# BOOK OF ABSTRACTS
## ORAL PRESENTATIONS

### SCIENTIFIC SESSION: TOOLS FOR POLICIES IMPLEMENTATION IN AGRICULTURE

## Large scale restoration of the EU agricultural soils: facilitating carbon farming in the post 2020 Common Agricultural Policy

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Following the Paris Agreement, the EU reinforced its commitment with GHG emission reduction. Under the 2030 Climate Plan, the EC proposed a reduction of 55% below 1990 levels by 2030, to achieve net zero emissions by 2050. Agriculture accounts for 10% of total EU GHG emissions, with 80% of these emissions being attributable to enteric fermentation and cropland and grassland soils. The EC agricultural sector is called to reduce its net GHG balance, which may be done by reducing GHG emissions or by sequestering carbon in soils, although reaching the desirable neutrality requires combining both approaches.

EU agricultural soils are degraded by intensive practices (such as incorrect tillage, excessive mineral fertilization and insufficient use of cover crops in mineral soils, and drainage in organic soils). 60-70% of our soils are unhealthy in terms of organic matter, a key driver of soil environmental services. Data indicate that, through carbon farming, the EU has a climate mitigation potential of 3 to 12% of EU total annual GHG emissions. Therefore, the post-2020 Common Agricultural Policy is calling Member States to stimulate carbon sequestration in soil which is a golden opportunity for soil restoration at large scale. But engaging farmers in sustainable practices demands a correct design of eco-schemes to be financed, to facilitate training and support for monitoring and certification at enticing costs. We will communicate the ideas contained of our on-going report to the EU parliament on the construction of eco-schemes for C sequestration in the post-2020 CAP.



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## Can conservation agriculture enhance soil organic carbon sequestration in Mediterranean and humid subtropical climates? A meta-analysis

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Mediterranean and humid subtropical climate is characterized by a medium-low soil organic carbon (SOC) content and a high risk of land desertification. Recent EU policies pointed out the need to enhance SOC accumulation by promoting the adoption of conservation agriculture (CA). In fact, the effectiveness of CA in increasing SOC in comparison with conventional agriculture has been addressed by several published articles even if the methodology shortcomings make sometimes difficult to draw reliable conclusions. In our meta-analysis, we applied a robust methodology to comply with the meta-analytic assumptions and we did not use pedotransfer functions. Thus, we defined a conservative and replicable approach to deal with measured soil carbon data, explaining the differences between conventional (control) and CA management (treatment) in terms of SOC stock accumulation in the first 0-0.3 m plough layer.

A final database of 47 studies summarized the CA overall effect and allowed us to study also several pedoclimatic moderators. An overall positive effect of about 12% change in SOC accumulation was found due to CA practices compared to the control. To better explain the data variability, we created two different groups of studies based on the low (LC) or high (HC) amount of SOC in control (40 Mg $ha^{-1}$ as a threshold). In the HC group, a positive correlation was found between clay and carbon sequestration. In both soil groups, experiment duration positively impacted SOC sequestration, with a greater effect found in the soils with low SOC content. In addition, in these soils, the retention of crop residues enhanced the CA positive contribution.

We conclude that under these climates, the most benefits from CA application in terms of SOC increase apply to agricultural soils with low SOC content and located in the middle latitudes and in dry areas.



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## Spatial modelling of soil carbon and nitrogen dynamics in agricultural systems in the UK

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Besides supporting food, feed, fuel and fibre production, soils provide ecosystem services such as storing carbon, filtering water and maintaining biodiversity. Fertile soil is being lost at a rate faster than it can be recovered, primarily as a result of inadequate agricultural management practices and climate change. Reducing soil degradation and improving soil health are key aspects of the climate-smart approach, which includes maintaining or increasing yields, mitigating global warming and adapting to climate change. Soil quality is a key component of global sustainability, being central to the 'Zero Hunger', 'Life on Land', and 'Climate Action' Sustainable Development Goals. Soil health is also relevant for agricultural and environmental policies in the UK, such as Defra's 25 Year Plan to Improve the Environment, the new Environmental Land Management system (ELM) and in the UK's 2050 net zero target. Sampling and analysing physical, biological, and chemical properties of soils at landscape and regional scales poses challenges due to spatial and temporal variability driven by differences in management, topography, climate, parent material and biotic factors. Advances in remote and proximal sensing technology have provided opportunities to assess the spatial and temporal dynamics of soil properties, and advanced computing techniques have enabled the analysis of large amounts of environmental data. Process-based modelling is an important tool in understanding the complex interactions between the climate, soil and crop management in agricultural systems.

The focus of this project was to integrate remote sensing, spatial databases and process-based modelling to monitor changes in space and time in key soil quality indicators, with focus on soil carbon stocks and nitrous oxide emissions in agricultural systems in Yorkshire, UK. The DayCent process-based model was used in this project to assess the soil carbon and nitrogen dynamics in agricultural systems. DayCent simulates fluxes of C and N between the atmosphere, vegetation, and soil. The main submodels include plant production, soil organic matter decomposition, soil water and temperature by layer, nitrification and denitrification, and CH4 oxidation. Spatial data for recent and current climate (HadUK-Grid), future climate (UKCP18), soils (JRC/HWSD/LandIS), land cover (LCM2015) was used to drive the models to produce high resolution maps of carbon stocks and nitrous oxide fluxes each year until 2100. The framework developed in this project has the potential to support decisions on land use and management in agricultural systems, accounting for changes in atmospheric CO2 concentration, and precipitation and temperature patterns.



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## Climate change and agriculture: modelling and DSS for environmental and production sustainability of Mediterranean cropping systems

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In the Mediterranean area, climate change (CC) causes the increasing of average temperature, reduces rainfall, and increases the frequency of extreme events, for instance frosts and heat waves, periods of dryness and storms.

Therefore, in agriculture it is necessary to provide strategies for adaptation and mitigation of the effects of CCs. Adaptation strategies aim to minimize the negative effects of CCs on agricultural production, and to optimize the use of inputs (water, nitrogen). Mitigation strategies aim to reduce greenhouse gas emissions, and to maintain or increase the organic carbon content in soil.

Integrated analyses are necessary to redesign and adapt the crop systems to the new climate, in areas with homogeneous agronomic, pedological and climatic characteristics.

In this context, CREA-AA aims, through the modelling study, to develop innovative tools to support farmers in the identification of sustainable strategies, both from the productive and environmental point of view, for cultivation systems in conditions of limited water availability.

The teamwork is dealing with four project synergically related: PON-W4AF “Improvement of Mediterranean agri-food production in conditions of water shortage”; PSR-SFOF “Support for projects and development of new products, practices, processes and technologies”; Agridigit-Agromodelli “Agrotechnical itinerary for the adaptation and mitigation to climate change”; ERA HDHL KH FNS SYSTEMIC “An integrated approach to the challenge of sustainable food systems: adaptive and mitigatory strategies to address climate change and malnutrition”.

As part of the activities of these projects, the research group is developing two Decision Support System tools. The first (DSS_SFOF) aims to support the farmer agronomical decisions in order to optimize the organic cereal systems as regard the agronomic practices for durum wheat cultivated in two distinct areas of the Puglia region, in a context of mitigation of climate change. The second application (DSS_W4AF) is a DSS to support territorial policies of climate change adaptation for the management of water resources for durum wheat and industrial tomatoes in two territories defined in the province of Foggia and the territory of Metpontino (Southern Italy).



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## A S-DSS tool to support CAP implementation at regional scale.

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The new CAP for 2023-2027 – strongly connected to the European Green Deal and, thus, to Farm to Fork and biodiversity strategies – was recently formally adopted, paving the way for a fairer, greener and more performance-based CAP.

It will seek to ensure a sustainable future for European farmers, providing more targeted support to smaller farms, and allowing greater flexibility for EU countries to adapt measures to local conditions.

The current priority is to overcome the serious environmental problems raised by intensive agriculture (pollution, biodiversity loss, climate change, and the abandonment of extensive systems of high natural value, among others), as well as socioeconomic problems, also linked to agricultural intensification (mainly rural depopulation, increased regional inequalities and speculation with agricultural products and land).

More specifically, article 12 states that "Member States shall define, at national or regional level, minimum standards and good practices taking into account specific characteristics of the areas concerned, including soil and climatic conditions, existing farming system, land use, crop rotation, farming practices and farm structures". Hence, a proper implementation of the CAP, indeed, requires (i) to know the pedoclimate of the specific area of interest; (ii) to evaluate the best suite of farm management practices for that specific pedoclimate that may enable to perform the required Statutory Management Requirements (SMRs) and Good Agricultural and Environmental Conditions (GAECs) and (iii) to select, from the above farm management practices, the most relevant ones on the base of the specific farm structure/system.

Among the many others, we here present the best practice tool, implemented within the LandSupport S-DSS for the evaluation of optimized agronomic solutions for i) enhancing crop production, ii) improving soil fertility and iii) reducing nitrate leaching, at different spatio-temporal scales. The tool is based on the process-based ARMOSA model, specifically enhanced to be launched in real time through the LandSupport platform and whose results were combined to easily get the best combination of farming systems (conventional vs organic) – cover crop insertion (yes vs no) – nitrogen fertilization rates (standard vs reduced vs highly reduced) – tillage solutions (conventional vs minimum vs no tillage) – crop residues retainment (yes vs no) for a particular region of interest, characterized by a specific pedoclimatic condition.



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## An overview of the LANDSUPPORT tools for agriculture (vineyard, olive grove, agroclimatic service)

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Landsupport DSS includes several tools applied from local to regional scale thought for specific aspects in agriculture. More in detail, the DSS has the ambition to provide support to winegrowers and wine sector as well as the olive growers through tools designed to support vineyards and olive groves planning and management. The parent tool "d" named "Support Institutions in rural development plan and designation of origin" is the place where the users interested to the viticulture and olive growing can find several instruments delivering data and information in different forms, such as thematic maps, graphs, tables and technical reports. Ranging from the compilation of documents containing environmental data regarding your vineyard or olive grove, to the production of maps about bioclimatic indexes, potential risk of plant disease or viticultural zoning these instruments are able to support your choices. Several data are generated by Landsupport on the fly thanks to modelling procedures, and all the data are delivered within the area of interest drawn by the user. For example, a tool named "Agricultural and agroclimatic services" works processing on the fly weather datacubes (multi temporal raster data) from ERA5 Land and Cosmoleps services as well as local weather data, to generate in the area of interest graphs and tables reporting weather information (temperatures, rainfall and solar radiation) including past, current and forecast (five days) data. A tool named "Enotourism – cultural and environmental tool" has been recently completed and launched. It is designed to support cultural and environmental wine tourism by providing on the fly cultural or naturalistic data (i.e. historic residences, archaeological sites, monuments, museums, monumental trees, particular viewpoints, etc.) in the surroundings defined by the user of a point or place in the territory he is interested to.



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## SCIENTIFIC SESSION: TOOLS FOR LAND DEGRADATION AND LAND TAKE

### Stocktaking for Agricultural Soil Quality and Ecosystem Services Indicators and their Reference Values; The EJP SOIL projects 'SIREN' and 'MINOTAUR'

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The SIREN project (2021-'22) has made an inventory of indicator systems for assessing soil quality and ecosystem services derived from agricultural soils, as currently used by Member States associated in the EJP SOIL program and beyond. The project aimed to identify and review the national approaches to make use of soil data in the assessment of soil-related ecosystem services, and has surveyed the knowledge gaps and needs for development hindering policy implementation as experienced in the 20 countries participating in the SIREN consortium. A comprehensive conceptual framework linking soil quality to ecosystem services has been collated from earlier proposals in the scientific literature, unifying various concepts associated with soil quality and ecosystem services, and providing a glossary of consistent terminology. SIREN has also taken stock of evaluation criteria for indicators of soil quality as implemented in national soil monitoring schemes. Based on reviews of literature, international policy, international stakeholder views, wide application in national soil monitoring and application in EU projects contributing to agricultural soil quality assessment, a synthesis was produced of policy-relevant soil quality indicators with high potential for harmonised application in national and European monitoring. A tiered approach is proposed for implementation of such a minimum dataset. Follow-up research is scheduled in the EJP SOIL 'MINOTAUR' project, where indicators for soil biodiversity and key ecosystem services for agricultural soil will be developed and field-tested across Europe (2022-'24), especially with respect to effects of changing climate and effectivity of climate proofing management.



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## Food security and carbon sequestration need soil protection

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Soils fulfil vital functions, such as the production of food, feed, fibre and fuel. Furthermore, soil is an important repository for water, nutrients and carbon and provides a habitat for soil organism. For all these soil functions, sufficient high quality land is needed. Even so, 11.5 hectares of soil per day are consumed in Austria, 41% of which are sealed (Environment Agency Austria) and thereby these soil functions can no longer be fulfilled. The Austrian project "BEAT" evaluated productivity potentials of agricultural soils with regard to the current and predicted food consumption under two different climate change scenarios ("moderate" and "extreme"). It turned out that the potentials for food production decreased, especially under extreme climate change assumptions. In the Northeastern Plain and Hill areas, an important agricultural production area, sites with low and high water storage capacity were affected. Another goal of this project was to identify fertile soils with high productivity by using data of the agricultural soil map and the soil taxation survey. These soils are proposed as agricultural priority areas that should especially be protected for the maintenance of agricultural production and food security.

Furthermore, it is important to maintain and increase sustainable agricultural management to ensure fertile soils, stable yields and product qualities and to avoid adverse environmental impacts. Long-term field experiments (LTEs) are indispensable to detect and understand impacts of agricultural innovations and climate (drought, heat, floods, frost) on soil and plant parameters. A special focus should be laid on the maintenance/increase of soil organic carbon. One reason is that in order to combat climate change, a reduction in atmospheric $CO_2$ concentrations is required, which can be achieved by reducing $CO_2$ emissions and increasing carbon sinks. The Austrian project CASAS (Carbon Sequestration in Austrian Soils) and the H2020 project CarboSeq, are currently assessing which soil management practices have the potential to achieve the desired effects. Novel and historical data from long-term field experiments on arable lands are evaluated and the most promising management practices to optimize the carbon sequestration potential in cropland soils are proposed. Among these, two strategies are promising, i.e. increasing carbon inputs (for instance enhanced primary production, organic fertilizers) and reducing SOC losses, e.g. reducing soil erosion, managing soil respiration (Tiefenbacher et al., 2021). These strategies will not only support climate protection but also soil fertility and food security - provided that the soil is not consumed for other purposes.

Tiefenbacher, A.; Sandén, T.; Haslmayr, H.-P.; Miloczki, J.; Wenzel, W.; Spiegel, H. (2021) Optimizing Carbon Sequestration in Croplands: A Synthesis. Agronomy, 11, (5).



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## Spatial strategies for a location of multifunctional ground-mounted photovoltaic sites

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To achieve the goals of the amount of renewable energy percentages in the district of Freising (Bavaria) nearly 800 ha ground-mounted photovoltaic sites are needed.

The selection of the sites is very often determined by economically and energetic criterias such as the feed-in points for energy and sun exposure.

Furthermore the location of ground-mounted photovoltaic sites should also take into account effects on biodiversity, the landscape aesthetic, erosion, soil protection and agricultural needs. An intelligent spatial strategy the photovoltaic sites can avoid conflicts with nature conservation and can lead to benefits to the mentioned aspects.

In the lecture a short overview about the implementation of such a spatial strategy will be given. Working steps like the development of a methodology and a set of criterias for the nature friendly selection of sites will be explained; also some recommendations for a design of ground-mounted photovoltaic sites, which will increase the biodiversity, the soil protection, the protection of ground water will be explained.



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## Windbreaks and multifunctional hedges as instruments of soil protection – experiences in Lower Austria

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Soil conservation structures – also known as windbreak hedges or shelter belts – are strips of agricultural area planted with native trees and/or shrubs. These hedges secure and improve agricultural production conditions, provide diverse habitats for natural flora and fauna, and enrich the landscape.

The staff of the soil conservation stations in the Authority of Land Refom plan, plant, and maintain up to 25 ha of new soil conservation facilities each year. In addition, maintenance work is carried out until the plant is secured and then handed over to the landowners for further conservation.

Since 1958, the Soil Conservation Stations have planted 5 million trees and 10 million shrubs to create more than 3,000 hectares of soil conservation facilities covering more than 4,000 kilometers. These 15 mio. shrubs protect and improve up to 100.000 ha of agricultural land, mainly arable land in Lower Austria.

Facing the advancing climate change, the following functions of windbreak hedges take on added importance: In addition to protection from wind erosion, water retention, microclimate improvement, natural habitat connectivity, and fruit utilization are becoming increasingly important.

If hedges perform several functions, we talk about multifunctional or multi-use hedges. In cooperation with the Lower Austrian Chamber of Agriculture, research institutions and committed farmers, we have succeeded in obtaining funding for the new planting of multi-use hedges in the new agri-environmental program ÖPUL from the year 2023.



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## Land Take Monitoring and Assessment in Italy

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ISPRA and the National System for Environmental Protection are in charge for land cover and land take monitoring activities in Italy. Every year, new data, maps and indicators at national and local level are produced using Copernicus and other satellite images, and the report “land consumption, land cover changes and ecosystem services” is published to assess the trends and the impact on landscape and soil ecosystem services.



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## Geospatial Decision Support tools to challenge land take in Europe and Italy

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LandSupport is a web-based geospatial decision support system which provides multidisciplinary operational tools useful for a multi-stakeholder community to challenge land take in whole Europe. The platform includes various technological and technical features in which a basic WebGIS tier is combined with on-the-fly geospatial processing based on GPU computing, specifically designed to allow real-time requests. Different kinds of quantitative analysis related to land take and soil sealing can be potentially performed at any nuts level, even though the standard user is mostly limited to NUTS 4 or 3 according to a threshold. The imperviousness data used as input for calculations changes according to the territory analyzed: LandSupport switches between the Copernicus High Resolution Imperviousness Layers (20m resolution at three years step: 2006, 2009, 2012,2015, 2018) for all territorial scales except those located in Italy and the ISPRA Imperviousness Layers (10m resolution at one year step from 2015) for any territorial scale located in Italy. The Land Take Monitoring (LTM) tool quantifies the total loss and gain of land belonging to a selected Region of Interest (RoI). Generally, the platform allows the user to define three different types of RoI: (1) administrative limits (at any NUTS level), (2) drawn by hand, (3) uploaded (so that the user can use a finely defined RoI in its analysis). The LTM Advanced allow a run in which more RoIs (of type (1), i.e. admin limits) can be compared also using more than one contrasting couple of years. In this multi-RoI context, it is possible to filter results and gather useful information about the type of soil sealing dynamics. Many users highlighted the key importance of having on-the-fly the production of the map of rural fragmentation for any drown RoI in Europe. This map quantifies the landscape integrity of the rural and natural areas and enables to better locate both a new green corridor or a new urban development while minimizing the environmental impact of human activities. Very useful is the opportunity of quantifying a pool of spatial planning indicators at the municipality level (mainly NUTS 4, but also NUTS3). LandSupport provides tools such as the Largest Class Patch index, the Mean Residual Patch Surface, the Edge Density, the Urban Sprawl and so forth which can all contribute in depicting the state and the evolution of land take and tips about the model of urban development. For a selection of tools, reports in PDF format are prepared by LandSupport to provide more details (e.g. population growth and land use) and support the processes of both awareness raising and/or decision making.



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## Soil filtering capacity towards groundwater protection from pesticide and nitrates

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This work presents two new web-based, freely-available dynamical tools, named the *pesticide fate tool* and *nitrate fate tool* to assess the groundwater vulnerability to both pesticides and nitrate within the geospatial Decision Support system (s-DSS) of LandSupport.

The *pesticide fate tool* is based on the extended transfer function model (TFM-ext), specifically expanded to simulate the transport of reactive solutes, i.e., pesticides, from the surface, through the unsaturated zone, till the groundwater table depth. The *nitrate fate tool* is based on the coupling of the crop-growth ARMOSA model, used to simulate the nitrate leaching within the most biological active zone (i.e., the rooting depth of the soil) and the TFM-ext model, used to assess the transport of nitrate till the groundwater table depth. The tools leveraged the COMPSs programming framework, which allows to parallelize the execution of multiple model runs.

Principal inputs of the tools are: soil physical and hydrological properties, climate, groundwater table depth, type of crops and managements (seeding, harvesting, tillage, irrigation, fertilization, pesticides and residual management). Results are shown through the LandSupport GUI both as coloured maps and cumulative charts, representing the relative concentration of solute arrivals at the water table. The work presents the tool implementations for different case studies across three European regions (AU, HU, IT), with different spatial scales (from local to regional scales) and pedo-climatic conditions, as examples of application of the LandSupport s-DSS in supporting the Water, Pesticides and Nitrate directives, demonstrating that they represent valuable instruments for public authorities, environmental planners, as well as agricultural extension services.



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## A geospatial DSS tool to address landslide in the Campania region (Italy)

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Landslides represent a severe geohazard in several countries. The availability of inventories regarding spatial and temporal distribution of landslides is commonly recognized as crucial for assessing the related hazard and risk as well as for investigating landscape evolution. Nevertheless, landslide inventories are usually not of public domain and their applicability is often limited by spatial inhomogeneities in mapping and different classification criteria used. Such problems have been fully recognized by comparing different landslide inventories of the Campania region, which is one of the Italian regions with the highest percentage of areas and people exposed to landslide hazard. To this scope, in the framework of the LANDSUPPORT project, a Geospatial Decision Support (S-DSS) tool was built to address landslides in the Campania region. The S-DSS tool – after having drawn an Region Of Interest (ROI) (it can also be an administrative unit), produces a pdf report that – for that specific ROI) returns information on the number and type of landslide, on their activity status and on their geographical location. The report also includes addition info such as statistics about geology, soils, land use, loss of organic carbon and many other environmental information. The S-DSS tool uses and communicates multiple environmental databases, among these there is the revised landslide inventory for the Campania region, resulting from a very large effort which enabled to process existing landslide inventories. The implementation of this inventory, with its 83284 records, enabled to drastically overcome current limitations when analysing landslide susceptibility and risk assessment at detail scale (e.g. municipal scale). The tool was created for a wide range of users ranging from the administrator, to geologists, to researcher.



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## SCIENTIFIC SESSION: TOOLS FOR BIODIVERSITY AND ECOTOURISM

### The contribution of EXCALIBUR project towards SDG's policy implementation

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Modern agriculture faces two big challenges today: increased global demand for food and the need to grow crops more sustainably. The 'Farm to Fork Strategy' at the heart of the EU Green Deal aims to create a healthier and more sustainable EU food system. One of its key targets is to reduce by 2030 the overall use and risk of chemical pesticides by 50%. The reduction of chemicals in agriculture is also in the frame of the SDG.2 of the Agenda 2030, which aims to end hunger, improve nutrition and promote sustainable agriculture. Moreover, considering that most of the soil processes and functions related to the provision of soil ecosystem services are driven by soil biota, soil biodiversity is considered a keystone towards more sustainable soil management, especially in agriculture. Yet, relatively little is known about the dynamics and functional role of soil biodiversity and how belowground biodiversity can be stimulated to enhance soil functioning or crop performances under climate change and adverse conditions such as drought or soil borne diseases. In this scenario, the new EU Fertilizing Products Regulation (FPR), EU 2019/1009, will enter into force in July 2022 and provide strict rules and requirements for all fertilizers to be traded across EU. It will open to marketing a very wide range of fertilizing products such as organic fertilizers, organo-mineral fertilizers, growing media or biostimulants, including microbial-based products, provided that they comply with the environmental and safety requirements of the new legislation. Actually, although microbial inoculants are widely accepted as potential alternatives or complements to chemical fertilizers and pesticides in agriculture, methods for evaluating the persistence of microbial inoculants and their impact on soil biodiversity are still missing.

All these issues are addressed in activities performed by the EXCALIBUR project (www.excaliburproject.eu), which aims to improve the efficacy and application of biocontrol and biofertilization practices in horticultural farming (apple, tomato, strawberry). The project will provide reliable strategies and tools (i.e. DSS) to farmers to promote more sustainable biodiversity-driven soil management practices and develop methods for evaluating the persistence of applied bioinoculants in the soil and their impact on soil biodiversity. Such information will be utilized to develop guidelines supporting the regulatory process of this category of products in both organic and integrated horticulture. The EXCALIBUR project will ultimately help the development of derivative legal provisions (i.e. implementing EU Regulations, national requirements necessary to fully adopt EU legal provisions, registration and control guidelines, etc.), proposing their adoption for bioproducts registration.



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## Innovation in soil management of fruit orchards and grape vineyards to promote biodiversity

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Organic soil management is based on practices that are expected to enhance biodiversity. However, specialization of intensive organic orchards and grape vineyards has resulted in a conventional-like approach, with increased use of external inputs, which impact negatively on the overall biodiversity. However, enhancing the functional biodiversity both above and below ground can be pursued by slightly modifying the cropping system in both organic and conventional orchards and vineyards. Beside the use of flower strips and hedgerows, other methods can be utilized, exploiting the potential multifunctionality of plants. Living mulches grown on the tree row (understory) can be a suitable practice to increase biodiversity, control weeds and support beneficial organisms (both above and below ground). However, using herbs (e.g. mint) or fruiting plants (e.g. wild strawberry or pumpkin) as living mulches can also provide additional income to the farmer, making these practices economically sustainable. Flower strips can also be introduced along the row, as living mulches, in orchards or as "islands" in case of vegetables or short-term fruit crops (e.g. berry species). The use of cover crops rich in leguminous species in the inter-row can increase the overall biodiversity and provide additional benefits (ecosystem services) to the soil, particularly in perennial crops. Examples of these innovations will be presented, considering also the monetization of the ecosystem services provided, underlining the need of adapting them to local conditions.



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## Save soil microbial diversity for sustainable agriculture

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Soil biodiversity is important for nutrient cycling and ecosystem functioning. The soil and plant microbiomes are interlinked, and both are crucial for health and functioning of the holobiont (1). Beyond, they are important for planetary ecosystem functions and health issues (2). Plants are the key component of a healthy diet providing food for a fast-growing world population. Many current plant production practices result in pollution and contribute to loss of biodiversity, natural resources, and climate change.

Plant-associated microbial diversity mainly originates from seeds and soil. Both, the vertical and horizontal transmission route is essential for a healthy plant microbiome and local adaptations to the environment. However, breeding and intense plant production systems contribute to loss of biodiversity and natural resources. In the past, human activities influenced the interconnected microbiomes significantly. These shifts resulted in high pre- and post-harvest yield losses, drug-resistant plant and human pathogens, and a spread of antimicrobial resistance (AMR). This typically depleted microbiome signature of the Anthropocene is often followed by a dysbiosis, which leads to outbreaks of viruses, pests and pathogens (3).

Microbiome management and biotechnology is one option to restore and improve soil and plant microbial diversity (4). Examples for research and commercialization are presented and should inspire the development solutions to restore and save plant- and soil-associated microbial diversity for ecosystem and the closely connected human health (5).

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## The LANDSUPPORT Biodiversity SDSS tool in Campania region

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"Biodiversity is the variety of life on Earth, it includes all organisms, species, and populations; the genetic variation among these; and their complex assemblages of communities and ecosystems" (V.V. A.A., 1985). It also refers to the interrelatedness of genes, species, and ecosystems and in turn, their interactions with the environment. In such framework, the Natura 2000 initiative is crucial being a network of core breeding and resting sites for rare and threatened species, and some rare natural habitat types which are protected in their own right.

Most recently, the EU's biodiversity strategy for 2030 aims to further implement the EU-wide network of protected areas on land (and sea) also by enlarging existing Natura 2000 areas, with strict protection for areas of very high biodiversity and climate value. More generally, the EU's biodiversity strategy for 2030 must be considered a comprehensive, ambitious and long-term plan to protect nature and reverse the degradation of ecosystems. The strategy aims to put Europe's biodiversity on a path to recovery by 2030, and contains specific actions and commitments.

Natura 2000 initiative has already his own data viewer (https://natura2000.eea.europa.eu/#) but such data view is somehow disconnected with other key environmental data such as geology, soil, land use, climate etc. and in addition the data cannot be queried at the scale of administrative bodies (e.g. municipalities, province, regions) and this may limit a more widespread adoption.

In such framework, this LANDSUPPORT tool - working at the regione Campania scale - aims to further empower the use of Natura 2000 data by delivering biodiversity reporting – at any NUTS level or also at any Region of Interest freely drawn by the enduser. In addition this reporting which connect standard Natura 2000 data with many other environmental data having a much more integrated analysis of the biodiversity context of any specific site.



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## Creating, harmonising and implementing a geospatial database for cultural heritage in rural Campania

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Nowadays Ecotourism represents a fundamental resource for the sustainable development of a territory. Campania is one of the richest Italian regions in terms of cultural emergencies that blend in harmony with the environmental setting and with the local food and wine heritage. For this reason, Campania is affected by remarkable tourist flows. However, these tourist flows are directed above all towards the great destinations that are better known to the public, such as Napoli or Caserta vecchia. This cuts out a huge patrimony of hidden treasures, almost unknown (archaeological sites, museums, castles etc.), which are located in the inland rural. These territories are most subject to abandonment and depopulation phenomena. The aim of tool Ecotourism is to contribute to the revitalization of inland rural areas and their local economy; this could lead to directing at least part of the tourist flows towards these areas. However, in order to achieve this goal, a coherent database must be created. In fact, there are indeed many existing databases – including those available online on official sites or those on tourist itineraries but these databases are fragmented and often contain contradictory information and many errors. The work underlying the construction of the database of the Ecotourism tool is articulated around three points: 1) the census of all environmental, cultural and food and wine emergencies in Campania, except for the capitals Avellino, Benevento, Caserta, Naples, Salerno; 2) the geolocation of every environmental and cultural emergencies through the use of a GIS platform; 3) the harmonization of all existing databases (websites, scientific literature) through the correction of errors and the creation of scientifically correct and informative metadata. The result contributes to the development of a tool that is organised into the following features: naturalistic emergencies (panoramic points, caves, paths, etc.), cultural emergencies (archaeological sites, museums, ancient military architecture, etc.) and food and wine heritage (wines, olive oil, slowfood presidia etc.).



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## A S-DSS TOOL TO SUPPORT ECOTOURISM AND RURAL TOURISM AT REGIONAL SCALE

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Nowadays the world of ecotourism and rural tourism is a very important activity for many inland areas, enabling them to both produce important income and sustain the rural economy.

Recent progress in digital tourism promises to deliver important changes, but most of this digital progress is addressed at well-known tourist cities and destinations, so missing the challenge of inland, rural and ecotourism.

In this framework the development of a new and innovative tool can provide a valuable web-based operational tool which can be offered to both ecotourism and rural tourism end-users and planners, so that they might better plan and manage this type of sustainable tourism.

The DSS tool known as EcoSmarTour, applied to a large area of 13,590 km2 (the entire Campania Region, South Italy), which also uses an extensive database built specifically for the land-support project, is designed to address ecotourism planning by providing operational support for local companies, public tourist services, farmers involved in agritourism and farmer associations involved in sustainable rural tourism and ecotourism.

Output of the system include ecotourism planning and management scenario analysis, as well as maps and evaluation of potential ecotourism footpaths or areas of interest.

The tool will also be demonstrated through a short selection of practical case studies.



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