identifying the evaluation tools that allow the proposed intervention solution(s) to be screened from a variety of angles, and the various options to be considered in relation to one or more sustainability objectives.

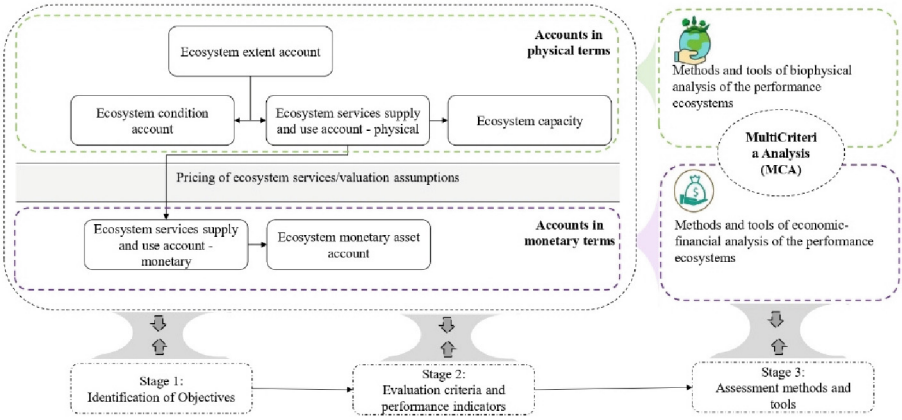

Fig. 2. Methodological framework approach for integrated economic-environmental assessments.

4.2 Operative Framework

Figure 2 shows the outlines of the logical-functional relationships that enable integrated economic-environmental assessments; it serves as the backbone structure for the Operational Framework described in Fig. 3 for the economic assessment of urban transformation initiatives. It is intended to direct intervention planners to adopt solutions chosen from an integrated and sustainable economic-environmental perspective and then, to direct public and private decision-makers in identifying, for example, the best intervention alternative taking into account the effects generated in terms of ecosystem services on the territory, according to the sustainability objective to be achieved-re and the interests of the stakeholders involved in the specific urban area transformation initiative.

The creative process of defining the solutions to be adopted in a settlement transformation intervention can be structured in three stages that lead to the evaluation of the economic and environmental effects generated by the adopted design solutions and then in the case of several alternative solutions to the possibility of choosing the one that meets the best level of sustainability. They are:

- Step 1 (Context analysis and definition of the objectives of the intervention): study of the current state of the urban context, including bioclimatic, infrastructural, urban planning, economic and social aspects, among others. This is done to gather information on the situation of the area prior to the intervention (ex-ante), including in terms of ecosystem services, and identify advantages, disadvantages, opportunities and potential hazards associated with the type of intervention to be designed/implemented, and finally to define the specific objectives to be achieved as well as identify potential strategies to be adopted to achieve the ecological objectives related to the bioclimatic, environmental, human settlement, infrastructural and socioeconomic characteristics present in the urban context of reference;
- Step 2 (meta-planning): in this phase, taking into account what emerged in the previous phase, the actions and solutions to be adopted (masterplan) in the intervention in order to reduce and/or contain impacts on the environment, ecosystems, and at the social-economic level and ensure the production of eco-system services must be defined and systematized with respect to the general and specific objectives.
- Step 3 (impact assessment): quantification, measurement, and evaluation of the financial costs and revenues of the intervention, as well as the economic benefits; evaluation of the effects produced by the intervention in terms of the provision of ecosystem services; use of economic models to support the decision-making systems of public and private entities when assessing the cost-effectiveness of the process.

In Step 1, information is gathered on the set of economic, social, and environmental factors of the intervention context. In particular, those key factors that in terms of their effects can be "improved" or worsened" with the urban transformation project should be identified, assessed, and emphasized, and thus those on which action can be taken for the provision of ecosystem services to the community and for the maintenance or improvement of the existing natural capital. Among the key factors, land-use and land-cover patterns, socio-demographic characteristics of the population, physical-natural implications of ecosystems, and the situation of the surrounding environment can have a strong impact on the supply of regulating, supporting, providing, and cultural services. In order

to assess project success after project implementation (ex-post), the ecosystem services survey and quantification of the natural capital present prior to the implementation of the intervention is an indispensable reference. The use of tools often employed in biophysical and environmental studies of ecosystems, such as the i-Tree program (in particular, in Fig. 3 describing the proposed Operational Framework, the i-Tree Canopy Tool is indicated) can allow to quantify ex ante the ecosystem services and natural capital in the intervention area and then (Step 3) to foreshadow the change in their consistence and quality in relation to the design choices adopted (ex-post) by simulating in the application of the tool the configuration adopted. According to the logic of SWOT analysis, the results of the context analysis and those derived from the use of tools designed to quantify in the pre-intervention state of affairs the ecosystem services (e.g., i-Tree Canopy) can be used as components in the development and creation of an intervention context assessment matrix. In fact, the application of the SWOT matrix is aimed, in the proposed Operational framework, at expressing and synthesizing information about the current situation of the area in terms of the advantages, disadvantages, opportunities, and potential hazards associated with the type of intervention to be carried out, and at identifying the type of ecosystem services that predominantly characterize or may characterize the intervention area.

Through the identification of the type of ecosystem services to be considered in order to enhance the context and the intervention area and to maintain or improve of the existing natural capital, it is possible to define the specific programmatic objectives to be pursued in the drafting of the intervention master plan (Step 2). Already, the aims and methods of implementation of the first phase alone provide evidence of the usefulness of the proposed 'integrated evaluation approach (Fig. 2) from the earliest stages of intervention definition and elaboration.

In Step 3, in addition to the usual assessments of financial and economic feasibility and sustainability based on estimates of costs, revenues, and benefits, the ecosystem services of interest are recalculated, as already highlighted, to determinate the possible influence and effects that the intervention, as foreshadowed in the master plan, may have on the supply of ecosystem services, either directly or indirectly through the preservation, modification, or addition of new components to the existing natural capital. The value of ecosystem services that change as a result of project implementation is also quantified in monetary terms at this stage using an appropriate multicriteria valuation technique. Figure 3, which illustrates the proposed Operational Framework, shows the use of a particular tool, such as the Natura-Capital Planning tool. Developed by the Consultancy for Environmental Economics & Policy in March 2018, this tool is based on the calculation of the environmental net benefit relative to the inhibitory transformation intervention. The environmental net-gain illustrates the potential of the impact a single project may have on the existing natural resources and vegetation, as well as the ability to provide ecosystem services. It allows the scoring of the effect of the intervention for each ecosystem service to be represented, starting precisely from the implementation of the data of the initial set-up and then those following the intervention. Changes in the value of ecosystem services are particularly significant because they describe the impact produced by the way the spatial economic asset was changed. The implementation of this procedure on alternative intervention solutions (master plans) makes it possible to

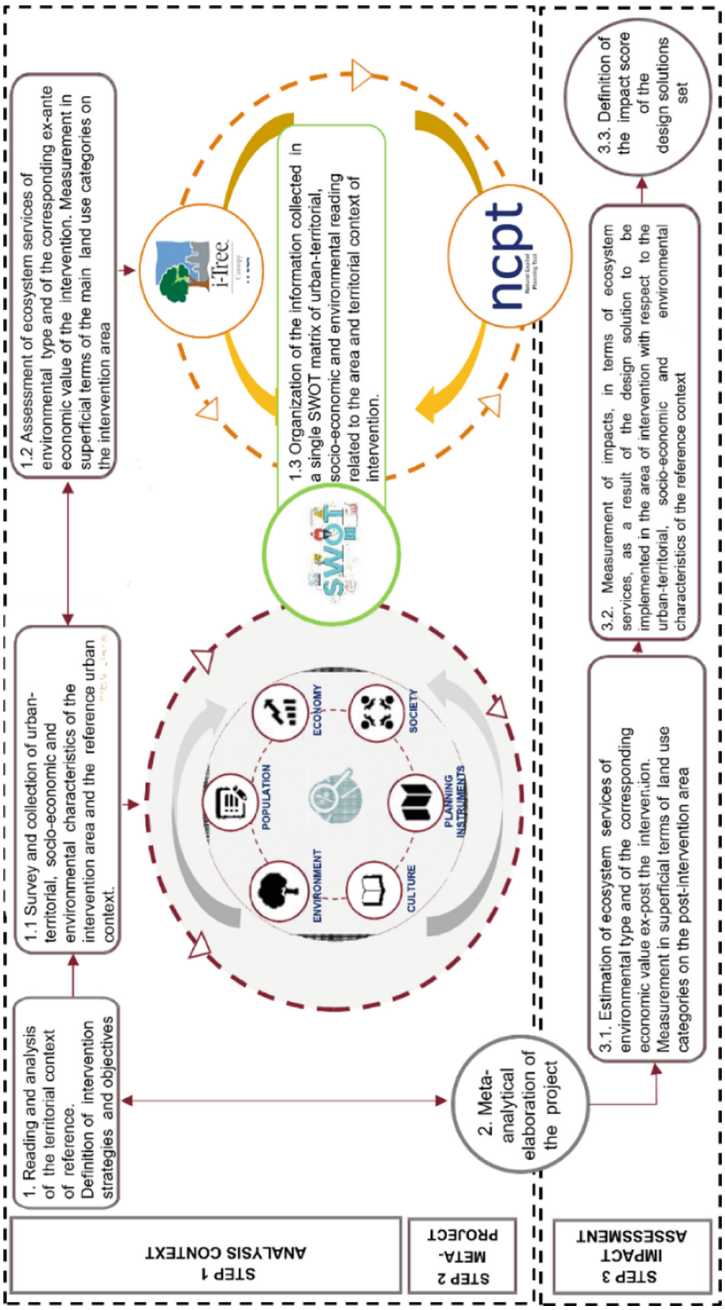

Fig. 3. Operative framework for economic-environmental assessment of urban projects.

choose, among the different prefigured intervention solutions, the one that in the complex produces the least impacts on human and natural environmental, economic and social ecosystems.

5 Conclusions

Multicriteria supporting tools are necessary in order to include the biophysical and financial advantages of ecosystem services into the decision-making processes. They want to instill a range of values—including social, environmental, and economic ones—in nature so that both public and private subjects can orient their choices upon a variety of considerations. The benefits of using tools with many criteria may first be observed in the transformational city development processes where the built and natural environments interact in order to meet the sustainable goals set at an international level.

To activate sustainable policies and decision-making processes, it is crucial to use appropriate assessment models to take into account the variety of effects produced by this type of intervention, including with respect to the morphological characteristics of the reference context. This is because the SEEA-CF shows how the environmental asset interacts with the value system of the urban context. In order to create settlement transformation processes from the standpoint of sustainable urban development, the study suggests an assessment procedure that is inspired by SEEA-CF. The option to create several assessment models is provided by the use of evaluation procedures based on multi-criteria analysis. This may also be done by choosing the proper condition and performance indicators, which vary based on the objective to be met and the kind of ecosystem service to be quantified.

It is clear how important this tool is for economic policy, especially with a view to urban renewal and environmental improvement. This viewpoint assumes that the suggested assessment framework would be used as a guide for developing operational models to assist public-private choices about sustainable land governance. Such models will be built using optimization algorithms in accordance with the syntactic patterns of the operational research. Each model will be constructed in accordance with the assessment issue under consideration, and it will also take into account the biophysical-economic measurement of certain ecosystem services using relevant software suitable to the problem at hand.

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