Ecosystem Services and Land Take. A Composite Indicator for the Assessment of Sustainable Urban Projects

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Abstract. The worrying levels of land take and insufficient ecosystem services related to phenomena of uncontrolled urban expansion in the cities force many countries far away from achieving Sustainable Development Goals of Agenda 2030. It is necessary to promote strategies which lead to effective and efficient measures in the perspective of sustainable development.

The work aim is to propose an evaluation protocol useful to support public and private subjects for sustainable practices in urban contexts. Depending on the types of use and land cover envisaged, the implementation of the proposed methodological framework allows for the definition of a Composite Indicator (CI) to measure the urban environmental and economic sustainability level. The proposed CI expresses qualitatively and quantitatively the socio-economic and environmental impact (*trade-off*) that single initiative generates in the reference context in terms of ecosystem services as a function of the land use change between *ex-ante* and *ex-post* phases of the urban transformation process.

Multi-parameter methodological approach by a sequence of logical-operational phases that lead to the definition of the CI is proposed. Steps of the proposed method are characterized by the algebraic structures typical of the Benefit of Doubt Approach (BDA) and Goal programming principles. Testing of the proposed protocol for CI construction is in progress.

Keywords: SDG · Ecosystem services · Land take · Composite indicator · Operational research · Sustainability assessment

1 Introduction

The 2030 Agenda of the United Nations (UN) (2015) is a programmatic reference for Member States at international level in the definition of practices to achieve shared sustainable development objectives by 2030 [1] through the pursuit of minimum target levels referred to 17 Sustainable Development Goals (SDGs).

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Among the SDGs proposed by the UN, some are intended, in general but also in particular in cities [2], to improve the living conditions (health and well-being) of people (SDG 3); to ensure the economic-productive development of the territory (SDG 8); to create inclusive, safe, resilient and sustainable cities and human settlements (SDG 11); to foster the protection of existing natural resources against climate change (SDG 13) and to reduce the consumption of available land (SDG 15). Others can be refereed also to the finance field where the increasing trend of the Green Bond investments make the sustainability performance criterion to be considered in the economic evaluations for urban transformation projects. [3]. According to the Sustainable Finance Disclosure Regulation, environmentally sustainable economic aspects must be an essential part of the investment workflow at multiple territorial administrative [4].

Annually, the Sustainable Development Goals Report provided by United Nations Organization (UNO) screens the target level for each SDG at local and international level [5, 6]. The 2020 Report highlights how the Pan-Europeanisation of COVID-19 has triggered an unprecedented crisis, causing further disruption to progress towards the 2030 SDGs. This in the face of uneven efforts and progress where significant imbalances remain due to the deterioration of the natural environment, persistent and pervasive social, economic and environmental inequalities [7].

The monitoring of the SDG achievements is conducted on the basis of appropriate sustainability performance indicators. The 17 SDGs are categorized into 169 targets, which in turn are expressed through 231 indicators [8]. The measurement of the SDGs and the use of specific performance indicators is a function of the spatial dimensions, as well as the economic, social, environmental and building features of reference context of urban and territorial type.

Furthermore, part of the debate that has been going on for some time at international level on overcoming Gross Domestic Product (GDP), as the only economic indicator capable of expressing the wellbeing level of a territory [9]. Following the *Istanbul Declaration* of 2007 and the *Global Project on the Measurement of the Progress of Societies* by the OECD, a growing number of countries have introduced methodological and political initiatives on how to go "Beyond GDP" to measure well-being and sustainable development. There is a growing sense that the benchmark against which the progress of a society cannot be based only on the market value of all the final goods and services produced in a country over a given time period but should be complemented through the use of composite sustainability indicators that also consider the fundamental social and environmental dimensions of well-being, accompanied by measures of inequality and sustainability that escape GDP accounting.

In particular, at European level, in August 2009, the European Commission published the communication: "Not only GDP. Measuring progress in a changing world" [10]. In September 2009, the Commission on the Measurement of Economic Performance and Social Progress (Stiglitz-Sen-Fitoussi Commission) published a report with 12 recommendations for the measurement of social well-being in all its dimensions, reaffirming the need for policy choices to be based on indicators capable of representing different aspects of the current progress and future sustainability of a society. In 2010 the European Statistical System Committee (ESSC) mandated a "Sponsorship Group on Measuring Progress, Well-being and Sustainable Development" to translate the recommendations

of the Stiglitz-Sen-Fitoussi Commission report and the European Commission Communication into actions to be undertaken to update the European Statistical System (ESS) to the changing needs for new information by improving existing statistics. This in order to promote and provide more appropriate indicators [11].

Despite large overlaps between the SDGs and "Beyond GDP", it should be kept in mind that the conceptual framework within which the SDGs were produced puts sustainability first and must address all countries around the world with different levels of well-being and development. Since this means that some of the indicators identified by the UN are not relevant in some more developed national contexts, individual countries are free to supplement the list of indicators defined at supranational level. This is also in order to take into account criteria, indicators and relationships closely linked to the different levels of political, programmatic and operational action related to spatial planning [12].

In Italy, the National Institute of Statistics (ISTAT) plays an active coordinating role in the measurement, elaboration and monitoring of indicators related to the SDGs at the national and existing urban level. The production of these indicators has been integrated with the development of a project (proposed and carried out since 2010) aimed at defining indicators to measure "Equitable and Sustainable Well-being" (ESW) at the national level, integrating traditional economic indicators, first the GDP, with measures on the quality of people's lives and the environment. The ESW project has placed Italy at the forefront of the international panorama in terms of developing indicators on the state of country health that go beyond GDP. This activating a process that takes the multidimensionality of wellbeing as its starting point and, through the analysis of a broad set of indicators describing all the aspects that contribute to the citizens' life quality. In fact, the ESW is configured as a dynamic system and its information base is subject to progress revision thanks to the contribution of experts in order to improve its timeliness and representativeness. Periodically, ISTAT presents and publishes an update on the breakdowns of the indicators useful for measuring sustainable development and monitoring its objectives.

The two sets of indicators are partially overlapping, and complementary (see the framework of ESW indicators included in the SDGs framework: https://www4.istat.it/it/files/2016/12/figuraBES-SDGS.jpg). Among the indicators by ISTAT, some relate to the 231 indicators of sustainability; others, instead, to specific parameters that make it possible to measure the structural and functional organization of the reference context.

From the analysis of the results of the last monitoring of the SDGs promoted by ISTAT in collaboration with the Italian Alliance for Sustainable Development (ASviS) in May 2020, it emerges that the overall pre-covid situation in Italy is positive for most of the SDGs, with the exception of SDGs: 9 (Resilient infrastructures, innovation and fair, responsible and sustainable industrialization), 11 (Inclusive, safe, resilient and sustainable cities and human settlements), 14 (Oceans, seas and marine resources for sustainable development), 15 (Sustainable use of natural resources) [13, 14]. In particular for SDG 11, land consumption resulting from the sealing of natural surfaces due to actions of: *i*) urbanization, *ii*) infrastructure and *iii*) industrialization of cities rises among the main causes for the difficult pursuit of the SDGs in highly urbanized contexts. This with obvious repercussions, above all, on existing natural ecosystems and their

intrinsic capacity to produce goods and services (*ecosystem services*) to the population [15, 16]. Green spaces in urban areas, in fact, provide several vital ecosystem services that contribute to the wellbeing and health of inhabitants [17]. These includes basic resources of: *i*) support, *ii*) regulation, *iii*) supply, and *iv*) cultural recreation [18].

The production of ecosystem services depends by multiple features of reference urban context. In detailed terms, to morphological-urban characteristics, specificities of economic, social and environmental type regarding the analysis territory, and to its resilient capacity to adapt at sudden shocks of different nature, like pandemic crisis [19].

In the light of this scenario, it seems especially advisable to adopt strategies aimed at reducing the consumption of natural soil in cities. This is done by encouraging the implementation of initiatives designed to address the multiple effects (eco-systemic services) that natural resources produce on the social and economic life of a place according to a logic of contamination and integration between functionally independent subsystems [19–21].

In order to deal with the complexity of a project process implemented according to some integrated and complementary modus operandi with a view to the SDGs, it is essential to use suitable tools capable of leading decision-makers in the decisional phases, guaranteeing the achievement of results that are easily measurable, quantifiable, and openly usable [22]. In recent years, Composite Indicators (CI) have been widely adopted as systems for monitoring performance, determining specific benchmarks and measuring the level of the sustainable urban mobility, the community disaster resilience and the landscape fragmentation within the built environment to the applications for addressing the corporate social responsibility of firms or analyzing the business cycles and the financial stress and economic dynamics related to several enterprises [23–25]. In particular, with the spread of big data, specific methodologies and analytical tools have become necessary to extract and relate a considerable amount of heterogeneous data in order to investigate the links between different phenomena with the ultimate aim of establishing specific strategies to manage them in the most appropriate way [26]. At a local scale, the diffusion of the use of composite indicators in the evaluation of environmental, social and economic-financial aspects of urban transformation projects has had a rapid growth in the 21st century due to the awareness that an efficient control of all the parameters of the project process allows reducing the negative impacts on the built and natural environment by enhancing the positive ones [27–29]. Dobrovolskiene et al. [30] developed a composite sustainability indicator for real estate projects using multi-criteria decision methods (MCDM). The weighted sum method (WSM) is the most applied MCDM within composite indicator creation for urban projects assessment [31]. By comparing the WSM with the COmplex PRoportional ASsessment (COPRAS), Podvezko [32] concluded that if all indicators must be maximized, the calculation results are similar. According to Ferreira et al. [33] there is no absolute best MCDM and the choice of the method should always depend on the decisional context of analysis. Their ability to be a quick communication tools able to support the spread of increasing awareness of specific issues in society, depends greatly on the aggregation and weighting schemes of each indicator considered in the system [34]. Attardi et al. propose a multi-criteria approach to the construction of non-compensatory composite indicators. These for the evaluation of environmental and social performances of urban and regional planning

policies. The authors suggest the Land-Use Policy Efficiency Index (LUPEI) to apply on municipal scale [35].

For this reason, the integration of MCDM techniques with goal programming algorithms are applied in the academic and professional field in order to reduce the uncertainties and black-boxes that rise up in the different phases of CI construction.

2 Work Aim

In the above context the aim of the work consists in an evaluation protocol which, based on a theoretical and methodological framework, represents a reference document for guiding private and public subjects to create a CI that is able to assess the economic and environmental sustainability level of urban transformation projects at multiple analysis scales (territorial, city, neighborhoods, plot, street).

The theoretical and methodological framework on which the evaluation protocol is based consists of the following main steps: *i)* data collection of the morphological structure *ex ante* intervention of the urban plot subject to a transformation project *ii)* assessment of eco-systemic qualitative impacts in the surrounding intervention area *ex-post* project; *iii)* implementation of the BoD approach for the construction of the Composite Environmental Indicator (CEI); *iv)* benchmark weighting phase; *v)* definition of the final Composite Environmental-Economic Indicator (CEEI).

The relationship between land use type and environmental-socio-economic feature of the surrounding urban context is expressed with the ecosystem services logic. From a computational point of view, in the present work specific tools are proposed to support the theoretical framework and steps above cited. In particular, the BoD approach is applied to determine the CEI proposed by setting the related optimal benchmark through a goal programming algorithm under adequate constraints. The mathematical programming environment used for writing the regression system is A Mathematical Programming Language (AMPL). It is a simple and intuitive tool used for structuring mathematical programming problems. Resolutions can be developed through specific software. Some examples are CPLEX, FortMP, MINOS and KNITRO.

In this way, public and private subject can be able to take into account the environmental and economic features of urban project that produce positive and/or negative impacts at different analysis contexts in order to *i)* identify the most sustainable alternative; *ii)* improve the morphological composition of a project that is related to a poor CEEI level; *iii)* avoid spending (limited) public and private financial resources on urban projects that do not perform well according to the new sustainability features required by world policy documents provided on a European and global scale.

The paper is structured as follows: Sect. 3 consists in the introduction of the existing main tools and indicator systems designed to achieve the sustainability goal in the literature. Section 4 describes the theoretical and methodology framework of the evaluation protocol proposed. Section 5 provides future developments of the work in order to support an easier achievement of the SDGs.

3 Indicator Systems for Assessing Sustainability

The concept of sustainability born in the early 1970s after the first evidence on the industrial progress damages on health and quality of life [28, 36, 37]. Successively, after the Brundtland Report and the World Summit on Sustainable Development in Rio de Janeiro, in 1992, the sustainability debate has been translated into specific target with the establishment of the Kyoto Protocol in 1997, the Paris Agreement in 2015 and later the Agenda 2030 SDGs.

Since then, different public and private stakeholders ranging from the local to the global importance, have been discussing on tools to assess the sustainability. A lot of quantitative and qualitative data-based decision support tools have been developed in the last decades in order to give a contribution on the topic [38, 39]. Recently, the emerging trends focused attention on the index theory due to its suitability to address a complex issue, such as the sustainability one, which is composed by different and correlated dimensions (social, environmental, economic and politic ones) that can't be assessed individually.

However, there are many questions that need to be carefully analyzed for defining, selecting, measuring and assessing an adequate sample of indicators in order to return a composite indicator that contains all the issues addressed. This gives importance to standardized frameworks of urban indicators. Actually, there are three organizations that produce international standardization studies worldwide*: i)* International Organization for Standardization (ISO), *ii)* the International Telecommunication Union (ITU) and *iii)* the European Telecommunication Standards Institute (ETSI). The European Committee for Electrotechnical Standardization (ECES) and the European Committee for the standardization (ECS), instead, are responsible for ensuring that standards are consistent with European legislation [40].

The standard ISO:37120_2019 (Sustainable cities and communities – Indicators for city services and quality of life) [41] describes indicators system as quantitative, qualitative and descriptive measures that provide information, such as long-term trends or short-term changes, of a complex urban environment system. For these reasons, the indicator systems are mostly applied as decision support tool that are able to clearly highlight the strength and weaknesses of a city [42]. In this way, it can be easier to set priorities and identify the most critical or best performing areas within urban and environmental priorities [43].

In the existing literature, indicator systems that work well for specific criteria, but less well as a comprehensive measure of sustainability can be found [44, 45]. Other studies, instead, in order to assess all the related issues, provide a multi-hierarchy structure such as the Pressure-State-Response model, the three-component model or the Analytic Hierarchy Process [46]. The most important phase of the process and, at the same time, the most critical one, is the selection of indicators for the possible subjectivity attitude. There are some quantitative tools that are implemented for an objective identification of indicators and to determine which indicators account for most of the observed issues, but often, still now, they appear restricted to those have advanced technical skills [47]. Indicators can also be selected after the application of participative or questionnaire-based techniques by using the Contingent Valuation or the Delphi method [48]. More generally, each indicator considered must be scientifically robust, must have a target level

(benchmark) with which to compare it and a social and political resonance. At the same time, is important that *i)* reflects the stakeholders' interests, *ii)* is easily comprehensible to decision-makers and *iii)* is replicable by the final users [49–51].

The often subjective interference in the weight's determination process is a critical instance. In order to overcome such limits, the so-called Benefit of the Doubt (BoD) approach has been widespread applied after the study carried out by Melyn and Moesen [52] on the macroeconomic performance evaluation, especially by researchers in Europe [53]. It directly derives from the Data Envelopment Analysis (DEA) which is a linear mathematical programming technique that performs an objective development able to avoid the above cited issues. It has been used to provide different weighting systems for the Human and the Sustainable Development Indexes [54]. In particular, the BoD approach derives the set of optimal weights for each indicator considered from the observed sub-indicator values themselves and by integrating a goal programming algorithm [55]. Several extensions of the BoD approach have been proposed in the literature for its suitability into different research context representing one of the most efficient methodologies for creating a robust composite indicator [56, 57].

In the present work an integration between BoD approach with linear mathematical programming technique is proposed. In the specific terms the linear principles of the Goal Programming are referred. Through these one set of optimal weights can be measured in optimal manner than other analysis and computational methodologies (e.g. Analytic Hierarchic Process, and not only). The description of evaluation protocol for Composite Indicator construction is described in the following Sect. 4.

4 Evaluation Protocol for a Composite Environmental-Economic Indicator Construction

In order to detect the logical-functional dependencies between study variables representative land use types and ecosystem services a multi-parametric optimization analysis is implemented. This allows both to identify the relationships between the parameters, and to establish the terms useful for the creation of environmental and economic composite indicator.

The proposed evaluation protocol consists of the following steps:

1. Data collection *ex-ante* intervention on urban area considered;
2. Assessment of eco-systemic qualitative impacts in the area of intervention *ex-post* renewal project;
3. Implementation of the BoD approach for the construction of the CEI;
4. Optimal benchmark weighting with Goal Programming Model;
5. Definition of the CEEI.

The Figure 1 illustrates the methodological framework on the basis of the evaluation protocol proposed. Subsequently each part of evaluation protocol proposed is described.

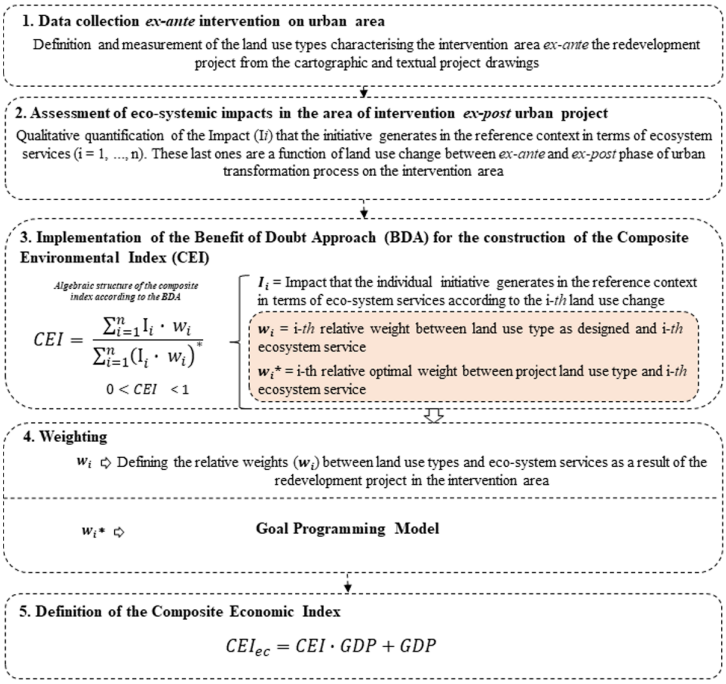

Fig. 1. Methodological framework

4.1 Data Collection *Ex-ante* Intervention on Urban Area

To define an evaluation index under environmental-economic point of view according to the socio-economic and environmental features of territory, the data set is constructed with the values of the variables considered: land use and ecosystem services type. This concerns the *ex-ante status* at the time of implementation of the project in the site of interest.

The values of the variables can be collected using different information systems geo-referenced and not. Among these, e.g. not exhaustive, the best well-known are: *i-Tree Landscape Tool* that gives information on tree cover, land use and basic demographic characteristics of the census areas in United States of America; *Urban Atlas* provides Pan-European comparable land cover and land use data for Functional Urban Areas. These are mainly geo-referenced information layers that give information on social, economic and environmental features of intervention plot. In relation to each land use type ecosystem services are estimated. This through specific performance indicators.

The information on land use type qualifies the survey area according to its capacity to produce goods and services to the community. In addition, it allows to estimate the trade-off between *ex-ante* and *ex-post* urban project implementation in terms of impacts on the ecosystem services production by the land use changes.

4.2 Assessment of Eco-systemic Impacts *Ex-post* Urban Project

The classification of the intervention area in terms of land use and capacity to implement ecosystem services in the reference context is preliminary to the estimation of the trade-off concerning the impact of the project initiative on the urban ecosystem. In order to quantitatively assess the ecosystem impact of the project on territory, multi-criteria evaluation methods and techniques based on operational tools currently in use can be implemented. Among these, for example, it is notable the Natural Capital Planning Tool (NCPT). It is an assessment tool developed specifically for the planning context. The NCPT allows the indicative but systematic assessment of the likely impact of proposed plans and developments on Natural Capital and the ecosystem services it provides to people such as recreational opportunities, air quality regulation and climate regulation. The NCPT was designed as a fit-for-purpose Excel tool which can be applied by non-specialists and in a short period of time; acknowledging the time, resource constrains planners and developers face in everyday practice. NCPT helps planners to create more sustainable places for people and wildlife, whilst at the same time delivering the housing and infrastructure the country needs.

With the use, e.g. of NCPT, *trade-off* in terms of impact (I) on the ecosystem services production regarding specific intervention features are estimated. The I values are on the basis of environmental-economic indicator construction.

4.3 Implementation of the BoD Approach for the Construction of the Composite Indicator

The construction of the environmental-economic indicator to support the evaluation of urban initiatives in ecosystemic key will take place by implementing multi-criteria/multi-objective techniques with the help of goal programming algorithms and advanced techniques for the management and big data use, such as the BoD approach, in charge of a composite indicator definition.

The need to solve complex decision-making processes, characterized by high uncertainties and conflicting goals, has led to the identification of goal programming as one of the most widely used multi-criteria decision-making techniques most of all – but not limited to – within the issues of environmental, financial, social and political assessment [58–62].

The DEA employs linear programming tools to estimate an efficiency frontier that would be used as a benchmark to measure the relative performance of unit elements of different type. This requires construction of a benchmark (the *frontier*), and the measurement of the distance between unit elements in a multi-dimensional framework. The application of DEA to the field of composite indicators is known as the BoD approach, and it was originally proposed to evaluate the macro-economic performance of specific territorial context. In the BoD approach, the Composite Environmental Indicator (CEI) is defined as the ratio of the actual performance to its benchmark reference:

$$CEI = \frac{\sum_{i=1}^{M} I_q \cdot w_q}{\sum_{i=1}^{M} I^* \cdot w_q^*} \tag{1}$$

where I_q is the normalized score of q_{th} individual indicator ($q = 1, \ldots, Q$) for project's performance p ($p = 1, \ldots, M$), and w_q the corresponding weights. The last ones can be drawn on the basis of the matrix for the assessment of the different land cover types' capacities to provide selected ecosystem goods and services by Burkhard et al. [63].

Cherchye et al. [64] suggested obtaining the benchmark as the solution of a maximization problem. I* is the score of the hypothetical element unit (Project) that maximizes the overall performance (defined as the WeiGhTed average, WGT), given the (unknown) weights set (WGT) of i-*th* element *w*. The $CI_{environmental}$ value is in [0–1] range.

4.4 Weighting

The *w* referred to I* can be solved by using the programming algorithms of Operational Research, capable of solving systems of linear equations in order to maximize and/or minimize an objective function. In this case, Linear Programming algorithms are used.

The AMPL software is used to structure the model. In practice, the use of the AMPL programming environment allows to write the regression problem through the following steps:

1. identification of the problem elements as SETs;
2. specification of the parameters (PARAM) to be included in the system to be solved;
3. definition of the variables' value (VAR);
4. structuring of the objective function, of maximization (MAXIMIZE) or minimization (MINIMIZE), as a linear algebraic expression.

These steps define the structure of a model in parametric form (.mod file) to which the problem data are associated with a separately written.dat file.

The model written in the AMPL programming environment is in Table 1.

The analysis units (set WGT) are described according to three factors (set PARAMETERS): weights and services. The parameters weights are referred to the ordinary values *w* it is possible to define in corresponding of each ecosystem services type. They are found in the scientific reference literature.

The unknowns (x) are continuous. The objective function is:

maximize *objective*: sum {i in WGT} x[i]*services[i];

The MINOS optimization program is used as a solver implementing algorithm for the linear problem considered in the respect of the CONSTRAINTS.

4.5 Environmental-Economic Composite Indicator

To achieve sustainable development, there is a pressing need to move beyond conventional economic measures like GDP. In fact, it is able to summarizes a vast amount of economic information in a single monetary metric that is widely used by decision makers at different urban planning and design levels. However, GDP fails to capture fully the contributions of nature to economic activity and human well-being. To address

Table 1. The model written in A Mathematical Programming Language (AMPL) software (.mod file).

Model
SETS
set WGT;
PARAMETERS
param weights{WGT}; *param* services{WGT};
VARIABLES
var x{i **in** WGT} >= 0;
OBJECTIVE FUNCTION
maximize objective: sum{i in WGT} x[i]*services[i];
CONSTRAINTS
s.t.vinc_1: sum{i in WGT} x[i] >= 0;
s.t.vinc_2: sum{i in WGT} x[i] - sum{i in WGT} weights[i] >= 0;
s.t.vinc_3{i in WGT}: x[i] – weights[1] >= 0;
s.t.vinc_4: sum{i in WGT} x[i]*services[i] >= 0;
s.t.vinc_5: {i in WGT}: (x[i] + 1)*services[1] <= TARGET [i];

this critical omission, we develop a measure of (*CEEI*): a measure that summarizes the value of the contributions of nature to economic activity that summarizes the value of ecosystem services in a single monetary metric.

To this regard, Sautton, P. and Costanza, R. [65] express the level of urban economic productivity of an urban area by means of the Subtotal ecological-economic Product (SEP):

$$\mathrm{SEP} = \mathrm{GDP} + \mathrm{ES} \tag{2}$$

i.e. the sum of GDP as thepressure on the level of economic productivity of a territory) and ES, or rather Ecosystem Services due to the existing and/or new natural component, as percentage of GDP value.

According to the (2), the composite environmental-economic indicator ($CEEI_{en}$) proposed is structured as follow:

$$CEEI = CEI \cdot \mathrm{GDP} + \mathrm{GDP}$$

where *CEI* is obtained by BoD approach in conjunction whit Goal Programming model implementation (see Table 1).

5 Conclusions

The correlation between the urbanization and industrialization processes and the deterioration of the available natural capital with effects on global warming has made the need to overcome social, economic and quality of life disparities of a territory. This has led to the need to pursue sustainable development in economic, social and environmental terms, including through the establishment of specific international agreements that incentivize participating countries to implement effective strategies to mitigate and control the damage caused by human activities to the natural environment and people's life quality. These include the SDGs promoted by the 2030 Agenda.

The current statistical monitoring system used, in an integrated (and complementary) manner, at the global level (UN and OECD), European level (EUROSTAT) and in the various States through the Central Statistical Institutes (in Italy, ISTAT) to determine the achievement of each SDG is based on a system composed of specific social, economic and environmental indicators capable of representing in a simple and effective manner the different reference frameworks for the use of composite sustainable indicators. The importance of synergistic actions promoted at national and local field emerges as part of the different choices to be made at multiple decision-making systems, not least in urban planning and economic-financial evaluation of investments for territorial growth.

The work aim is to propose an evaluation protocol for the definition of a composite indicator able to determine the environmental and economic performance level generated by urban transformation projects. To this end, technical specifications have been implemented in relation to the objectives of each phase of the proposed protocol.

Future insights may concern the application of the proposed protocol and operational framework to real urban transformation interventions in order to test the corresponding effectiveness and limitation. The inclusion of additional environmental variables and the identification of social criteria will allow for the creation of a composite indicator able to synthesize all aspects of sustainability associated with urban transformation projects and the reciprocal relationships of functional dependence.

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