ID 882

Special session: Planning

Soil ecosystem services assessment to support land use planning - applications in Italy and a reflection for the future

Francesca Assennato[1], Andrea Strollo[1], Marco d'Antona[1], Paolo De Fioravante[1], Alice Cavalli[1], Michele Munafò[1]

[1]*ISPRA, francesca.assennato@isprambiente.it*

Abstract: The ecosystem services assessment (ESA) has an increasing visibility and more recently soil-related ecosystem services are under attention. Loss of agriculture and natural soil due to land consumption is one of the main causes of degradation of soil and loss of ecosystem functions. Decisions upon land use and cover at local scale are the arena to effectively foster soil ecosystem services provision. While there is some coherence in global and national ESA, the experience in land use planning is still fragmented. The discussion moves from the experience of national ESA in Italy, measuring variations in eleven soil-related ecosystem services (carbon storage and sequestration, habitat quality, crop production, timber production, pollination, hydrological cycle regulation, fresh water availability, water purification, erosion protection, microclimate regulation, particulate and ozone removal) related to 2012-2017 land consumption changes. The aim is to highlight the barriers and opportunities for integration in land use planning, and to provide critical suggestions around the potential role of ecosystem service knowledge at different levels. Results point out potentials of the ESA in representation of soil functions, together with methodological and procedural uncertainty that makes ESA potentially prone to improper uses and misleading results, in the absence of a common framework for application.

Keywords: land consumption, soil functions, ecosystem services, land use planning

Introduction

The attention towards the land consumption issue has increased in the last decade, particularly at European level with the Thematic Strategy for Soil Protection (European Commission, 2006; European Commission, 2011). Loss of agriculture and natural soil due to land consumption is recognized as one of the main causes of degradation of soil and loss of ecosystem functions. The Roadmap to a Resource Efficient Europe (COM (2011) 571) proposes, by 2020, EU policies to consider their impacts on land use, with the aim to achieve 'no net land take' by 2050. European Commission has prepared the 'Guidelines on best practice to limit, mitigate or compensate soil sealing' (SWD(2012) 101 final/2) and in 2013 the publication 'Hard surfaces, hidden costs- Searching for alternatives to land take and soil sealing' as well.

Those documents, underlying the relevance of the environmental problem, recognized the urbanisation and the conversion of land for development as a major threat in Europe, together with the hidden economic dimension and the explicit connection with soil ecosystem vital functions, from providing the basis for farmland and forests, and our food, textile and timber production, to filtering water, reducing the frequency and risk of flooding and drought, supporting biodiversity, and helping to regulate the local and global climate.

In Italy, soil suffered artificialization and degradation phenomena at unsustainable rates, with soil consumption continuously increasing despite scientific, media and legislative attention. The relevance of land consumption in Italy, made it one of the main challenges for spatial planning and land management to achieve a more efficient, sustainable and durable use of natural resources. In the last years, land consumption increased without a direct correlation to demographic growth (Indovina, 2009), mainly driven by demand for industrial, commercial infrastructures and transportation (ISPRA, 2018).

Decisions upon land use and cover are the arena to address land consumption limitation, thus the local scale is the proper one to effectively foster soil ecosystem services provision. In this context the ESA is a challenge to be undertaken by planners (De Groot *et al*. 2010), who has too long ignored to consider the benefits that the natural environment provides to human well-being. The question is what analytical framework can be usefully applied for this purpose. There are different ways to evaluate the dimensions of ES, in terms stocks of resources, potential or actual dimension of functions, potential or actual fluxes of services or benefits. The choice of the classification system to be adopted depends on the purpose, i. e. if the ecosystem services analysis focus on ecological systems or socio-economic ones (La Notte *et al*. 2017). The evaluation of the "benefits that people obtain from ecosystem" (MEA, 2005) can be used by the public administration as an incentive to limit land consumption and urban sprawl. It must be pointed out that the monetary evaluation of ecosystem services has the main risk of underestimating the natural resource values and can generate a trade based on compensation, with evident unequal effects on people and inefficient protection of the environment.

Since 2016, ISPRA produces the evaluation of the biophysical and economic loss of the main ecosystem services resulting from the increase in land consumption. In this vision, the economic evaluation is proposed at the national level to reveal the importance of those functions to humans. The purpose of evaluation should be to associate a value to the soil as a resource – with a unit of measure easily comprehensible by everyone – in order to motivate the public opinion to avoid its uncontrolled urbanization. This approach is necessarily different from the one devoted to assessing benefits in the national economic accounts, to be compared to other forms of capital and services, that follows more socio-economic purposes.

The objective of protecting soil functions in spatial planning make it necessary, from our point of view, to prioritize biophysical based approaches, in order to assure a close connection to soil functions in the evaluation of related services and benefits. More, there is a need for criteria of evaluation homogeneous within territories, to ensure a balance between local needs and practices and the protection of soil functions, also addressing trade-off between different services. There is also a need to identify priority services, as the regulating ones, often on the background of economic evaluations because of the difficulties in assessment of non-market values and in modelling of complex biophysical functions. In conclusion, the ESA in land use planning non necessarily includes the economic evaluation but must include a biophysical assessment of soil functions at the proper scale, that can be different between services evaluated.

Soil-related ecosystem services and assessment approaches

The Ecosystem Services Assessment (ESA) was created to encourage the consideration of the value of nature in decision-making and policy-making processes, and, consequently, can highlight the soil value and support planning towards more conscious and balanced choices. Nevertheless, although there is a growing interest on the institutions side, remains a lack of shared reference both in methodologies and in practical application of the ESA, particularly as far as territorial and urban planning are concerned.

Costanza et al. (1997) defines ecosystem services (ES) as the *benefits human population derive, directly or indirectly, from ecosystem functions,* estimating the economic value of 17 ES for 16 biomes. Considering an ecosystem as a dynamic complex of organisms, communities and the abiotic environment, interacting as a functional unit the Millenium Ecosystem Assessment (MEA) describes *the benefits people obtain from ecosystems* as ES, classified in four different groups, such as provision, regulation, cultural and support (MEA, 2005, TEEB - Kumar, 2010).

In recent years, these categories have been substantially modified both by the European Environment Agency, within the International Classification of Ecosystem Services reached the 5th version (CICES V5.1 - Haines-Young and Potschin, 2018), both from the TEEB (De Groot *et al*. 2010). In the CICES the ESs are defined as the contributions that ecosystems bring to human well-being and distinct from the goods and benefits that people subsequently draw from them. It is thus useful to clarify between ecological phenomena (functions), their direct and indirect contribution to human well-being (services) and the welfare gains they generate (benefits).

In particular CICES, as TEEB classification, does not include supporting services, identified as habitat category not as services, which is necessary to highlight the importance of ecosystems as habitat providers for biodiversity but includes the category of regulating and maintenance services (La Notte *et al.* 2017, EU Commission, 2014).

The European Commission established a program on Mapping and Assessment of Ecosystems and their Services – MAES in response to Biodiversity Strategy by 2020 (see Target 2, Action 5). This specific action aims to provide a knowledge base on ecosystems and their services in Europe. A coherent analytical framework as well as common typologies of ecosystems for mapping and a typology of ES for accounting have been developed.

The fifth technical report (MAES, 2018) provides an integrated analytical framework and set of indicators for mapping and assessing the condition of ecosystems in the EU. A specific report on Soil ecosystems, as an output of the Pilot working group within MAES, to which ISPRA contributed, has been published by Deltares in March 2018 in support of the implementation of the EU Soil Thematic Strategy (Van der Meulen and Maring,2018).

Recently, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has developed an analysis on the health status of biodiversity and the services that ecosystems offer (IPBES, 2019), in terms of Nature's Contributing to People, largely consistent with CICES V5.1 and with the importance of the basic functions of ecosystems at different scales.

National ESA for Italy

The evaluation of the biophysical and economic loss of the main ecosystem services resulting from the increase in land consumption is produced by ISPRA each year, since 2016. The experience of national assessment of ES variations related to 2012-2017 land consumption changes in Italy (ISPRA, 2018), is associated to eleven soil-related ES selected from the vast series of services associated to soil functions by international classification (Dominati *et al*. 2010, Van der Meulen *et al*. 2018).

In this national application ES are analysed with the specific aim to highlight the effects, in both biophysical and economic terms, of land consumption occurred in Italy in the period considered, offering an opportunity to evaluate the effects of landscape transformation. This evaluation, based on available data at the national level, must be integrated for further advance with information on soil functions, agricultural actual practices, data from forestry inventory, climate and water balances at river basin level, etc.

Table 1: Soil ecosystem services considered in the ESA for Italy

Regulation and maintenance	**carbon storage and sequestration**
	habitat quality
	pollination
	hydrological cycle regulation
	water purification
	erosion control
	microclimate regulation
	particulate and ozone removal
Provisioning	**crop production**
	timber production
	freshwater availability

For the development of analytical framework, results of experiences carried out by projects at different scales were considered, such as LIFE SAM4CP, SOILCONSWEB, LIFE MGN, SOS4LIFE, together with a constant comparison on methodologies with the scientific community, as the one launched for the 2018 edition of the Report on land consumption, which involved 7 Italian universities and research centers (University of Urbino, University of Molise, University of Rome Sapienza, University of Padua, Federico II University of Naples, CNR Florence, CREA of Arezzo) and 2 regional agencies for environmental protection (Puglia and Veneto) in addition to ISPRA.

In this work we define land consumption as the replacement of a non-artificial land cover to an artificial land cover, both permanent and non-permanent. The study of each ES is based on the national land consumption map for Italy for the two reference years 2012 and 2017 with a very high resolution (10m spatial resolution). Maps are developed by ISPRA by photointerpretation of very high-resolution images and semiautomatic classification of high-resolution remote sensing images RapidEye, Sentinel-1 and Sentinel-2, and are appropriate to detect land consumption, both for the urban densification and for the sprawling phenomena, from national to local level.

Results in terms of biophysical dimension are described in following paragraph, together with some methodological element useful to understand the potential use of results in planning processes. Full methodology is available in the annex to 2018 edition of the Report on land consumption, territorial dynamics and ecosystem services (Assennato *et al*. 2018).

Results in terms of economic loss produced by soil consumption between 2012 and 2017 in Italy is calculated for each service flow, with a reference to a minimum and maximum value, in order to take account of the uncertainties. Variations in regulating and maintenance ES provision, that represent most of the losses, are shown in Table 2. It must be pointed out that this evaluation includes only a part of services provided by soil, thus the “hidden costs” (European Commission, 2013) can be much higher than those represented.

Table 2: Variation in the flow of regulating and maintenance ecosystem services due to the soil consumption between 2012 and 2017 in Italy. Source: ISPRA processing

Regulation & Maintenance Ecosystem Services	Minimum value of service loss[€/year]	Maximum value of service loss[€/year]
Carbon sequestration	102.056	538.898
Pollination	4.109.804	5.487.373
Regulation of local climate/temperature	2.251.732	9.006.928
Removal of particulate and ozone	950.980	2.938.569
Water flow regulation	1.535.630.715	1.789.521.660
Control of erosion	10.521.848	112.385.949
Water purification	226.033	60.297.780
Total	1.553.793.168	1.980.177.157

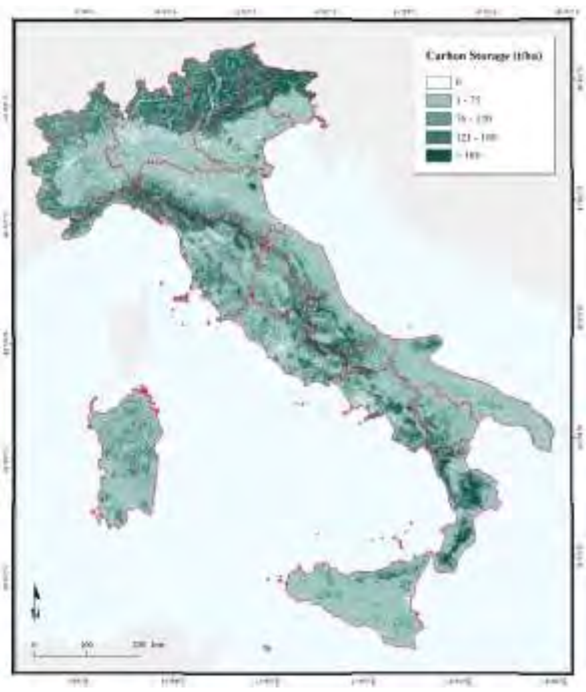
Carbon storage and sequestration

This service contributes to climate regulation at global level and plays a key role in climate change mitigation and adaptation. Intergovernal Panel on Climate Change (IPCC) identifies five main carbon pools: living biomass, as above ground biomass (stem, stump, branches etc.) and below ground biomass (roots), dead organic matter, as dead wood (non-living biomass not contained in the litter) and litter (non-living biomass with a small diameter) and soil organic matter, which includes organic carbon in mineral and organic soils up to 30 cm. Degradated or sealed soil are not able to store carbon, which is emitted in the atmosphere.

The Carbon Storage and Sequestration model adopted provides a map that links land use/land cover codifications with the sum of the carbon values of those five natural pools. Reference values for living biomass for the forest land use categories are obtained from the biomass volumes (stock and growing) charts published by the Italian Forest Inventory (*“Inventario Nazionale delle Foreste e dei Serbatoi Forestali di Carbonio”* - INFC) and other sources related to living biomass in permanent crops (Canaveira e*t al*. 2018), and calculated through coefficients derived from scientific literature (IPCC, 2006). The soil carbon pool is assessed using the new Soil Organic Carbon map produced as an Italian contribution to the Global

Soil Partnership/FAO Initiative (CREA, 2018), with resolution of 1 Km. Some values (continuous urban fabric, port areas, dumpsites and building sites) were forced to zero.

Figure 1: Variation in the flow of regulating and maintenance ecosystem services due to the soil consumption between 2012 and 2017 in Italy. Carbon storage (t/ha) Source: ISPRA processing



Pollination

Crop and wild plants productivity rely on pollination. Over the past few decades, pollinator insects have declined in Europe, both in abundance and diversity, and their decline has raised much attention because animal pollination is essential for wild plant communities. The main drivers of the decline include land-use changes which cause habitat fragmentation, pollution (due to pesticides), loss of biodiversity and increasing of alien species, pathogens and climate change (Martin *et al*. 2019). The assessment of the spatial distribution of pollination services has become a policy priority in Europe with the EU biodiversity strategy (EC, 2011). In this study 50 pollinator species were considered, and input data was determined through a bibliographic research. Output data are two indexes (0-1) which represent the pollinator potential presence and their ability to reach croplands.

Habitat quality

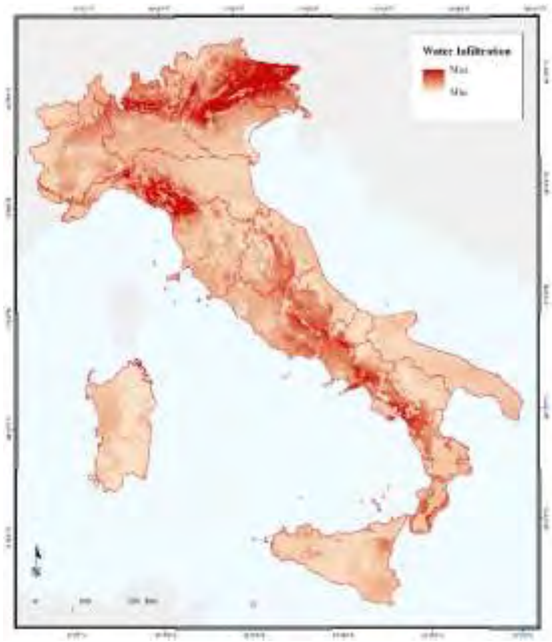
A primary goal of conservation is biodiversity protection, including the range of genes, species, populations, habitats, and ecosystems. The habitat quality service considers biodiversity as the base of the production of ecosystem services. It considers the provision of different essential habitats for the life of any species and the preservation of biodiversity. It represents one of the main reference values in the evaluation of the ecosystem state of soils. For the evaluation the Habitat Quality model of InVEST suite of models (Integrated Valuation of Ecosystem Services and Trade-offs, Natural Capital Project) (AA. VV. 2015) was used. This model considers the ability of the habitat to sustain animal and plant life forms; the impact of threats on different habitats; the sensitivity of each individual habitat to be influenced by different types of threats and distance of the habitats from its sources of alteration. Biophysical results are represented in form of an indicator (0-1) of habitat quality for each pixel.

Figure 2: Variation in the flow of regulating and maintenance ecosystem services due to the soil consumption between 2012 and 2017 in Italy. Habitat quality (adim). Source: ISPRA processing

Hydrological cycle management

The infiltration of water in soil is one of the main elements of the regulation of hydrological cycle, in terms of surface runoff regulation, and is directly affected by soil consumption. This study is based on an evaluation of water balance related to different scenarios of land use and land cover, in order to evaluate the consequences due to land consumption (Assennato *et al*. 2018). In the figure 3 the values from maximum to minimum variation in water infiltration between 2012 and 2018 is illustrated.

Figure 3: Variation in the flow of regulating and maintenance ecosystem services due to the soil consumption between 2012 and 2017 in Italy. Hydrological cycle management (adim). Source: ISPRA processing



The water budget components at monthly temporal scale for the whole national territory is calculated by an automatic GIS-based procedure named BIGBANG version 1.0, produced by ISPRA (Braca and Ducci, 2017), working on a 1km grid, using precipitation and temperature data mediated for the period considered (2012-2017) and information on the soil's hydraulic and geological characteristics and the different scenario on land cover and use obtained from ISPRA 20 m resolution grid map of soil consumption (ISPRA, 2018).

Erosion control

The magnitude of erosion depends on many factors, including different land use/land cover conditions. The variation of the retention capacity through the comparison between the steady state of land use/cover and soil properties and a different scenario, can be considered as an indicator of the ecosystem service change in biophysical terms. The SDR "*Sediment Delivery Ratio*" InVEST model (AA.VV.,2015) represents the avoided soil loss, expressed in tons/hectar, by the current land use compared to bare soil, weighted by the SDR factor. The figure 3 shows the geographical distribution erosion control loss in terms of sediment retention in tons/ha.

Figure 3: Variation in the flow of regulating and maintenance ecosystem services due to the soil consumption between 2012 and 2017 in Italy. Erosion control (t/ha) Source: ISPRA processing

Microclimate

The expansion of artificial areas influences the energy exchange process between the earth and the atmosphere, having significant effects on local climate in urban areas. The urban heat island phenomenon increases the need for summer cooling (Lai X. *et al.* 2018) and results in a higher energy request. Urbanization can cause a temperature increment between 1 and 3 °C. It can be estimated An average increasing of 0,6 °C of temperature in urban area every 20 ha of more urbanization, 0,9 °C in summer can be estimated, leading to an increasing of 0.04 °C produced by the increasing in urban density estimated in 0,081 ha/km^2..

Water purification

Ecosystems such as forests and wetlands contribute considerably to improving the quality of water resources. Vegetation and soil can absorb and therefore remove pollutants and water nutrients and reduce their speed in order to regulate their infiltration into the soil (Elmqvist *et al*. 2010). Water infiltrated in soil undergoes a process of "purification" through bio-chemical processes carried out from the mineral part of the soil, and even more from its biological components. The purifying capacity is function of soil properties (cationic exchange capacity, organic matter, the reaction (pH) and its depth) and is linked to climate, management practices, and inputs of nutrient and pollutant load in water. This service is evaluated using purification capacity information (selected layers from JRC map of soil properties for Italy) as indicator (0-1) of service provided by soil.

Particulate and ozone removal

Currently, exposure to air pollutants is the main environmental risk factor in Europe (EEA, 2014), thus the improvement of air quality has an important role among the ecosystem regulatory services (Manes *et al*. 2012). In this context, the highest number of deaths is estimated for Italy premature from atmospheric pollutants (8,440; EEA, 2015). The estimation is carried out using the pollutant removal level for each ecosystem following classification for Italian territory (Blasi *et al*. 2016; Capotorti *et al*. 2015). Pollutant removal estimation is obtained from a 10 Italian metropolitan areas research (Manes *et al*. 2016) which evaluate concentrations of PM10 and O_3 through the AMS-MINNI model on air quality (Mircea *et al*. 2014).

An overview of potentials and limits of the ESA from experiences at local level

Loss of agriculture and natural soil due to land consumption is driven the most by decisions upon land use and cover at local scale. Thus, spatial planning is the arena to effectively foster soil ecosystem services provision. The practical application at the local scale of ESA in planning is still fragmented and only few cases provide an operative application in planning tool. The existing experience of ESA in Italy was analysed based on a comparative analysis of local scale application of ESA within projects LIFE SAM4CP, SOILCONSWEB, LIFE MGN, SOS4LIFE and the most recent SOIL4Life, together with other experiences analysed within the development of the national analytical framework. This comparison points out potentials and limits of the ESA and offering a contribution towards an effective application of this innovative and powerful evaluation methodology. Considerations come from experience of planning in different contexts (Municipalities of Bruino, Chieri, None Settimo Torinese from LIFE SAM4CP, San Lazzaro di Savena and Forli from SOS4life, Rome from SAM4CP and SOIL4life, Romano di Lombardia).

For the purpose of limiting land consumption , local land use planning is the final tool to address. The difficulty comes from the need to consider the actual biophysical land coverinstead of the land use destinations. A second difficulty is how to address excessive and unrealized forecasts of land consumption or unworkable compensation. In some of the experiences analysed the evaluation of ES was referred to land use destinations. In this condition the actual reduction of ES produced by land consumption is masked by reduction of transformations for the future, as compared to the present prevision of plan, or balanced by only potential improvements of the environmental conditions, obtaining a virtual, not effective balance in ecosystem services provision.

The scale of application is also a matters. In the available experiences different ESA methodologies were used on different "evaluation objects", from the national level to the scale of the single transformation intervention (a few dozen square meters). The great flexibility of the instrument allows a multiscalar application, but it should be verified at different levels for appropriate inputs and proper use of results. the It must be emphasized that the ESA at local level loses much of its effectiveness if it does not find an adequate regional reference, in terms of availability of data and references for the selection of ESs. At the scale of single transformation ESA should be limited to a qualitative assessment linked to the eventual quantification on a higher scale, becouse of the little significance to draw conclusions on biophysical balances carried out on an excessively reduced scale. This is particularly valid for some services, i.e the Habitat Quality Service or Pollination, for which the minimum dimensions must be comparable to the biophysical "distances" considered in the analysis. More in general regulatory services, such as hydrological cycle management, sediment retention and filtration of contaminants, must be referred to hydrological basin or sub-basin scale.

Experiences of ESA in Strategic environmental assessment (SEA) procedures are still very limited . THigh complex application as ESA rarely is practicable in local planning, without methodological reference and data at higher scale. From experience analysed emerged thatESA clashes with the Italian practice of proceeding with non-general variants of the urban planning instruments, which in most cases limit the environmental assessment to the variant areas only, making not effective with the evaluation of effects i.e on ecological networks or the protection from hydrogeological risk. Moreover, partial revision lead in most cases to the absence of an effective participation in SEA, not foreseen by the norm for small transformations. As evidenced by the case of Romano di Lombardia, in which the participation was cared of particularly, ESA results was of great interest for the citizen, who were able to use scientific results to build their positions on transformation priorities.

It must be said that, as in many public-decision contests, there is still an under-representation of soil natural values, functions and ecosystem services. Among the institutional actors obligatorily foreseen by the planning conference,with the exception of environmental agencies and some “lucky” regional cases, these issues are not well represented. The development of planning support tools will help to tackle this problem, providing sets of indicators (as the one produced by ISPRA) or tools for the direct evaluation on selected areas, such as the one developed by the LIFE project SAM4CP (Simulsoil & Playsoil). A guideline for the evaluation of the soil component in the SEA process, to be more inclusive of the quality of the soils and the ecosystem services offered by them, is currently under study by SNPA (National environmental protection agencies network)..

Some methodological barriers emerged from the experience. Majority of biophysical methods are quite complex and there is a need for information and support to professionals and local administrations for their correct use. The given flexibility of open tools with direct access to data and the possibility of using local values, represents a further vulnerability of the results, which the user is not always able to evaluate. There are some criticalities also on the analytical side. The multi-criteria analysis with the identification of synthetic “multi-service” indexes must be further discussed. It represents an opportunity, in terms of communicative strength, however it represents a risk of inconsistency of the results as well as of loss of information on individual services. As emerged from some of the cases analysed, the multiservice index mask trade-offs and negative effects on “critical services” with benefits on other less strategic services (such as in some cases the services from agricultural land in comparison with those from urban green). Furthermore, the use of normalization parameters makes this type of representations not comparable (in space and time) and not useful for scenario analysis.

Another criticality comes from the identification of usage thresholds for ecosystem, that is a very sensitive topic under debate. In some of the analysed cases, thresholds applied to multi service index have been used to exclude a part of the project/plan from the evaluation and, consequently, excluding mitigation and compensation too. In those cases, the mechanism lead to an underestimation the effects whose extent cannot be known. It is therefore essential to identify the different services and related biophysical indicators coherently, to be analysed and compared separately to verify the consistency of the conclusions. The selection of which SEs to consider and how to treat the tradeoffs between the different services should not be left to the individual local experience but should always complement the local participatory choice with an adequate indication from a higher level. It is always better to consider all the possible SEs initially, only after the analysis, if possible, exclude those that are not pertinent (Cortinovis and Geneletti, 2017). In this choice, a major attention must be paid to “urban ecosystem services”, because the proposed application of new technological solutions (eg vertical woods or green roofs or drainage systems) must be verifies in terms of its ecological effectiveness.

Money or not money? The economic evaluation is one of the most critical issues in ESA. The introduction of economic terms risks to open to a possible exchange market of non-renewable natural resources (Pileri et al 2018 in ISPRA 2018). With a view to strong sustainability, we must consider ESA as a tool to make the intrinsic value of the resources that benefit human beings even more evident, tangible and clear, considering the economic parameters only as indicators for scenario comparison, not for exchanges. There are several technical questions in economic ESA, related to market vs social costs, to the evaluation of actual or potential flow, or stocks of resources, and to the evaluation of offer and demand of services. The evaluation of actual services is not always useful for the planning purpose, potential services would be more appropriate to compare different scenarios. For the purpose of planning, the choice of economic value to be consider is critical. The evaluation via a direct expression of the local population, is not always able to adequately represent the need for protection of collective or global interest on natural resources. The effort of translation into money is crtitical for its natural outcome of translation in economic compensation. Compensation means the restitution elsewhere of the destroyed environmental values without therefore resulting in a modification of the impacts of the transformative project. It has long been perceived as the canonical "way out" of environmental negotiation, however in practice it turned into the main element of the negotiation. In this condition, the use of economic value from ESA can be a complete misusing of results. The value of the actual service flow is not representative of the entire value of the resource and should not be used as a measure of a compensation. For a correct determination, it would be necessary to evaluate the amount of stock of consumed resources, but this is far from present evaluations capabilities.

The need for a common framework for application.

This first comparison allows to observe that ESA is an effective reading tool, able to integrate the different topics involved in territorial transformation analysis and,more, it is scalable at the different levels. It is also able to represent and summarize the values of soil and naturalness, and the costs associated with their loss, in a language suitable for discussion within planning processes and for the public. However, it remains a still "young" tool, whose applications can vary a lot in terms of methodology, scale and subject of investigation, and in terms of final use.

The complexity of this tool is thus related to the methodological, procedural, regulatory and political side. In the absence of a more solid methodological and procedural reference to be used in the decision-making process, its application is potentially subject to improper uses or misleading of results.

Having as a target the zero net consumption of land, it must be underlined that the sole inclusion of ESA, even in the presence of a common methodological reference, cannot be enough to protect Italian soil from further aggression without an upstream, quantifiable and not circumvented, limitation of consumption.

References

AA.VV., 2015, *InVEST 3.3.0 User's Guide*. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund

Alam, M., 2018, Ecological and economic indicators for measuring erosion control services provided by ecosystems *Ecological Indicators*, 95(1), 695-701

Assennato, F., d'Antona, M., Di Leginio, M., Strollo, A., Munafò, M., 2019, Assessing land consumption impact on ecosystem services provision: an insight on biophysical and economic dimension of loss of erosion control in Italy. Poster presented at Global Symposium on Soil Erosion, 15-17 May 2019, FAO, HQ, Rome, Italy

Assennato, F., Braca, G., Calzolari, C., Capriolo, A., Di Leginio, M., Giandon, P., Marchetti, M. Marino, D., Mascolo, R., Morri, E., Pettenella, D., Pileri, P., Sallustio, L., Salvati, L., Santolini, R., Soraci, M., Strollo, A., Terribile, F., Ungaro, F., Vinci, I., Munafò, M., Mappatura e valutazione dell'impatto del consumo di suolo sui servizi eco sistemici: Proposte metodologiche per il rapporto sul consumo di suolo. 2018, Annex to ISPRA-SNPA, 2018 Consumo di suolo, dinamiche territoriali e servizi ecosistemici, Rapporti 288/2018

Blasi C., Capotorti G., Alòs Ortì M.M., Anzellotti I., Attorre F., Azzella M.M., Copiz R., Manes F., Marando F., Marchetti M., Garfì V.,Mollo B., Zavattero L., 2016, Ecosystem typification and mapping at the national level: On the importance of detailed thematic maps when addressing biodiversity conservation targets. Submitted to *Applied Vegetation Sciences*. Manuscript ID AVS-RA-01764.

Braca, G., Ducci, D., 2018, Development of a GIS Based Procedure (BIGBANG 1.0) for Evaluating Groundwater Balances at National Scale and Comparison with Groundwater Resources Evaluation at Local Scale. In: Groundwater and Global Change in the Western Mediterranean Area, Calvache, M.L., Duque, C., Pulido-Velazquez, D. (Eds.), Springer, January 2018. DOI10.1007/978-3-319-69356-9_7

Canaveira, P., Manso, S., Pellis, G., Perugini, L., De Angelis, P., Neves, R., Papale, D., Paulino, J., Pereira, T., Pina, A., Pita, G., Santos, E., Scarascia-Mugnozza, G., Domingos, T., and Chiti, T., 2018, Biomass Data on Cropland and Grassland in the Mediterranean Region. Final Report for Action A4 of Project MediNet. http://www.lifemedinet.com/

Capotorti, G., Alós Ortí, M.M., Anzellotti, I., Azzella, M.M., Copiz, R., Mollo, B., Zavattero, L., 2015, The MAES process in Italy: contribution of vegetation science to implementation of European Biodiversity Strategy to 2020. *Plant Biosystems*, 149,949–953

Cortinovis, C., Geneletti, D. Ecosystem services in urban plans: What is there, and what is still needed for better decisions Urbanistica Informazioni. - 272:s.i.(2017), pp. 841-847

Costanza, R., d'Arge, R., de Groot, R., Farber, S., Grasso, M., Hannon, B., Limburg, K., Naeem, S., O'Neill, R.V., Paruelo, J., Raskin, R.G., Sutton, P., van der Belt, M, 1997, The value of the world's ecosystem services and natural capital. *Nature* 387, 253-260

CREA per GSP-Italia, 2018, Carta italiana del carbonio organico, CREA. Download: http://54.229.242.119/apps/GSOCmap.html#

Daryanto S., Fu B., Wang L., Jacinthe P., Wenwu Z., 2018, *Quantitative synthesis on the ecosystem services of cover crops* Earth-Science Reviews

De Groot, R. S., Alkemade, R., Braat, L., Hein, L., & Willemen, L., 2010, Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making. *Ecological complexity*, 7(3), 260-272.

Dominati, E., Patterson, M., Mackay, A., 2010, A framework for classifying and quantifying the natural capital and ecosystem services of soils. *Ecological Economics,* 69, 1858 – 1868

Elmqvist, T., Maltby, E., Barker, T., Mortimer, M., Perrings, C., Aronson, J., Pinto, I. S., 2010, *Biodiversity, ecosystems and ecosystem services. TEEB Ecological and Economic Foundations* (London, U.K.: Earthscan), 41-111

EUROPEAN COMMISSION, 2014, Mapping and assessment of Ecosystem and their Services Technical Report 2014/080

EUROPEAN COMMISSION, 2013, Hard surfaces hidden costs searching for alternatives to land take and soil sealing. Luxembourg: Publications Office of the European Union

EUROPEAN COMMISION, 2011, Our Life Insurance, Our Natural Capital: An EU Biodiversity Strategy to 2020: Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Publications Office of the European Union

European Commission, 2006, Strategia tematica per la protezione del suolo, 231

European Environmental Agency, 2014, Costs of air pollution from European industrial facilities 2008–2012 an updated assessment EEA Technical report No 20/2014
European Environmental Agency, 2015, Air quality in Europe 2015 report EEA Report No 5/2015

Haines-Young, R.H., Potschin, M., B., 2018, Common International Classification of Ecosystem Services (CICES) V5.1 and Guidance on the Application of the Revised Structure. Fabis Consulting Ltd [In English].

Indovina, F., 2009, *Dalla città diffusa all'arcipelago metropolitano* (Milan, IT.: Franco Angeli)

ISPRA-SNPA, 2018, Consumo di suolo, dinamiche territoriali e servizi ecosistemici, Rapporti 288/2018

IPCC, 2003 *"Good practice guidance for land use, land use change and forestry*." IPCC Technical Support Unit, Kanagawa, Japan. Published by the Institute for Global Environmental Strategies

Lai X., Tang Y., Li L., Chan P., Zeng Q., 2018, Study on microclimate observation network for urban unit: A case study in a campus of Shenzhen, China Article in press *Physics and Chemistry of the Earth*

La Notte, A., D'Amato, D., Mäkinen, H., Paracchini, M.L., Liquete, C., Egoh, B., Geneletti, D., Crossman, N.D., 2017, Ecosystem services classification: A systems ecology perspective of the cascade framework. *Ecological Indicators* 74, 392-402

Maes, J., Teller, A., Erhard, M., Grizzetti, B., Barredo, J.I., Paracchini, M.L., Condé, S., Somma, F., Orgiazzi, A., Jones, A., Zulian, A., Vallecilo, S., Petersen, J.E., Marquardt, D., Kovacevic, V., Abdul Malak, D., Marin, A.I., Czúcz, B., Mauri, A., Loffler, P., BastrupBirk, A., Biala, K., Christiansen, T., Werner, B., 2018, Mapping and Assessment of Ecosystems and their Services: An analytical framework for ecosystem condition. Publications office of the European Union, Luxembourg

Manes, F., Incerti, G., Salvatori, E., Vitale, M., Ricotta, C., Costanza, R., 2012, Urban ecosystem services: tree diversity and stability of tropospheric ozone removal. *Ecological Applications*, 22(1), 349-360

Manes, F., Marando, F., Capotorti, G., Blasi, C., Salvatori, E., Fusaro, L., Ciancarella, L., Mircea, M., Marchetti, M., Chiici, G., Munafò, M., 2016, Regulating Ecosystem Services of forests in ten Italian Metropolitan Cities: Air quality improvement by PM10 and O3 removal. *Ecological Indicators*, 67, 425-440

Martin, G., Fontaine, C., Accatino, F., Porcher, E., 2019, New indices for rapid assessment of pollination services based on crop yield data: France as a case study *Ecological Indicators*, 101, 355-363

Millenium Ecosystem Assesmment, 2005, *Ecosystems and Human Well-being: Synthesis*. Millenium Ecosystem Assesment. Island Press, Washington, DC

Mircea, M., Ciancarella, L., Briganti, G., Calori, G., Cappelletti, A., Cionni, I., Zanini, G.,2014, Assessment of the AMS-MINNI system capabilities to simulate air quality over Italy for the calendar year 2005. *Atmospheric Environment*, 84, 178–188

Munafò. M., Salvati, L., Zitti, M., 2013, Estimating soil sealing rate at national level—Italy as a case study. *Ecological Indicators*, 26, 137-140

Panagos P., Borrelli P., Meusburger K., van der Zanden E.H., Poesen J., Alewell C., 2015, *Modelling the effect of support practices (P-factor) on the reduction of soil erosion by water at European Scale*. *Environmental Science & Policy*, 51, 23-34

Pushpam Kumar, 2010, *The Economics of Ecosystems and Biodiversity: Ecological and Economic Foundations*. (London and Washington: Earthscan,)

P. Pileri, F. Assennato, C. Calzolari, P. Giandon, M. Marchetti, D. Marino, E. Morri, D. Pettenella, L. Sallustio, L. Salvati, R. Santolini, F. Terribile, F. Ungaro, I. Vinci, M. Munafò, 2018. *La sfida dei servizi ecosistemici alla cultura della monetizzazione e della compensazione*. In ISPRA 2018 Rapporto sul consumo di suolo, dinamiche territoriali e servizi ecosistemici, in pubblicazione. ISPRA, Roma

Van der Meulen S., Maring, L., 2018, *Mapping and Assessment of Ecosystems and their Services Soil ecosystems* Deltares under SOILS4EU service Contract no. ENV.D.1/SER/2016/0041, European Commission