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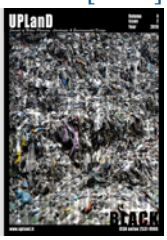

Research & experimentation
Ricerca e sperimentazione

LANDSUPPORT, A DECISION SUPPORT SYSTEM FOR TERRITORIAL GOVERNMENT

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HIGHLIGHTS

- Soil consumption is one of the most severe degradation processes of ecosystems, because it is responsible for drastic limitation or even complete removal of essential ecosystem services.
- An immediate action is needed to reduce the gap between major policy statements and the lack of operational and scientifically robust tools to tackle land consumption.
- Soil consumption can also be faced through an innovative web platform designed to determine different indices related to the quantification of this degradation phenomenon.
- LANDSSUPPORT is a useful tool for regional and metropolitan planning, even in regenerative processes.

ABSTRACT

The objective of LANDSUPPORT is the construction of a smart geoSpatial Decision Support System (S-DSS) , providing a powerful set of decision supporting tools – that will be open and freely accessible through the web – devoted to (i) support sustainable agriculture/forestry, (ii) evaluate their interaction and trade-off with other land uses, including spatial planning and (iii) support the achievement of selected land policies of both EU and UN agenda, with special emphasis to the key, "achieving a land degradation-neutral world" and climate change mitigation goals. By doing that, LANDSUPPORT will reconcile urban regeneration policy ambitions with operational reality addressing the often overlooked support for planning/management actions at the very local scale. In fact, only by this approach incorporating the local dimension it is possible to produce DSS tools to simultaneously fulfil all high demand ing specific challenges such as the evaluation of "land use trade-offs", "incentivising real actions / behaviour / investments" contributing to "sustainable management of land resource" and considering societal needs. This is exactly what the high performing LANDSUPPORT integrated scientific approach promise to do, unlike the aggregated Territorial Modelling Platform already in use for the ex-ante evaluation of EC policies.

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1. Introduction

The project Horizon 2020 LANDSUPPORT (www.landsupport.eu) aims to develop a geospatial Decision Support System (DSS), based upon the Web and open-access, which points at contributing to the development and implementation of land utilization policies in Europe and will promote an integrated and participatory approach to rural development and environmental policies. Some features (land-take, green infrastructure) are particularly useful for territorial planning and environmental evaluation, understood as both strategic environmental assessment both environmental impact assessment. The INU (Italian National Urban Planning Institute) contributed to the project and attended to the presentation of alpha version of web platform, presented at the general assembly of research group in Balatongyörök, Hungary, from 27th to 29th of May 2019.
The project is built upon the experience grown during several experiments and successful projects, like "SoilConsWeb" (www.landconsultingweb.eu) and "Soil-monitor" (http://www.soil-monitor.it) with the collaboration of different research units. The system contains roughly 100 DSS instruments, dealing with topics of strategic interest: agriculture, environment, planning. Users can display data for the selected periods and area of interest, and then they can access modelling and services provided by LANDSUPPORT project, using different scales. Results are shown through maps, graphic figures and reports able to be exported and allowing comparisons between different scenarios. The project integrates existing databases, with different scales, with new high-performance modelling tools that simulate agriculture and sylviculture, land degradation and environmental issues.
The system will be based on cutting-edge technologies for the development environment, high performance calculation and massive raster data management and will be validated by remote sensing data. LANDSUPPORT aims to integrate decisions on many geographical scales into a single set of instruments, allowing to coordinate policy ambitions for agricultural and environmental sustainability with local operating realities, that are very often overlooked. A test will be carried out on four geographical scales: EU, national (Italy, Hungary and Austria), regional (an Italian and a Hungarian region) and local (pilot sites in Austria, Italy, Hungary, Tunisia and Malaysia). The project also provides for the organisation of end-user workshops during the development phase and training courses as soon as a first subset of tools is available. One of the Italian areas of experimentation will be the Cilento National Park, thanks to the collaboration with the LUPT Centre of the University Federico II of Naples (coordinator of the experimentation prof. F. D. Moccia).

2. Construction of the decisional system

With the Work Package 1, the tools of LANDSUPPORT are optimized on the basis of real demands coming from policy-makers, farmers, territorial planners and land managers at the European, national and regional/local level. The activities in the WP1 are connected to the approach of the living laboratory developed in WP7 and WP6. As first footstep of the DSS development, Work Package 2 is establishing the base of services for LANDSUPPORT, harmonized with the integrated management of raster data, vector data and metadata, that allow "any queries, in any moment and on any dimension" to be managed as explorable data. Work Package 3 will be based on this platform and develop a multi-scale and modular modelling system that will be at the heart of LANDSUPPORT's DSS tools. Meanwhile, Work Package 4 will collect, pre-process and provide a portfolio of Earth observation maps (EO) and outputs of Copernicus Sentinel satellites, with the aim of enabling continuous monitoring of highly dynamic land surfaces and providing biophysical vegetation variables, in order, evaluate and validate model results.
At this point, the core of DSS will be completed, therefore the Work Package 5 will come into play, designing and developing a highly customized LANDSUPPORT spatial DSS web application, as well as integrating engine modelling and data levels into the web-based geospatial-cybernetic infrastructure (GCI). The living-lab process is developed on two work packages, namely WP6 and WP7. In WP7, the operational needs of future users (policy makers, farmers, space planners and other land managers) will be explored during dedicated workshops at national and local level. The WP6, then, will test, evaluate and validate the results and products of LANDSUPPORT together with future users. Moreover, WP7 will also include capacity building activities with future users, as

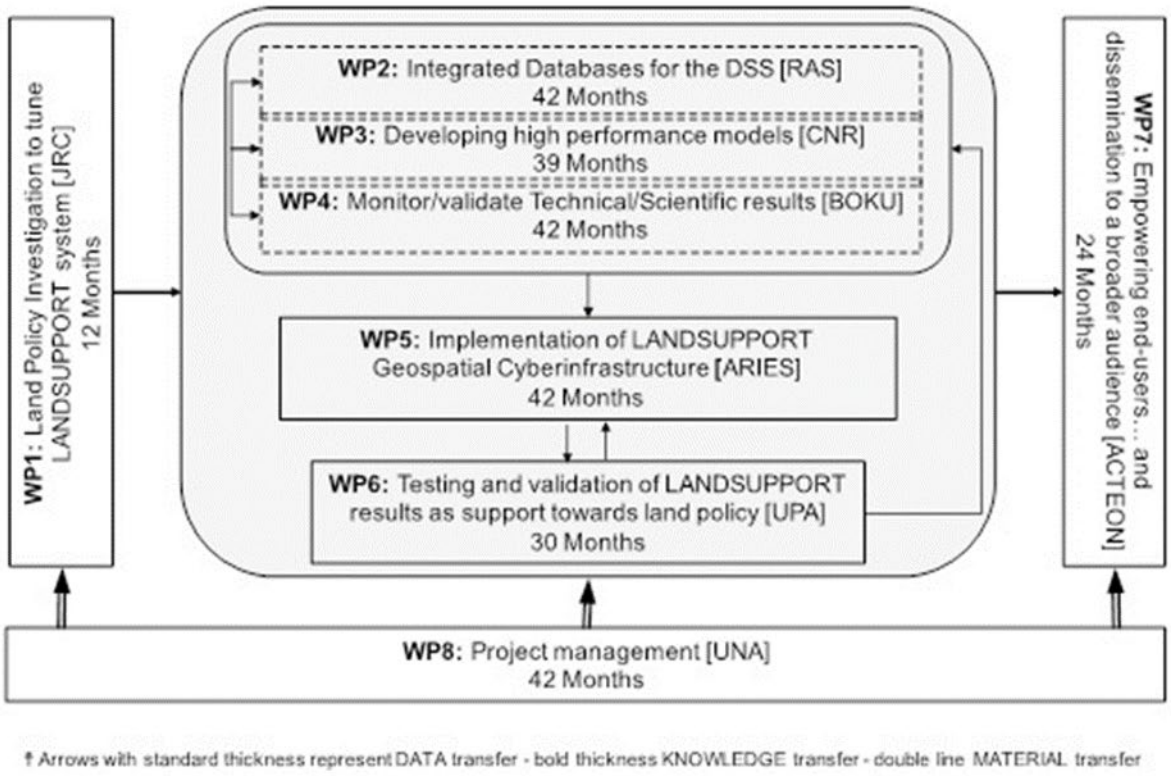

Figure 1: Project diagram. *Source: Moccia et al. 2018*

well as communication, awareness and dissemination activities aimed at a wider audience. Work package 8 includes all project management and coordination activities, while work package 9 includes all activities to meet ethical requirements.

3. Soil consumption, urban planning and ecosystem services

Soil consumption is one of the most severe degradation processes of ecosystems, because it is responsible for drastic limitation or even complete removal of essential ecosystem services. Although important European policy documents (Roadmap to a Resource Efficient in Europe - SDG'S) promise to mitigate this phenomenon, there are still no clear signs of change and land consumption continues to grow alarmingly worldwide. As stated by Moccia, Sepe and Terribile (2018) "We believe that immediate action is needed to reduce the gap between major policy statements and the lack of operational and scientifically robust tools to tackle land consumption". These instruments must aim to support the decisions of politicians and all those who have the task of managing, controlling and contrasting this harmful phenomenon.

Soil consumption can also be faced through an innovative web platform designed to determine different indices related to the quantification of this degradation phenomenon. The "ground consumption" function (land-take) was one of the main functions present in the previous experience of the web-GIS (Geographic Information System) Soil-monitor designed by the CRISP (*Centro di Ricerca Interdipartimentale sulla* "Earth Critical Zone") Centre. The land take tool will be a powerful support to the ex-ante assessment of new urban development actions or new green corridors in the hands of European spatial and urban planners and planning public bodies. All European municipalities and other public bodies dealing with spatial planning and agriculture and not having specialised expertise. Thanks to LANDSUPPORT website, on-the-fly they can assess metrics/map/statistics/reports about soil consumption/land fragmentation, simulate land use change scenario,

land use change and much more at no cost. This paramount objective will not be achieved by a top-down approach but rather by empowering any final end-user about the impact of planning. LANDSUPPORT, in fact, implements on a European scale the previous experience of web-GIS Soil-monitor - specifically designed for Italy. It is useful, in this regard, to take up the salient points of the previous experiment lead by INU Campania on Soil-monitor. The Soil-monitor platform, while being a prototype of a geospatial cybernetic infrastructure, has shown that - thanks to research - it is now possible to reduce the distance between the major environmental policy statements (e.g. SDG) and the direct implementation of measures to reduce land consumption. Soil-monitor has also been designed to support some national policies related to land consumption (AS 1181, AS 2383, Act n. 86 of 22/05/2015, Act n. 221 of 28/12/2015) associating actors related to scientific research with population, settlement, politics and economy. In order to maximise the reliability of the results delivered by the web platform, the data used for calculations are provided by ISPRA (Italian Institute for Environmental Protection and Research) with high spatial resolution. The coherence of the calculation procedures of various indicators of land use and urban and territorial planning has been tested by the National Institute of Urban Planning. The measurement and quantification of soil consumption performed by the Soil-monitor had the merit of raising awareness of the phenomenon. The calculation has been designed and implemented to be adaptable in relation to the available hardware resources, allowing real-time answers even for the most challenging indicators (for example, the fragmentation of rural and urban landscapes) required for large geographical areas of interest (a province, a region or even the whole Italian territory). The codes have been written in CUDA-C and use NVIDIA graphics card processors for massive parallel computation. The Soil-monitor made it possible to quantify:

1. changes in land use at different times;
2. fragmentation of rural landscape;
3. loss of ecosystem services;
4. the impact of ecological corridors restoration.

LANDSUPPORT, on the basis of these premises, can have as its objective the mitigation and the achievement of neutral land consumption on the European scale. Beyond land consumption, another important application for planning is the "fragmentation" and the implementation of the ecological network. The Observatory on soil consumption of the INU Campania tested the Soil-monitor tool on May 10th and 31st, 2017, at the Computer Laboratory of the LUPT (*Laboratorio di Urbanistica e Pianificazione Territoriale*) Centre - University Federico II. Fifteen INU members took part in the test, which included a guided test and three sessions of test related to the use of indicators on land consumption, ecological fragmentation and urban hierarchies. In order to improve the application and make it more accessible to potential users, a subsequent experiment was carried out on a specific but significant territorial area, coinciding with the metropolitan area of Naples.

The results obtained from the use of indicators belonging to Soil-monitor were compared with the environmental analyses and the proposal of the main ecological network of the Territorial Coordination Plan of the Metropolitan Area of Naples (PTC) adopted in January 2016. The results of the test were presented in the 2017 Report of the Research Centre for Soil Consumption (CRCS). The results of that research are, in part, here proposed again, in order to illustrate the application at the planning level.

Territorial planning, especially in metropolitan contexts, must deal with the changing landscape, due to the persistent phenomenon of soil sealing that causes the loss of ecosystem services. Indeed, the fragmentation of ecosystems, produced by soil consumption, has a significant impact on services related to the protection of biodiversity. The Campania Regional Territorial Plan (PTR in Italian) of 2008 states that the spatial and ecological fragmentation of the regional territory is one of the main causes of landscape degradation, and provides indications to pursue the objective of "defragmentation" through multiple interventions at different scales: regional, provincial and municipal policy guidelines for agriculture and major infrastructures design. In fact, agricultural areas, if reorganized according to environmental sustainability principles but without losing productivity, may constitute a small network of links between areas which are best preserved from an environmental point of view and which have a high level of bio-permeability. Major linear infrastructures (motorways, railways, reclamation channels, main power lines) if designed or restructured with suitable criteria, could be a complement to the backbone of the regional ecological network, contributing to the connection of large natural areas. The analysis of soil consumption led by ISPRA empha-

sizes even more clearly the absence of large areas with a high level of bio-permeability. The metropolitan scale thus becomes an interesting area of analysis, in order to monitor the impact of land consumption on potential green infrastructures of the metropolitan area of Naples. The web platform is an innovative tool that interacts with the ISPRA databases and the GIS information platforms, allowing not only to evaluate, monitor and quantify land consumption within municipalities, metropolitan cities and Italian regions, but compute and compare ecological indicators of great interest for environmental analysis. The web platform allows users to select any portion of territory, being able to provide as output not only the amount of land consumed over time, but also the impact on soil of a new urban settlement or ecological corridor.
Within the web-GIS can be applied and calculated two macro-categories of indicators:

- land change matrices and land cover - indicators based on Corine Land Cover map;
- land use indicators.

The latter group includes the most ecologically sound indicators such as "fragmentation" (urban and rural) index. Specifically, the layer of the Provincial Ecological Network (REP in Italian) of the Provincial Plan of Naples has been superimposed with the indicator of the rural fragmentation of the Soil-monitor showing that the REP, even if more detailed than the RER (Regional Ecological Network), does not intercept the difficulties due to the fragmentation of the area. Instead, fragmentation monitoring induced by land use allows the identification of possible connecting elements and the estimation of their fragility in order to identify planning actions.
The analysis of the environmental system is based on the analysis of the core areas or parks and protected areas and biodiversity starting from the reading of the Corine Land Cover map. The fragmentation map allows identifying different types of fragmentation, urban and rural. If in Soil-monitor the resolution was quite modest and suitable for the large scale (resolution of 200 metres), the

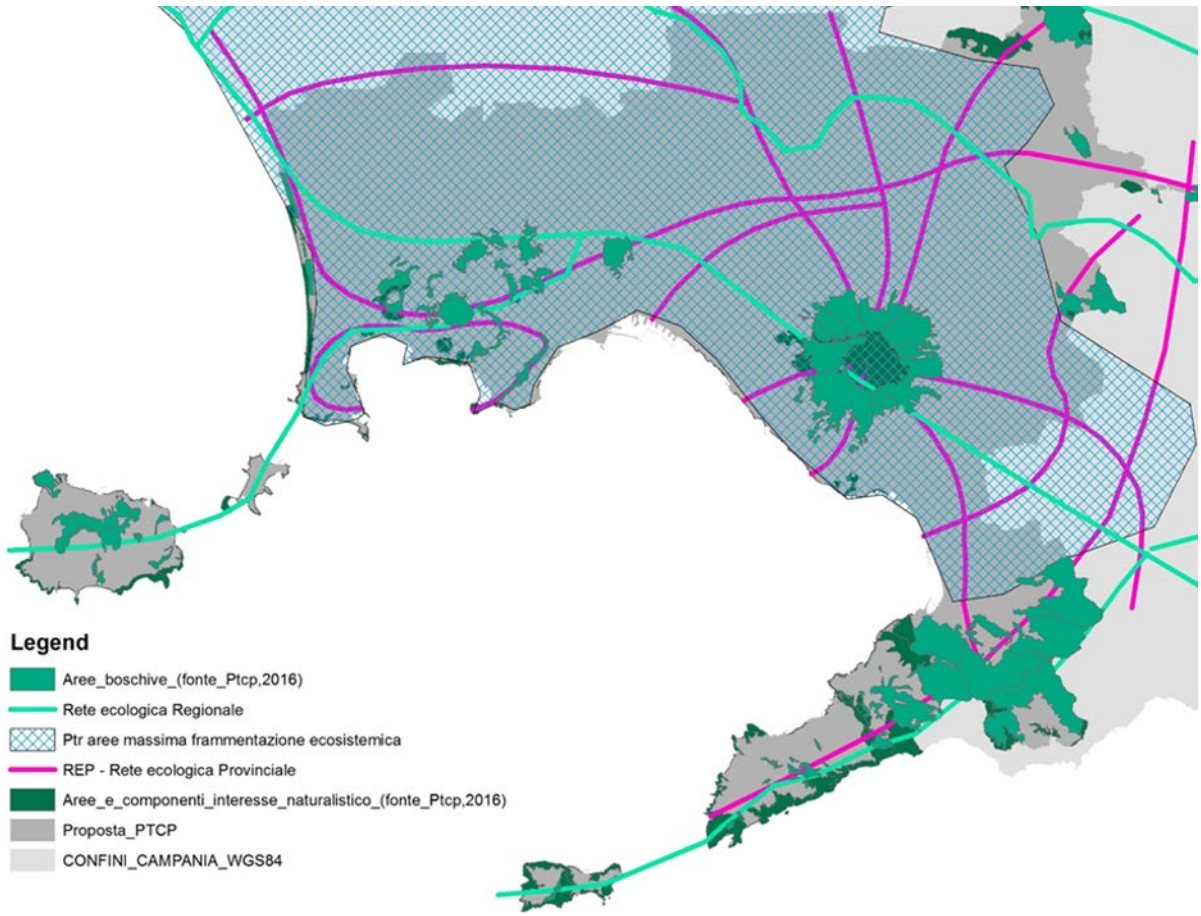

Figure 2: Ecological network. *Source: Coppola et al., 2017.*

resolution of LANDSUPPORT - that comes from the use of the Copernicus system - is greater (the cells are 20 x 20 m) and therefore are more useful at the urban scale.

4. Decision support systems applied to urban planning

As was underlined by Moccia, Sepe, Basile, and Terribile (2018) in modern society, one of the most binding problems for planners is certainly the mitigation of soil consumption and land sealing. The key role given to the mitigation of soil consumption by Moccia et al. (2018) lifts the interest of the tool on urban rather than territorial issues, since soil sealing - determined by the coverage of lands with impermeable materials, which partially or totally inhibits the ability of the soil to perform its vital functions - is a problem mainly concentrated in metropolitan areas.

Soil sealing, or the permanent covering of part of the ground and its natural soil with artificial materials (such as asphalt or concrete) for construction, for example, of buildings and roads, is the most obvious and widespread form of artificial cover. Generally, part of the settlement area is watertight, while gardens, urban parks and other green spaces must not be considered (European Commission, 2013). Other forms of artificial soil cover range from total loss of "soil resource" through removal by excavation (including opencast mining), to partial loss, more or less remediable, of functionality, due to phenomena such as compaction, e.g. unpaved parking areas (ISPRA, 2018). Soil sealing is the main cause of soil degradation in Europe, since it involves an increased risk of flooding, contributes to climate change, threatens biodiversity, causes the loss of fertile agricultural land, natural and semi-natural areas; together with urban sprawl contributes to the progressive and systematic destruction of landscapes, especially the rural ones (European Commission, 2012).

The data coming from the new cartography SNPA (*Sistema Nazionale per la Protezione dell'Ambiente*) show that, at the national level, artificial coverage of soil has increased from roughly 2.7% in the 1950s to 7.65% (7.75% net of the surface of the permanent water bodies) in 2017, with an increase of 4.95 percentage points and a percentage growth of more than 180% (and with a further 0.23% increase in 2017). In absolute terms, land consumption now affects 23.063 square kilometres of the Italian territory with a net growth of 5.211 hectares (52 square kilometres) in 2017 due to the difference between new consumption (5.409 hectares, 54 square kilometres) and restored soil. The most affected areas are the northern plains, the Tuscan axis between Florence and Pisa, Lazio, Campania and Salento, the main metropolitan areas, coastal areas, in particular the ones along the Adriatic Sea and within Liguria, Campania and Sicily (ISPRA, 2018).

The most striking effect of soil sealing is certainly related to water management. The complete sealing, in addition to reducing water infiltration, prevents evaporation and transpiration, decreasing soil moisture, which - among other effects - is no longer able to function as water reservoir, also decreasing the ability to recharge the aquifers. The inability of sealed areas to absorb most of the water greatly increases the surface flow and can facilitate the transport of contaminants to nearby areas (Coppola, 2016). The industrial decline of some cities has led to the abandonment of large, currently unused, sealed areas (brownfields), and on the other hand has encouraged the migration of the population to areas of new expansion, often taken away from agricultural areas or green areas (woods and forests).

It is worth remembering that, in the 1990s, there was a loss of 10 hectares of land per day in the EU solely for the construction of new motorways. In these areas the loss of soil functions is practically total, and also the adjacent areas, generally not sealed, are often severely damaged by contamination due to traffic and road maintenance products. Very often the expansion of inhabited centres corresponds to the construction of buildings in fertile

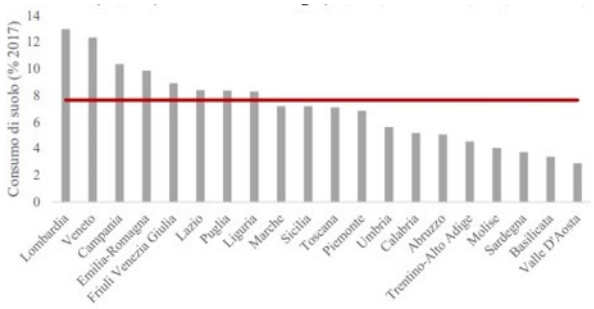

Figure 3: Land consumption at regional level (% 2017). In red the national average. *Source: ISPRA, 2018.*

Table 1: Ecosystem services.

Services	Indicators	Calculation tool
Carbon storage and sequestration (flow and stock)	Amount of carbon captured from natural and semi-natural forest ecosystems	Formulas taken from academic literature
Habitat quality	Presence of biodiversity according to land use classes "on the assumption that areas with a higher quality of habitats host a higher wealth of native species and that the decrease in the size of a specific habitat and its quality lead to the decline of the persistence of species"	InVEST software Habitat Quality model
Agricultural production (flow and stock)	Average agricultural value associated with land use classes	Data Agency of Revenue LIMIT: territorial extension ISTAT agricultural regions
Wood production (flow and stock)	Wood extension	CUAS
Pollination	Presence of pollinating species	InVEST software Pollination Crop model
Micro-climate regulation	Thermic increase associated with increasing energy costs	
Removal of particulate matter and ozone	Removal of two air pollutants, atmospheric particulates (PM10) and tropospheric ozone (O3), by forest ecosystems	GIS software
Protection from erosion	Potential erosion of soils	InVEST Software Sediment Delivery Ratio (SDR) software
Availability of water	Storage capacity and retention of water by soil and subsoil; degree of permeability and slope	InVEST Software Bigbang 1.0 model (developed by ISPRA)
Regulation of the hydrological regime	Reduction of the fraction of water flowing to the surface and its speed and availability of water in the soil and recharge of the aquifers	InVEST Software Bigbang 1.0 model (developed by ISPRA)
Water purification	Soil depurative ability	NDR model (work in progress)
Support to human activities	Scarcity of soil resource	Suitability

Source: ISPRA, 2018

areas of the territory, more subject to natural phenomena such as flooding. For example, the airport of Rome was built in an area characterized by soils of good fertility, or the numerous industrial settlements built with the funds of the "Cassa del Mezzogiorno" in the productive plains of southern Italy (ISPRA, 2016). The comparison between urbanization and land use capacity classes (Land capability classification) showed that urban expansion has affected areas with high agricultural production potential. Such instruments should become an essential part of urban plans, industrial development plans, etc. with the aim of highlighting the risks of degradation, or ultimate loss, arising from

inappropriate uses of the soil resource. Some indicators of ecosystem services have been suggested for the implementation of the new web-GIS LANDSUPPORT, namely the most accredited ones by the ISPRA Report and those of the Research Centre for Soil Consumption (CRCS).

5. Conclusions

Despite important European policy documents (COM 571, 2011; SWD, 2012) aiming at zero net land consumption by 2050, it seems necessary to introduce the principle that actors causing soil sealing should be obliged to re-establish the original state of the soil before the intervention or, alternatively, to compensate the community for the loss of the resource. Certainly, as many observers argue, to be effective, the fight against soil consumption must be carried out through the tools of urban planning and landscape planning, and this happens very rarely (Artmann, 2014).
Careful and skilful planning, and choose building techniques with limited negative effects, could minimize soil sealing. Spatial planning can involve large areas through the protection of natural zones and agricultural soils, but also by strengthening these areas and creating a green network of connection, in order to increase the resilience level of territories. Spatial planning can affect municipal planning with technical measures related to implementation planning through densification, i.e., building taller buildings, thus entailing limited land use. This must necessarily be combined with the challenge to climate change, where planning must take on a central role, able to guide transformation, especially in urban areas.

Table 2: Ecosystem services.

Services	Indicators	Calculation tool
Micro-climate regulation	Difference in the level of cooling between "zero option" and various projects in relation to the presence of weak population groups	n. of inhabitants weighted with intensity of class change
Nature-based reconstruction	Potential reconstruction Recreation Opportunity Spectrum	GIS software ESTIMAP model (Zulian et al., 2018; Zulian et al., 2013)

Source: Cortinovis & Geneletti, 2018

Table 3: Ecosystem services.

Services	Indicators	Calculation tool
Cooling caused by green urban infrastructure	Shadow effect	% area covered by shadow / open space area
	Evaporation - transpiration	ETA

Source: Zardo et al., 2017

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