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LANDSUPPORT Decision Support Systems: performance at EU, country, regional and local scale

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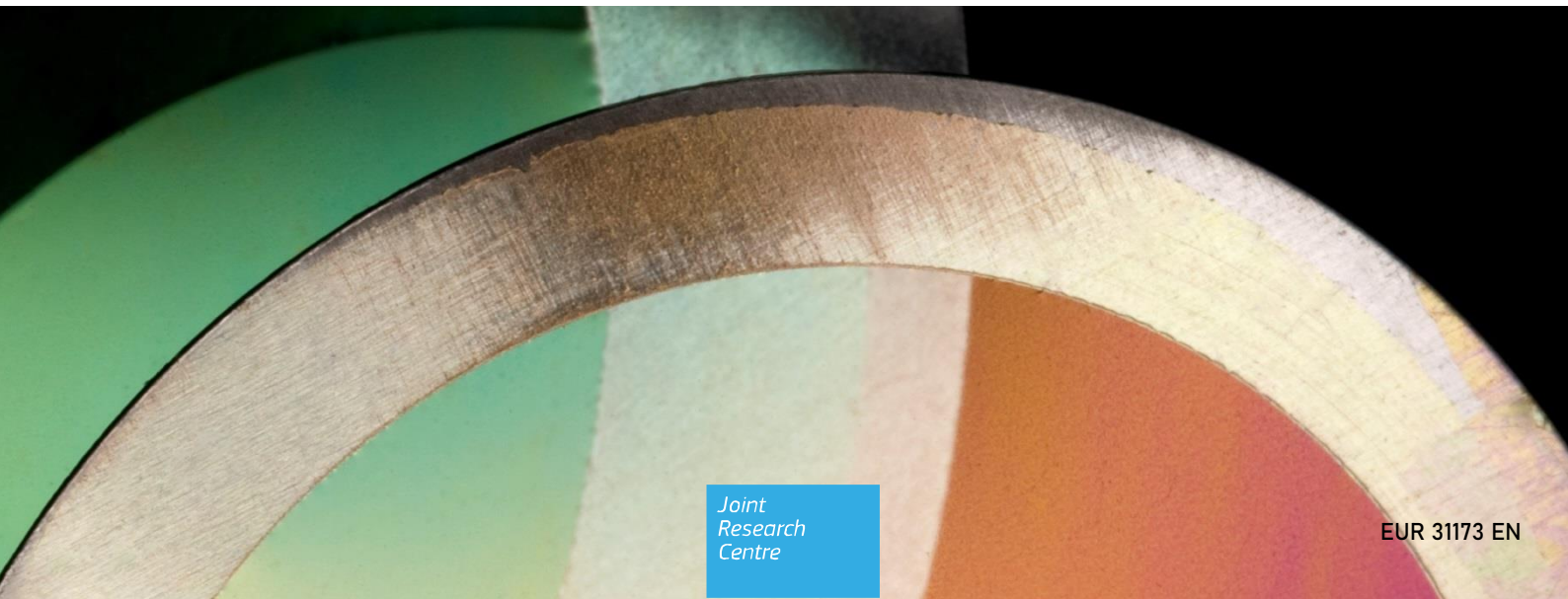

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Contents

Abstract

Developing a methodology for the analysis of the anthropogenic intervention on natural capital is an ambitious process. The LANDSUPPORT project implemented a Decision Support System (DSS) to help support better land use planning. The LANDSUPPORT DSS aimed at creating an innovative and intuitive environment that will improve the readability of measured and modelled geo-information, making it accessible to a wide range of stakeholders. A cross-evaluation analysis has been developed to measure the ability to support policy-related stakeholders and help them make informed decisions.

In the field of land use and land management, appropriate data are essential to support effective land planning in which different sources of available information need to be synthesised to provide an holistic picture of their combined effect. Policy stakeholders play a pivotal role in designing the DSS to be transversal and able to cope with issues at local, national and regional scales.

National and regional land monitoring projects are often evenly disseminated or unsuitable for policy needs. Many attempts were recently made to overcome this problem, and the concept of decision dashboards is now extensively used to address these challenges.

DSS are growing in popularity. They are often distributed as open access online interfaces that use georeferenced data and visualization tools to present model metrics and key performance indicators. Data behind DSSs can be static or dynamic as it is for the LANDSUPPORT DSS. The set of tools developed at different scales within different domains of application, are regularly updated and obtained from the state-of-the-art scientific development.

With the user in mind, the LANDSUPPORT DSS encourages an extensive range of policy stakeholders to perform land use analysis, improving the tool's usability and making informed decisions for land sustainability. Decisions on land management at local scale are already benefiting from such information systems.

For the EU, specific tools were developed, tailored to the specific needs of stakeholders. For instance, in line with its strategic plan, Italy uses specific functionality and indicator sets to support its decision-making across agriculture sectors (viticulture and oliviculture tools are tailored examples of the DSS dynamism).

Another goal of DSS is to improve geodata integration across highly compartmentalized sectors. Each tool which appears in the dashboard will undergo regular improvements as the backend platform is refined. The LANDSUPPORT tool allows for the analysis of soil sealing in the land take tool, the land degradation neutrality tool (SDG 15.3.1 indicator), and the climate change resilience through another dedicated tool embedding future scenarios of climate change based on CORDEX ensemble models and (Representative Concentration Pathways, RCPs).

Given the challenge of identifying and gaining access to good quality data from local partners, the LANDSUPPORT project fostered the capacity building among partners through workshops and other interactions and drew attention to better data management and improved accessibility and sharing. Embedding data access and its use in end-user organizations is vital to generating and sustaining interest in the dashboards.

This demonstrates that the data are being incorporated into the decision-making dashboards; equally important, they are presented in an accessible format that allows their visualization and re-analysis. As the capacity to enhance the accessibility of scientific evidence grows, LANDSUPPORT will be able to provide end-users, from government officials to communities - with more affluent and more helpful information to support critical decision-making processes. The dynamic process behind the development of decision-making dashboards imparts stakeholder groups the value of data and evidence in decision-making processes and enhances their capacity to use such information. This is likely to bring about transformative change in using scientific evidences in decision-making.

This report presents the analysis carried out to test the LANDSUPPORT DSS's ability to support EU policies when applied at the EU scale. Key EU policies of interest include the 7th Environmental Action Porgamme; COM 2006/231 Soil Strategy, Dir 2000/60/EC Water Directive; Dir 2007/2/EC INSPIRE

Directive. and the land-related targets of the 2030 Sustainable Development Goals (SDGs) in particular, SDGs 2 "Zero Hunger", 3 "god healh and well-being", 13 "Climate action", 15, with a special emphasis to the key SDG 15.3.1, "achieving a land degradation-neutral world" (LDN) and climate change (CC) mitigation goals.

To achieve this objective, three main actions were undertaken:

1. Evaluation of the LANDSUPPORT DSS's ability to support selected EU policies and soil related Sustainable Development Goals (SDGs).
2. Semi-structured interviews with senior EU officials and experts of the European Commission, to test the usability of the selected tools at different scales[1]
3. Test the LANDSUPPORT platform, through an assessment of the European scale tools output, an analysis and conformity check of the data delivered by the tools and a critical review of results.

As a general outcome, the tools were co-designed and conceptualized to deliver an overview of the regional extent using the Classification of Territorial Units for Statistics (NUTS) at 1, 2, 3 level and local administrative units, giving the planner and the policymaker an instrument to use these results as a viable solution which will help achieve policy objectives. The EU scale tools, i) Land Take, ii) Evaluating land degradation (LD) threats, and iii) Climate resilience agriculture, can communicate salient trends to decision-makers without a geodata management background and without downloading a high amount of geodata in local computers and geographical information systems available.

[1] as requested in the amended version of the grant agreement beginning of the year 2022

Foreword

LANDSUPPORT stands for "Development of Integrated Web-Based Land Decision Support System Aiming Towards the Implementation of Policies for Agriculture and Environment".

The project aimed at developing a web-based completely free, open-access GeoSpatial Decision Support System (S-DSS) devoted to reconciling agriculture, environmental sustainability and policy support and implementation.

LANDSUPPORT is an H2020 funded call in which the JRC was involved as a partner. The JRC D3 Sustainable resources Unit, was involved in several WPs and with this technical report an overview on the performance at EU, country, regional and local scale is given to a broader audience.

Overall, the S-DSS contributed to inform policy stakeholders and support the implementation of land policies in Europe, and it will promote an integrated and participatory approach towards rural development and environmental policies allowing, among others, evaluation of trade-offs between different land uses.

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1. Introduction

In the EU, the protection of Natural capital is mainly ensured through policies. Policies are improving over time and scientific data and evidences are the only way to help shaping more informed and more effective policies. In this context, the development of tools that help policymakers make more informed decisions is important, especially to safeguard our land.

The LANDSUPPORT DSS platform and integrated modelling approach supply multiple applications to support the sustainable management of land resources and sustainable agriculture and forestry practices. LANDSUPPORT tools combine up-to-date data sources with state of the art algorithms that can help take better informed and effective decisions and use a dynamic system that can offer the closest picture to reality using the best available geodata source (European, national and local scale).

By co-designing geospatial tools with the local and country policy stakeholders, the LANDSUPPORT project helped local government agencies to improve their capability. Engagement and collaboration with policy stakeholders were the pillars of LANDSUPPORT project, together with the highly performing data analysis and visualization in the platform dashboard.

Geospatial dashboards have been developed at the national and county levels to help users gather, visualize, analyze spatial data, and advise policy stakeholders. LANDSUPPORT tools used state-of-the-art research findings to translate the data into knowledge and the visual capacity of the interactive geospatial dashboard, which includes additional map integration, spatial data analytics, and geographic visualization for decision support and monitoring.

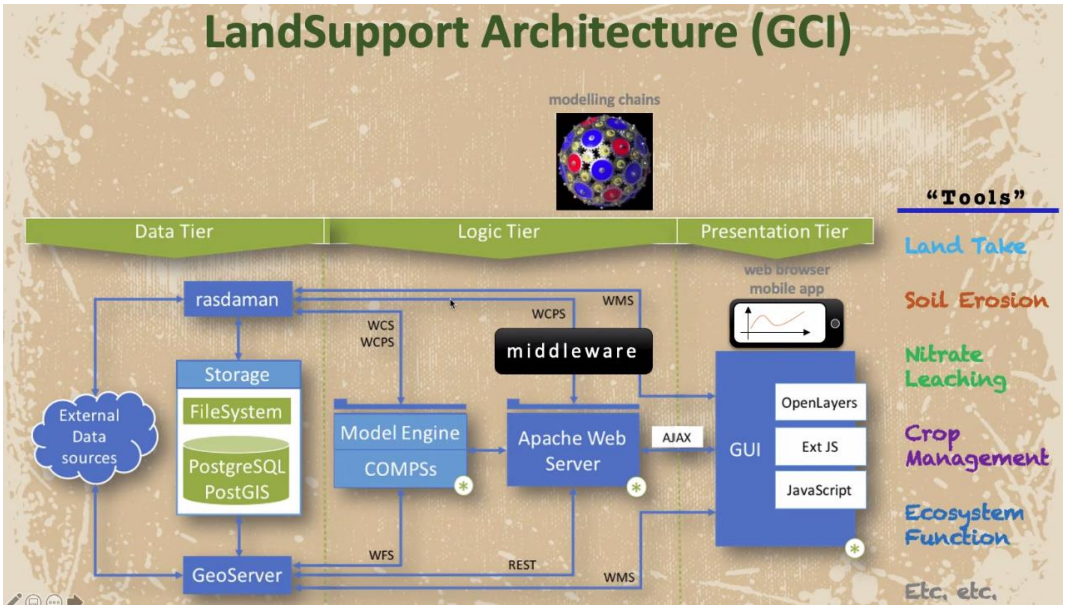
The LANDSUPPORT project mainly focused on land indicators and spatial information models, including land take trends, climate change, and land degradation (SDG 15.3.1) indicators at a European scale. Such data can be directly used to inform decision-makers on the trends in land conditions.

The data sources used in the land support platform are gathered from official governmental websites and trusted institutions. Policies and Directives considered in this report were retrieved from the official website containing EU laws (EUR-Lex).

LANDSUPPORT has linked multiple actors and institutions involved in a policy network. Despite the complexity of policy-making, tools for measuring and informing policymakers can drive the development of new ideas and contexts.

As we experienced during the pandemic outbreak, new threats need to be tackled, through geospatial dashboards and web-based applications, information can be shared faster and effectively. The LANDSUPPORT toolset allows for a quick analysis of soil sealing in the land take tool, an analysis of the status of the land degradation (SDG 15.3.1 indicator), and analysis of climate change resilience through another dedicated climate change tool embedding future scenarios of climate change (Based on CORDEX ensemble models and (Representative Concentration Pathways, RCPs).

Figure 1. LANDSUPPORT architecture



In the EU, with one of the most developed regulations on natural capital (water, air and soil), measurements for specific land monitoring issues and their accounting needs constant improvement. Member states face challenges with science and innovation, but data availability often represents the bottleneck. When data are available and at detailed spatial and temporal resolution, a second common issue is data processing, data analysis and graphical display.

In the EU, land-related data are provided by the statistical office (Eurostat) and environmental institutions such as the European Environmental Agency (EEA). The national and European statistical offices monitor major land use accounting based on their value, often measured through market prices and trends. This knowledge is derived from census-based information, modelling, and remote sensing data often aggregated at the NUTS 2 level.

The LANDSUPPORT tools developed at European level can inform policy on environmental pressures and flows (Figure 1); for instance, an added value feature in the land take tool monitoring is represented by the associated soil quality measurement (Toth et al., 2013). The LANDSUPPORT DSS has the potential to address the measurement of multiple environmental challenges and provide more complete measures to inform policy. All tools inherit the limitation of the original dataset, each of the available tools is designed for a specific application and a specific scale.

The LANDSUPPORT 's ability to support policies depends on specific policy objectives that can respond to incoming challenges and develop workable solutions that will add value to the lives of people in the EU. We collect and interpret the available outcome of the European scale LANDSUPPORT tools and compare country and local scale results with scientific literature, other similar initiatives, and ancillary data on land management.

In this report, Chapter 1 presents the evaluation of LANDSUPPORT in terms of its relevance, performace and potentiality for relevant EU policies for the 3 family of tools: climate change & resilience, Land Degradation Neutrality and Zero Land Net Take. Chapter 2 presents the evaluation of LANDSUPPORT tools to support soil related SDGs with their data availability. The third chapter presents the results of semi-structured interviews with senior EU officials and experts of the EC. The fourth chapter presents the performance of LANDSUPPORT at country, regional and local scales (Hungary, Austria and Italy), while the final chapter describes thefuture outlook for the LANDSUPPORT tool.

1.1. Review of previous DSS for environmental policy

A literature review of existing applications of DSS for environmental policies support has been carried out in the frame of the WP1 project Task 1.3 (LANDSUPPORT WP1, De Paoli et al., 2019), to see how such tools have effectively supported environmental policy so far, for the uptake of existing models and tools, to discover the reasons behind failure or success of these models and collecting additional good practices which might serve as an inspiration for the project. This has been done to dentifying the potential of applying LANDSUPPORT DSS geospatial tools to a multi-scale analysis of the main socioeconomic parameters relevant for the land management implementation. As it was repoted, other DSS tools have been developed and applied to environmental decision-making; these efforts have yielded heterogeneous results because of technical issues and issues involving decision makers which are often the recipients of the DSS systems. The literature review provided recommendations on ensuring and maximizing the uptake of LANDSUPPORT tools during and after the project. According to McIntosh et al., (2011), despite the perceived value of DSS applications to environmental and natural resource management, DSS tools often fail to be adopted by intended end-users. LANDSUPPORT was conceived and designed to ensure users' participation in the DSS design and testing, as well as technical training on the DSS functioning: promoting the DSS use during and after the project's end. Matthies et al. (2007) identified three different user groups, i) Environmental scientists or system analysts; ii) Environmental managers or decision-makers; and iii) Environmental stakeholders. The most common usage seems to be a person driving the DSS as a system analyst in collaboration with environmental managers and decision makers. Secondly, what are the success factors already identified in the literature? The factors highlighted by McIntosh et al. (2011) can be

summarized as: i) design for ease of use the usefulness of the tools, ii) establishing trust and credibility, iii) promoting DSS for acceptance, iv) planning for longevity and starting simple and small are the best practice recommendations. Although there have been found several examples of DSS applications to environmental policies in the literature, only four case studies were related to the aspects listed in the WP1 technical report, namely MULINO DSS, SEAMLESS, RUBDA and NB DSS in the Nile Basin[1.1]. The decision-making context of supporting a Framework Directive implementation, targeting water management authorities MULINO DSS: Mysiak et al. (2002); is a researchers' initiative about the integration of socioeconomic and environmental modelling techniques with GIS capabilities and multi-criteria decision aids. The decision-making question is the development of river basin management plans, in particular: identification of pressures and assessment of impacts, identification of best options and stakeholders involvements in the planning process. Other examples can be the SEAMLESS project van Ittersum, M.K. & Wery, J. (2008) which developed science and a computerized framework for integrated assessment of agricultural systems and the environmet, funded by the EU Framework Programme 6, targets at a working version of the integrated framework by 2009 for its prime users in the European Commission. The RUaha Basin Decision Aide (RUBDA) aimed at supporting users, such as the Rufiji Basin Water Office or the District Councils in making decisions regarding the allocation of water between sectors. It provides means of running policy-driven scenarios, physical changes scenarios and water demand scenarios Cour, et al. (2005). Information on the participatory process, the uptake after the end of the project and success factors were the most complex information to be found. Of course, evaluating the success of a DSS after the end of the project is very challenging because the project is over and, in general, no funds are allocated after the official project's end – also because, usually, projects focus mainly on the development and testing of a DSS. In addition, as pointed out by McIntosh et al. (2011), how the success of DSS should be evaluated is still one of the main challenges facing the development and adoption of DSS: whilst success can be framed in terms of interactions with end users, difficulties of definition and measurability emerge about the extent to which DSS achieve the intended outcome.

In three cases out of four, the DSSs were developed under the initiative of researchers, and only in the Nile basin was the DSS developed under users' request: how to make sure that a DSS proposed by researchers is helpful for decision-makers or for other groups which are intended to use the DSS remains an open question. In all cases, a participatory process was implemented in the course of the project mainly in the development phase and in the form of technical training after the DSS was developed. Involvement of stakeholders from the very beginning of the project, in the DSS planning phase, does not seem to be common practice, although it would definitely be helpful for the development of an applicable DSS. The uptake of the DSS after the project's end is documented only in the case of SEAMLESS, whereas for the NB DSS, only technical training for the user is mentioned. Nevertheless, in both cases, some valuable suggestions to improve the success of the LANDSUPPORT DSS, as well as its uptake after the project's end, were retained as a source of inspiration for the LANDSUPPORT project and namely:

- **Creation of a DSS users' association to maintain and disseminate the DSS;**
- **Creation of a helpdesk and a user community portal;**
- **Joint ownership by institutions using the DSS;**
- **Commitment to financing the system after the project (e.g. by the Government or other institutions).**

LANDSUPPORT project has improved communication between stakeholder, continuous support for users and extensive testing activities (this report is part of it).

1.1 https://nilebasin.org/87-information-hub/26-nile-basin-decision-support-system-nb-dss

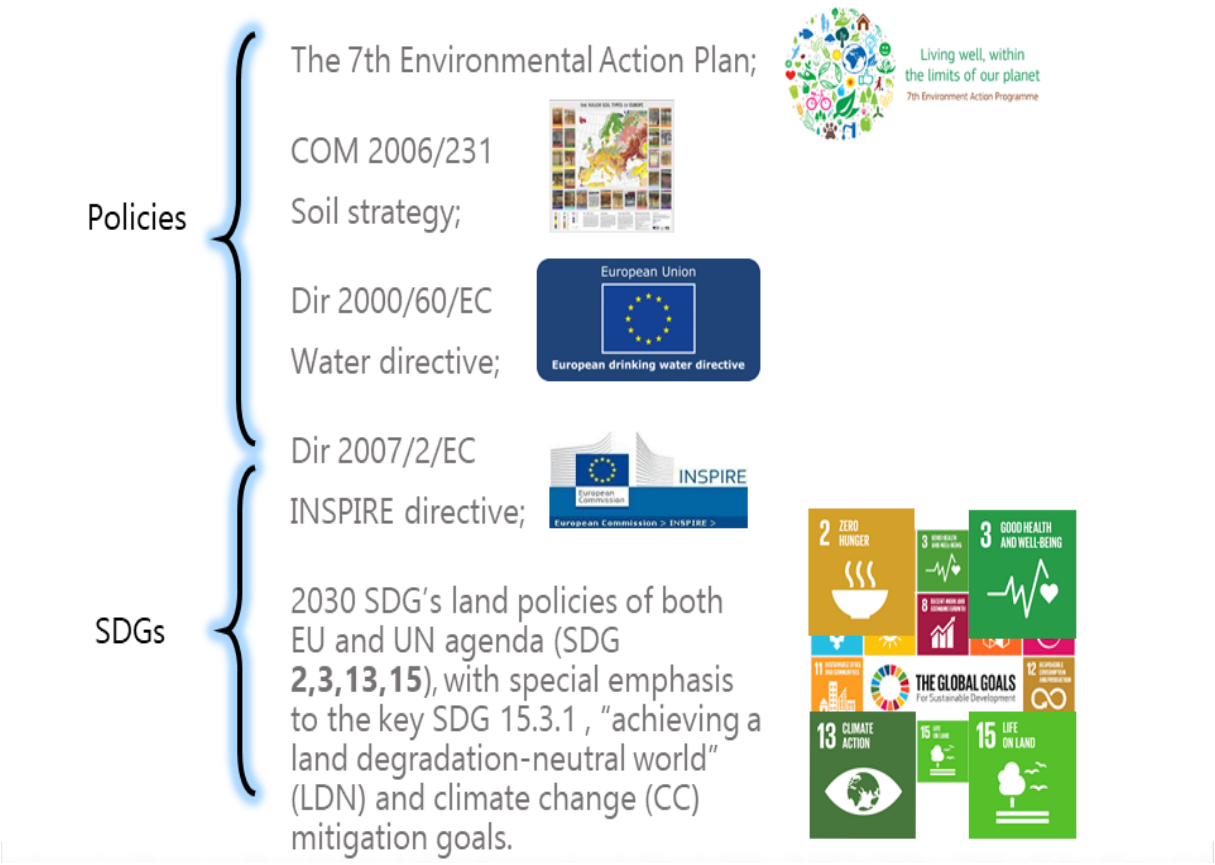
1.2. Evaluation of LANDSUPPORT tools relevance, performance and potential for EU policies

The LANDSUPPORT grant agreement contains four relevant land policies, directives and SDGs as recipients of the project outcomes.

- 7th Environmental Action Plan;
- COM 2006/231 Soil Strategy,
- Dir 2000/60/EC Water Directive;
- Dir 2007/2/EC INSPIRE Directive,

These could benefit from the results delivered by the tools. The relevance and potential contribution of the DSS to the policy are assessed qualitatively according to the ability of the tool to inform policy and provide timely analysis and to drive decisions (Figure 2).

Figure 2. LANDSUPPORT tools performance and potential for EU policies.



We assessed the performance of the LANDSUPPORT at European, national and local scale tools regarding selected EU policies and SDGs based on the analysis of the tool output (table 1. Tools relationship with policies, and table 4, Tools relationship with SDGs), the usability of the DSS, which included participation at workshops with stakeholders and evaluation of the participants' feedback.

Next, to define which DSS tool could be highly policy-relevant, we examined the 15 sub-tools of the three European scale tools and ranked their potential relevance using the Likert scale (1=low, 2=moderate, 3=adequate, 4=high and 5=very high) as it was adopted in (Pe'er et al., 2019). For the INSPIRE directive we refer to fully compliant (5) when data and metadata are available for visualization and download in the LANDSUPPORT platform, otherwise, partly compliant (3).

The analysis was performed by the authors of this technical report and by senior EU officials and expert employees by EC with a high level of familiarity with the specific policies and SDGs, selected randomly while trying to achieve a balanced number of interviews for each policy and representation

of scientific topics. We obtained 14 replies, with a proportional representation between EU officials and expert employees by EC (n=7) and EC experts from modelling and earth sciences (n=7). Some answers with qualitative replies (e.g. neutral) were replaced by their average value. The potential relevance of the LANDSUPPORT tools and data to each selected policy was then classified as low, moderate, high and very high based on the result of the interviews.

Finally, we identified potential improvements for the proposed LANDSUPPORT tools based on the literature, usability and results of the interviews of stakeholders. A set of actions is presented to further develop the tools, build upon the existing tools, create missing instruments, improve data flows from providers to end-users, and allow users to download row data and modelling results.

LANDSUPPORT Graphical User Interface (GUI) has been implemented as a modular dashboard: system administrators and users will be able to configure the GUI to adapt the systems to distinct contexts and user requirement. The system contain several tools addressing agriculture, environment and spatial planning analysis. Through the GUI, users can see data for selected periods and for their area of interest and then they can access to data modelling and services provided by the LANDSUPPORT Project. Results are visualized in different forms: maps, tables and reports can be downloaded.

Table 1. Tools relationship with selected policies, 7th Environmental Action Plan; COM 2006/231 Soil Strategy, Dir 2000/60/EC Water Directive; Dir 2007/2/EC INSPIRE Directive,

FAMILY OF TOOL	TOOL	Sub-tools	7th Environmental Action Programme	COM 2006/231 Soil protection strategy 2014,	Dir 2000/60/EC	Dir 2007/2/EC
b. Climate resilience agriculture	**Climate Change resilience**	**Land general climatic anomalies**	High	High	High	Moderate
i. Evaluating, multilevel land/soil degradation (LD) threats	**Evaluating land/soil degradation (LD) threats**	**Land Degradation Neutrality SDG 15.3**	Moderate	low	low	Moderate
k. Land Take	**Geospatial knowledge**	**Environmental report**	Moderate	Moderate	Moderate	Moderate
		Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS	High	low	Moderate	Moderate
	Monitoring	**Land take monitoring and advanced**	High	High	Moderate	Moderate
	Planning	**New urban development and Model urban development and new green corridor**	High	Moderate	Moderate	Moderate
		Land use Land Cover Change (LULCC)	High	Moderate	Moderate	Moderate

1.3. "Climate resilience agriculture" Tool

With this tool, future climatic scenarios can be investigated to better plan territorial policy interventions to increase the climate resilience of territories. Climate change is an ever growing threat for the EU like the rest of the world, and we expect future weather extremes and related issues[2]. This leads to many adverse impacts on ecosystems, economic sectors, and human health and well-being. Therefore, actions to adapt to climate change are paramount and should be tailored to the specific circumstances in different parts of Europe. In addition, global efforts to reduce greenhouse gas emissions can play a role in limiting wheater extremes such as prolonged droughts, floods and other natural hazards.

The LANDSUPPORT "Climate Change indicator" tool should be used preferentially at the national level and is meant to support the implementation of EU Member States' National Adaptation Strategy and National Adaptation Plans. The tool is also helpful for a wide range of stakeholders (e.g. environmental protection authorities, water district authorities, regional parks, service management companies, trade associations, non-profit associations, and business groups) involved in the national adaptation strategy/plan planning and implementation.

The Tool results are printed in the form of a .pdf report containing the following set of indicators:

- **Maximum Temperature anomaly Indicators**
- **Minimum Temperature Indicators**
- **Mean Temperature Indicators**
- **Precipitation anomaly indicators**

Anomalies of the General Climatic Indicators are calculated (and thus reported) as the difference between the selected Scenario period (2041-2070 or 2071-2100) and the reference period (1981-2010) by taking into account the selected IPCC scenario (RCP4.5 or RCP8.5) Table 2. The tool can be helpful for warning on the potential climate condition with no actions taken; land planning can benefit from it. For example, a policymaker can use an analysis of scenarios to design policies that prevent and minimize the impacts of climate change on the territory. The same can be said of planning future activities that reduce environmental impacts and waste resources.

[2] the Representative Concentration Pathways, RCP models ("Climate Change 2022: Impacts, Adaptation and Vulnerability | Climate Change 2022: Impacts, Adaptation and Vulnerability," IPCC) in many regions (https://ec.europa.eu/clima/eu-action/adaptation-climate-change/eu-adaptation-strategy_en).

Table 2. Climate resilience, Territorial scale: Europe Name : Administrative Limit, Ispra, NUTS level 4

Extention [ha] : 1628.2 Centroid location : 45.81393 N 8.61216 E, IPCC scenario (RCP4.5 or RCP 8.5).

Indicator	RCP4.5		RCP 8.5	
	Reference period 1981-2010 vs 2030-2070	Scenario period 1981-2010 vs 2070-2100	Reference period 1981-2010 vs 2030-2070	Scenario period 1981-2010 vs 2070-2100
Maximum Temperature Indicators (9)				
Maximum Temperature (°C): mean of daily maximum temperature - T (°C)	2	2	2	4
Minimun value of daily maximum temperature - Txn (°C)	2	2	2	4
Maximun value of daily maximum temperature - Txx (°C)	2	2	2	5
Ice Days - number of days with maximum temperature less than 0°C - ID (days)	-1	-1	-1	-1
Summer Days - number of days with maximum temperature greater than 25°C - SU (days)	20	20	24	47
Hot Waves - number of days with maximum temperature greater than 35°C - HW (days)	2	3	4	10
10° percentile of maximum temperature (°C) - tx10prctile	2	2	2	4
95° percentile of maximum temperature (°C) - tx95prctile	2	2	2	5
99° percentile of maximum temperature (°C) - tx99prctile	2	2	2	5
Minimum Temperature Indicators (9)				
Minimum Temperature (°C): mean of daily minimum temperature - Tn	1	2	2	4
Minimun value of daily minimum temperature - Tnn (°C)	2	3	2	5
Maximun value of daily minimum temperature - Tnx (°C)	2	2	2	5
Frost Days - number of days with minimum temperature less than 0°C - FD (days)	-20	-28	-30	-51
Tropical Nights - number of days with minimum temperature greater than 20°C - TR (days)	8	9	12	29
Consecutive Frost Days - maximum number of consecutive days with minimum temperature less than 0°C - CFD (days)	-9	-12	-13	-21
10° percentile of minimum temperature (°C) - tn10prctile	2	2	2	3

95° percentile of minimum temperature (°C) - tn95prctile	2	2	2	5
99° percentile of maximum temperature (°C) - tn99prctile	2	2	3	5
Mean Temperature Indicators (6)				
mean of daily mean temperature - TG (°C)	2	2	2	4
Heating Degree Days - sum of 17°C minus mean temperature - HD17 (°C)	-550	-667	-754	-1368
Growing Degree Days - sum of mean temperature greater than 4°C. GD4 (°C)	410	481	563	1069
10° percentile of mean temperature (°C) - tg10prctile	1	2	2	4
95° percentile of mean temperature (°C) - tg95prctile	2	2	2	5
99° percentile of mean temperature (°C) - tg99prctile	0	-1	-1	-1
Rainfall indicators (15)				
Precipitation sum - PRCPTOT (mm)	-20	112	60	37
Total Precipitation - precipitation sum in wet days (days with precipitation greater than or equal to 1 mm) - PRCPTOTW (mm)	-20	109	60	38
maximum 1-day precipitation amount - Rx1day (mm)	3	9	6	15
maximum consecutive 2-day precipitation amount - Rx2day (mm)	4	13	9	19
maximum consecutive 3-day precipitation amount - Rx3day (mm)	4	14	10	16
maximum consecutive 5-day precipitation amount - Rx5day (mm)	4	20	13	17
simple precipitation intensity index - SDII (mm/wet day)	0	1	1	1
number of wet days - number of days with precipitation greater than or equal to 1 mm - RR1 (days)	-4	0	-2	6
number of heavy precipitation days - number of days with precipitation greater than or equal to 10 mm - R10 (days)	-1	2	0	-2
number of very heavy precipitation days - number of days with precipitation greater than or equal to 20 mm- R20 (days)	-1	2	1	0
Consecutive Wet Days - largest number of consecutive days with precipitation greater than or equal to 1 mm. CWD (days)	-1	0	0	-1
CDD (days): Consecutive Dry Days - largest number of consecutive days with precipitation less than 1 mm	0	-1	-1	-1
90° percentile of precipitation (mm) - pr90prctile	-1	1	0	0
95° percentile of precipitation (mm) - pr95prctile	0	2	1	1
99° percentile of precipitation (mm) - pr99prctile	2	7	4	7

The “Climate change resilience” tool is potentially used in the context of the following EU policies :

- **The 7th Environmental Action Plan**

The tool informs policy stakeholders of an increase in temperatures and a reduction of frost days all over the EU, which is very preoccupying. Droughts seem to be the major challenge foreseen by both RCPs scenarios.

- **The Soil protection strategy 2006 (COM 2006/231)**

The tool climate general anomalies informs the policy stakeholder of the future climates. To mitigate the effects of rising temperatures, the capacity of soils to retain water and sustain crop production is under threath; these data can be used to define susceptibility maps of land proned to desertification.

- **Dir 2000/60/EC, the WATER Directive.**

The tool warns the user about the reduction of the Frost days and altered precipitation regime that will impact the water availability.

- **Dir 2007/2/EC, the INSPIRE Directive**

Data delivered are partly compliant with the INSPIRE directive. All metadata is available in the technical sheets, along with the methodology and data sources.

1.4. "Evaluating land/soil degradation (LD) threats" Tool

This tool evaluates multilevel land degradation (LD) threats using the SDG 15.3.1 indicator

Changing climates, food safety, and land protection make land degradation monitoring a top priority in the new set of transformative policies like the EU green deal and the new soil strategy. LANDSUPPORT implemented the tool Land degradation neutrality (LDN), at the European scale, using the sub-indicators suggested by the Good Practice Guidance document delivered by the UNCCD (Sims et al., 2019). The indicator available on the platform is calculated via Trends.Earth software using the available data (Sims *et al.*, 2019, 2020). A novelty of the LANDSUPPORT approach used to calculate the SDG 15.3.1 is that high resolution land cover data (CORINE land cover) have been used to calculate the land cover sub-indicator. The indicator results reports the share of "degraded", "stable" and "improving" land. The results are presented in an accessible format that allows policy stakeholders as well as general public to visualize the data.

The tool contains a pre-calculated layer of the SDG 15.3.1 indicator. The indicator is calculated through the Trends.Earth plugin into the QGIS open source software. The plugin is able calculate the selected sub-indicators in cloud via Google Earth Engine (GEE). It computes the sub-indicator and also generates descriptives statistics for the Land cover change and the associated land productivity. The tool has the same pre-calculated layer at all levels (national, regional and local). This information is highly valuable for local project partners and associated policy stakeholders to assess the effect of land degradation on climate, population dyamics and food security.

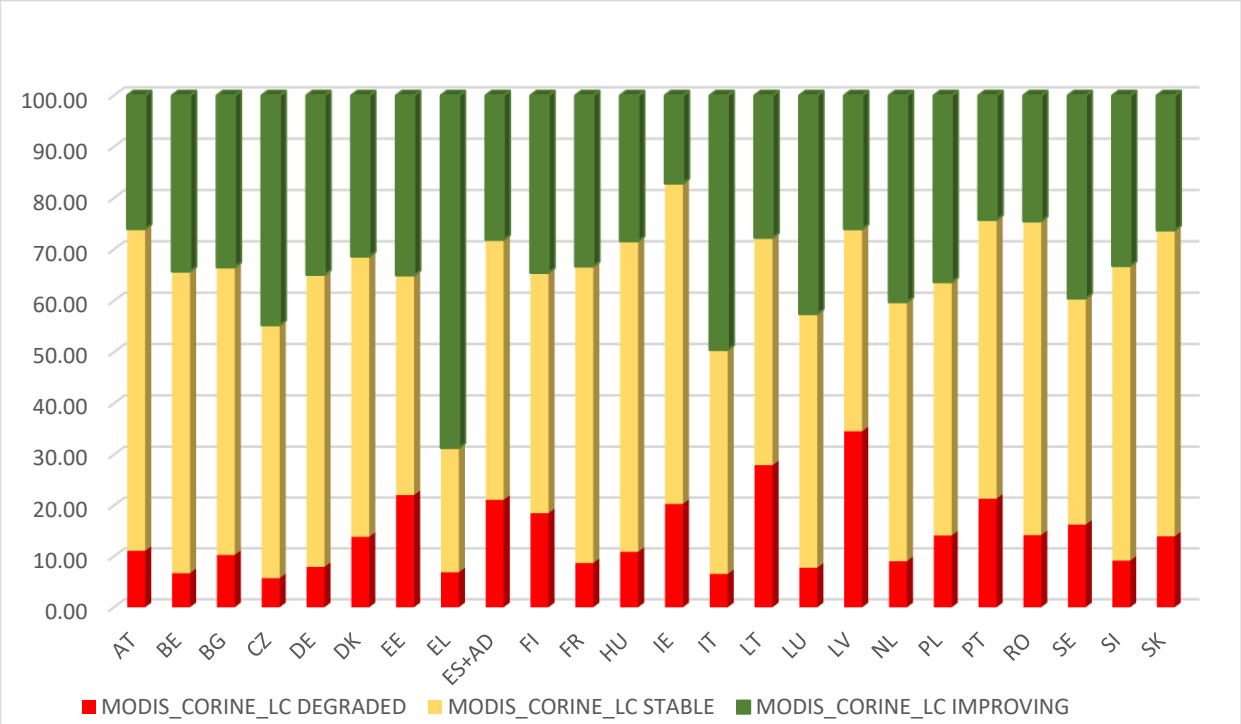
To assess the potential degraded areas as indicated by the SDG Indicator 15.3.1, the software uses the information of three sub-indicators: (i) vegetation productivity, (ii) LC, (iii) SOC stock. For that reason, using, the Trends.Earth software (Conservation International, (2018); Green et al., (2017) was used in this study, since it was developed specifically for that purpose of tracking LDN. The development was funded by the Global Environment Facility, in the frame of the "Land Degradation Monitoring Project", which is a partnership of Conservation International, Lund University, and the National Aeronautics and Space Administration (NASA) http://trends.earth. 2018 (Table 3).

Table 3. Sub-indicators and its spatially explicit maps & dataset

LD Sub-indicator	Spatial resolution/ Baseline period	Reference LD t_0	Reference / source
Land Productivity			
MODIS NDVI time series	250 m (2000-2015)	2000-2018	lpdaac.usgs.gov/products/mod13q1v006/
Land cover			
CORINE	100 m (2000-2018)	2000-2018	https://land.copernicus.eu/pan-european/corine-land-cover
Soil Organic Carbon			
SoilGrid SOC stock	250 m (2000-2018)	Static Layer, derived from the land cover change	www.soilgrids

The high degree of Improvement is still debated in the scentific community and many research are trying to disentangle the effect of Vegetation Indices time series which result in improvement of land conditions for the reporting period.

Figure 3. Land Degradation indicator, based on the MODIS Land Productivity, CORINE land cover, Soilgrid soil organic carbon stock.



Relevance, performace and potential for EU policies

- **The 7th Environmental Action Plan**

  The Tool can inform policy stakeholder about the share of degradation in a specific administrative level. The SDG 15.3.1 indicator can report the amount of degraded land but does not address the process that is acting. In the present form, it can not display the spatial extent of degraded land (Figure 3) but only the share. Further development is needed to, improve the calculation as well as the visualization and data sharing options.

- **Soil protection strategy 2004 (COM 2006/231)**

  The indicator provides an estimation of land degradation (sub-indicator SOC stock change); According to the Good practice guidance (GPG) document version 2 (Green et al., 2021), in future assessments, the SOC stock sub-indicator will be changed with the total Carbon (aboveground and belowground), which will likely lower the relevance of the soil in the indicator and will not allow to target specific soil protection strategy. In the LANDSUPPORT platform the EU scale assessment of the SDG 15.3.1 indicator was produced using the GPG v1. To improve the understanding of the role of each single sub-indicators used, further research is needed. The use of a more direct indicator of SOC dynamics (Based on LUCAS soil monitoring) can be beneficial to improve the accuracy.

- **Dir 2000/60/EC, the WATER Directive.**

  The indicator does not provide detailed information on freshwater bodies since the original spatial resolution of the data available on the platform is 300 meters there is not enough detailed to assess the status of small water bodies, large rivers and water bodies can have in their surrounding vegetation patterns highly depended on the seasonality and rainfall regimes, therefore natural trends can be observed in these particular ecosystems.

- **Dir 2007/2/EC, the INSPIRE Directive**

  Data delivered are partly compliant with the INSPIRE directive. All metadata is available in the technical sheets, along with the methodology and data sources. The detailed technical sheet, guide the users into the data sources and the software procedure to calculate the indicator from the three sub-indicators.

1.5. "Land Take" tool

The regular mandate to produce a European wide Land Take assessment is a task of the European Environmental Agency (EEA). Land take includes areas sealed by construction of infrastructures, sports and leisure facilities. The trend shows a land take increases in the last decade, but the increase was less significant after 2012, primarily due to the economic recession. The EU plan defined by the EC Roadmap to a Resource Efficient Europe (COM(2011) 571 – "no net land take by 2050") is a non-binding target, and few EU Member States have quantitative policy targets to reduce land take.

Among the valuable data and tools to map land take, the sources are: i) Copernicus Corine Land Cover (Bossard *et al.*, 2000) where only changes above 5 ha are considered, ii) Imperviousness which offers a high resolution but does not allow to know what type of land has been lost, iii) Urban atlases.

Imperviousness is the covering of the soil surface with impervious materials resulting from urban development and infrastructure construction (buildings, constructions and layers of entirely or partially impermeable artificial material, e.g. asphalt, metal, glass, plastic or concrete). Sealed/Impervious areas are characterized by substituting the original semi-natural land cover or water surface with an artificial, often impervious cover (Haase & Nuissl, 2007).
These artificial surfaces are usually maintained over long periods. Changes in imperviousness have significant implications for biodiversity, soil functions (including carbon storage and sequestration), hydrological properties, provision of ecosystem services and nature conservation. In particular, exchanges of energy, water, and gases are restricted, and pressure on the adjacent, non-sealed areas is increased (Altobelli *et al.*, 2020; Ronchi *et al.*, 2019).
Land monitoring at the EU scale would benefit from having a multiscale system of accounting which can deliver a detailed inventory of the trends and the most populated regions. Under the Land Take toolset, specific tools such as Fragmentation and Green Infrastructure can also raise awareness among local stakeholders to take action to reduce habitat fragmentation, soil sealing and pollution and improve flood protection.
The EEA imperviousness products capture the percentage and change of soil sealing. The imperviousness captures the spatial distribution of artificially sealed areas, including the level of sealing of the soil per area unit. The classification in different levels of sealing "packed soil" (imperviousness degree 1-100%) is produced using a semi-automated classification based on calibrated NDVI. In the LANDSUPPORT (k) tool, the imperviousness high-resolution dataset is available at 10-20 m spatial resolution and covers all European countries. The results given by the tool also consider the soil quality index (Tóth et al., 2013), where soil productivity was evaluated by three main land-use types (cropland, grassland, forest) using a validated expert model called SoilProd. Models include soil, climate and topographic criteria.

Land take monitoring

The main advantage of this set of tools is to adapt the model to the data available at different scales. For instance, the Land take tool used Imperviousness data at 20 and 10-meter spatial resolution (EEA) for 2006-2018. ; In Italy, the Istituto Superiore per la Protezione e la Ricerca Ambientale ISPRA monitors land take regularly. Imperviosness data produced by the ISPRA have a detailed temporal resolution and an additional validation. The tool land monitoring addresses the local issue up to the European point. By analyzing the 1481 tests at NUTS 3, we highlighted some inconsistencies between the European and Italian data; this can be seen in a test carried out in the Biella district (ITA) figure 4 and 5. In this case, false positives can be recognized visually on the platform; the user can evaluate potential gain visually and double-check between various sources (map and spreadsheet).

Figure 4. National (Italian) Scale Land take Tool, data ISPRA imperviousness changes 2006-2015.

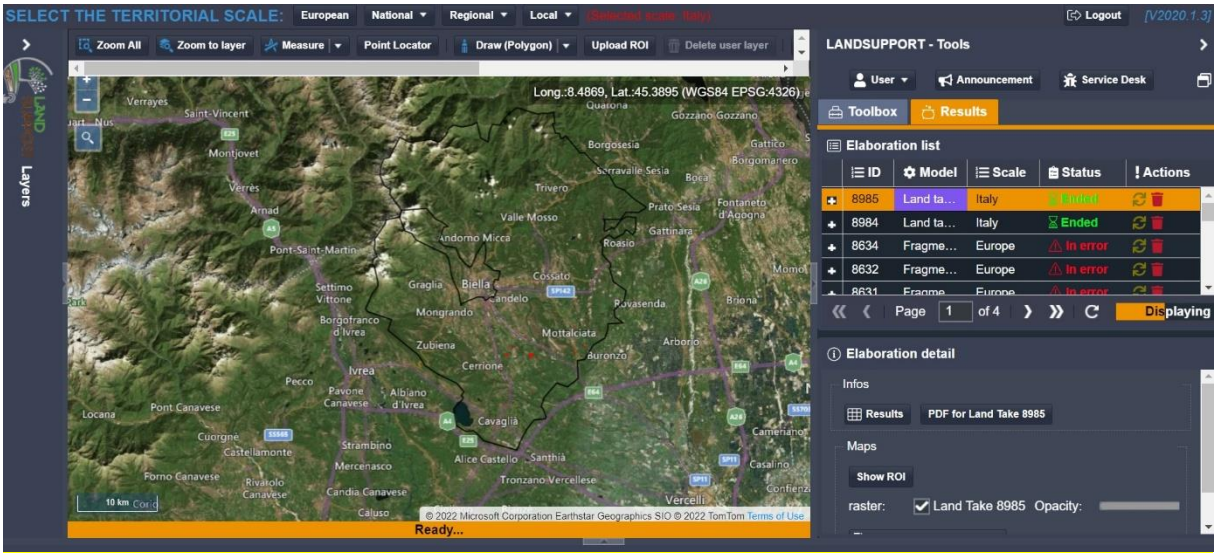
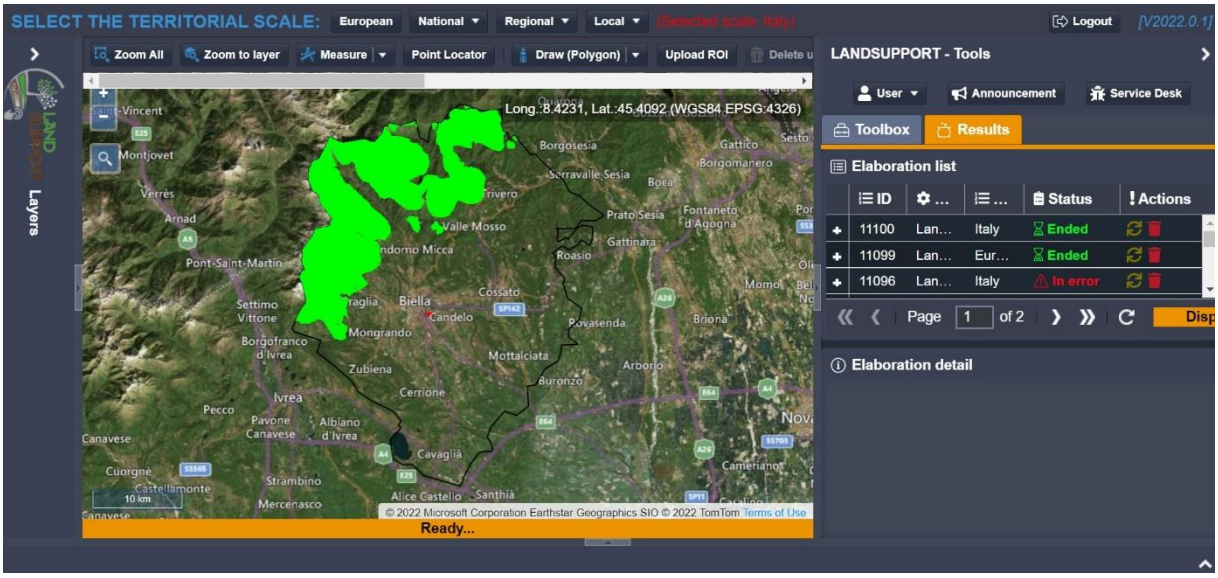


Figure 5. National (Italian) Scale Land take Tool, data EEA imperviousness change 2006- 2015.



The aim of the land take tool is two-fold: soil sealing + assessment of soil quality. By using the tool, each query will display the land take. Analysis of the losses of land, are more accurate than the recuperation of sealed spaces to natural. Analysisng the 1481 NUTS 3 queries, we hae seen that the losses identified false recuperation of free of sealing surfaces due to artefacts in the data, for instance, (fig.5) showed the false recuperation, (2006-2015 LTM), LANDSUPPORT allow the user to recognize the false positive data graphically without download data in local personal computers, however the user must look carefull at the potential dynamic of the sealing or re-naturalization. The data behind the EU scale Land Take monitoring tool are Imperviousness (EEA, Copernicus 2006, 2012, 2015, 2018), whereas at National Scale, the data are provided by the ISPRA (2000, 2006, 2012, 2015, 2018, 2021).

Soil productivity regions Toth et al., 2013

The addedd value of the LANDSUPPORT report on land take is the concurrent assessment of the soil productivity status, evaluated using a validated expert model called SoilProd. The tool can warn a

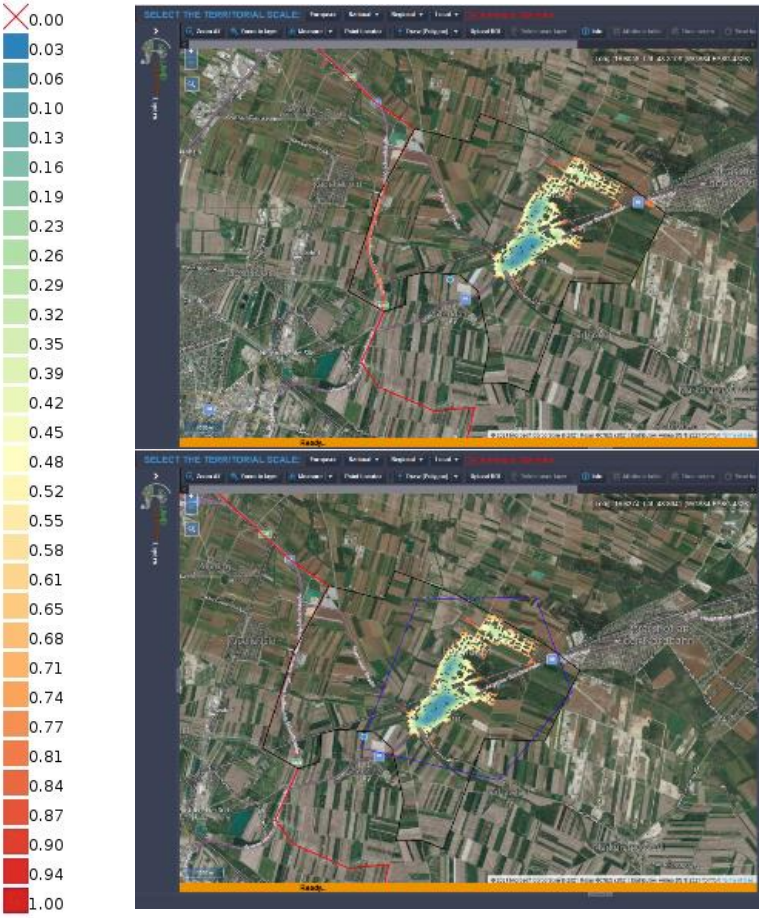
decision maker about the soil sealing, since the objective of LS is to be useful for multiple level stakeholders.

Some usability problems of the tool were encountered, for example it is not easy to sort the result PDFs. IDs of test areas are not displayed on result PDFs. Names of the NUTS sometimes get mispelled because the shapefile use original language names in the PDF report - this could be easily overcome by implementing a standard language for all EU NUTS. The system is slow in responding whenever large calculations are done, e.g for the fragmentation tool when larger areas are selected. Overview of the whole NUTS 3 at EU27 was obtain with an ad-hoc query performed for this report to test the geometries in a GIS environment.

The tool provides broad options to include the potential user (local, regional etc.) and to deliver data to them. Satellite data and soil information is not easy to get, it might be expensive, and data sources are often difficult to be reached out for the user. The LANDSUPPORT DSS system provides one single data platform to get spatial information, soil information and planning tools. As the toolboxes are free to use the interested user from the policy sphere as well as from the scientific domain from all over the world can use it free of charge.

In particular for NUTS and Local Administrative Units stakholders and especially local planners will benefit from a planning tools which deliver maps and aggregated data. The DSS need some technical literacy, the results of some tools, taken as it is might lead to misinterpretation of the results. Trainership programmes and a more extensive documentation is required to better contextualize the results prior to involve the general public.

Figure 6. Fragmentation tool results



At first sight, the difference between the Rural and Urban parameter was not very clear (Does "Rural" mean that built-up areas are fragmented by green areas, or is it the other way round?). If you run the

tool with both parameters once, it becomes clear, however a short description of the use cases of the parameters could be helpful. Several tests with different parameters were carried out, the results were displayed on the map (Figure 6). When trying to look at different results in the same Region of Interest ROI, the results of a previous test have to be deactivated, before selecting the next, otherwise the displayed fragmentation overlaps. If the next test is selected, without deactivating the previous it is not possible to see which fragmentation result is displayed on the map already. It is necessary to check all the tests, because it is not possible to see witch fragmentation is displayed on the map, in the result .csv file. It was not possible to determine the effect of the parameter "time-series". It was obligatory to pick a date but the selected dates were not displayed in the results. It was possible to download the results but it was not possible to immediately display them on a computer screen.

The 7th Environmental Action Plan

- **Environmental reporting tool** can inform the user about the biogeographical settings per administrative levels.
- **Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS** are Indicators useful for local scale planning, in particular for urban planning and restoration actions.
- **Land take monitoring** can inform of a rate of soil sealing using time series imperviousness at least at 20 meters spatial resolution and covers the period taken into account by the policy action.
- **New urban development, Model urban development and new green corridor** can promote urban planning that prioritise area under urban densification, brownfield management and land reuse.

Soil protection strategy 2004 (COM 2006/231)

- **Environmental reporting tool** can inform on the main geographical elements of a specific NUTS, soil information are only at a coarse spatial scale, ecosystem services information not suitable for policy purpose in the current state.
- **Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS**, have no direct soil information taken into account.
- **Land take monitoring and advanced**, soil information are taken into account. Considering that Soil protection strategy was proposed in 2004 and the EC outlined its commitment to address them in Member States potential contribution to all relevant aspects of sustainability. The approach which was used to develop the Land take tool links soil quality (Toth et al., 2016) with the soil sealing (EEA).
- **New urban development, Model urban development and new green corridor** provide a reference for urban planning at regional scale.

Dir 2000/60/EC, the WATER Directive.

- **Environmental reporting tool** the water bodies and their related information (e.g. lakes dimension, rivers length) are reported for each administrative level according with their full size, it might be useful to calculate the share of these features per each administrative level (e.g. river length and lakes area) as the proportion of the administrative unit taken into account by the analysis.
- **Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS,** Water related information not taken into account.
- **Land take monitoring,** there are water related information but the tool is not focussed on it.
- **New urban development, Model urban development and new green corridor** no water related information on it.

Dir 2007/2/EC, the INSPIRE Directive

Data delivered are partly compliant with the INSPIRE directive. All metadata are available in the technical sheets as well as methodology and data sources.

2. Monitoring SDGs at EU scale

In this section, we present the assessment of the LANDSUPPORT EU scale tools for monitorng SDGs. We focus on four SDGs, (2 "Zero Hunger", 3 "Good Health and Well-being", 13 "Climate Action", 15 "Life on Land"). The SDGs considered in the LANDSUPPORT work programme have direct relevance to land and soil resources, as well as for climate. In particular the need to track land take and land degradation at EU scale are closely related with the 2030 SDGs land targets of both EU and UN agenda (SDGs 2,3,13,15) as in figure 7 and Table 4.

Figure 7. SDGs considered in the testing activities.

Among the rapid land use change effects that threaten European soil, the increase sealing surfaces is one of the most impacting threat (Stankovics *et al.*, 2020). The JRC has produced soil threats assessments (e.g. soil erosion modelling, soil organic carbon content and SOC potential sequestration in agricultural soil) to quantify the extent and the potential loss of natural capital that has occurred (Lugato *et al.*, 2014; Montanarella & Panagos, 2021; Panagos *et al.*, 2015). However it is hard to assess progresses towards the acheivement of the zero soil loss (SDG 15) because infrastructure and logistics are consuming large shares of land (Strollo *et al.*, 2020) and their impact is not only limited to their share. The availability of two tools that allow for the assessment of sealing and land degradation offers a unique occasion to understand the main factors of the processes and to counteract soil degradation with tailored approaches based on specific environment and socio-economic conditions.

Under the category of physical land degradation the most studied process is soil erosion (Panagos et al., 2020). Soil sealing act negatively by generating runoff (due to the lower flow resistance) and increase the rate of saturation in permeable areas which favors the accumulation of storm water and enhanced local flood risk (Fox et al., 2012). Under soil physico-chemical point of view, the most studied element is the Organic Carbon in agricultural and forest soils. Soil organic carbon is well studied in terms of concentration in the topsoil (LUCAS) as well as its fluxes, Greenhouse Gases emission (CO_2, CH_4). The biological component of the degradation is much harder to be assess due to the lack of direct biodiversity data. Proxy like the land cover distribution, land fragmentation (a sub-tool of land take package) can offer a methodology for the assessment of this element. By using the LANDSUPPORT Land take and land degradation tool, a picture of the present processes in action can be drawn. Such results are needed for more effective action planning and it is also a priority to overlay the elements

of land degradation to understand how to offset impacts of land cover change prior to worsening the capacity of providing ecosystem services.

SDGs were adopted in 2015. Since 2015 a total of 193 countries have made a commitment guided by the United Nation to reach the objectives of the seventeen SDGs by 2030 and 2050.

In 2019, the European Commission adopted the European Green Deal [3], which aims to transform the European Union into a modern, resource-efficient and competitive economy where climate and environmental challenges are addressed and turned into opportunities, while making the transition just and inclusive for all. In this context, the Commission's overall approach towards implementing the SDGs is described in the staff working document (SWD) 'Delivering on the UN's Sustainable Development Goals - A comprehensive approach' (European Commission, 2020). According with this document and the updated version of the Monitoring report on progress towards the SDGs in an EU context report published in 2021 and 2022, the LANDSUPPORT evaluation of the relevance, performance and potential for SDGs monitoring was carried out (Fugure 3).

While the EC outlined its commitment to evaluate SDGs in 2016 (European Commission., 2021), there is limited literature available to assess the data avilability for SDGs monitoring. Nonetheless, we used an indirect approach to measure progress toward the acheivement of the SDGs objectives in the timeframe integrated within each SDG. We assigned a score for the LANDSUPPORT tool compliance to the current SDG (from low "1" to very high"5"). The results of this analysis are presented in the following section.

The SDG 15.3.1, "achieving a land degradation-neutral world" (LDN)

Among the most relevant features related to food security (The EU Green Deal and Farm to Fork strategy) is soil productivity loss, a central concept of land degradation (UNCCD 1994). Land degradation has a operative indicator SDGs (15.3.1), United Nation Convention to Combat Desertification UNCCD is the custodian institution. Land degradation refers also to the process leading to the reduction of soil water holding capacity, loss of soil biodiversity, pollution, and/or nutrient excess loads.

In the context of big data, to contextualize and provide synthesis is extremely important to develop improved soil and biophysical properties at detailed spatial scale, only when these aspects of soil quality can be assessed and monitored, much of the SDGs can be fully implemented to take more informed decisions. The level of implementation of the tool can help SDGs monitoring (Eurostat, 2021),

Uncertainty and limitations of the LANSDUPPORT products is strictly related with the original data and can be found in the reference of each single tool output. The products/tool development has been done to achieve a product useful for the policy needs.

[3] Green Deal, Published: 2021-07-26, Corporate author(s): Directorate-General for Communication (European Commission) Themes: Environment policy and protection of the environment Subject: carbon neutrality , climate change policy , environmental protection , EU environmental policy , EU financing , green economy , quality of the environment , reduction of gas emissions , sustainable development , sustainable mobility PDF ISSN ISBN 978-92-76-39487-7 DOI 10.2775/595210 Catalogue number NA-02-21-151-EN-N

2.1. Results

LANDSUPPORT products impact on the SDGs monitoring is strictly related with the original data and can be found in the reference of each single tool output https://www.landsupport.eu/dss-platform/suite-of-tools/. The SDGs calculation that can be provided for some of the EU scale tools has been done to understand the data availability and identify future needs for specific soil related products for the policy needs.

The testing of the EU scale tools required an ad-hoc session with the developer and a batch request for all the NUTS 3 level. This assessment included land take (gain in sealed soils from 2006 to 2015 of 22216 km^2), land degradation UNCCD indicator (between 2000-2018, +11 % of degraded land) and climate change resilience (average +1 Celsius degree increase in the next 30 years and -20 forst days across the tested NUTS).

Land degradation neutrality tool was directly implemented in terms of SDGs compliance (15.3.1) and support, but not to EU law evaluation and detection of violations.

Thanks to remote sensing imagery, and derived products, land and environmental monitoring is possible through LANDSUPPORT geopatial dashboard thereby supporting the effective implementation of the SDGs monitoring framework.

Progress towards some SDGs was faster than in others due to the policy action that were undertaken in the last few years, this has mainly focuss on health and well-being (European Commission., 2021).

Table 4. LANDSUPPORT Tools relationship with SDG; (1=low, 2=moderate, 3=adequate, 4=high and 5=very high)

FAMILY OF TOOL	TOOL	Sub-tools	SDG 2	SDG 3	SDG 13	SDG 15.3.1
b. Climate resilience agriculture	**Climate Change resilience**	**Land general climatic anomalies**	moderate	low	moderate	adequate
i. Evaluating, multilevel land/soil degradation (LD) threats	**Evaluating land/soil degradation (LD) threats**	**Land Degradation Neutrality SDG 15.3**	adequate	low	moderate	high
k. Land Take FAMILY OF TOOL	**Geospatial knowledge**	**Environmental report**	moderate	adequate	adequate	adequate
		Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS	moderate	moderate	moderate	adequate
	Monitoring	**Land take monitoring and advanced**	adequate	moderate	moderate	high
	Planning TOOL	**New urban development and Model urban development and new green corridor**	adequate	moderate	moderate	adequate
		Land use Land Cover Change (LULCC)	adequate	moderate	moderate	adequate
		Sub-tools	adequate	moderate	adequate	adequate

2.1.1. SDG 2 End hunger, achieve food security and improved nutrition, and promote sustainable agriculture

— SDG 2. Achieving healthy diets and ensuring agricultural systems to remain productive and sustainable are the key challenges associated with SDG 2 in the EU. Soils strongly contributes to the delivery of ecosystem services that, in turn, contribute to the UN Sustainable Development Goals (SDGs) and, more recently, to the EU Green Deal objectives. Relevant soil ecosystem services are biomass production, resources efficiency, Nutrient re-cycling,

Baseline: in this case the baseline period can can assessed using the share of agricultural lands within the land Cover Change sub-tool under the Zero net land take tool (Table 5). Objectives can be adapted by using input data from country or EU statistical offices in terms of commodities demand and import of the most important food crops. **Short-term trends** can be calculated using the tools at national scale (National data). Moderate progress is visible for SDG 2 in terms of government support to agricultural R&D, Intensify the regulation about the ammonia emissions from agriculture, and nitrates in groundwater. Progresses can be assessed by modelling crop soil relatiship via the Tool CAP, Agriculture and forestry, sub tool dynamic crop modelling (available only at local scale). Future improvements will consider gathering data on the Land Parcel Identification System LPIS (Sagris *et al.*, 2013). Maintaining the current scope of policies (Water and INSPIRE Directives) and aligning the list of indicators useful to map the progresses of the SDG 2 will enable better land management practices that have positive impact on climate change, increase food security and land degradation mitigation.

Table 5. Indicators measuring progress towards SDG 2, LANDSUPPORT tools supporting the SDG

Indicator	Long-term trend (past 15 years)	Short-term trend (past 5 years)	Landsupport tool
Sustainable agricultural production			
Government support to agricultural R&D	Data available at EU scale	Data available at EU scale	Climate change resilience
Harmonised risk indicator for pesticides (HRI1)	No data available at EU scale	No data available at EU scale	Groundwater vulnerability tool
Environmental impacts of agricultural production			
Ammonia emissions from agriculture	No data available at EU scale	No data available at EU scale	Dynamic crop modelling
Nitrate in groundwater (*)	No data available at EU scale	No data available at EU scale	Production- N leaching, SOC in your soil

2.1.2. SDG 3 Healthy lives and promote well-being

— SDG 3. Aims to ensure health and promote well-being for all at all ages by improving reproductive, maternal and child health; ending epidemics of major communicable diseases; and reducing non-communicable and mental diseases. It also calls for reducing behavioural and environmental health-risk factors. Health and environmental risks

According to our analysis, only the health determinants indicators can be supported by LANDSUPPORT tools. Many factors affect the health of individuals and populations. These include socio- and economic aspects, the state of the environment, city design, access to use of health services, and a person's individual characteristics and behaviour (Table 6). Lifestyle-related risk factors, such as an unhealthy diet, physical inactivity, smoking and harmful alcohol consumption, directly affect citizens' quality of life and life expectancy. They also have a negative impact on national health and social systems, government budgets and the productivity and growth of our economy.

Baseline in this case can be attributed to the share of agricultural lands computing the calculation in the land Cover Change tool under the Zero net land take tool. Objectives can be adapted by using input data from country/ Eu statistical offices in terms of demand of commodities and import of the most importat food crops.

Short-term trends, moderate progresses can be assess for SDG 3 using the land take at EU scale. National autorities can better support the policy actions (e.g. such as the introduction of street limits based on the noise and pollutants).

Table 6. Indicators measuring progress towards SDG 3, LANDSUPPORT tools supporting the SDG

Indicator	Long-term trend (past 15 years)	Short-term trend (past 5 years)	Landsupport tool
Health determinants			
Exposure to air pollution by particulate matter	No data available at EU scale	No data available at EU scale	Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS Land take monitoring and advanced New urban development and Model urban development and new green corridor
Population living in household suffering from noise	No data available at EU scale	No data available at EU scale	Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS Land take monitoring and advanced New urban development and Model urban development and new green corridor

2.1.3. SDG 13 Climate Action

Take urgent action to combat climate change and its impacts.

— SDG 13. Goal 13 seeks to implement the United Nations Framework Convention on Climate Change commitment to achieving a climate-neutral world by mid-century to limit global warming to well below 2°C —with an aim of 1.5°C — compared with pre-industrial times. It also aims to strengthen countries' resilience and adaptive capacity to climate-related natural hazards and the resulting disasters, with a special focus on supporting least developed countries. Climate mitigation effect of carbon capture and reduction of greenhouse gas emissions (SDG 13 – climate action).

Moderate progress is visible for SDG 13. Climate forecast are often optimistic, integration of tools will be need to assess the potential offset of greenhouse gasses via C sequestration and climate mitigation than can derived from it (table 7).

Baseline in this case can be attributed to the actual climate in the tool climate change resilience. Objectives can be adapted by using input data from RCP 4.5 and 8.5 in terms of severity of the future scenarios and derived climate crisis (e.g reduction of commodities and import of the most importat food crops). **Short-term trends**, Useful in this case to assess the scenarios. No progresses in terms of climate stability are visible for SDG 13 in the long term. Temperature are rising, drought more prolonged and frost days decreasing. Urgent policy actions are needed.

Table 7. Indicators measuring progress towards SDG 13, LANDSUPPORT tools supporting the SDG

Indicator	Long-term trend (past 15 years)	Short-term trend (past 5 years)	Landsupport tool
Climate impacts			
Mean near-surface temperature deviation	Data available at EU scale	Data available at EU scale	General climate anomalies tool

2.1.4. SDG 15 Life on land

Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.

— SDG 15. Seeks to protect, restore and promote the conservation and sustainable use of terrestrial, inland-water and mountain ecosystems. This includes efforts to sustainably manage forests and halt deforestation, combat desertification, restore degraded land and soil, halt biodiversity loss and protect threatened species, and biodiversity preservation (SDG 15 – life on land)

Baseline in this case can be attributed to the share of degraded land from the year 2000-2015, using the default data according to the SDG 15.3.1. Southern European countries show the highest rate of degradation.

Short term trends are not easy to be detected due to the climate variability, it will be better to use more soil related indicators. Policy actions (e.g. such as the introduction of additional subsidies for best agricultural practices) are needed.

In the future, the Land Parcel Identification System IACS will provide parcel data for a more precise calculation of the crop rotation and management, therefore better mitigation policies are envisaged. The degraded land assessment needs further analyses for the mapping of hotspot of degradation where adaptation and mitigation strategies needs to be promoted. Enabling and where possible promoting better land management practices that have positive impact on climate change, increase food security and citizen wellbeing.

The SDG 15.3.1 is reported for the first time by the LANDSUPPORT and provided at EU scale as indicator of land degradation[4].

Table 8. Indicators measuring progress towards SDG 15, LANDSUPPORT tools supporting the SDG

Indicator	Long-term trend (past 15 years)	Short-term trend (past 5 years)	Landsupport tool
Ecosystem status			
Share of forest area	No data available at EU scale	No data available at EU scale	Land use land cover changes tool
Land degradation	Data available at EU scale	Data available at EU scale	Land degradation neutrality tool SDG 15.3
Soil sealing index	Data available at EU scale	Data available at EU scale	Fragmentation, Edge density, Urban SPRAWL, LCPI, RMPS, Land take monitoring and advanced, New urban development and new green corridor
Biodiversity			
Surface of terrestrial sites designated under Natura 2000	No data available at EU scale	No data available at EU scale	Ecotourism tool

[4] https://sdgs.un.org/goals/goal15

Discussion

The LANDSUPPORT project developed a set of tools over a short timeframe that will need further improvement to be more user friendly and deliver harmonized data across the EU. Among the issues encountered, we can distinguish between **Short-term operability and Long-term updating issues**. Among the strengths, the EU scale NUTS 1 implementation is a valuable tool for policy support. Long-term updating, calculations and results are available on various level: regional, district and municipality. Comparable data platforms often only provide data on administrative units (NUTS), whereas LANDSUPORT provides results for any area chosen by the user. Visual and quantitative information is available. The results can be calculated and often visualized directly on a map and are displayed on the user's screen. They are also available for download. The methods used for calculation are stated on the printed reports, ensuring transparency. The results are provided not only for the past scenario, but the platform also works as a planning tool. The tools can warn a decision-maker about the high soil sealing rate, for example. Three tools provide European comprehensive and national data. Earth observation and remote sensing products will allow evaluating the interactions and trade-offs with other land uses, including spatial planning and support the achievement of selected CAP and 2030 SDGs land targets of both EU and UN agendas (SDG 2,3,13,15), with particular emphasis to SDG 15.3.1, "achieving a land degradation-neutral world" (LDN) and climate change (CC) mitigation and adaptation goals.

3. Evaluation of LANDSUPPORT tools

The results of Semi-structured interviews with senior EU official and expert employees by EC

In the WP6, several activities, including national experts and stakeholder workshops were performed to test the content and the liability of the results, their usability or easy understanding. The approach was first to teach the interviewed partner the various functionalities of the LANDSUPPORT platform to receive feedback. These activities were performed in cooperation with the dissemination and outreach working package partners of the LANDSUPPORT project.

Eleven senior EC officials and EC expert were interviewed. Anonymized answer were summarized in table 9. Expert feedback were collected for the toolf family "Land take", "Evaluating land/soil degradation (LD) threats", "Climate resilience agriculture". The semi/structured interviews lasted for 1 hour each. The semi-structured interview consisted in a brief introduction about the project, platform (both development and public) followed by a first round of questions. In most cases, the people involved had a strong background in their fields and already knew the data sources. Results of the interoperability of the platform were appreciated and resulted in a high score throughout the different groups. Data behind the tools were also evaluated. Methodologies used for the assessment of Land Degradation Neutrality is debated. The discussion was focused on the capability of the platform to perform calculation on flight considering the newest data sources when available. And the lack of row data for the download.
Average score of the reliability 3.9/5, average score policy needs 3.5/5

Table 9. Shows all the detailed scores of the semi structured interviews to expert knowledge and evaluation of LANDSUPPORT tools

Semi-structured interviews		land degradation-SDG 15.3.1	land take & Green infrastructure - SDG 2-3	Water Directive - SDG 2-3	climate change resilience-SDG 13	INSPIRE Directive	Average
RELIABILITY	Are the outputs of the LANDSUPPORT tool valid and reliable?	2±1	4±1	4.5±0.5	4±1	4.5±0.5	3.5±1
POLICY NEEDS	Do you think these data sources are accurate enough?	2.5±0.5	4±1	3.5±	4.5±0.5	4.5±	3.5±1
	Do you think it is good that the platform collect all the data sources at European scale?	3.75±1	4±1	5	4±1	3.5±	4±1
	Do you think that using the standard information (e.g. CORDEX, IPCC scenarios, CORINE, UNCCD SDG 15.3.1, Imperviousness EEA, Ecosystems services assessment MAES) represent good sources of data for all policy stakeholder?	4±1	4.5±1	4.5±0.5	3±1	3±1	3.5±1
	Do you think it might be useful for international agreement reporting at national scale?	3±1	3±1	4.5±0.5	3 ±1	2.5±2	3.5±1
	Do you think that the tool would support your work in this regard? (Considering your specific objectives)?	3.5±1	3±1	3±2	2.5±2	2±2	2.5±1.5
ADDITIONAL OPINIONS	Did the tool actually meet your expectations or did you expect other functionalities and content?	3.5±1	3±1	4±1	3±1	2.5±2	3 ±2

3.1. Detailed comments senior EU official and expert employees by EC

WATER:
- data for water are not very detailed, there are better data to be used.
-Tool climate resilience, needs the possibility to export tables with the data, tools in general (Land take, environmental reporting) will need summary statistics dedicated for the NUTS level which they refers (example is the municipality of Laveno Mombello, how much is the share of lake coastline, or how much of the river cross the municipality boundaries?)
- To be fully usable in our modelling task we will need to download the raw data and perhaps maps using the platform

CLIMATE
-Uncertainty in current data and models are big, it need to be underlined in the result of the Climate resilience tool.
-Precipitations might be more subject to high variability than temperatures.
-It is good to have .pdf files as results, but a text file or a table raw data will be help decision makers to summarize information to collect the whole picture of a region.
-Better graphic output will be beneficial for the users
-Prefer to use raw data will be useful to add also other countries (former EU members) and countries nearby EU (e.g. Norway, Switzerland, Balkan countries)
-Maybe useful for climate related assessment (e.g., greenhouse gasses)

LAND DEGRADATION
-Comments related to the methodology used, there is room for improvement.
-For international scale, reporting there is the need to look at sources of the problem (processes and threats) at local scale, and were the management can act.
-Improve the input data, improve data processing, and include other data (Land take, Soil erosion, Soil organic carbon, contamination, agriculture intensification).
-Spatial scale is a big issue because, the input do not allow assessing land degradation in detail.
-The input data are limiting the output.
-Better input data will allow for more reliable results.

LAND TAKE
Only NUTS 4 (Local Administrative level) works during the test. It will be useful to run the tool at NUTS 0-1-2-3. Tool fragmentation hard to interpret without previous knowledge.

INSPIRE
Results are partly compliant with the INSPIRE directive. The EU assessment are fair, not accurate for MS.

3.2. Testing of LANDSUPPORT tools as decision support system

To test the functionality of the LANDSUPPORT tool, various queries were performed. This report summarise conclusions drawn from several tests performed in EU Member states to make sure that the DSS tool is suitable for different biophysical zones, land-use systems, and socioeconomic conditions and, as a result, is reliable for informing policy stakeholders. The evaluation is a two-step process that involves assessing the data behind the tools and evaluating the tool's usability. From a testing point of view, the tools work smoothly without major technical issues in the development platform. Whenever the DSS system enabled selecting different scenarios or parameters, they were tested. European countries' statistics (area of the NUTS) can be aggregated to draw a general picture for the main tools-processes analysed. One >30 tests were performed at NUTS 3 and >1000 at NUTS 4 (Local Administrative Levels). Selected areas were chosen by the senior EU official and expert employees of the EC (Table 10).

Table 10. Number of tests carried out during the testing phase

FAMILY OF TOOL	TOOL	Sub-tools	Number of test at NUTS3	Number of test at NUTS4
b. climate resilience	Climate Change indicator	Land general climatic anomalies	10	10
i. Evaluating, multilevel land/soil degradation (LD) threats	Land degradation	Land Degradation Neutrality SDG 15.3	50	20
k. Zero Net Land Take by 2050	Geospatial knowledge	Environmental report	20	20
		Fragmentation, Edge Density, Urban Sprawl, LCPI, RMPS	5	5
	Monitoring	Land take monitoring and advanced	30	1481
	Planning	New urban development, model urban development	5	5
		New green corridor	5	5
		Land use Land Cover Change (LULCC)	5	5
m. green infrastructure			5	5

4. Performance at country, regional and local scales

The LANDSUPPORT Horizon 2020 project applies an integrated approach toward rural development policies by linking science and practices through the development of a free web-based, open-access Geospatial Decision Support System (S-DSS) devoted to supporting sustainable agriculture and forestry; evaluating trade-offs in spatial planning; contributing to the development and implementation of land use policies in Europe.

To achieve this, LANDSUPPORT developed 17 operational tools and related sub-tools based on a Geospatial Cyber Infrastructure (GCI), aiming to achieve a set of innovative scientific, technical and land policy-oriented specific specific specific specific specific specific requirements objectives.

Project activities were carried out on different geographical and governance scales, from the European level to the national (Italy, Hungary and Austria) and regional/ local scale (Campania Region, Zala County, Marchfeld). LANDSUPPORT's vision aims to reconcile agriculture and the environment, showing that the sustainable management of "land as a resource" is not simply a wicked, unsolvable problem but a complex reality that can be dealt with by using appropriate S-DSS tools.

In this Chapter, the performance of several LANDSUPPORT tools at country, regional and local scales are summarized for the Hungarian, Austrian and Italian case studies.

4.1. Hungary

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4.1.1. Zala County on the regional level and Keszthely on the local level were the reference regions of Hungary.

Keszthely occupies a small part of Zala County, but its diverse economic potential made it an excellent choice as a reference local area. It is the second-largest town on the shores of Lake Balaton and one of the most important cultural, educational and economic centres in the region. Zala County has located in the South-West part of Dunántúl. It's diverse in different landscapes and it is one of the rainiest regions in the country, on an average of 130 days of rainfall, around 750 millimetres fall. The role of agriculture is more emphasised in the county compared to Hungary. 56% of its 274-thousand-hectare production area is affected by agriculture, of which nearly three quarters are arable and one-fifth grassland. Vineyards are typical of this region it includes a wide part of two vine regions (Balatonmelléki and Balaton-felvidéki). 44% is forest area which makes Zala the second most forested county in Hungary.

These activities contained three main phases:

(i) the preparatory phase,
(ii) the testing phase,
(iii) Feedback phase.

4.1.2. The Hungarian preparatory phase

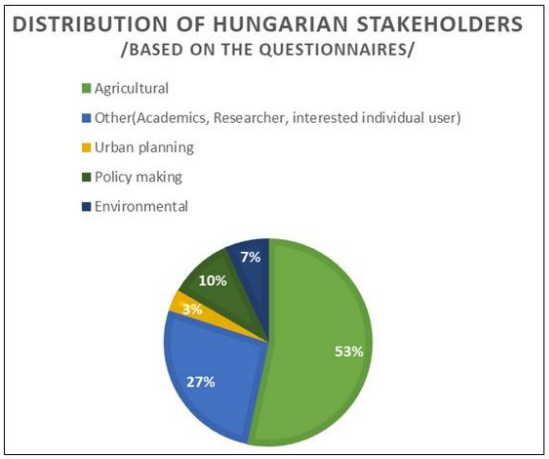
In this phase, the identification of the relevant policies based on the issues tackled by the tools of LANDSUPPORT platform was selected. After that, it started the identification of the potential stakeholders (institutions/persons) involved in decision-making processes with a possible interest in the tools. Following this, the next step was building contacts and setting up testing events. iASk organised training sessions for those who made the interviews to have a common understanding of the tools and the relationships between the tools and the policies. This phase included the developing and preparing of introductory materials (e.g. Hungarian tutorials, posters, descriptions) that helped the understanding of the tools and their operation.

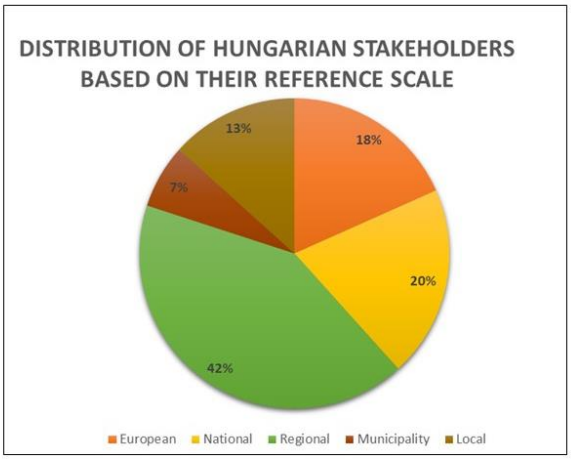
Types of the Hungarian stakeholders:

- **Public bodies responsible for land policies implementation**
- **Agriculture stakeholders**
- **Environmental stakeholders**
- **Spatial planning stakeholder**

Other perspective users: eco-tourism companies, local communities, educational and research institutions were identified as prospective users (Figure 8).

Figure 8. Distribution of Hungarian stakeholders by field of expertise and their reference scale





4.1.3. The Hungarian testing part

The actual testing with Hungarian stakeholders was made with different methods. Since the development of the tools was an ongoing process during the testing period, it became a best practice to inform the developers of the timing of the testing events and test the tools before the event. Taking notes during semi-structured interviews and workshops was an important activity of the testing phase, the notes proved to be very valuable for the developers.

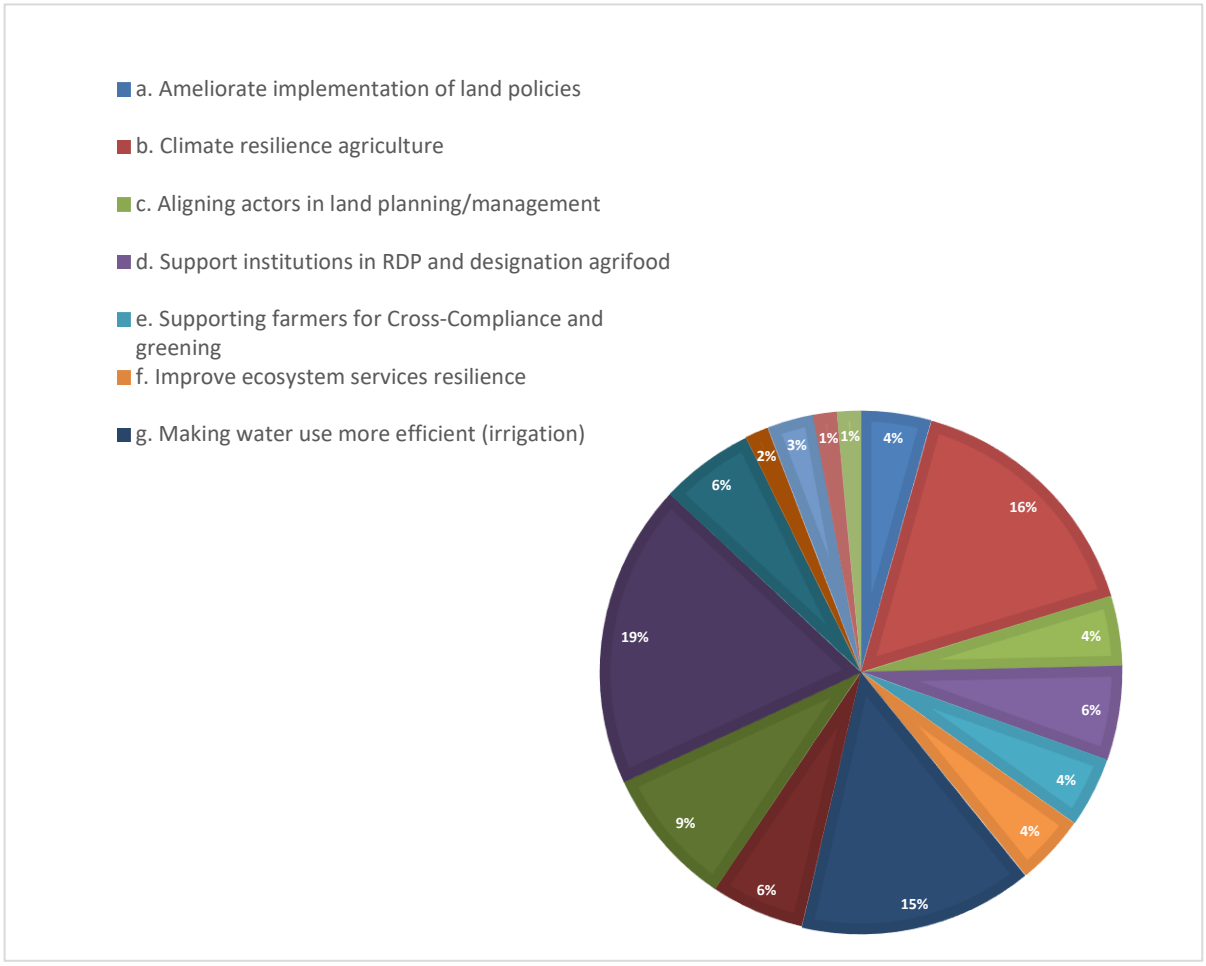
The following methods were used for testing:

- **semi-structured interview**
- **hands-on test and development**
- **moderated tests**
- **unmoderated tests**
- **workshops**

4.1.4. The Hungarian feedback phase

Feedback to developers had different kinds of forms depending on the issue regarding the platform. Feedback phase activities included feedback to developers in the form of (i) reports on semi-structured interviews, including questions, and remarks of experts; (ii) e-mails describing tools related issues; (iii) direct communication with developers. The feedback activities helped the co-development and co-creation of the S-DSS tools by identifying the main issues and concerns of the stakeholders regarding the tools. It created a direct link between the stakeholders and the developers.

Figure 9. The tools tested by the stakeholders in Hungary /based on the questionnaires/



4.1.5. Testing results at the national level

The result below is a demonstration of the most important outcomes of the Hungarian national testing managed by iASK (Figure 9).

LANDSUPPORT tools functionality and applications for current policy

To demonstrate functionality and applications for current policy support national strategies adopted by the Hungarian Parliament, or the Hungarian Government were reviewed to assess the relevance of LANDSUPPORT tools. All documents addressed more than one issue such as the need (i) to change the negative trends in the transformation of land use; (ii) to maintain and improve soil functions; (iii) to prevent the reduction of biologically active areas, (iv) rehabilitate and to improve urban green areas, (v) to increase of ecological services in agriculture. It was emphasized by all documents that land and soil protection has a direct impact on economic development and the well-being of society. The strategies' review proved that LANDSUPPORT tools are functional, and their application would provide support for current policies in Hungary.

Experts opinion

Semi-structured interviews and moderated tests were made with experts with different kinds of expertise (spatial and urban planning; water management and protection; nature protection; policy making for sustainable development; environmental protection; eco-farming; climate change relevant health issues) and with different kinds of organizational background (mainly public bodies responsible for policy decisions including developing, elaborating, taking, reviewing, implementing policy decisions).

In general, the platform was well received by the experts. The semi-structured interviews allowed to assess their opinion according to the performance indicators (usability, operational capabilities, accessibility, interoperability, reliability, policy needs) and their concerns and/or questions raised were channelled back to developers as part of the feedback phase.

Concerning **usability**, all experts found more than one tool addressing their specific policy issue and agreed that the platform with the various tools provides new opportunities to solve those issues.

Operational capabilities of the platform and the information obtained were found mostly adequate in detail, and quality, and fit into the set of information experts need for their work, even though experts noted differences in information needs due to their role in policy making and organizational background.

Regarding **accessibility**, experts welcome having a platform that gathers and provides access to different sets of information and organise them around different aspects of land use. It was considered positive to have access to not just national but regional and local data since national policy development and implementation are very much dependent upon policy implementations at the regional and/or local level.

Concerning **interoperability**, experts found it important that the final version of the platform would offer the possibility to integrate their own data and database to gain information on specific regions(e.g. water river basins, Natura 2000 territories). This function would significantly improve the use of the platform.

Reliability is often a key question about who and for what issues S-SDD can be used. Compared to laymen, experts are aware of the different limitations of the various sets of data, and models. For that reason, experts found it utmost important to have a clear indication on the platform about those limitations (including references to level, and/or size of ROIs) and emphasizing the need of expert evaluation of the results by visualisation this need. There was a general agreement, that all data describing the chosen territory (different NUTS or designated ROI) supports reaching policy objectives irrespective to which set of family the tool belongs to. Thus experts concluded that the platform's tools strengthen the horizontal approach to land and soil protection.

As part of the **additional opinion**, there was a general agreement among experts that it would be in the governments' best interest to allow the integration of country specific public data obtained and managed by public bodies at different levels.

The semi-structured interviews allowed us to review the tools from the various policy aspects, that experts represented. They expressed their special needs, concerns, and questions. Along with the general assessment, policy specific feedbacks were sent to the developers.

4.1.6. Environmental and agricultural stakeholders

Workshops and moderated tests were performed for environmental and agricultural stakeholders. **Environmental stakeholders** were approached at the **30th Hungarian Civil Green Parliament**, the National Assembly of the Environmental and Nature Protection Civil Organisations. In general, HGP users found it good to have a set of tools helping decision making and the various sets of information combined. It was appreciated, that the project allowed feedback thus providing a forum for public participation. They found it utmost important that during the development of tools helping policy makers the public could have a voice on the tools. It is for this reason that several organisations, including umbrella organisations offered an opportunity for testing the tools (e.g. WWF, agro-economic network). Environmental organisations represented all sorts of expertise and policies interest, that corresponded with the fields mentioned above. The results of the workshops and moderated tests were mostly in line with the opinion of the experts' views, while the feedbacks were pointing out where the environmental approach should or could be strengthened in order to promote sustainable decision making.

Along with **agricultural stakeholders**, members of the **Young Farmers Association Agrya**, and members of the **Head Office of the Hungarian Chamber of Agriculture** were approached, and moderated test and semi-structured interviews were performed during workshops. It was a general view that all the tools available to farmers could help a better decision making in order to protect land and soil. Tools would

help the implementation of the national agricultural policy and the platform has an important function in awareness raising by the visualization of the results. The possibility to upload own data was well received, and a hope expressed by the Chamber, that the government would allow the integration in some ways of the already existing public data. Questions and concerns raised were channelled back to developers.

4.2. Austria

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4.2.1. Austrian reference region Marchfeld

The Marchfeld-Region (Lat. 48.20°N, Long. 16.72°E) is a semi-arid agricultural production area in Lower Austria with more than 60,000 ha (20,000 ha regularly irrigated during the summer) of agricultural land cropped with vegetables, sugarbeet, potatoes and (winter & summer) cereals. The farm structures are large and economically viable compared to other areas in Austria (Figures 10 and 11). There are 884 farms with more than two-thirds (72%) professional farms where farming is the only source of income. The average size of a farm is around 55 ha and there is an upward tendency towards less farms with larger areas and an increasing number of organic farms. The average annual precipitation in the area is 500–550 mm that can drop to 300 mm making it the driest region of Austria. Groundwater is used for irrigation and also as a major source of drinking water. In the last few decades nitrate concentration in groundwater has increased dramatically as a result of climate conditions, soil structure and management practices and agriculture is reported to be the main source of groundwater contamination by nitrate. Moreover, due to the dry climate and a high carbonate content in the soil, chemical weathering is low which leads to a lack of Nutrients (e.g. potassium).

Figure 10. Austrian reference region "Marchfeld" Region selected in LANDSUPPORT

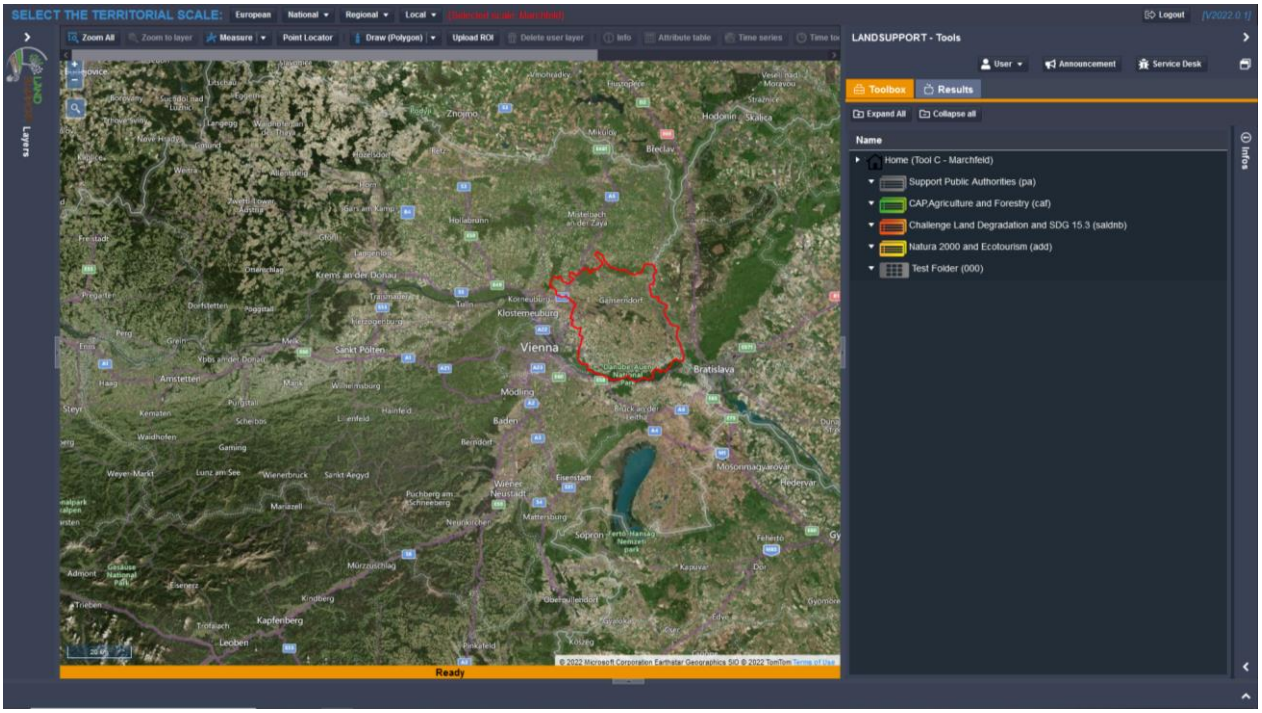

Figure 11. Agricultural Area at Austrian reference region "Marchfeld" ©Birli 2020

4.2.2. Involvement of potential stakeholders to elaborate performance of the platform at different scales.

The following methods were applied to receive feedback from users.

- **Training of users**
- **Interviews**
- **Expert's consultation**
- **Stakeholder feedback via Google forms**
- **Reaching out to stakeholders for co-creation**

Trainings: Trainings were performed to ensure that the future user is familiar with the respective tool. Trainings were done online in most cases due to the Covid 19 – pandemic. Only few trainings were performed face to face.

Interviews: Evaluation of the LANDSUPPORT tools requires a test of usability as well as functionality and reliability with users. In order to map feedback from LANDSUPPORT stakeholders and future users interviews on personal level as well as via Google form sheets were performed in the period of time from 2020 to 2022.

The aim of these interviews was to ensure not only functionality and usability but in particular to test the liability and precision of the tools.

Expert's consultation consisted of two parts. First, a tutorial in the respective tool with explanations on how to use it and the facilities the respective tool provides. The second part was written and oral exchange on the experts judgements.

The expert interview results in this report have thus a descriptive nature and not a standardized format, as each of the themes that has been elaborated by the experts, is a "single case". In the report, the tasks are outlined, the test methods are described for each task, followed by screenshots and a short evaluation.

Stakeholder feedback via Google forms: Google form surveys consist of an online tutorial and a google form. Feedback had been collected online.

Google form interviews were mainly performed when no specific/technical expert knowledge was required to provide answers and / or a large group of persons had to be reached.

Reaching out to stakeholders for co-creation: Stakeholders were contacted to support the development of tools by using national data (e.g. for validation). Their advice has been collected and reported back to the system developers for enhancing the performance of the tool. This co-creation for example had been performed in the development of the pesticide tool with various sessions in between the developers and the team from Austria or in the development of the forestry tool.

Table 11. Tool evaluation 2020 – 2022 – Main test sessions

Tool evaluation	Date
All tools on platform	18.06.2020
All tools on platform	07.10.2020
All tools on platform	24.10.2020
Pesticide Tool	08.02.2021
Pesticide Tool	09.02.2021
Pesticide Tool	16.03.2021-
Pesticide Tool	24.03.2021
Pesticide Tool	14.04.2021
Land take Tool	07.05.2021
Pesticide Tool	25.05.2021
Pesticide Tool	17.06.2021
Pesticide Tool	22.07.2021
Sustainable tourism	01.09.2021
Sustainable tourism	29.09.2021
Forestry Tool validation	October - November 2021
All tools	11.11.2021
Land take Tool	02.12.2021
New Urban Development	08.02.2022
Edge density	08.02.2022
land use and land cover Change	08.02.2022
Land take monitoring	08.02.2022
Land take monitoring	10.02.2022
Pesticide Tool and land take tool	17.02.2021
LDN Austria	22.02.2022
Sustainable tourism	04.03.2022
Land Take Tool, Urban development	08.03.2021
LDN Austria	11.03.2022
All tools on platform, "suitability tests"	November 21 - February 2022

4.2.3. Performance and evaluation

Suitability of the LANDSUPPORT tools for different biophysical tools

To prove that the decision support tool provides correct "answers" independently from the site, and so is (as outlined in the application) suitable for different biophysical zones, land use systems, socioeconomic conditions and policy frameworks 205 test were performed (compare D6.1). To enable a comprehensive test and to avoid mistakes whenever possible two administrative limits were selected per test.

- **The LANDSUPPORT Platform proved to be suitable for use in different biophysical zones. However some few usability problems were encountered. (Compare 6.1)**

Land take Interpretation:

The Land take Monitoring Tool is able to detect soil sealing in a high spatial resolution and a 3-year cycle adequately. The loss of rural area due to construction of buildings, streets or other building activities align quite well in comparison to national data. However, there is a rather poor agreement for regain of rural areas (green areas in the tool results maps) between LANDSUPPORT outputs and the national database. There is a potential risk of an overestimation of gain of rural areas within the Land Take Monitoring Tool.

Nitrate Tool and pesticide tool

The Nitrate Tool designed in LANDSUPPORT, offers the possibility to visualize arable land at risk of leaching and thus information on where mineral fertilizers should be used more sparingly. Furthermore, the results of the Nitrate Tool could also be used for the evaluation of the groundwater monitoring network with regard to its representativeness.

In the tests of the Pesticide Tool some problems are seen in the validation of the outcomes and in the usability of the pesticide tool by users. While the user interface and the results sheets are too complex for laymen (farmers), it is too general for pesticide experts.

Biodiversity

Experts´ judgements concerning the use of LANDSUPPORT Tools "New Urban Development", "Edge density" and "Land use and Land cover Change" in regard to the support of the "Biodiversity Strategy" were elaborated:

In the performed cases the tool outcomes give a very good overview of potential loss in ecosystem services (MAES approach), but miss grassland/crop areas. The experts assume that the MAES-input data for the model is not detailed enough for small-scale analyses (e.g. industrial expansions). In general the data about land use and land cover changes seem reasonable for the underlying area.

Sustainable Tourism

The LANDSUPPORT Tourism Tool provides potential for education, land resource awareness and sustainable tourism and agro-tourism. By the availability of this tool, awareness on the landscape is improved and tourists or tourism associations receive an additional service. Extension with national and international bicycle routes (e.g. EuroVélo) would be an additional benefit.

4.3. Italy

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ISPRA and the National System for Environmental Protection (SNPA, composed of ISPRA and the Agencies for the protection of the environment of the Regions and Autonomous Provinces) monitors land consumption according the law 132/2016, producing a land consumption raster map and publishing an annual report (ISPRA, 2021). The land consumption map adopts three level of classification system (1st level: consumed, non-consumed, 2st level: permanent consumed and reversible consumed) with several classes to identify at 3rd level sealed areas and different artificial surfaces (e.g. buildings, roads, quarries etc.). The final output has 10 m spatial resolution and it is available since 2012; all data are freely available (www.consumosuolo.isprambiente.it) at different administrative level (Luti et al., 2021; Strollo et al., 2020).

Land take tool implemented within LANDSUPPORT has been updated with most recent data (https://groupware.sinanet.isprambiente.it/uso-copertura-e-consumo-di-suolo/library/consumo-di-suolo/indicatori/consumo_2020) and the revision of entire historical series 2006-2020. This information is quite different compared to European level where land take data are collected every three years from EEA considering the degree of imperviousness (HRL, last update 2018). The general overview between data of the same year (2018) does not highlight critical errors. Considering the following thresholds (non impervious areas, 1-29%, 30-100%) the results compared with national reporting on soil consumption show: Total impervious surface (HRL, 2018) 1.674.944 ha (+5,49%), Total land take (ISPRA, 2018) 2.134.599 ha (+7,08%)

With these possibilities:

Imperviousness (HRL, 2018) = land take (ISPRA, 2018) = 47,36%

Imperviousness (HRL, 2018) omission compared to land take (ISPRA, 2018) = 29,5%

Imperviousness (HRL, 2018) commission compared to land take (ISPRA, 2018) = 15,33%

Imperviousness (HRL, 2018) non land take (ISPRA, 2018) linked to differences in class definitions = 7,61%

However, a different classification system lead to final results not ever homogeneous. In particular, national data of land consumption ("land take") is defined as "transformation of a natural land cover to an artificial one", with a pixel based approach that does not take into account the density of the artificial cover but the prevailing cover (> 50% of the pixel surface). These data include in the definition some classes excluded from European level such as: quarries, dump sites, railways, and construction site areas without built-up structures. The definition of greenhouses differs between the two data: in the national reporting they are divided into greenhouses paved and unpaved, regardless of the duration of the coverage. Finally, land take at national level presents a more detailed representation of the road and rail network.

The comparison on urban areas shows commissions in green areas (such as flower beds and courtyards) and on the edges of patches (see figure 12). Some linear features as railway tracks or intermittent rivers are often included in imperviousness stratum.

Numerous omission errors happen for isolated buildings (see figure 13) and roads in mountain areas. Solar panels are often partially mapped too.

Figure 12. In the area of Rome where identified possible differences linked to classification system and omission/commission errors (IMD= Imperviousness Density, HRL= High Resolution Layers, LCM= Land Consumption Map).

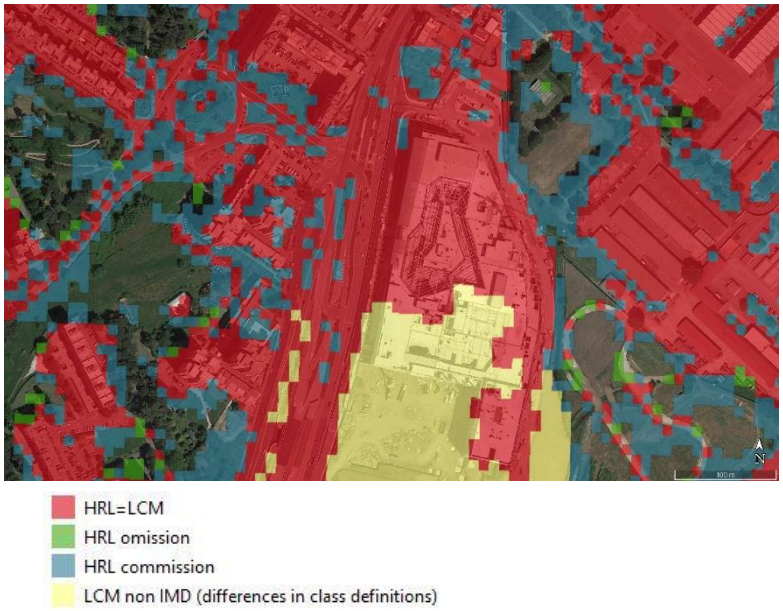

Figure 13. Examples of scattered houses (in green) not included within Pan-European High Resolution Layers (IMD= Imperviousness Density, HRL= High Resolution Layers, LCM= Land Consumption Map).

Detailed information on land take dynamics or the type are not available at national scale as for other socioeconomic related data (i.e. populations, climate, agricultural practices, etc.), so the LANDSUPPORT DSS platform will give under this vision an additional value to land planning. Soil information are strongly fragmented in Italy also considering the absence of a national law for land/soil protection. During the years some regions have promulgated specific regulations for limiting land take within their territory. The adoption of different laws produces in many cases not homogeneous definition of land take often in contrast to national monitoring system used by National System for Environmental Protection (SNPA). Currently a Web-GIS platform just exists for publishing maps, data and indicators of national monitoring on soil consumption (https://webgis.arpa.piemonte.it/secure_apps/consumo_suolo_agportal/?entry=6) but it doesn't

provide answers of spatial planning choices as LANDSUPPORT platform is able to do putting together a suite of tools and producing a report containing many information (i.e. ecosystem loss, protected areas, Sustainable tourism, etc.).

The interviews collected among colleagues working in the regional agencies for environmental protection (main interlocutors for ISPRA at local scale) or in other local administrations pointed out the needs and the importance of these instruments mainly for environmental impact assessment, creating the basis of sustainable agriculture and forest management/conservation. The interest shown during the workshops, webinars and seminars should be confirmed in the daily work, using tool "land take" with a deeper knowledge of the platform. In few case difficulties for operating on the application were attributed to a graphic user interface not properly immediate, but this aspect could be surely improved in the future.

Additional reads

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ISPRA, 2021. HRL 2018 look & feel verification report for Degree of Imperviousness.

5. Outlook

LANDSUPPORT final event

During the final LANDSUPPORT general meeting, Napoli 26-28 April 2022 JRC presented the results of the work package six of the LANDSUPPORT H2020 project "testing the tools delivered by the project and evaluating their potential support to selected policies and SDGs". The concept of a Geospatial dashboard with calculation capacity and **ability to combine different geodata to inform policy** has been proposed for the possible utilization for regional scale land management, e.g. climate change resilience, soil sealing and for land degradation in the EU.

Potential of LANDSUPPORT Tools

This document discuss on the policy framework that can be supported at EU scale, and its consequences to the LANDSUPPORT project and its evolution. There is a high potential for increasing the tools effectiveness with a focus on their **accessibility** for multiple stakeholders and report their uncertainty. To continue the development of the tools to accommodate new stakeholders needs, driven by new deeply transformative policies such as the EU green deal, the project has received by the Department of Agricultural Sciences of the University of Napoli an additional year of funds to ensure the development of the platform and update the EU, country and local scale relevant tools. Moreover, the collection of feedback has suggested the developers to add some supplementary features to the result .pdf reports obtained by querying the tools. The costs associated with the management of these tools and platforms will be offset by the platform's media capacity to inform stakeholder of the general public as well as the administrative municipality and district level.

Current developments of the LANDSUPPORT Tools

There was a focus on data **accessibility** (Tools the at European scale are using data with EU spatial coverage (for the tool Climate change resilience, land degradation neutrality and Zero net land take) compared with original geo-data accessibility (whether the user has to query data starting from raw data). According to the semi-structured interviews with EC senior officials and experts, the results suggested the **potential capacity of the tools to inform the policy stakeholder in obtaining services**, producing a set of indicators in the report given to the end user. New needs and possible avenues are emerging in light of current soil strategy and mission development. The availability of an integrated geospatial dashboard for soil monitoring and big-data processing will be crucial for the hotspot detection of land degradation and soil sealing. The LANDSUPPORT event "save our soils" fostered discussions on the policy framework and its consequences to the project development (27-28/ 04/ 2022). Interaction between LANDSUPPORT partners and external stakeholders from member states, national agencies and public services in charge of these aspects were discussed. During this event (Luca Montanarella, JRC) has make an explicit link to the set of deeply transforming policies such as the EU green deal and especially to the soil strategy focusing on healthy soil definition, sustainable soil management for the ecosystem services, soil restoration for the soils that have lost the capacity to provide their ecosystem services. Regarding the possible interaction with the European Soil Observatory EUSO, the new LANDSUPPORT platform will gather and deliver data to the EUSO dashboard and vice-versa, for EU scale and MS State monitoring using soil indicators that will help supporting some activities in the JRC work programme.

Future Interaction with EUSO

LANDSUPPORT major achievements (data and methodologies) at EU scale developed during the project will be made available at the **European Soil observatory** dashboard, including the evaluation of the SDG 15.3.1 indicator via the LDN tool. The research activity has allowed to update the land degradation 15.3.1 indicator according to the semi-structured interviews with EC senior experts and employees of the EC. Additionally, practical examples of how to better assess land degradation were discussed, and new sub indicators at higher spatial resolution will provided by the ISPRA for establishing a country scale case study. The LANDSUPPORT geospatial dashboard for the European

scale selected tools provided transparency in obtaining aggregated and local data with high relevance or land planning and accounting. The LANDSUPPORT consortium has made a policy proposal at the Italian level for healthy soils law. The work carried out in the frame of LANDSUPPORT will inform policymakers and warn them about the unsustainable soil consumption, degradation processes in action, rising awareness among general public and enhance soil literacy. In addition an in depth SDG's assessment related to soil is provided for the first time.

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Abbreviations

AI - Aridity index

BD - Bulk density

CAP- Common Agricultural Policy

CEC - Cation exchange capacity

DASHBOARD – A platform that can gather, visualize, analyze and advise by analysing data to support decision

DWT - Depth to Water-Table

Dir - DIRECTIVE

FAO – Food and Agriculture Organization

EC – European Commission

EU – European Union

EU28 – Member States of the European Union

GHG – Greenhouse gases

iLUC – Indirect Land use changes

IPCC- Intergovernamental panel on climate change

ISPRA - Istituto Superiore per la Protezione e la Ricerca Ambientale

LUC – Land use changes

LUCAS - Land Use and Coverage Area frame Survey

NUTS - Nomenclature of territorial units for statistics

SDG – Sustainable Development Goal

SOC – Soil organic carbon

UNEP- UN Environment Programme

UNCCD- United Nation Convention Combat Desertification

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Annexes

Annex 1. List of meetings

Date	Scale	Organizer	Tools tested	Worshop title
2 March 2022	Italy	UNA/ANCI	Land take (k), Evaluating land/soil degradation threats (i) + Nitrate and pesticide (j) + climate resilience agriculture (b)	IL PROGETTO LANDSUPPORT: UN NUOVO STRUMENTO PER IL SISTEMA NAZIONALE PER LA PROTEZIONE DELL'AMBIENTE
12 April 2022	Regione Campania	Regione Campania	Forestry (h)	LANDSUPPORT TECHNICAL DISSEMINATION WORKSHOPS : DALLA RICERCA UN NUOVO STRUMENTO PER LA CONOSCENZA E IL MONITORAGGIO DEL CONSUMO DI SUOLO
May 7, 2021	Austria/Marchfeld	BOKU/Marchfeld	Land Take (k)	Das Landtake tool - Live demo session land take tool
November 11, 2021	Austria	EAA	Ø	Presentation within a more global workshop called : "Beitrag der Bodenfruchtbarkeit zu Klimawandelanpassung und Klimaschutz"
December 2, 2021	Austria	EAA	Multiple tools on the theme of soil sealing	LANDSUPPORT TRAINING AT WU VIENNA SCIENTISTS, EVIDENCE-BASED POLICY AND RESEARCH
17 February 2022	Austria	EAA	Land take (k) and Nitrate and pesticide (j)	LANDSUPPORT TRAINING BAW
7 March 2022	Austria	EAA	Land take (k)	Information for municipalities in lower Austria
8 March 2022	Austria/Germany	EAA	Land take (k)	Information for the city of Plattlingen
July 28, 2021	Zala county	ZALA	Agrotourism - Label of your farm; Gain of Ecosystem services; New urban development; Fragmentation; Land-	Landsupport - Workshop for the working TOOL's

			general climatic anomalies	
September 30, 2021	Zala county	ZALA	Climate resilience agriculture (+ "Supporting farmers for Cross-Compliance" and "Greening Zero Net Land Take by 2050")	Landsupport Tool Workshop
October 26, 2021	Hungary	IASK	All the tools relevent for agriculture: viticulture, forestry.	LandSupport tesztelés
17 February 2022	Hungary	IASK	All agricultural relevant tools operated at the time were tested	
22 February 2022	Hungary	IASK	Land take (k), climate resilient agriculture (b) and improve ecosystem services (f), sustainable tourism (o), CAP institutions (d)	LandSupport tesztelés
23 February 2022	Zala County	ZALA	Tools from the Agriculture set (Climate resilience agriculture (b), CAP institutions (d), Cross-compliance and conditionnality (e), agricultural practices (g) and Nitrate and pesticide (j))	Climate Platform meeting
11 April 2022	Zala county	ZALA	Tools from the Agriculture set	Strategy development meeting

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