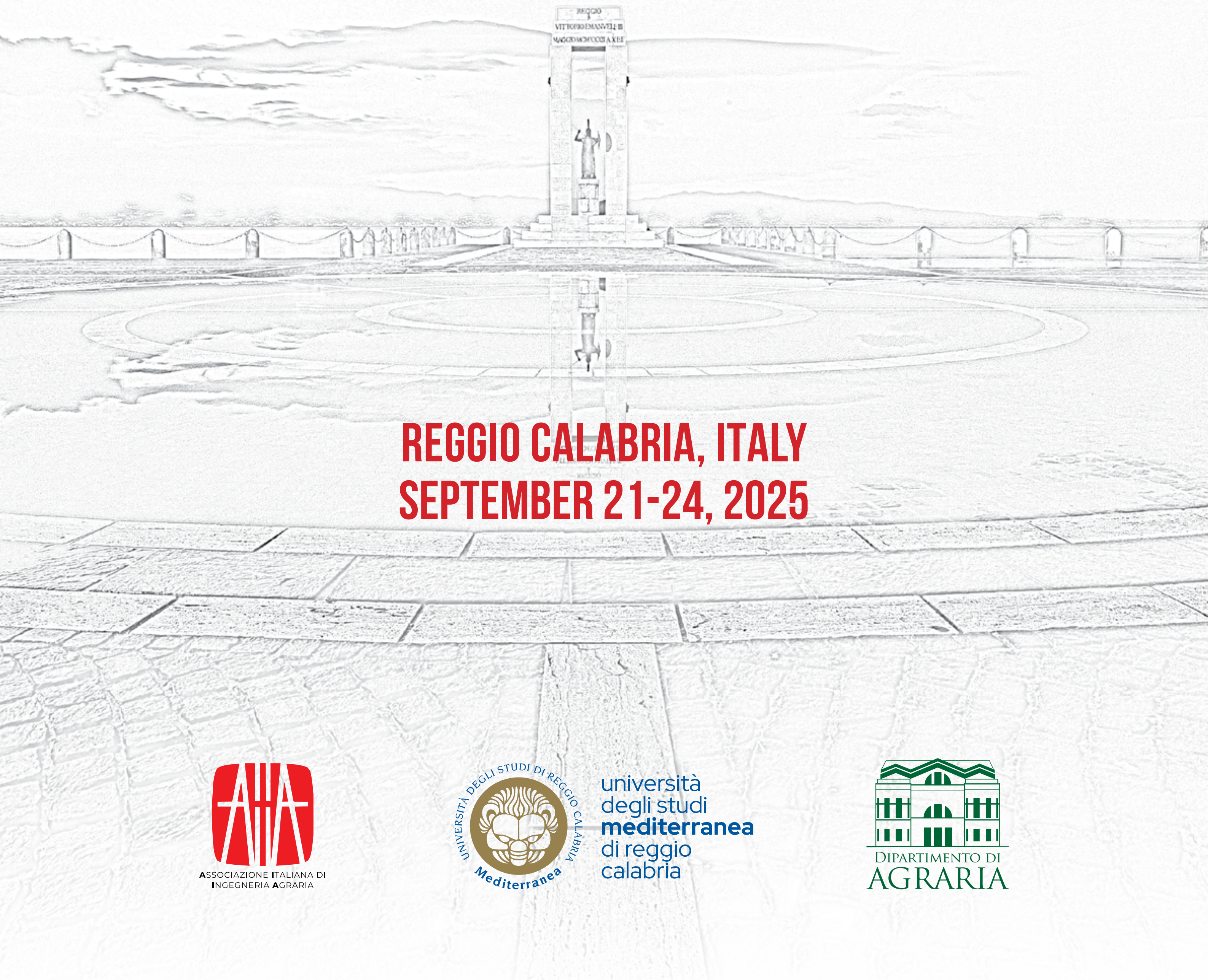
REGGIO CALABRIA 2025
INTERNATIONAL CONFERENCE

BIOSYSTEMS ENGINEERING FOR THE GREEN TRANSITION

BOOK OF ABSTRACT



REGGIO CALABRIA, ITALY
SEPTEMBER 21-24, 2025

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CONTENT TABLE

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Paper ID: 002

Valorization of wasted olive tree leaves through an innovative polyphenols extraction process

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Abstract. European and international policies are strongly focused on the sustainability of agro-food productions and on by-products valorization. Despite the very interesting nutritional benefits of EVOO, this production chain is critical from an environmental point of view. Olive tree leaves represent one of the most interesting olive mill by-products. In several countries of the Mediterranean area, there is the common illegal practice of burning olive tree leaves, significantly increasing fire risks and environmental pollution. For this reasons, specific valorization strategies for olive tree leaves are urgently needed, thus motivating this work. To valorize this important waste, one of the most interesting strategies could be related to the extraction of polyphenols. A great number of extractions methods have been tested, mainly based on methanol, ethanol, acetone, ethyl acetate, and diethyl ether, as well as aqueous alcohol mixtures. Moreover, more modern, rapid, and green techniques like microwave-assisted extraction, pressurized liquid extraction, supercritical fluid extraction, and ultrasound-assisted extraction, have been developed. Nevertheless, these methods are characterized by lower oleuropein yield and/or higher costs. The suggested innovative extraction process is based on the leaves drying using microwave, followed by the pulverization of the dried leaves, the extraction of polyphenols by mixing the powdered leaves in an acidic aqueous solution, and, finally, the centrifugation, filtration, and freeze-drying of the recovered extract. This innovative approach provides an improved and lower-costs process for the extraction of polyphenols which allows to obtain higher amounts of oleuropein with a degree of purity between 45% and 60% or higher without using alcoholic solvents.

Keywords: EVOO; olive waste; by-product valorization; circular economy; polyphenols; olive tree leaves.

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Paper ID: 004

Modeling and simulation of a chiller secondary circuit: valve performance analysis

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Abstract. This article aims to improve the energy efficiency and environmental sustainability of industrial refrigeration systems currently used in the fresh-cut product sectors. These chiller systems predominantly use 3-way valves with constant flow rates in secondary circuits, often neglecting the energy consump-tion of the pumps. Additionally, the perceived high cost of inverters for each pump has limited their adoption. In this study, we propose an alternative ap-proach by replacing the 3-way valve with a 2-way valve and incorporating a variable-speed pump in the secondary circuit. A central hypothesis of this re-search is that such modifications can improve energy efficiency while reducing both operational and initial system costs, especially considering that the costs associated with 3-way valves often exceed those of inverters in certain configu-rations. To support this investigation, a Simulink model is developed to simu-late the behavior of secondary circuits under both configurations (3-way valves and 2-way valves) with and without inverter-driven pumps. Additionally, the research examines design optimizations for air coolers in cold rooms, focusing on geometry and configuration adjustments enabled by varying the secondary fluid flow rate. By integrating these strategies, the study aims to demonstrate potential energy savings, cost reductions, and environmental benefits, contrib-uting to the development of more sustainable industrial refrigeration solutions.

Keywords: Chiller, secondary circuit, valve, Simulink model, cold storage, re-frigeration system.

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Paper ID: 006

Indoor vertical greening for buildings: a case study at the University of Bari

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Abstract. Integrating green infrastructures into buildings is a key strategy for increasing the sustainability of urban and peri-urban contexts. A specific green infrastructure for building envelopes consists of the application of plants vertically on the walls according to various engineering solutions. Beyond its un-quantifiable effects, such as increased aesthetics and pleasantness, vertical greenery is a passive living technology that provides several quantifiable bene-fits in terms of improved energy performance, air quality and acoustic insulation of buildings. Vertical greening systems can be applied outdoors as well as indoors. Since indoor applications need to be more thoroughly investigated in their physical functioning, this research has been started. With the aim of study-ing the energy and gas exchanges that take place in an indoor vertical greening system, a prototype was designed and realized at the University of Bari. The experimental prototype consists of a sealed chamber with indoor evergreen plants inside. This is equipped with fans for air circulation and sensors to detect air, plant and soil parameters. The data collected through the system are useful for analyzing the indoor vertical greening functioning and effects and, ultimately, for promoting its informed and widespread application.

Keywords: Green infrastructure, Green wall, Passive system, Energy saving, Heat Transfer, Air quality.

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Paper ID: 007

Development and optimization of a prototype machine for the injection of truffle patè inside cheese

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Abstract. The growing demand for innovative food is driving the dairy sector, ever interested to find new solutions to diversify the market. There is, for istance, a strong interest for cheese enriched with flavors, honey, pates and creams. This paper summarizes the steps of developing an innovative machine for injecting cheese, tested on the "Pecorino di Filiano " type sheep cheese. The research was characterized by the following issues: - standardization of the automatic injection process avoiding the variability of the handmade process; - overcoming the limitations of existing machines designed for brine/flavor solutions, starters, and liquid ingredients. In the study both industrial and experimental research were carried out, which led to the realization of the prototype, followed by experimental trials to validate the machine's performance. Trials took into considerations some process variables: moisture/aging level of the cheeses and physical characteristics of the truffle pâté. Samples were collected to quantify the injected pâté and assess the texture profile analysis (TPA) of cheese before and after the process. Tests were carried out at MacLab (https://machimplab.wordpress.com/) also in cooperation with a local machine workshop. The following results were reached out: 1. the optimization of the needle size of the injection head; 2. the pressure levels with reference to the aging of cheese (optimal range of 6–8 bar); 3. the validation of the prototype machine's functionality with reference to the physical properties of the truffle pâté; 4. texture characterization of the enriched cheeses.

Keywords: Innovative Cheese, Texture profile analysis (TPA), Injection pressure, Rheology; Cheese Filling.

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Paper ID: 008

Classification of Common Beans Seed and Flour Using Hyperspectral Imaging and Deep Learning

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Abstract. An accurate, fast and non-destructive detection method to identify the varieties of common beans (Phaseolus vulgaris L.) is important for improving cultivation, optimizing resource management and protecting biodiversity. This study explores the application of hyperspectral imaging (HSI) and deep learning (DL) techniques for the accurate and efficient classification of common bean seeds. Four different DL models including 1D convolutional neural network (1D-CNN), 2D-CNN, temporal convolutional network (TCN) and temporal convolutional network-attention mechanism (TCNA) were applied. Also various types of CNN architecture, such as LeNet, ResNet, DenseNet, MobileNet and EfficientNet were assessed. Different pre-processing methods, including Savitzky-Golay smoothing (SGS), multiplicative scatter correction (MSC) and standard normal variate (SNV) and feature selection strategies, such as Principle Component Analysis (PCA), Competitive Adaptive Reweighted Sampling (CARS) and Iteratively Retaining Informative Variables (IRIV) were used to improve the quality of spectral data. Best results were achieved by topology of SNV-CARS-2D-CNN-ResNet and the precision, sensitivity, specificity, Recall and F1 score were 0.985, 0.981, 0.972, 0.944 and 0.943, respectively. All the results will provide a new way for developing a rapid HSI equipment for comprehensive quality inspection in the agricultural and food industry.

Keywords: Artificial intelligence, Machine learning, Legumes, Digitalization, Intelligent sensors

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Paper ID: 009

Technical and Economic Features of Tree Stumps Removal in a Chestnut Orchard in Calabria (Southern Italy)

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Abstract. Chestnut orchards (*Castanea sativa* Mill.) have long shaped the socio-economic structure of large part of Italian mountain regions, functioning as a typical agroforestry system. However, socio-economic changes during the 20th century and plant diseases led to a dramatic decline in chestnut cultivation, reducing the orchard area from 800,000 hectares in 1900 to just over 30,000 hectares today. Despite this, the demand for chestnut products remains strong, stimulating interest in reviving production through modern orchard management and the restoration of abandoned groves. A key challenge in restoring these groves is the removal of invasive tree stumps, which obstruct mechanized operations and must be managed with minimal soil disturbance. This study evaluates the performance of a remote controlled, high-mobility, mini-crawler equipped with a forestry mulcher in grinding alder stumps in a restored chestnut orchard in Calabria Region (Southern Italy). Over a two-day trial, 250 stumps were treated, achieving an average grinding time of 53 seconds per stump and a productivity of 61 stumps per hour. The tested solution minimized soil disturbance and provided a cost-effective solution for stump management. Results suggest that this technology is well-suited for chestnut orchard restoration, particularly on challenging terrains. Future research should explore applications for different invasive species and compare the mini-crawler with alternative stump removal methods.

Keywords: tree stumps removal, time work analysis, remote controlled machinery, agroforestry systems, orchard restoration

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Mechanical-aeraulic Device for Sustainable Pest Control of Xylella fastidiosa

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Abstract. Xylella fastidiosa (Xf) is a quarantine pathogen that colonizes the plant's wood, occluding the xylem and preventing water supply flux to the canopy, causing leaf scorching and plant death. The pathogen is spread by Aphrophoridae insect vectors, which acquire and transmit the bacterium by piercing. In its nymphal stages, the insect is green and lives in "cuckoo-spit", a frothy mass of bubbles. Emergency measures for the prevention and control of Xf, including soil tillage or large-scale use of broad-spectrum insecticides, are in force in the national territory. Still, they have a drastic ecological and environmental impact. In this paper, a sustainable pest control method to contrast the spread of Xf is presented. A motorized wheelbarrow equipped with an innovative mechanical-aeraulic device has been developed. This device generates a hot airstream of proper shape and velocity, able to cause the impairment or the death of nymphs of Xf. As is known, an airflow of speed v [$m \cdot s^{-1}$] and having density ρ [$kg \cdot m^{-3}$] produces an aerodynamic force F_a [N], on a target of section S [m^2] and resistance factor C_d, defined by:

$$F_a = 1/2 \cdot C_d \cdot \rho \cdot S \cdot v^2 \qquad (1)$$

The aerodynamic force is proportional to the square of the air speed and the area of the target. Moreover, a suitable vision system device with implemented image analysis algorithms is being developed. It will be mounted onto the motorized wheelbarrow to detect the white foam produced by the nymphs automatically.

Keywords: Xylella fastidiosa, Physical pest control, Mechanical-aeraulic device, Automated pest detection.

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Paper ID: 011

Study of Monitoring Systems for the Use of Personal Protective Equipment in Agriculture, “Safety in-out”

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Abstract. Agriculture remains one of the sectors with the highest workplace injury rates in Italy, driven by persistent inefficiencies in safety practices, inadequate work-er training, and limited risk awareness. Non-professional and untrained workers frequently fail to adhere to safety protocols or use personal protective equip-ment (PPE), further increasing the problem. Improper machinery handling and the prevalence of traditional practices contribute to high injury rates, highlight-ing the need for stronger prevention policies. Enhanced worker training, rigor-ous control systems, and targeted safety awareness campaigns are essential to address these critical issues in a sector fundamental to the Italian economy and society. Advances in sensor technology present a promising route to improve PPE monitoring through real-time data tracking. Miniaturized, reliable, and en-ergy-efficient sensors enable accurate monitoring of PPE usage, ensuring com-pliance with safety regulations while maintaining cost-efficiency. Such systems enhance accident prevention and facilitate adoption in resource-constrained contexts, aligning technological innovation with practical needs. This study ex-plores the development of an integrated sensor-based system combining active and passive sensors to monitor PPE usage throughout all operational phases in agriculture. The methodology involved testing different sensor configurations in scenarios with specific risks, including machinery operation, chemical handling, and adverse environmental conditions. Results demonstrated continuous and accurate PPE tracking, achieving a detection rate above 95% and adaptability across different agricultural contexts. The system proved to be robust in challenging environments, such as high humidity and vibrations, with minimal implementation costs. Consequently, its confirmed effectiveness in enhancing compliance and reducing risks, contributing to improved safety standards in agricultural operations.

Keywords: Workplace injuries, Personal protective equipment (PPE),Sensor technology ,Agricultural operations

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Paper ID: 012

Proximity vs. Positioning vs. Video Tracking: A Comparative Analysis of State-of-the-Art Technologies for Studying the Social Interactions of Dairy Cows

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Abstract. Analysis of video recordings is one of the most effective ways to study the social interactions of animals. However, the challenge is to filter out, from hundreds of hours of footage, what may or may not resolve into a social interaction. In this study, it is assumed that interactions occur if the distances between animals are close. To achieve this goal, three different technologies were compared: proximity recording based on the radio signal strength of Bluetooth devices, indoor location tracking using UWB (Ultra-Wide Band) modules, and finally image analysis based on artificial intelligence using the renowned YOLO (You Only Look Once) algorithm. The three solutions were analysed both separately and in combination, specifying that data recording with the three technologies always occurred simultaneously and at the same location on 12 cows. It is believed that the ability to discern between "short" and "long" distances between dairy cows confined in the barn can facilitate and accelerate the analysis of their social behaviors, but it can certainly also lead to the analysis of individual behaviors thanks to the location data.

Keywords: Social behaviour, Dairy cows, Dairy barn, Distance-based, Ultra Wide Band, Image Analysis.

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Paper ID: 013

Using Horse On Rural Farms: Investigations Methodology And Rural Development Practices

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Abstract. The role of the horse is becoming more and more relevant, not only from a sports point of view, inside equestrian centers but even within agricultural businesses that, through this animal, can offer rural tourism activities, pet therapy, and educational and social workshops (educational and social farms). If the federations of the Equestrian Industry carry out comprehensive control in the sports field, the lack of reliable data on the number, use, and husbandry techniques of horses within farms, which still represents a significant percentage of the number of subjects present in Italy, is equally substantial. As much growth is the spread of agricultural holdings that enter the world of horse tourism, educational and social farms, especially those that use horses for these activities. The purpose of this study is to fill the data gap in the Tuscany region by conducting a survey that focuses on the management, activity, and breed of horses found in agricultural holdings., The widespread nature of this activity, especially in Tuscany, makes it crucial to conduct a specific study to enhance our knowledge of horse welfare and the sustainability of these activities. The study through a specific methodology (which consists of comparing data from different databases, direct surveys, and filling out online questionnaires) aims to test a new data collection technique that can give an updated and comprehensive picture of the use and the modalities of keeping horses in farms. The research takes as a case study the Tuscany Region, making a specific survey in the various provincial territories achieving results that will certainly be of interest to the administrations and bodies in the sector.

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Paper ID: 014

Integrating Building Footprints and Bioenergy Potential in Rural Areas: a Case Study

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Abstract. Building morphology is crucial for tackling energy demands and achieving sustainable energy solutions in the face of climate change and global energy transitions. This study aims to analyse the spatial distribution of building footprints and heights in Jianghan Plain, China, and examine their relationship with energy demand using advanced spatial analysis techniques. The study also evaluates bioenergy potential as a renewable energy source to supplement rural energy systems. Using the high-resolution 3D-GloBFP dataset, building morphology is assessed to identify energy user distributions across rural areas. Bioenergy potential is calculated from agricultural and livestock by-products, with annual biogas availability estimated at 6.3×10^{12} kJ. Spatial correlations are analysed between building morphology and energy demand, while energy poverty indicators contextualise disparities in energy access. Preliminary findings reveal the robust performance of the 3D-GloBFP dataset in characterising building footprints and heights, enabling detailed mapping of energy demand. Correlations between building morphology and energy poverty highlight critical areas for renewable energy interventions. Integrating bioenergy potential into energy planning demonstrates opportunities to mitigate energy poverty and enhance sustainability. This research highlights the significance of leveraging building morphology data and bioenergy resources to inform rural energy planning, offering actionable insights for sustainable development and energy resilience.

Keywords: Building footprints, Rural planning, Spatial analysis, Circular economy, Energy demand.

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Paper ID: 016

Buried Plastics: exploring the fate of polyethylene mulching films in agricultural soil

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Abstract. Polyethylene mulch films are among the plastic applications widely used in agriculture due to their ability to enhance crop yields and conserve soil moisture. However, their environmental impact, particularly their fragmentation into microplastics and the release of chemical additives, raises significant concerns, necessitating in depth investigations. This study aims to analyse the behaviour of polyethylene mulch films buried in agricultural soils.

Polyethylene film samples were buried for 29 months at the experimental field of the University of Bari, in southern Italy climatic conditions. Periodic samplings were carried out to monitor the behaviour of the film over time. Data loggers and sensors were used to monitor climatic and soil parameters in the field. Preliminary observations revealed a slow degradation process. After 870 days, the polyethylene film samples were characterized both by surface alterations and by a 3% decrease in apparent surface compared to the initial condition.

The findings underscore the critical importance of field experiments to understand how environmental factors influence the degradation of polyethylene films and their interactions with soil systems. Such studies are essential for assessing the long term environmental sustainability of polymer based materials in agriculture, promoting informed decision making on their use, and encouraging the development of more sustainable agricultural practices.

Keywords: Polyethylene soil interaction, Plastic fragmentation, Polymer based materials in agriculture, Microplastics, Environmental impacts, Plastic pollution.

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Assessment of the thermal behaviour of compost-bedded pack barn facilities for dairy cows in central-western Brazil

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Abstract. Dairy farming has undergone significant changes in recent years, necessitating the intensification of its processes to enhance production efficiency in accordance with animal welfare conditions and more sustainable practices. In this context, the Compost-bedded pack barn (CBP) facility has been widely adopted. However, there is a lack of studies on its applicability in certain promising regions, such as the state of Goiás, Brazil. Therefore, this study aimed to evaluate the microclimate inside a CBP, focusing on the spatial distribution of thermal-environmental data and comfort indices. Thermal maps were generated to identify the spatial distribution of microclimate variables and verify the occurrence of heat stress zones.
The research was conducted in a CBP with open sides and positive pressure ventilation. The internal area of the CBP was divided into a regular grid consisting of 84 equidistant points, and data were collected during the summer. The thermal maps generated revealed a lack of homogeneity in the distribution of the analysed variables across the facility, with greater spatial variability observed in the afternoon. The thermal environment variables indicated alert conditions throughout the facility, with temperatures exceeding 30°C. Additionally, the air speed values were below the recommended levels in a large part of the internal area of the facility, highlighting the need to increase the ventilation flow to enhance thermal comfort for the animals. These findings can be used to guide decision-making processes to establish more suitable environmental conditions for raising dairy cattle.

Keywords: Compost Barn, Dairy Cattle, Heat stress, Livestock housing, Thermal comfort.

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Paper ID: 019

Comparative analysis of weed management strategies in vineyards and evaluation of NDVI/NDRE indices to assess their effectiveness

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Abstract. Soil degradation in vineyards highlights the need for sustainable practices to preserve soil health. This study evaluated and compared three weed control strategies implemented in vineyard under-rows. The first strategy, based on tillage, included an initial intervention with a rollhacke followed by an intervention with a blade weeder. The second strategy employed an under-vine mower for both interventions, while the third one employed a mulcher. The findings indicate that the tillage-based strategy provided superior weed control, with a recorded weed biomass value of 45.85 g d.m.·m^{-2} after the second treatment, compared to mowing and mulching, which yielded an average biomass of 87.11 g d.m.·m^{-2}. Notably, immediately after the first treatment, the tillage-based approach was less effective, with a biomass value of 471.50 g d.m.·m^{-2}, compared to the cutting-based strategies, which achieved an average biomass value of 52.21 g d.m.·m^{-2}. However, before the second intervention, plots managed with tillage exhibited significantly lower weed infestation levels compared to those managed with cutting-based methods, demonstrating a delayed but effective weed control effect of the tillage approach. Additionally, the study assessed the efficacy of these management strategies using RapidSCAN technology, which recorded NDVI and NDRE indices near the first intervention. NDRE results were consistent with post-treatment biomass measurements, with rollhacke yielding the highest index values. Pearson's correlation analysis further confirmed a robust positive linear relationship between weed biomass and NDVI/NDRE values. NDVI and NDRE indices show strong potential for efficient and quick estimation of weed control outcomes across various management strategies.

Keywords: Soil tillage, Sustainability, Resource depletion, Mechanical methods, Conservation agriculture, Vegetation index

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Sustainable Solutions for Water-Energy Nexus in Mozambico: a GIS-based methodology

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Abstract. Addressing energy and water management challenges in rural Mozambique is essential for sustainable agricultural development. This study focuses on Nampula Province, where limited access to electricity and water resources exacerbates socio-economic inequalities and environmental degradation. The research aims to promote sustainability by identifying, planning, and implementing innovative and socially validated solutions to enhance the water-energy nexus for agricultural growth. An integrated approach combining Geographic Information System (GIS) tools and participatory methodologies was developed to assess and address local needs. The first phase involved a detailed analysis of the rural context, including field surveys, stakeholder engagement through interviews, focus groups, and community workshops, and site visits to validate and supplement data. Tailored questionnaires and digital platforms like KoboToolbox were used to standardize data collection.

In the second phase, collected data were processed and graphically represented using GIS software, building a geodatabase with layers such as land use, crop distribution, water demand, energy needs, and locations of processing facilities. Advanced QGIS tools generated maps highlighting resource potential, critical deficits, and spatial disparities.

These maps and analyses represent essential insights to inform the planning and prioritization of sustainable interventions, enabling the identification of critical areas and opportunities for optimizing resource use and addressing deficits. This integrated and participatory approach could efficiently ensure the development of solutions that were contextually appropriate, technically robust, and socially validated, thereby laying the groundwork for effective and sustainable resource management strategies in Nampula.

Keywords: WEF nexus, spatial analysis, GIS, agricultural water management, Bioenergy production, agricultural waste.

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Optimization of Bioenergy Production from Plant Biomass in Nature-Based Solutions

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Abstract. Nature-based solutions, such as constructed wetlands (CWs), rely on vegetation for their ecological benefits. However, unharvested vegetation can lead to excessive biomass accumulation, resulting in operational issues such as clogging, reduced treatment efficiency, and the proliferation of invasive species. To sustain ecosystem functionality, regular harvesting is crucial. Yet, this practice generates waste that demands sustainable management strategies to mitigate environmental impacts and reduce costs. To address these challenges, the valorization of harvested vegetation offers a promising pathway. This re-search explores the potential to convert CW biomass waste into valuable re-sources, specifically through anaerobic digestion for biogas production. Labora-tory tests evaluated the biogas production potential of four plant species com-monly found in CWs (e.g., *Iris pseudacorus*, *P. Australis*, *Carex spp* and *Typha latifolia*).

The findings revealed that species with higher water content exhibited higher initial biogas production rates. However, the total biogas yield depended significantly on the presence of biodegradable compounds and an optimized carbon-to-nitrogen (C:N) ratio. Additionally, the study examined the impact of seasonal harvesting and post-harvest maturation on biogas output. Preliminary results showed that the highest biogas yield for these two factors reached up to 359 mL_{CH4}/gVS and 190 mL_{CO2}/gVS, respectively, highlighting the importance of optimizing both harvesting schedules and storage conditions. These results emphasize the potential to enhance the ecological and economic value of CWs by integrating sustainable waste management practices, such as biomass-to-biogas conversion, into agricultural and environmental management systems, taking into account the importance of optimizing harvesting schedules, storage conditions, and growth stages.

Keywords: Constructed Wetlands, Plant Biomass, Biogas, Bioenergy, Circular Economy.

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Assessment of the Use of Bedding from Compost-Bedded Pack Barns as Organic Fertiliser in Maize Crops

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Abstract. Dairy cattle production in Compost-Bedded Pack Barn (CBP) systems is notable for its economic viability and sustainability, particularly due to the use of bedding as fertilizer. However, it is crucial to evaluate the specific effects of using bedding as organic fertiliser on soil fertility and crop productivity to ensure its efficient and safe application. In this context, the present study aimed to assess the impact of using CBP bedding as organic fertilizer on the chemical properties of soil in maize cultivation.

The study, conducted in Cláudio—MG, Brazil, included chemical analyses of CBP bedding and soil from the plots designated for maize. Treatments with four dosages of CBP bedding were evaluated (T_1—no fertilisation; T_2—2 ton·ha^{-1}; T_3—4 ton·ha^{-1}; and T_4—6 ton·ha^{-1}), through chemical soil analyses throughout the maize production cycle. Soil chemical properties for each treatment varied throughout the production cycle. CBP bedding fertilization positively impacted Phosphorus (P; highest in T_4—34.70 mg·dm^{-3}), Potassium (K; highest in T_3—120 mg·dm^{-3}), Calcium (Ca; highest in T_2—3.46 cmol$_c$·dm^{-3}), Magnesium (Mg; highest in T_4—0.84 cmol$_c$·dm^{-3}), Potential Acidity (H + Al; lowest in T_2—0.66 cmol$_c$·dm^{-3}), Base Saturation (SB; highest in T_3—4.56 cmol$_c$·dm^{-3}), Cation Exchange Capacity at pH 7 (CEC; highest in T_4—6.01 cmol$_c$·dm^{-3}), and Organic Matter (OM; highest in T_4—6.01 cmol$_c$·dm^{-3}). CBP bedding enhances soil chemical quality; however, physical, microbiological, morphological, and productivity analyses are necessary to enable more informed decisions regarding its application.

Keywords: Compost Bedding, Dairy Cattle Production, Crop Production, Soil Chemical Properties, Sustainability.

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Innovative Use of Low-Quality Sheep Wool Waste in CRM Bio-Composite for Sustainable Building Solutions

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Abstract. The construction sector has a significant environmental impact due to high CO_2 emissions and the use of non-renewable materials. To mitigate these effects and preserve natural resources, there has been a growing focus on developing sustainable solutions, such as incorporating by-products and natural fibers. One of the most innovative approaches is the production of bio composites, like Composite Reinforced Mortar (CRM), which integrate natural fibers, polymeric resins, and mortars to create high-performance materials suitable for structural and reinforcement purposes. Among natural animal fibers, low-quality sheep wool, often considered waste, is gaining increasing attention. While it is already employed in insulation panels due to its well-established thermoacoustic properties, its potential in structural applications remains largely unexplored. This study examines the feasibility of incorporating low-quality sheep wool into CRM composites. Wool yarn was used to assembly a prefabricated grid, reinforced with polymeric resin, and integrated into an inorganic mortar. The mechanical properties of the composite, particularly its tensile strength, were examined, with a focus on fiber-to-resin adhesion and compatibility with the cementitious matrix. Results demonstrated promising mechanical properties, highlighting wool-based CRM as a viable and sustainable reinforcement material. However, further development is needed to optimize its performance and expand its potential applications. This research represents an initial step toward the valorization of sheep wool in structural applications, promoting circular economy principles and contributing to the sustainability of the construction sector.

Keywords: Circular Economy, Waste Valorisation, Sheep Wool, Composite Reinforces Mortar, Biocomposites, Sustainable Construction

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Machine Learning techniques application for accurate meat quality prediction

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Abstract. The growing demand for high-quality meat products has driven advancements in technologies for rapid and accurate meat quality assessment. Machine Learning (ML) has emerged as an interesting tool for predicting meat quality attributes by analyzing data collected through technological tools such as biometric sensors and real time monitoring systems. The presented manuscripts, aims to present an overview of the available algorithms and their performances regarding the estimation of meat quality for relevant livestock species. The performed bibliographical analysis showed that thanks to the ability to identify patterns and relationships, that traditional statistical methods often overlook, ML could improve conventional methods for meat quality estimation. In particular, supervised learning models, such as support vector machines, random forests, and neural networks have demonstrated high accuracy in predicting meat quality traits from different input features. Moreover, the integration of ML not only enhances prediction accuracy but also accelerates the decision-making process, reducing reliance on time-intensive and destructive laboratory analyses. Although, challenges, such as the need for robust datasets and model interpretability, remain to be addressed. Nevertheless, the adoption of ML in meat science holds significant potential for improving supply chain efficiency, ensuring product consistency, and meeting consumer preferences.

Keywords: Meat Quality Estimation, Machine Learning, Supervised Learning Techniques, Precision Livestock Farming, Digital Farming

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Sustainable technologies for renewable energy production through agricultural waste and by-products valorization

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Abstract. Technological and industrial development, coupled with global population growth, has led to a rising demand for energy and resources, accompanied by uncon-trolled waste production and increasingly severe environmental degradation. The agro-food sector contributes significantly to this issue, generating large amounts of liquid, solid, and gaseous waste, which contain high levels of organic material. Im-proper management of these wastes exacerbated environmental problems, facilitating the spread of contaminants in soil, and water. Furthermore, greenhouse gas emissions from agricultural activity contributes to climate change. In alignment with the sus-tainability goals outlined in the 2015 Paris Agreement, this research aimed to explore ecological and sustainable approaches for managing agricultural waste and agro-industrial by-product. In this paper, a comprehensive literature review is presented. The primary objective of this study was to highlight and discuss the viability of dif-ferent technologies for the processing of agricultural by-products and wastes into valuable products, such as bioenergy. This review encompassed a wide range of tech-nologies, including emerging and innovative methodologies, evaluating their sustain-ability based on environmental, economic, and social impacts. By synthesizing the latest research and advancements in the field, the review identified critical gaps re-quiring further investigation and proposed pathways for advancing and implementing these technologies. This was highlighted as an essential step toward the implementa-tion of a circular economy model, where resources are continuously reused and repur-posed, contributing to both environmental protection and sustainable development.

Keywords. Sustainability, Bioenergy, By-product, Agricultural waste, environmental impacts, valorization.

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Assessing Drought-Induced Stress in Sicilian Citrus Orchards Using Remote Sensing

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Abstract. Citrus cultivation is a cornerstone of Mediterranean agriculture, and particularly in Sicily, covering about 71,000 ha. However, ongoing climate change has led to recurrent severe droughts, posing significant threats for these agro-systems. This study appraises the impact of drought on Sicilian citrus orchards at regional scale. Specifically, it aims to: (i) assess long-term drought conditions using climate reanalysis data; (ii) map citrus cultivation areas through high-resolution satellite imagery; and (iii) evaluate the effects of drought on citrus crops through vegetation indices.
ERA5-Land soil moisture data (1950–2024) were analyzed to compute the Soil Moisture Index (SMI) and Soil Moisture Anomaly (SMA), quantifying regional drought conditions. Sentinel-2 Normalized Difference Vegetation Index (NDVI) time series (2016–2024) were, then, used to map citrus orchards through Random Forest models. Trends in SMI and SMA were correlated with NDVI and the Normalized Difference Red-Edge Index (NDRE) to identify the impact of soil moisture deficits on citrus crops.
This study provides a robust methodological framework for monitoring the drought impact on citrus cultivation at regional level, offering valuable insights to enhance the water resource management of these agro-systems in the context of climate change.

Keywords: Earth Observation, Agricultural drought, Soil moisture, Vegetation indices.

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Optical sensor prototype for in-line must turbidity determination

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Abstract. Grape pressing is a fundamental process in wine production as it affects the quality of the must. It is, therefore, necessary to better understand the changes that occur by continuous monitoring of key parameters during the entire press-ing cycle with the help of non-destructive sensors. The present research aims to develop a low-cost optical prototype to measure must turbidity with potential in-line application. The designed and assembled prototype mounts an IR LED light source and two IR photodiodes with peak sensitivity at 900 nm. The opti-cal chamber is made of aluminum, blackened internally, with a removable cover for cleaning, sealed glass windows for LED and photodiodes and with input and output lines for the must. The two photodiodes are mounted in two modes with respect to the LED: in transmission, therefore functioning as a turbidimeter, ex-ploiting the must shielding effect, and at 90° therefore functioning as a nephe-lometer, exploiting the must scattering effect. The signals generated by the pho-todiodes are amplified by a double operational amplifier appropriately circuited. An electronic board with microprocessor manages the signal and the activation of the peristaltic pump for the temporized fluxing of the must in the optical chamber. Preliminary tests conducted on musts of different turbidity show a satisfying functioning of the device. Future developments include calibrating the prototype using a turbidimetric calibration kit to convert the signal into nephelometric turbidity units, NTU as well as the implementation of a low-cost wireless board for IoT data management.

Keywords: Must turbidity; Optical prototype; Low-cost nephelometer; IoT implementation; In-line sensors; Infrared light and photodiodes.

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Test different techniques to reduce the vegetation disturbance for soil loss estimation at plot scale

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Abstract. Recent studies showed the suitability of photogrammetric technique for monitoring soil loss at plot scale. However, the presence of vegetation on the plot could be led and overestimation when the monitoring was done using UAV. In this paper, different methods were tested to evaluate the capability to recognize the vegetation and obtain a better estimation of the soil loss. The analysis was conducted at the SERLAB experimental site (central Italy), equipped with systems for directly measuring soil loss. The plot monitored were four, two length 22 m and width 8m and two length 22 m and width 4m with a slope of 16%. In two of the plot monitored, the cover crop traditional management are applied, i.e. sown in September-October and devitalized by ploughing in early spring to prepare the sowing of the cash crop (sunflower) and in the others two plots the cover crop mulch-based no-tillage management are applied. A DJI Phantom 4 multispectral to obtain the reconstruction of the surface was used. The images acquired from UAV were processed using the Agisoft Metashape software, with a 0.5cm/pixel resolution. As showed by previous studies, the presence of vegetation, alter the capacity of reconstructing the actual dynamics of the microtopographic variations of the soil surface. In particular, vegetation variations (positive or negative) between two successive surveys could be erroneously interpreted as a soil deposit or removal.

Keywords: Photogrammetry, soil erosion, cover crops, UAV

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Tests of a renewable energy polygeneration system by means of a thermal load simulator apparatus

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Abstract. Rural areas lend themselves well to the use of renewable energy sources to power buildings of the agro-industry sector. The use of renewable energy sources can be optimized if the different sources work synergistically. A system of polygeneration based on solar and geothermal energy was realized and tested at the University of Bari. Hot water is produced by solar collectors and used for feeding a solar absorption cooling system, in turn producing cold water. Electricity is generated by a photovoltaic system and used for feeding the geothermal heat pump. Four tanks store hot and cold water. An air-water reversible heat pump was used as thermal load simulator, producing hot water as load for cooling demand. This paper presents the results of a test in which the thermal load of a building for production, aging and marketing of wine was simulated. The polygeneration system produced cooling energy for building climate control. The research showed that the polygeneration system met the thermal demand, mixing the different renewable energy sources as a function of the source availability. The geothermal heat pump covered the periods when the absorption chiller was not able to produce cold water.

Keywords: PV, Absorption chiller, Solar collectors, Cooling.

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Performance and benefits of an indoor location system for real-time cow tracking

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Abstract. Precision Livestock Farming has become widespread on dairy farms, especially those with large numbers of cattle and higher productivity. Among the many devices and systems used to collect and process data, real-time cow location systems have been introduced in recent years.
By locating animals in the barn, it is possible to continuously track the movements of each animal, providing detailed information on their habits, preferences and health status. As part of the "Spazio" project, financed by the Lombardy Region 2014-2020 Rural Development Program, two demonstration installations (barns with 60 and 140 cows respectively) have been carried out. The indoor cow tracking system used is based on the transmission of Bluetooth Low Energy signals to antennas capable of determining the angle of arrival. The server to which the data from the antennas placed in the barn are sent is equipped with the "Position Engine", i.e. the software that processes the data and determines the position of each animal.
The results obtained in 5 months of data collection in the two barns confirm the effectiveness of the real time positioning system, which obtained an average error of less than 70 cm in the detection of animals under operating conditions. The possibility of analyzing the movements of the cows in the barn and the use of the different areas in combination with other information from the cows, can be used for management purposes and for early detection of animals with abnormal situations.

Keywords: Cow Behavior, Early Disease Detection, Smart farming, Animal welfare, Precision Livestock Farming

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Environmental impact of medium-powered tractors with different gaseous emission stages

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Abstract. Since 1996, both Europe and USA have implemented anti-pollution regulations aimed at a dramatic reduction of gaseous pollutant emissions from vehicles equipped with internal combustion engines, including those in the non-road machinery sector. Among these, agricultural tractors, and more broadly self-propelled agricultural machinery, play a significant role in environmental pollution, primarily due to emissions from their diesel engines. Key pollutants include particulate matter (PM), nitrogen oxides (NOx), carbon monoxide (CO) and unburned hydrocarbons (HC). Additionally, there is increasing focus on CO_2 emissions, a parameter long considered in the automotive sector.

This study aims to compare the emissions impact of tractors within the same power class (65–80 kW) but adhering to different anti-pollution standards. The analysis evaluates the environmental impact of open-field operations, based on power requirements for specific tasks at steady engine operating points, followed by replication of these conditions in stationary scenarios.

Measurements will be conducted using an electromagnetic brake connected to the tractor PTO, recording both power output and gaseous pollutant emissions amount. The results will also be analyzed against regulatory emission limits corresponding to each tractor's homologation stage.

Furthermore, the study will estimate the environmental impact of emissions based on the time spent and frequency of each operation within defined production chains and farm areas. This approach will provide a comprehensive understanding of the environmental footprint of tractors adhering to different emission standards and may assist users in selecting the most suitable model to minimize gaseous pollution.

Keywords: Open-Field Tractors, Engines Pollutants, Emission Standard, Production Chain, Environmental Footprint

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Optimize tractor's driver comfort with correct seat suspension adjustment

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Abstract. Agricultural tractors drivers are frequently exposed to high vibration levels, caused by dynamic forces generated when travelling over uneven surfaces. To mitigate vibration transmission, modern tractors are equipped with comprehensive suspension systems, including front axle, cab and seat suspension. However, many older tractor models still in use are equipped solely with mechanical seat suspension.

Regardless of the type, seat suspension systems typically include a stiffness adjustment mechanism, referred to the operator's mass, generally ranging from 50 to 130-140 kg. Improper or neglected adjustments (whether too soft or too rigid) can significantly compromise suspension efficiency, resulting in reduced driver comfort.

This paper shows the impact of incorrect seat suspension adjustments on vibration levels transmitted to the driver during both transport and field operations. Tests were conducted on various tractor models, operating alone or coupled with implements, either towed or attached via the 3-point hitch. Measurements included transport on a well-maintained farm road, while towing a loaded trailer at varying speeds, and fieldwork, such as ploughing on uneven terrain.

Vibration levels were recorded using a tri-axial accelerometer placed on the seat cushion and a mono-axial accelerometer fixed on the platform, to assess suspension damping performance. Drivers with different body masses participated in the trial, testing both correctly settled and progressively misadjusted suspension settings.

The results, also analyzed against relevant standards, reveal the detrimental effects of improper suspension adjustments, including the identification of harmful resonance frequencies. The findings emphasize the need of accurate suspension adjustment in enhancing operator comfort and safeguarding long-term health.

Keywords: Vibrations, Mechanical Suspension, Stiffness, Driver Mass, Setting

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A survey on the technical strategies for the reduction of gaseous pollutant emissions in agricultural tractors

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Abstract. Over the past 25 years, the progressive reduction of pollutant gas emissions from engines fitted on self-propelled agricultural machinery has achieved an extraordinary decrease of up to 98%. This excellent result has been driven by major technological advancements in diesel internal combustion engines, including the fitting of newly developed, specialized devices. Apart from carbon monoxide and unburned hydrocarbons, emission reduction efforts have primarily targeted particulate matter and nitrogen oxides. These reductions have been achieved through the implementation of advanced technologies, such as EGR (Exhaust Gas Recirculation), SCR (Selective Catalytic Reduction), DPF (Diesel Particulate Filter) and DOC (Diesel Oxidation Catalyst).

These advancements, while occasionally causing a slight reduction in engine efficiency (and a corresponding increase in specific fuel consumption), have also significantly augmented production and operational costs, partly due to the use of diesel exhaust fluid ("AdBlue").

To encounter the stringent requirements of current Stage/Tier 5 emission standards, manufacturers of self-propelled agricultural machinery have adopted various technical and design strategies, custom-made to the baseline level of technological development of their engines. Thus, the environmental impact extends to the construction, maintenance and disposal of the described devices.

This study investigates the environmental impacts of engines installed on tractors and self-propelled agricultural machinery that comply with the highest emission standards. By analyzing currently available models on the market (categorized by power class), the research aims to compare these impacts also through Life Cycle Assessment (LCA). Where applicable, the study also considers the expected use conditions of the machinery equipped with these engines.

Keywords: Environment, Agricultural Machinery, Anti Pollution Devices, Diesel Exhaust Fluid, Production Chains, Life Cycle Assessment

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Conventional and Smart Technologies to evaluate spatial variability in maize subjected to mineral and organic fertilisation

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Abstract. This work addressed growth and final grain yield of a maize (DKC4109 hybrid; FAO 300) crop subjected to mineral vs. mineral and organic (farmyard manure) integrated fertilisation. The crop was grown on a 5.46 ha farm plot in the Po Plain, Italy (Lat. 44.810306°, Long. 11.147113°). The aim of the research was to compare the two fertiliser treatments by combining con-ventional surveys as field evaluations of crop growth and development, and da-ta obtained through smart technologies including remote sensing (PlanetScope imageries 3mx3m, UAV image 0.015mx0.015m), proximal sensing (NDVI by GreenSeeker spectroradiometer), and soil canopy cover (Canopeo image analy-sis tool). At harvest, yield mapping was carried out using a combine harvester equipped with after-market sensing system. The results showed no significant yield difference between the two fertiliser treatments. The vegetation indices obtained from the different optical sensors (satellite sensor, multi-spectral UAV camera, GreenSeeker sensor) were substantially consistent. Overall, they indi-cated a non-negligible spatial variation in maize growth status that needs to be monitored in the follow-up of the research programme in the subsequent years.

Keywords: Yield Mapping; Remote and Proximal Sensing; Vegetation Index; Maize; Fertilisation.

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Integrating Conversational AI and Large Language Models for Smart Food Processing in Industry 4.0/5.0

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Abstract. The present study explores the potential of conversational AI in industrial 4.0/5.0 applications. It focuses on the integration of advanced Large Language Models (LLMs) for monitoring, control and optimization of food processes. Specifically, the study aims to develop a python toolkit for smart food systems based on the open-source project named Cheshire Cat AI: an AI-agnostic conversational framework for building AI Agents. In the context of Industry 4.0 and 5.0, the implementation of AI Agents and LLMs has the potential to address significant challenges in food processing, including high resource consumption, environmental impact and inconsistent product quality. For the intended purpose, a case study approach was employed, implementing and testing the toolkit in a smart food drying system, with the aim of enabling real-time interaction with an LLM to monitor and control the processing unit. Conventional drying systems often rely on operator expertise and reactive strategies, resulting in inefficiencies and wastage. The integration of AI agents with LLMs within the proposed toolkit enables real-time decision-making, potentially improving human-machine interaction and, thus, product and process sustainability, as well as food safety and security. In addition, this study provides a foundation for the implementation of conversational AI in achieving human-centered industrial practices, aligning with the objectives of Industry 5.0.

Keywords: Conversational AI, Large Language Models, AI Agents, Cheshire Cat AI Toolkit, Industry 4.0/5.0, Smart Food Drying

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Advancing Circular Bioeconomy in Agriculture: GIS-Based Strategies for Agricultural Bioresources Supply-Chain and Valorization

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Abstract. Agrifood systems face significant structural, political, demographic, and environmental challenges. Their fragility is compounded by inefficient and unsustainable patterns in food production, distribution, and consumption. Transforming agricultural systems into circular models through the reuse of biowaste and by-products offers a promising solution. This approach positions agricultural residues as valuable resources, supporting energy production (e.g., bioenergy, biofuels) and enhancing food production (e.g., biofertilizers).

This paper presents the methodology applied within the Horizon Europe TEAPOTS project to develop GIS (Geographic Information Systems) maps that identify suitable soil areas for biomass production in pilot locations. These maps aim to optimize feedstock selection and facilitate the valorization of residual biomass for diverse applications, including biochar, compost, and energy generation (electricity and thermal).

By leveraging multispectral, SAR (Synthetic Aperture Radar) from open-source satellites, three annual maps with 10-meter resolution were produced: a cover crop classification map, a biomass availability map, and a residual biomass availability map in France and Veneto region (Italy). The model was validated firstly in two physical farms in Greece and Italy and then applied in the two virtual sites, showcasing the model's adaptability and scalability. The findings underscore the critical role of data validation and the accessibility of open plot data for replicating the model across Europe.

Keywords: Circular economy, Bioresources, Spatial Analysis, GIS, Remote Sensing.

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Evaluation of Heating Cables for Preventing Late Frost Damage: A Pilot Vineyard Study

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Abstract. Late frosts pose a significant threat to vineyards, particularly in spring, as they can severely damage vine buds, leading to substantial economic losses. Climate change has increased the frequency of these events, highlighting the need for more effective and sustainable frost protection systems.

This study aimed to assess the effectiveness of electric heating cables ap-plied in different configurations to grapevines under varying physiological conditions (water and nutrient status). The heating effectiveness was quantified as the temperature difference measured at specific vine parts (trunk, cane, and bud) between heated and untreated (control) plants.

Two cable configurations were tested, conventional application, with the cable wrapped along the cane, and alternative application with the cable wrapped around the trunk.

Results showed that heating the trunk indirectly raised bud temperatures, demonstrating the potential of this approach. Moreover, combining heating with water or water and fertilizer treatments led to higher temperature increases compared to untreated plants.

The energy consumption of the heated cables was 5.5 Wh/m. For the branch configuration, the total instantaneous consumption ranged between 20 kW and 36 kW per hectare. In the trunk configuration, which requires 60% more cable (60 cm), the total instantaneous consumption ranged between 32 kW and 57 kW per hectare.

Future studies should focus on testing the system under critical temperature conditions and optimizing cable configurations and materials. These findings can contribute to developing more efficient and sustainable solutions for pro-tecting vineyards from late frost damage.

Keywords: Late frost, Vineyard protection, Heating cables, Damage preven-tion, Sustainable agriculture, Temperature management.

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Evaluation of nature-based solutions efficacy at the landscape scale using a modelling approach

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Abstract. Climate change and urbanization significantly amplify urban flooding and heat island effects, escalating harm to both infrastructure and human health. Nature-based Solutions (NBS) have been widely implemented in different regions to mitigate these challenges. Among various nature-based solutions, rain gardens effectively mitigate urban stormwater im-pacts by increasing infiltration and reducing surface runoff. While exist-ing studies assess the efficacy of nature-based solutions at the local scale, comprehensive studies addressing these phe-nomena at the landscape lev-el remain scarce. A landscape-scale analysis of the wider adoption of this type of structure is useful to assess its right potential to mitigate urban flooding, optimize land use planning, support evidence-based policy-making, and guide stakeholders in implementing effective climate resili-ence strategies. Effectively, assessing NBS impacts at the landscape scale can increase stakeholder engagement and participation in different im-plementation and maintenance phases. In this regard, the present research aims to evalu-ate the efficacy of rain gardens at the landscape scale using a bi-dimensional hydrologic-hydraulic modelling approach. The identi-fied approach enabled the achievement of reliable results based on small-scale model calibration and subsequent application to a larger scale. The results demonstrate that the widespread adoption of rain gardens across the territory effectively reduces surface runoff, particularly for frequent rainfall events, enhancing flood man-agement and strengthening urban resilience.

Keywords: Nature-based solutions, Rain garden, Landscape-scale, Flood management

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Finite Element Analysis for Material Selection and Optimization of Frame Structures in Elevating Work Platforms

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Abstract. This study focuses on optimizing the design phase and selecting appropriate construction materials for developing a telescopic arm of an Elevating Work Platform (EWP) for agricultural use. Using a finite element analysis (FEA) model, the structural and physical properties of four materials were compared: aluminum alloy (EN-AW 1200), aluminum alloy (EN-AW 2014), high-strength low-alloy steel (HSLA) Fe275JR, and HSLA S700 steel. The evaluation was conducted under simulated operating conditions in accordance with the UNI EN 280 standard. Simulation results demonstrate that HSLA S700 steel provides superior structural performance, offering high strength, minimal deformation, and excellent safety factors, making it ideal for applications demanding maximum durability and load capacity. On the other hand, the aluminum alloy (EN-AW 2014), alt-hough less resistant and more prone to deformation—yet still within standard limits—offers a substantial weight reduction, improving the structure's overall efficiency and maneuverability. This significantly lowers the platform's center of gravity, improving maneuverability and compatibility with smaller, less powerful tractors. The use of FEA enabled the development of safer and more cost-effective EWPs, with a particular emphasis on enhancing productivity and safety in agricultural tasks such as pruning and harvesting.

Keywords: Finite Element Analysis, structural model, model optimization, structural material, elevating work platforms

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A Cost-Effective Ultra-Wideband Real-Time Location System for Indoor Autonomous Navigation of a Feed-Pushing Robot

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Abstract. Effective livestock ration intake requires continuous feed availability at the manger. Cows often push away less palatable ingredients, necessitating the regular repositioning of displaced feed. This repetitive and tedious task could be efficiently handled by a robot.

This paper presents an indoor localization system based on DecaWave DWM1001 devices, developed to support the operation of an autonomous feed-pushing robot. The system employs Ultra-Wideband (UWB) technology to implement a Real-Time Location System (RTLS) using two-way ranging.

The system consists of some anchors, positioned at specific locations within the building, and a tag mounted on the robot. Each anchor is assigned a precise position, with centimeter-level accuracy. The tag determines its spatial position at a frequency of 10 Hz, measuring the distances to the anchors.

Compared to typical sensors used in indoor robotics (such as LiDARs, cameras, and others), the described system offers several advantages in the cowshed environment. Specifically, the UWB RTLS system is resistant to dirt accumulation, unaffected by obstructions caused by feed or animal movement, and incurs relatively low maintenance costs.

Since the UWB RTLS system provides only positional data, the feed-pushing robot computes its orientation for autonomous navigation by fusing odometric information through an extended Kalman filter. The system's performance was evaluated by measuring the robot's position using a highly accurate laser tracker in a warehouse environment replicating the conditions of the intended deployment location.

Keywords: Autonomous Navigation, Indoor Localization, Ultra-Wide Band, Real-Time Location System, Barn Lane, Animal Feed Ration

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A 128-layer LiDAR System for Discretizing the Vineyard Canopy, for Selective Plant Protection Treatments Based on Volume and Density

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Abstract. The several applications of LiDAR include high-resolution mapping of landscapes and terrains, measuring the distance between objects and surface features, as well as capturing the shape of buildings and infrastructure. It is also valuable for environmental monitoring, specifically in measuring vegetation dimensions and density.

This paper illustrates the potential of using powerful 128-layer LiDAR sensors for canopy recognition in vineyards, along with a sprayer equipped with PWM (Pulse Width Modulation) nozzles with a variable duty cycle for performing plant protection treatments, by adopting advanced real-time Variable Rate Technology.

The system was mounted on a motorized tracked platform, equipped with a sprayer and various sensors. In addition to manual operation, the platform can be controlled by an on-board computer, enabling the use of AI algorithms for task planning and data processing. This computer also acquires and processes data from the sensors on the machine, including two 128-layer LiDARs, an Inertial Measurement Unit, and a dual-antenna RTK receiver.

The entire system can thus be considered a robot, able of autonomously navigating and maneuvering between vineyard rows. Using one of the two 128-layer LiDAR sensors, a 3D representation of the vineyard canopy is created while the robot autonomously navigates between the rows, simultaneously regulating in real time the amount of sprayed mixture. By using PWM nozzles, each individually controlled to regulate flow, the spraying optimization is achieved not only along the rows but also across different horizontal layers of the canopy.

Keywords: Autonomous Navigation, LiDAR, Vineyard, Variable Rate Technology, Plant Protection Products.

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Integral monitoring of manure management practices in three dairy cow farms in Italy

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Abstract. Best practices for manure management have been studied in numerous research projects and their effectiveness and usability under operational conditions have been evaluated. Some of these techniques have become widespread among livestock farms, but there are limited examples of a systematic and integrated monitoring of the manure management chain. The objective of this activity, which will last at least 3 years, is to apply the state-of-the-art monitoring technologies in three dairy cow farms to assess their sustainability and to account for nutrient use efficiency, soil quality, gaseous emissions and nutrient leaching.

In addition, monitoring over time the effectiveness of the different techniques implemented will allow to collect information to define an environmental balance sheet for each farm including both the carbon footprint and the greenhouse and acidifying gases emissions in manure management.

The monitoring scheme is a combined approach including: IoT technologies for recording environmental variables inside and outside the barn (e.g. temperature, humidity, CO_2 and NH_3 concentrations), manure production and characteristics, water consumption; data obtained from livestock recordkeeping (number and category of animals, feed characteristics and quantity delivered); recordings of manure application (manual and/or automatic); field operations data ; crops yields; field and products analyses.

The information obtained is then used to obtain an integrated nutrient balance with the estimation of the losses of NH_3 in the barn and in the storage, nutrient efficiency and leaching considering different manure management options.

The results obtained will also provide useful guidance in directing regional policy toward sustainable livestock effluent management systems.

Keywords: sustainable agriculture, monitoring, nutrient efficiency, emissions, manure management

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Historical parks as ecosystem service providers: a framework for sustainable design

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Abstract. Urban ecosystem services (UES) support human well-being at different scales, but their evaluation in urban green spaces is challenging, especially when considering multiple categories simultaneously. Models and indicators offer practical proxies for estimating UES, although they often fit large-scale green infrastructure relying on land use/land cover data, making them less applicable to small-scale green spaces. Historical parks, with the coexistence of diverse planting configurations, species and management, and their cultural and social values, are important sources of UES. They act as complex ecosystems where services interact non-linearly, resulting in synergies or trade-offs. These features make historical parks ideal for testing design impacts on UES provision, using established models and indicators adapted to design-scale. The experimental area covers 50 ha of Monza Royal Park (Italy) which was recently requalified with PNRR funding. The methodology evaluates UES before and after requalification, considering the changes in vegetation configurations and its usability. Provisioning services, include timber from tree renovation and hay from grassland. Regulating and maintenance services—e.g. CO_2 sequestration, pollutant abatement, rainfall interception, water purification, erosion prevention—are assessed using models and literature-based equations. Cultural services are analyzed through questionnaires and visitor counting. Results are standardized and their sum produces three UES category indices for ex ante and ex post comparisons. Absolute values, reported for each vegetation configuration, highlight their contribution to UES supplying. This research provides a framework useful for landscape planners to realize new urban parks or requalify existing ones, enabling informed and socio-ecological design approach to enhance UES provision.

Keywords: Urban ecosystem services, models and indicators, sustainable landscape design, historical parks, vegetation configurations, user needs.

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A novel method to assess canopy rainfall partitioning of shrubs by simulating extreme rainfalls

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Abstract. Intense rain events have become more frequent due to climate change, especially in drylands. The interception of rainfall by vegetation is a critical hydrological process after rainstorms of drylands. There is a need to explore to what extent different species and sizes of shrub plants intercept and partition rainfalls. To this aim, this study proposes a novel method to estimate the canopy interception capacity and interception rates as well as stemflow of three typical Mediterranean shrub species of three size classes under a simulated extreme rainfall rate (~8 mm min^{-1}, historical return period of >100 years). This method was developed to assess both canopy interception and stemflow fraction using a portable rainfall simulator properly adapted to this purpose. Results showed significant differences in interception amount, rates, and storage capacity among the shrub species, with variations in plant morphology, such as shrub height and canopy diameter, being the key factors determining interception capacity. Linear correlations were found between canopy interception and shrub canopy diameter, when observations were grouped for size class. These linear correlations between shrub morphology and partitioning enabled multiple-regression linear models to be developed that predicted canopy interception and stemflow with good accuracy from shrub height, canopy diameter, dry biomass, size class, and species. Despite these measurements being conducted under one extreme storm depth and intensity, the results provide: (i) values of rainfall partitioning for important shrub species in Mediterranean dryland environments; and (ii) a simple but reliable model that may be further developed (e.g., embedding variable rainfall values as weather input or incorporating other morphological parameters) and may be integrated into complex hydrological models.

Keywords: canopy interception capacity; canopy interception rate; plant morphology; hydrological models; multiple-regression analysis; rainfall simulation.

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Dehydrated potato slices: optimization of blanching pretreatments through a reverse engineering approach

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Abstract. To obtain high-quality semi-dried potato slices, considering b rowning effects in advance is essential to study how to mitigate both enzymatic (PPO and POD related) and non-enzymatic (after-cooking darkening and Maillard reaction) dis-coloration during process. Indeed, these phenomena negatively affect output quality by reducing visual appeal, thereby decreasing consumer willingness to pay and marketability.

This study adopts a reverse engineering approach to understand and counter-act browning in 5-mm potato slices from Universa and Fontane cultivars, both provided by Consorzio Cooperativo Ortofrutticolo Alto Viterbese (C.C.OR.A.V.) in Grotte di Castro (Viterbo, Italy).

Various pretreatments were evaluated, i.e. blanching in distilled water, in $CaCl_2$ (0.3 % and 0.5 %) and citric acid (1.5 % and 3 %) solutions, alone or in combination at 70 and 85°C for 0 (control), 2, 4 and 6 min. To further standardize the process, potato slices were dipped in distilled water at room temperature be-fore blanching and in ice water after blanching for 2 min each.

Browning development was systematically evaluated through image analysis, performed in a dark chamber. Color data, expressed in CIELab coordinates, were acquired every three minutes over six hours of air exposure at room temperature. First results showed that dipping at 85°C was more promising than at 70°C in reducing browning, while the addition of 1.5 % citric acid helped to improve discoloration prevention.

This study provides critical insights for a three-year PhD project focused on integrating optimized protocols in a smart drying system; the aim is producing high-quality semi-dried potato slices as novel food.

Keywords: "Patata Alto Viterbese PGI", dehydration, browning, calcium chloride, citric acid, image analysis.

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Optimization of machines for sowing, transplanting and harvesting of "Cipolla Bianca di Margherita"

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Abstract. Onion (Allium cepa L.) is among the most cultivated crops in the world, also due to its positive effects on health. Along the Adriatic coastal strip of Italy is widely produced the Protected Geographical Indication (PGI) "Cipolla Bianca di Margherita". This product with unique characteristics is produced in a very specific geographical area characterized by sandy beaches. Therefore, it is essential to optimize the production techniques of both seeds and the final product.

This study concerned the analysis of the agronomic practices of sowing in nurseries, transplanting and harvesting of onions on the beach, in order to identify solutions to improve these practices through their mechanization.

The suitable identification of the main settings for the precision drum seeder allowed to optimize the filling of the cells with a filling rate of over 90 %.

The mechanized transplant on the Margherita di Savoia beaches required the modification of a semi-automatic transplanter. The machine was equipped with suitable floating systems and a drive roller. This allowed a correct deposition of about 99 % of the seedlings on a prepared convex soil. A subsequent modification of the propulsion and gearbox made it possible to work on unprepared soil with a working capacity of 10824 plants/hour.

The mechanized harvesting operation also required the modification of the harvesting components of an existing machine, a potato harvester. The adaptation of the main mechanical parts allowed a working capacity of up to 85700 onion bulbs/hour in a 17x17 cm planting layout.

Keywords: Precision Planters, Transplanting, Mechanized Harvesting, Precision Agriculture.

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Depuration of citrus processing wastewater in aerated lagoons: laboratory tests

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Abstract. Lagoons have been proposed as alternative system compared to activated sludge plants and viable solution for depuration of wastewater from different sources. Aerated lagoons have been investigated for several years, but little work has been done about lagooning of agri-food effluents. No investigations focused wastewater produced by citrus industries, although several depuration technologies have been proposed. To fill this literature gap, this study has carried out laboratory tests using aerated lagooning tanks to depurate wastewater collected in a citrus processing company. The experimental system simulates the upper aerobic layer of a full-scale lagoon. Batch tests (each one lasting six weeks) of raw citrus wastewater have been carried out in the experimental tanks by three test series, in each varying one of the following operation parameters: i) air flow rate; ii) COD:N; and iii) concentration of essential oils. The remaining parameters have been kept constant among the experimental tanks. The response variables are the depuration and energy efficiencies (removal rate of COD and specific energy supply per unit COD removed) under the effect of these variations. The tests have indicated the optimised operation parameters and the increase in energy efficiency and depuration reliability due to aeration and parameter setup. This study should provide useful indications to agri-food industry owners and technicians about the feasibility of optimized aerated lagoon systems for depuration of wastewater with high pollution hazard. A full-scale trial is recommended in a future experimental phase to validate these laboratory tests.

Keywords: wastewater treatment; depuration efficiency; aeration; COD; COD:N; essential oil.

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Soil impacts and recovery time after ground-based logging in Mediterranean beech forests

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Abstract. This study examines the effects of ground-based logging on the physicochemical properties of soil and the biodiversity of microarthropods in Mediterranean beech forests, with a focus on recovery processes in skid trails over a 5-year period. Research was carried out in three representative areas of Southern Italy, covering a chronosequence of cutting blocks harvested in 2021, 2017, and a control not-logged site. Soil samples were taken from both disturbed (DIST) and undisturbed (UND) areas to analyze bulk density, penetration resistance, shear resistance, organic matter content, and biodiversity using the QBS-ar index. The findings revealed significant soil compaction due to machinery, with bulk density increasing by 19% in skid trails compared to undisturbed areas. Penetration resistance in disturbed soils rose to 0.26 MPa, nearly three times higher than the 0.09 MPa measured in control soils, while shear resistance increased from 1.96 t m^{-2} in control areas to 7.18 t m^{-2} in newly harvested skid trails. These disturbances coincided with a 50% reduction in the QBS-ar index in disturbed soils relative to controls.

Partial recovery was observed after five years, with bulk density and penetration resistance in skid trails decreasing by 13% and 8%, respectively, though they remained significantly elevated compared to control. The study underscores the prolonged recovery periods needed for soil properties in skid trails, emphasizing that the current re-entry interval of 10–15 years in Mediterranean beech forests should not be shortened. To reduce soil degradation, strategies such as designated skid trail networks or protective logging mats are recommended.

Keywords: small-scale forestry, skidding, soil compaction, soil microfauna

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Proximal and remote sensing for variability assessment in an intensive almond grove in Italy

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Abstract. After years of sharp decline, almond cultivation in Italy is experiencing a period of renewed interest thanks to the stimulus provided by increased consumer demand. In turn, this is driving cropland conversion to almond cultivation. New specialised, high-intensity plantings allow mechanised harvesting and assisted pruning to be introduced, increasing interest in precision management practices. This paper addresses UAV and satellite imagery, proximal sensing, and field scouting in crop variability assessment. An intensive (2,600 trees ha^{-1}) four-year old, 0.9 ha almond grove (*Prunus amygdalus* Batsch., Vialfas cultivar), located in the Ravenna province (44° 15.4634' N, 11° 54.7993' E; 35 m asl), was monitored with multispectral and RGB images taken from a DJI Mavic Pro quadcopter drone (0.08 m grid resolution) and satellite scenes (PlanetScope images, 3 m resolution). On the same dates, some vegetation indices (NDRE, MSAVI, EVI and NDVI) were calculated to verify the consistency of the data obtained from the two different remote sensing approaches in the crop variability assessment and delineation of management zones (MZs) establishment. An NDVI proximal vegetation index measured by the GreenSeeker® (NTech Industries, Trimble, Sunnyvale, California, USA) handheld crop sensor, was also determined. Plant growth parameters (tree height, crown size, etc.) key soil parameters and digital soil mapping are in the process of being compared with the remote and proximal vegetation indices to validate the MZs establishment.

Keywords: Almond; proximal and remote sensing; soil digital sensing; vegetation index.

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Deep Chemometrics for Olive Oil Profiling: from Classical to Deep Chemometrics

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Abstract. Vis/NIR spectroscopy is often described as a fast and easy to use, economically accessible, non-destructive and multi-analytical technique. The great unspoken is the difficulty in using the NIR spectroscopy occurs prior to its use by the end user and essentially involves the researcher in the development of the mathematical models used to predict the analyte. NIR-based model de-velopment is subject to the empirical decisions of the researcher with related subjectivity issues in the processing of spectral data, with the risk of affecting the model performance and robustness. Research in Vis/NIR spectroscopy cur-rently undergoing a paradigm shift from classical chemometrics to deep chemometrics, which is based on the use of deep neural networks (DNNs), with the aim of handing over the feature engineering task to artificial intelligence. This study was focused on the development of predictive models for the chemi-cal profile of olive oil by combining the use of Vis and Fourier-Transform NIR spectroscopy with DNNs. The work was carried out in collaboration UM-BRIAOLII S.p.a (Perugia, Italy). which provided both olive oil samples (from extra virgin to refined) and analytical reports (acidity, peroxide value, ethyl es-ter, total sterol, K values, sterol composition, fatty acid composition, etc.). The spectral scans and training of the deep learning models were performed by the University of Tuscia (Viterbo, Italy). The results obtained demonstrated the fea-sibility of using DNNs as an overwhelming alternative to classical chemomet-rics, showing, for example, a prediction RMSE of 0.27 % only for the quantifi-cation of the olive oil acidity.

Keywords: Vis/NIR spectroscopy, artificial intelligence, deep neural networks, DNN, Fourier-Transform NIR spectroscopy, olive oil chemical profile

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Assessing the Sustainability of Tractor Electrification: Development of an Electrification Index Using Real-World Data

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Abstract. In 2020, the European Commission (EC) endorsed the European Green Deal, an ambitious set of initiatives designed to make Europe climate-neutral. Agricul-tural machinery in Europe generates approximately 70 million tons of CO_2 an-nually. To address this, industry and researchers are exploring hybrid and fully electric powertrains as a means to lower CO_2 emissions substantially. However, the sustainability of powertrain electrification strictly depends on tractor mis-sion profiles, which are difficult to assess because of the great variability of field operations. This paper aims to develop an electrification index (EI) able to assess the conversion sustainability of a conventional diesel tractor into a bat-tery-electric tractor using real-world data. Real-world data were collected for more than one year using a Controller Area Network (CAN-BUS) data loggers installed on a large fleet of conventional diesel tractors of different sizes and performing a wide spectrum of agricultural operations. Data were first classified into tasks and a series of energy demand indexes were elaborated. Then, for each tractor, a battery-electric counterpart was modeled keeping its external di-mensions unchanged, to estimate the maximum battery size that can be equipped. The EIs were calculated considering environmental and economic metrics that took into account both the production phase of the tractors and the operational phase in the field. The results show the convenience of tractor elec-trification depends on the scale and type of farming, access to charging infra-structure, and technological advancements in battery performance.

Keywords: Tractor Sustainability, CO_2 Emissions, Electric Powertrains, Real-World Data Analysis, Agricultural Machinery Electrification

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Weed detection in vineyards using very high resolution UAV imagery

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Abstract. Precision agriculture (PA) is gaining increasing interest due to its potential to reduce agricultural inputs for fertilization, as well as pest and weed control. In PA, uncrewed aerial vehicles (UAVs) and remote sensing (RS) techniques play an important role in collecting data for crop monitoring. RS can detect and map the spatial distribution of weeds within a crop by combining UAV imagery with machine learning techniques. In this paper, we present the first results of our ongoing research on monitoring and classifying weeds in vineyards using very high-resolution imagery. UAV-based surveys were conducted using the DJI Mavic 3M Enterprise UAV, which flew at a height of 12 m. The RGB and images captured have spatial resolution of 3 mm. The proposed methodology was tested in a vineyard in Palizzi (Reggio Calabria, Southern Italy). Weed detection was achieved using a geographic object-based image analysis (GEOBIA) with the commercial software eCognition Developer. Multiresolution and multi-threshold segmentation algorithms were implemented based on digital elevation models, followed by a classification step utilizing a rule-set algorithm. Preliminary results indicated that this approach facilitates the detection of weeds. Further testing is necessary to validate the procedure in various environmental contexts.

Keywords: Precision farming, uncrewed aerial vehicles, Smart agriculture, Weed detection, Crops management.

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Pilot-scale enhanced hybrid Constructed Wetlands for decentralised Wastewater Treatment and effluent Reuse in agriculture

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Abstract. The growing impact of climate change on water resources has intensified the need for alternative solutions to support agricultural irrigation while ensuring water quality and availability. The reuse of treated wastewater has emerged as a viable option to reduce water withdrawals in agriculture and preserve the quality or renewable resources. Nevertheless, it is imperative to ensure proper treatment of wastewater before re-use, in compliance with current regulations of this practice. Nature-based solutions, such as constructed wetlands (CWs), offer a sustainable and efficient approach to wastewater treatment and reuse. This study focuses on the design, construction, and implementation of a pilot-scale CW system aimed at treating domestic and urban wastewater. The pilot plant was developed to provide an effluent with a quality in compliance with the current European wastewater reuse regulatory framework. To optimize the treatment process, the study investigated advanced CW configurations, including combined systems (e.g., HF and VF CWs), aerated CWs, and the integration of innovative substrates such biochar to enhance pollutant removal efficiency. Additionally, the system integrated ultraviolet (UV) disinfection to achieve effective pathogen reduction. Preliminary results demonstrate the potential of the pilot system to consistently deliver high-quality effluent suitable for reuse in agriculture, showing also the capability of CWs to serve as a reliable and eco-friendly alternative to conventional treatment methods in decentralised systems, aligning with the principles of circular water management. These insights highlight the role of CWs in promoting sustainable agricultural practices while addressing global challenges in water resource management.

Keywords: Constructed Wetlands, Treated Wastewater, Reclaimed Water, Water Reuse, Agricultural Irrigation.

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Comparison of different wood harvesting systems in typical Mediterranean small-scale forests

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Abstract. More than 11 million hectares (more than 36%) of the Italian territo-ry is covered by forest vegetation. Among all regions of Italy, several southern Italian regions have a high percentage of forests and woodlands. Calabrian forests have enormous potential in terms of wood mass that can be utilized annually. Among the regions of Southern Italy, the region of Calabria has a forest area of 43% of the territorial surface area: more than the national average. The average volume per hectare of Calabria's forests is greater than in other southern Italian regions, at 225 m^3ha^{-1}. Consequently, Calabrian forests have enormous potential in terms of wood mass that can be utilized annually. Despite the im-mense forest heritage present in Calabria, the level of mechanization during wood harvesting is not completely advanced. The most commonly used method of timber extraction is the farm tractor equipped with forest winches. Secondly, timber is extracted by tractors with trailers or skips, cable cranes, forwarders, chutes and animals. The objective of the study is to analyze working time and productivity during the extraction operation in Mediterranean forests. The study was conducted in the Aspromonte National Park. Three sites with different oro-graphic conditions were monitored. At two sites, extraction was carried out with a tower yard; at another site, extraction was carried out with a farm tractor equipped with a forestry winch. Several cycles were monitored and times spent and number of logs recorded for each site. Both machines are well adapted to the orographic conditions and forest types in the area.

Keywords: Performance, forests operations, time-motion study, productivity.

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A statistical approach to site suitability of small agricultural reservoirs and application in Tuscany (Italy)

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Abstract. Agricultural production increasingly relies on irrigation to withstand droughts, precipitation variability or support agricultural intensification. Small agricultural reservoirs (SmAR) can contribute to sustainable agricultural water management by providing additional water without increasing pressure on surface or groundwater resources. The construction of new SmARs is usually subject to a phase of suitability analysis, which helps discern suitable places within a large area, before exploring the potential locations with major details. This task is traditionally performed using top-down approaches relying on multi-criteria analysis (MCDA), which are based on relevant macro criteria for the location of SmAR, often supported by hydrological modelling. In this work we present a bottom-up approach based on statistical modelling of a large database of existing SmAR locations. We compare this empirical approach with the conventional MCDA to show the potential advantages of data-driven suitability analysis within a case application in the Italian region of Tuscany. Our results can directly support high level suitability in Tuscany, while the proposed approach can be further extended and applied in different contexts, scales, and applications.

Keywords: Small Agricultural Reservoirs, water harvesting, irrigation, statistical modeling

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Forest Operations in Mediterranean Chestnut Coppices performance of different Mechanisation Levels and Extraction Systems

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Abstract. This study investigates the greenhouse gas emissions associated with different levels of mechanisation and extraction methods in Mediterranean chestnut (*Castanea sativa* L.) coppice forests. Located in Italy, these forests hold both economic and ecological significance. The research addresses a key gap in emissions data for broadleaf forest operations by examining the productivity and environmental impact of four logging systems. These systems combine semi-mechanised and mechanised felling methods with skidding and forwarding extraction techniques. The findings highlight that mechanised felling increases productivity by 44–66% compared to semi-mechanised methods but results in over three times the GHG emissions per cubic meter of wood. Extraction operations represent the largest emissions contributor, with skidding emitting nearly three times more than forwarding due to its lower work productivity. Notably, forwarding in a Cut-to-Length system demonstrated over double the productivity of skidding and reduced emissions of extracted wood by up to 63%. These results underscore that improving work productivity through optimised extraction techniques, operator training, and efficient road network layouts can significantly reduce emissions. Among the tested systems, CTL forwarding combined with mechanised felling achieved the highest productivity and the lowest emissions, offering a promising model for sustainable chestnut coppice management in Mediterranean forests. This case study provides valuable insights into environmentally and economically sustainable practices, with potential applications to similar forest ecosystems. Additionally, harvesting cost analysis was incorporated into this research, with results currently under elaboration.

Keywords: GHG, coppice, chestnut, productivity, skidding, forwarding

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Grading Bamboo Pruning Pellets

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Abstract. The cultivation of bamboo has been attracting increasing attention in Europe, recently. Bamboo is appreciated for its aesthetic value in ornamental gardening and is being increasingly used for textiles, flooring and furniture. Due to its mechanical properties, it can also be used in construction. Besides, it is a fast-growing plant that can contribute to carbon sequestration.

Bamboo cultivation generates residues that are currently challenging to valorise as by-products and as well in-situ burning does not represent a sustainable option from an environmental perspective. On the other hand, the valorisation of raw bamboo residues in biomass power plants is limited due to their low energy density, which results in high transportation costs per unit of energy.

Pelletising is a densification process that has proved to be beneficial both for improving combustion properties of biomass and for increasing its energy density, alleviating the impact of transportation costs, thus. In assessing the viability of using bamboo pellets for energy production, so far, studies have focused on pellets obtained from full bamboo culms. However, full culms can have other uses and can be directed to other competing markets.

The pellets obtained from bamboo pruning residues will be analysed according to the standards outlined in ISO 17225 and compared with the quality of pellets produced from spruce wood by-products, such as sawdust. This approach aims to evaluate the potential for valorising bamboo pruning residues and fostering circular practices in Europe.

Keywords: Bamboo, Pruning, Bamboo Pellets, Valorisation, Pellets Quality.

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Machinery-induced soil compaction during skidding operations in a Romanian forest

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Abstract. In the last decades the technological evolution in the forestry sec-tor has led to an almost exponential increase in the use of more powerful but al-so heavier machines in forest operations. At the same time, interest has also grown in more eco-sustainable and environmentally friendly working methods, also turning attention to soil perturbations. The passes of heavy vehicles on forest soil cause, in most cases, deep and persistent ruts generating serious impacts such as compaction and deformation as well as the functions of water and air storage capacity, fertility, biological activity and stability.

The research focused on the study of soil compaction by the soil penetration resistance, using a portable penetrometer, after repeated passes of a skidder during skidding operations, at different depths and, also, investigating the effects on the carriageways of the trail.

The main results consisted of identifying the critical number of machine passages that affects the state of soil compaction, also considering the carriageways: the lateral ones subjected to the weight of the machine and part of the timber that was semi-dragged, and the central one which instead was subjected exclusively to the weight of loads of transported logs, and how the ground responded according to the depth investigated.

Harvesting operations and heavy machinery use are linked to negative impacts on the soil since the damage resulting from harvesting operations cannot be completely avoided, however, knowing the phenomena that occur in the soil, these could and should be minimized where possible.

Keywords: Forest machine, Wood harvesting, Soil penetration resistance, Portable penetrometer, Skidding trails.

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The influence of rainfall kinetic energy on the agro-textiles permeability

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Abstract. The need to protect crops to fight the climate change impacts is a press-ing issue. Rain is one of the most impactful factors that can damage agricultural production, potentially limiting yields. Currently, there is an increasing use of agricultural nets for fruit crops protection, which offer greater advantages in terms of plant aeration and wind resistance. Laboratory activities are underway to test the precipitation permeability of agro-textiles, employing a rainfall simu-lator. The tests show a close correlation between the nets' rainwater permeability and the impact kinetic energy, the latter being a function of droplet size through mass and precipitation intensity affecting the drop speed. Experimental results showed that at higher precipitation intensities, to which correspond larger droplet sizes, permeability is higher. On the contrary, for lower rainfall intensities and smaller droplet sizes, the permeability is lower. In addition, the difference be-tween the average permeability values as rainfall intensity varies is more pro-nounced for agro-textiles with 10° inclination (about 15%-20%), and it is about 5% as anti-rain nets' inclination increases (20° and 30°). Therefore, it emerges from the research, which is to be expanded to additional anti-rain nets, that per-meability is not only an intrinsic characteristic of the nets, but it is also a function of the rainfall intensity and the size of the raindrops impacting them.

Keywords: Rain-proof nets; rain protection; nets rainwater permeability; agricultural nets; rainfall kinetic energy

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Setting up of a cost-effective hyperspectral prototype for agri-food product monitoring

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Abstract. Hyperspectral imaging (HSI) for agri-food applications, although promising, faces challenges such as high cost and equipment requirements. However, advances in technology and 3D printing are enabling promising low-cost solutions that still need to be validated in the field. This work presents the development of a cost-effective hyperspectral prototype, built using 3D elements and commercially available electronic components, and operating in the spectral range from 400 nm to 1000 nm. Two types of gratings have been compared, and different light source tested. The work presents the results of a few lab-scale tests on food matrices under controlled light conditions, which were conducted to evaluate the performance of the prototype. The data were explored with PCA (Principal Component Analysis), which confirmed the ability of the prototype to distinguish samples of different colours (first trial), assess the decay of different apple samples (second trial) and differentiate between healthy and damaged tissues (third trial). The experimental results were consistent, and both types of grating demonstrated adequate performance levels to envisage a future scale-up of the device.

Keywords: hyperspectral imaging, miniaturized, portable, low-cost, monitoring

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A potential strategy to enhance agricultural resilience to climate change: optimizing water retention in agricultural ponds

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Abstract. Climate change presents significant challenges to agriculture, with prolonged droughts and extreme rainfall increasingly disrupting farming sys-tems worldwide. Agricultural ponds offer a practical and cost-effective solution by serving as critical water reservoirs for irrigation while mitigating the impacts of extreme weather. These ponds perform dual roles: capturing rainwater during heavy rainfall and storing it for use during dry periods, ensuring a reliable water supply for crops. Additionally, well-designed ponds can reduce surface runoff, minimize soil erosion, lower flood risks, and enhance ecosystem diversity. The water retention performance of these ponds, however, depends on their design, maintenance, and environmental conditions. Factors such as water har-vesting efficiency, storage capacity, and retention ability are particularly im-portant. Meteorological variables, including air temperature, humidity, and wind speed, strongly influence evaporation rates, significantly impacting the amount of water available for irrigation. Thus, preserving stored water by min-imizing evaporation and infiltration until it is needed during drought periods is essential. This study examines the effects of various treatments and management practic-es on the water-holding efficiency of agricultural ponds. By identifying effec-tive strategies to maximize water retention, we aim to provide actionable recommendations for farmers to optimize pond performance. These insights are critical for improving agricultural water resource management, enhancing resilience to climate change, and advancing sustainable farming practices.
Keywords: Climate change; agriculture pond; resilience

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Hydraulic modelling to assess flood risk for sustainable stormwater management in urban area: the case study of Catania (Sicily, Italy)

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Abstract. Urban floods, intensified by climate change and urbanization, pose global challenges by reducing the landscape's capacity to intercept, store, and absorb rainwater. The evaluation of the flood hazard areas, at catchment scale, is usually conducted by using hydraulic models that allow to target the most affected areas at risk where the implementation of sustainable solutions (i.e. Sustainable Drainage System, SuDs) for effective stormwater management is necessary.

This study aims to identify areas with the highest hydraulic risk within an urban catchment located in the northern part of the municipality of Catania (Sicily, Italy) considering the "Tondo Gioeni" as basin outlet (110 ha). The hydraulic model simulations were performed by using the freeware software HEC-RAS with a return period (T) of 2, 5, 10, 50 and 200 years, allowing the production of the flood risk map.

The results highlighted a high hydraulic risk in the range of R2-R4 especially in the downstream part of the catchment in correspondence of the "Tondo Gioeni". The estimated peak flow values at the basin outlet for each T in the current scenario were equal to 2.1 $m^3 s^{-1}$, 10.2 $m^3 s^{-1}$, 16.9 $m^3 s^{-1}$, 32 $m^3 s^{-1}$ and 45.3 $m^3 s^{-1}$, respectively for T 2, 5, 10, 50 and 200 years.

The hydraulic model proved valuable for (i) identifying high-risk areas requiring SuDs interventions for flood risk mitigation; and (ii) estimating peak flow and runoff volume at the basin outlet, essential for SuDs design and dimension.

Keywords: floods hazard, runoff, urban area, green infrastructures, urban flooding, hydrograph assessment.

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Paper ID: 064

Rivers Ecological Restoration with Nature-Based Solutions: the case study of the Alcantara river (Sicily, Italy)

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Abstract. The Mediterranean Region faces critical challenges from warming, prolonged heatwaves, increased drought, and flooding risks. Up to 32% of its areas could suffer biodiversity and ecosystem service degradation under global warming of 1.5°C–2°C. Nature-Based Solutions (NBS), also known as Natural Water Retention Measures (NWRM), are key strategies to enhance climate resilience, addressing both adaptation and mitigation while offering co-benefits for societal challenges.

The Alcantara catchment in Sicily, Italy, is an area of significant environmental and landscape value, hosting diverse species and 11 Special Areas of Conservation (SAC). This study outlines the ecological restoration idea and design in two areas of the Alcantara River Park: "Cottanera" (5 ha) and "Passo Moio" (5.4 ha). In collaboration with the University of Catania, a system of small wetlands (NWRM measure N02: "wetland restoration and management") was created to support habitats of Mediterranean rivers and temporary ponds. Native vegetation such as *Tamarix africana*, *T. gallica*, *Nerium oleander*, *Salix purpurea*, and *S. gussonei* were used to restore fluvial terraces and marshes.

Remote sensing techniques will monitor pond ecosystem dynamics, and flood risk reduction will be evaluated using hydrological-hydraulic models at the catchment scale. The enhancement of some ecosystem services provided by the NWRM implemented in the Alcantara river, among which are water quality improvement, hydrological regime regulation, habitat deterioration prevention, and biodiversity recovery support, will be assessed. These wetlands could enhance water quality, regulate hydrological regimes, prevent habitat deterioration, and support biodiversity recovery, serving as nesting sites for migratory birds.

Keywords: wetlands restoration, ponds, natural water retention measure, biodiversity preservation, climate resilience.

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Has time come for Synthetic Fuels in Agriculture?

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Abstract. While renewable electricity generation is currently viable for farms, synthetic fuel production still requires significant cost reductions to be competitive. GHG emissions by agricultural sector mainly come from soils (N_2O) and the digestion of ruminants (CH_4), and few through the combustion of fuels for energy generation. Around 10-15% of total agricultural CO_2 equivalent emissions are due to agricultural transport, which is mainly powered by diesel engines. Thus, synthetic diesel fuel produced by renewable energy sources could replace fossil diesel to make a significant contribution achieving the reduction target of 20% of total agricultural emissions; along with the reduction of the consumption of engines by means of increasing machine efficiency, and substitution with electric motors where appropriate, almost CO_2-neutral operation could be reached. In the short term, Sustainable Fuels (SFs) produced from renewable electricity via Power-to-Liquids (PtL), also called e-fuel, can reduce net greenhouse gas emissions of transport and machinery in agriculture. Although currently more expensive than fossil fuels, their costs are expected to decrease significantly by 2050. Regional optimization of renewable energy resources can make production more cost-effective. Policy support, technological advancements, efficient land use, and cooperative ventures or shared resources, such as PV fields and Wind turbine, will play key roles in scaling up SFs production to meet agriculture decarbonization goals.

Keywords: synthetic fuels, e-fuels, PtL, agriculture, CO_2 emissions, renewable energies.

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Monitoring Ammonia Emissions in Livestock Farming: A Comparative Study of Dairy Buffalo and Cow Barns Across Different Climate Regions

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Abstract. Agriculture is responsible for approximately 94% of anthropogenic NH_3 emissions, contributing significantly to environmental pollution and posing risks to human health and ecosystems. To meet the national emission reduction targets set by the NEC Directive 2016/2284/EU, accurate monitoring is essential for quantifying emissions and implementing effective mitigation strategies. The integration of IoT technologies within the Precision Livestock Farming (PLF) framework offers an innovative approach to real-time monitoring of air quality and livestock microclimates. These systems deliver detailed insights into ventilation inefficiencies, enable optimized manure management, and support the development of targeted emission mitigation strategies. However, ammonia (NH_3) emissions from livestock are influenced by various factors, including species-specific traits, dietary nitrogen intake, manure management practices, barn design, ventilation efficiency, and climatic conditions, which create diverse emission dynamics. To explore these complexities, this study presents preliminary findings from a monitoring campaign conducted in two contrasting livestock contexts using a uniform advanced monitoring system: a dairy buffalo barn in Campania, Southern Italy, characterized by a Mediterranean climate, and a dairy cow barn in Lombardy, Northern Italy, with a temperate continental climate. Environmental parameters such as temperature, humidity and the bioclimatic index temperature and humidity index (THI) together with CO_2, NH_3, H_2S and particulate matter concentrations were continuously measured to capture variations in barn conditions. This comparative analysis highlights the fundamental role of IoT technologies in addressing region-specific challenges while enabling detailed monitoring and facilitating the comparison of environmental and management practices across diverse climate contexts.

Keywords: Ammonia Emissions, Naturally Ventilated Buildings, Environmental Monitoring, Dairy Cattle, Buffalo Breeding

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Thermal degradation profile of citrus grove by-products and sustainable use of the obtained biochar

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Abstract. Current environmental and socio-economic condition is leading the main exponents of the sector categories to implement policies aimed at the production of green energy to hinder the climate change and pursue the objectives set in the RED III and Fit for 55 community agreements. The most involved sectors in ecological transition policies are agriculture and energy, therefore the common interest of researchers and farmers is to study new management systems of agroenergy supply chains. Citrus groves generate a significant amount of waste, such as peels, seeds, and pruning, which, if not properly managed, can contribute to environmental pollution. Chemical degradation, through processes such as pyrolysis, gasification, combustion and anaerobic digestion, allows for the transformation of these by-products into useful compounds, such as biofuels, organic fertilizers, and valuable chemicals. These chemical processes not only reduce the volume of waste but also enable the recovery of nutrients and energy, contributing to a circular economy in the agricultural sector.
In the present work the thermal degradation of citrus pruning and peels will be studied using thermogravimetric analysis simulating the operative conditions of the conversion processes (pyrolysis and gasification). Subsequently, the biochar obtained from the pyrolysis of pruning and peels will be characterized to evaluate its potential applications in the agronomic field. Moreover, the chemical degradation of citrus grove by-products represents an innovative approach to the sustainable management of agricultural waste, by reducing greenhouse gas emissions and improving soil quality, contributing to more responsible resource management and a more sustainable agriculture.

Keywords: thermochemical conversion process, biomass, TGA analysis, pyrolysis, gasification, biochar.

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Rainfall erosivity and soil loss measurements at the Sparacia experimental area

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Abstract. Several soil erosion models have been proposed to predict soil loss and plan actions for the mitigation of the erosive phenomenon. The most applied empirical soil loss model is the Universal Soil Loss Equation (USLE) or its revised versions (RUSLE, RUSLE2). The mathematical structure of the model considers the event rainfall erosivity index (R_e), which accounts for rainfall intensity and kinetic power, soil erodibility, topographic, cover-management and support practice factors. The R_e index is based on the simplifying hypothesis that also its component due to the kinetic power can be estimated by empirical equations using only the rainfall intensity measurement. Moreover, these equations were deduced for the American environment. This hypothesis could affect the evaluation of rainfall erosivity and deserves to be investigated. Alternatively, the kinetic power can be obtained by disdrometric measurements, which are, however, extremely rare and, to the best of our knowledge, never associated with soil loss measurements. The present investigation benefits from contemporaneous measurements of rainfall intensity, kinetic power, and soil loss from four plots of the Sparacia experimental station (Sicily, Southern Italy) at the event scale, in the period September 2017- April 2020. According to the USLE/RUSLE scheme, for a given soil, plot topography, land use, and cultivation practices, the soil loss measurement is proportional to the rainfall erosivity measurement. A regression analysis between event soil loss and R_e, obtained by the two methods described above, allowed to compare the reliability of the USLE model for the two cases.

Keywords: Rainfall Erosivity, Raindrop size distribution, Soil Loss, Plot Scale.

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Paper ID: 069

Eco-design of sustainable rice cultivation

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Abstract. In Europe, Italy stands out as the main rice producer with about 50% of AUA dedicated to this cereal mainly concentrated in the West of the Po Valley. Rice cultivation is characterized by peculiar aspects regarding water management and weeds and pests control. Besides this, the achievement of high yield requires proper fertilization as well as a quite intensive mechanization of the different filed operations. Not negligible environmental impacts are related to rice cultivation due to methane emissions and fuel, fertilizer and pesticide consumption. Over the years, different solutions (e.g., variable rate fertilization, alternative water management, dry sowing, alternative fuels to diesel for grain drying) were designed and tested to reduce the environmental impact of rice cultivation.

This study, combining different mitigation solutions, evaluated the environmental benefits potentially achievable by a proper eco-design of the agricultural step of the rice supply chain. The Life Cycle Assessment approach was applied to data collected in different farms located in Lombardy and Piedmont. 1 ton of paddy rice at the commercial moisture (14%) was selected as functional unit while, about the system boundary, a “from cradle to farm gate” approach was considered. Primary data regarding productive performance, the cultivation practice as well as the consumption of seed, fertilizers, fuel and pesticides were collected by means of surveys at the farms. Secondary data was considered regarding the different emissions sources. The results highlight how the combination of different mitigation solutions can reduce the environmental impact up-to 30% for most of the evaluated impact categories.

Keywords: Life Cycle Assessment, Impact Assessment, Variable rate fertilization, Water Management.

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Energy and environmental performance of non-thermal processes and natural bioprocessing technologies

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Abstract. Changing our diets and the way we produce food is one of the key priorities to stay within the planetary boundaries and to improve our health. There is an urgent need to diversify protein sources, increase food processing efficiency and eventually reduce consumption of animal-origin foods while increasing the intake of plant-based foods. Current plant protein isolates and concentrates are typically produced by wet extraction technologies which include several chemicals and solvents altering also the protein functionality, among others. Processing significantly affects the health benefits, affordability, and sustainability of plant-based foods.

The Horizon Project "Sustain-a-bite: propelling health and sustainability through innovative food products and processes" (HORIZON-CL6-2024-FARM2FORK-01-2) focuses on minimally processed plant-based foods made of whole plant raw material and less refined ingredients, as well as industrial side streams. Sustain-a-bite innovative approach combines non-thermal technologies (Pulsed Electric Field (PEF), High Pressure Processing (HPP), Ultrasound (US)) together with bioprocesses (seed bioactivation, solid state fermentation) to produce nutrient- rich, wholesome plant-based ingredients while maximizing process efficiency and safety.

This review focuses on the energy and environmental performance of non-thermal processes and natural bioprocessing technologies applied to the production of plant-based ingredients and minimally processed plant-based food.

Keywords: Life Cycle Assessment, Pulse electric field, seed germination, solid state fermentation, minimally processed plant-based food.

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Comparative assessment of lump charcoal density using photogrammetry as an alternative to Archimedes method according to ASTM D2395-17 standard

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Abstract. Density is a critical parameter for evaluating the quality and perfor-mance of lump charcoal in industrial and grilling contexts, influencing factors such as combustion efficiency, storage, and transportation. Currently, there are no ISO stand-ards for determining the density of charcoal, with the only available standard being the American ASTM D2395-17, based on the Archimedean principle. However, this method is not highly precise, depending on the experience and accuracy of tech-nicians. Recent studies have explored new approaches in the biofuel sector, including image processing and photogrammetry, to monitor key physical and composition parameters. This study compares two methods for determining the density of char-coal: the ASTM standard method based on the Archimedean method and the photo-grammetric reconstruction using specific software such as Agisoft® Metashape.
Each measurement involved volume determination and density calculation based on the known mass of the samples. The results revealed significant differences be-tween the methods, with the photogrammetric demonstrating higher precision, partic-ularly when samples had at least one flat surface. However, for samples without flat surfaces, the photogrammetric method tended to overestimate volume, resulting in density underestimations, and required longer processing times. In contrast, the ASTM standard method provides measurements even with irregular samples and requires less time. Despite its limitations, the photogrammetric method presents a promising alternative for density determination, especially for studies requiring de-tailed volumetric reconstructions. These findings emphasize the need to choose meth-odologies that fit sample characteristics and application needs. Further research is needed to improve the accuracy of photogrammetric techniques for different charcoal morphologies.

Keywords: Charcoal quality, Volume Measurement, Density, Solid biofuels, Pho-togrammetry, Non-Destructive Testing

Paper ID: 072

Evaluating the effectiveness of wood-biochar addition against rill erosion

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Abstract. Even though the existing literature agrees about the improvements in soil physico-chemical characteristics using biochar as a soil amendment, its antierosive effectiveness has yet to be demonstrated. Indeed, some studies showed that biochar has a positive impact on soil erosion, infiltration, and runoff, while others found that, depending on its derivation and concentration, it can actually increase soil erosion and runoff. In this study, runoff and soil loss measurements performed for two rills incised in a soil amended with wood-biochar (initial concentration in weight of 3% and 5%) were compared with those conducted for a rill incised in the same unamended soil to test biochar antierosive effectiveness. Specifically, each rill was subjected to a constant clear inflow discharge, and the total runoff and weight of the eroded mixture (sediment+biochar) were measured by collecting all the outflowing mixture in a tank located downstream of the rills. The runs lasted until reaching a given volume (50 L) in the tank. After the mixture of each rill was weighed, some samples were collected and put into a muffle furnace to determine their biochar and sediment percentages. The general purposes of this paper are to assess if wood-biochar addition can be a valid antierosive practice and, if so, define which is the optimal concentration to be added for limiting runoff amount and soil loss.

Keywords: Biochar, soil erosion, runoff, soil loss, infiltration, rills.

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Using Inline Tools to Enhance Olive Oil Extraction Efficiency

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Abstract. The use of Near-Infrared (NIR) technology for multispectral analysis of olive pomace has demonstrated promising results in recent research efforts. Driven by innovation and technological challenges, a NIR device was integrated into an industrial olive oil extraction plant, positioned at the decanter outlet, to monitor real-time moisture content (%) and oil yield.

Data acquisition was conducted in the 761–1081 nm spectral range to analyze the pomace. The water and oil content were predicted using NIRS calibration models, which were successfully tested and validated.

The results demonstrated the reliability of the NIR approach, with the Partial Least Squares (PLS) calibration models showing strong correlations for both oil and water content during the calibration phase. The validation process also revealed consistent correlations, accompanied by minimal errors in both the prediction and validation stages.

These findings highlight the potential for large-scale adoption of NIR devices in the olive oil sector, enabling real-time monitoring of process parameters, improving process control, and enhancing the overall sustainability of the production process.

Keywords: NIR technology, olive oil mill process, PLS regression model, water/oil analysis

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Interrill overland flow and erosion during rainfall in a silty clay soil

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Abstract. The process of sediment transport during rainfall over eroding surfaces is more complex than fluvial transport due to factors like raindrop impacts on flow, var-iations in surface geometry, roughness, and particle properties. While splash erosion occurs, flow-driven transport is more significant. However, when flow is shallow, ignoring raindrop impact can lead to underestimations of sediment transport, especially for larger particles. Understanding overland flow processes is still limited, leading to reliance on fluvial transport equations in erosion mod-els, which have proven inadequate for overland flow, particularly during rain-fall. These equations often underestimate transport rates, show significant vari-ability, and fail to account for changes in flow characteristics due to rainfall. Models developed for streamflow don't work well for steep slopes, shallow flow, or specific soil conditions like fine particles under rainfall. Despite the ex-istence of various transport equations, their accuracy for overland flow remains uncertain due to insufficient validation for these specific conditions. The study reviewed transport formulas using data from simulated rainfall experiments in silty clay loam soil and presents the results of this evaluation.

Keywords: interrill overland flow, soil erosion, modelling, fine soil.

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Hyperspectral imaging to trace the origin of shelled pistachios

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Abstract. Starting January 1, 2025, it is mandatory to disclose the origin of shelled dried fruit (European Regulation No. 2429, 2023). Among dried fruits, pista-chios are notable for being among the most expensive, raising concerns about possible adulteration. The price and quality of pistachios are closely linked to their place of production. In Italy, cultivation is primarily concentrated in Bron-te, where the ideal conditions for producing intensely green, aromatic nuts that are highly sought after in international markets. Additionally, the "Bronte Green Pistachio" is the only variety have the Protected Designation of Origin certification (EN C130/18, 2009). This study aimed to develop a method utiliz-ing Vis/NIR hyperspectral imaging (450-1000 nm) for the rapid determination of the origin of pistachio nuts (*Pistacia vera L.*). Samples were sourced from It-aly (Sicily and the Bronte area), Iran, Turkey, and the United States (California) and were analysed in both whole and powdered forms. Additionally, mixtures composed of different percentages of each sample were investigated. Spectral data were processed by PLSDA to discriminate the samples based on their origin. The spatial distribution of origin was obtained by interpolating the clas-sification results for each pixel of the hyperspectral image. Pixels with similar spectral characteristics displayed similar colours, indicating that they belong to the same class (origin). Results obtained for the Bronte category, appear really promising in the light of the possibility of building a traceability model for this product. This technology could be utilized by regulators and suppliers t ensure that the pistachios are genuine and meet quality standards related to their geo-graphical origins.

Keywords: HSI, Pistachio, NIR, chemometric, origin

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Update small reservoirs's capacity in hilly areas of central Italy: SIGHTING project

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Abstract. Small Reservoirs (SRs) hold significant potential for enhancing water resilience in agricultural systems, particularly in the face of climate change. In Italy, SRs are common in highly productive hilly regions. However, reliable data on SRs is scarce, and several key issues remain to be explored, such as their storage ca-pacity and availability for use. Accurate estimates of reservoir capacity are es-sential in this context. Unfortunately, such data is often not publicly available for most global reservoirs, and when it is, it is frequently outdated, failing to ac-count for changes in reservoir geometry caused by silting processes due to soil erosion. Sedimentation reduces a reservoir's storage capacity and can alter the original topography, thereby affecting the elevation-volume or elevation-area (AVE) curves and the maximum annual volume of water that can be extracted. Updating reservoir capacity estimates is critical for providing water planners with more accurate information regarding future water availability. In the framework of the SIGHTING project, a procedure has been developed to esti-mate sediment volumes in SRs in Umbria. This approach leverages the SWAT model to estimate sediment production. The calibration and validation of the SWAT model were carried out using a database of hydrographs and sedimento-grams at the scale of erosive events, combined with sediment volume data ob-tained from bathymetric surveys. The model was tested on catchments with varying morphometric characteristics and land use patterns. Updating the AVE curves will provide a better understanding of the effect of water use in SRs on the risk of water scarcity in rural areas.

Keywords: water resiliency, water harvesting, silting, off-site effect, soil ero-sion.

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Testing of materials for mitigating phosphate pollution in surface water

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Abstract. Phosphates enter waterways from various sources such as agricultural runoff and wastewater. Excess of phosphates in surface water contributes to eutrophication, a process that causes abnormal microalgae growth, reduced dissolved oxygen levels, and detrimental impacts on biodiversity and water quality. Addressing phosphate pollution necessitates sustainable mitigation strategies. So far, Nature-Based Solutions (NbS) have shown variability in their effectiveness, often exhibiting limited phosphate retention or even releasing phosphates over time. This research aims to assess the effectiveness of low-cost, locally available, and environmentally compatible sequestrant materials for future field-scale integration within an existing NbS establishment (Forested Infiltration Area). Candidate materials, including fly ashes, limestone sands, and kaolin were tested through batch and flow-through column experiments using synthetic and field-drainage water. The fly ashes showed promising phosphate sequestration in batch tests with synthetic water but released significant amounts of phosphates and sulfates when field-drainage water was used. Limestone sands demonstrated good initial sequestering capacity but lacked long-term stability. Kaolin emerged as a standout material, effectively removing phosphates and maintaining performance even under complex operating conditions. The study highlights kaolin's potential as a sustainable solution for mitigating phosphate pollution. However, further research is required to optimize its use on the field scale. Kaolin addition to NbS could have the potential to greatly enhance the protection of aquatic ecosystems, mitigating the eutrophication of water bodies, while also promoting the sustainability of modern agriculture.

Keywords: Eutrophication, Nature-Based Solutions (NbS), Phosphate mitigation, Sequestrant materials, Environmental remediation, Biodiversity.

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Estimate of the correction factor of surface velocity for rough bed rills

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Abstract. The study of both rill and interrill erosion phenomena primarily depends on the determination of hydraulic parameters, especially the mean flow velocity. The dye tracer technique is a straightforward method for its determination by multiplying surface flow velocity by a correction factor, α_v. There is little research on the potential effect exerted by the soil roughness on α_v in rill flows. A recent study focused on developing a predictive equation to estimate α_v as a function of the Reynolds number, slope, and a dimensionless group embedding the roughness height. The latter was equal to 0 (smooth bed), 0.119, 0.135, and 1.317 mm. Although this relationship gave a good estimate of the correction factor, its applicability has to be further tested for roughness height values different from those used for calibration. The aim of this paper is testing the reliability of this relationship using measurements performed with a roughness height falling within the calibration range. In detail, the experimental runs were performed using a flume simulating a fixed bed rill. The bed and walls were covered by glued zeolite particles, with a mean roughness height of 0.64 mm. Ten slopes, *s*, ranging from 0.1 to 15%, were investigated, and five flow discharges, *Q*, were applied. For each of the 50 (*Q*, *s*) pairs, 20 measurements of surface flow velocity were performed. The mean flow velocity was calculated from measurements of discharge and flow depth.

Keywords: correction factor, fixed bed, roughness height, flow velocity, dye tracer, rill.

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Optimisation of organic waste treatment for sustainable production of compost for agricultural use

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Abstract. Organic fraction of municipal solid waste (OFMSW) is often processed in composting facilities to obtain soil fertilisers for agriculture. Both processes and outputs, however, need to comply with specific regulations in order to ensure the final product can be safely and effectively used.
The objective of the study is to evaluate the parameters most influential on the efficiency of the aerobic maturation process in order to optimize water resource use and promote more sustainable management. The process consists of four distinct phases: loading, maturation, stabilization and discharge. Each stage has specific operating conditions that affect the qualities of the final compost. Within each stage, various parameters such as pH, moisture, temperature, turning, amount of water used and duration were monitored, collecting a total of 68 observations for each parameter. The analysis, conducted during the period between December 2023 and March 2024 with regular monitoring, was processed through a correlation matrix developed in the R environment. A preliminary evaluation of the collected data shows a positive correlation between process duration and number of turnings with final temperature rise. In addition, the analysis showed a strong link between ripening temperature versus pH values. The correlation matrix made it possible to identify the most significant relationships subject to the predictive model.
Keywords: Agriculture, Recycling, Organic waste, Composting, Water saving and Predictive analysis

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Evaluating the effect of Italian ryegrass on soil and water conservation at the Sparacia experimental area

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Abstract. Soil erosion is a significant environmental issue, leading to the loss of fertile topsoil and land degradation. Even if the importance of vegetation in reducing soil erosion is well-known, the behavior of different species should be experimentally studied to quantify their effectiveness. In this study, the anti-erosive effect of Italian ryegrass (*Lolium multiflorum* var. *italicum*) for a high-rainfall intensity event occurred at the Sparacia experimental area on August 2024 was assessed. Six plots with dimensions of 8 x 22 m^2 and slopes of 14.9%, 22%, and 26% were used for runoff and soil loss measurements. For each slope, one plot was covered with Italian ryegrass at the end of November 2023, while the other was kept without vegetation as controls. The vegetated plots were mowed in May 2024. After the mowing, the removal of grass clippings was performed in each plot. The results of the analysis highlighted that the investigated species, even if characterized by a limited surface cover degree at the event date, guaranteed a significant reduction in runoff and soil loss. Moreover, ryegrass prevented rilling, which, conversely, occurred on the steeper control plots. These results were mainly attributed to the action of the root system. The collected data provided insights into effectiveness of ryegrass in mitigating erosion, emphasizing the importance of integrating cover crops into farming practices to promote sustainable agriculture and improve soil and water conserva-tion.

Keywords: Runoff, soil loss, natural rainfall, cover crop, ryegrass.

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The role of electrical resistivity tomography for exploring the hydrological response of different technologies in the framework of a Mediterranean green roof

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Abstract. Green roofs (GRs) represent an efficient Nature-Based solution for addressing relevant environmental challenges in urban areas by offering a vast array of benefits, e.g., in terms of water quality, energy and biodiversity improvements. Nowadays, numerous innovative technologies have been proposed for implementing the GRs, however their hydrological behavior has not been fully explored under Mediterranean climate conditions.
This study investigates the role of electrical resistivity tomography (ERT) for determining the hydrological response of different technologies in the framework of a GR installed at the Department of Agriculture, Food and Environment of the University of Catania in Sicily (Italy). For this purpose, several three-dimensional ERT surveys were employed under dry and wet conditions at the GR technologies, named as Draining Modules, Experimental and Green Safe. These surveys were complemented by monitoring ancillary soil-plant-atmosphere *continuum* variables, e.g., soil hydraulic parameters, soil water content (SWC) and thermal information.
Preliminary results of this study highlight the potential of ERT for characterizing the hydrological behavior of the GR technologies of interest according to the observed SWC and the soil hydraulic properties. Future outlook of this study will deepen the role of ERT, also coupled with hydrological modelling, for appraising the effects of multiple vegetation associations on the different GR technologies under study.

Keywords: Geophysical monitoring, Nature-Based Solutions, Surface temperature, Soil hydraulic properties.

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Analysis of Soil Salinization Induced by Seawater Intrusion in the Po River Delta

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Abstract. Soil salinization, driven by seawater intrusion (SWI), is a pressing challenge in coastal regions globally. In low-lying coastal areas, this phenomenon is primarily triggered by climate change, with prolonged dry spells, heatwaves, and extreme weather events among the major drivers. SWI-induced soil salinization processes impair vegetation by inducing salt stress, disrupting metabolic functions, and compromising crop cycles. Additionally, salinization alters soil structure and porosity, suppresses microbial activity, and depletes organic matter, potentially leading to micro-desertification. In the Po River Delta (Northeast Italy), extreme drought events and high summer evapotranspiration rates intensify SWI, threatening the sustainability of coastal agriculture. Land subsidence, exacerbated by historical methane extraction, further aggravates the problem. This study investigates salinization dynamics using soil sample analysis and Time Domain Reflectometry (TDR) measurements across three experimental sites in the Po Delta during the summer seasons of 2023 and 2024 (June to September). By assessing the spatial and temporal variability of critical parameters—soluble ions, soil electrical conductivity (EC), temperature and moisture— we provide new insights into the mechanisms driving salinization and its adverse effects on soil health and crop productivity in the region. Continuous multi-depth measurements of soil EC, temperature, and moisture further enhance the understanding of salinization dynamics, progression and impact.

Keywords: Soil Salinization, Coastal agriculture, Seawater Intrusion, Time Domain Reflectometry.

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Optimizing oxygen use in land-based aquaculture: environmental and energetic benefits of a novel control system

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Abstract. Aquaculture is among the fastest-growing sectors in the agro-food industry, and with this growth comes increasing attention to its environmental impact. In land-based systems, while feed is a significant environmental hotspot, no less important are the consumption of electricity and liquid oxygen, which are essential for maintaining adequate levels of water recirculation and oxygenation. Oxygen plays a critical role as a production factor, ensuring optimal conditions for fish growth and welfare. This study evaluates the environmental benefits of a novel oxygen distribution and measurement control system implemented in a land-based sea bass and sea bream farm. The system optimizes oxygen use by adjusting both the quantity and timing of its distribution in the tanks. The Life Cycle Assessment (LCA), conducted using a "from cradle to gate" approach, reveals that reducing oxygen consumption and achieving electricity savings significantly lower the environmental impact per kilogram of fish produced. The reductions are particularly notable in categories such as Climate Change, Photochemical Ozone Formation, and Acidification, where liquid oxygen and electricity are major contributors to the overall impact. Additionally, the optimization of oxygen usage not only improves environmental performance but also brings economic benefits by reducing operational costs. An indirect effect, which warrants further investigation, is the potential improvement in fish welfare. Enhanced oxygenation could lead to better Feed Conversion Ratios (FCR), enabling opportu-nities for further advancements in environmental performance.

Keywords: Aquaculture; Land-based system; Oxygen distribution; Energy savings; Environmental impact.

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Assessing energy and environmental benefits of insect-based feeds in trout farming

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Abstract. The rainbow trout (*Oncorhynchus mykiss*) is a key species in European aquaculture, where energy use and environmental performance are critical concerns. The newRIFF project, *"New life for rice by-products and agricultural wastes: insects bioconversion for fish feed production"*, investigates the replacement of traditional proteins with meals derived from two insect species (*Hermetia illucens* and *Tenebrio molitor*) reared on local by-products, such as rice industry residues, with the aim of improving the energy and environmental performance of trout farming. This study highlights the potential energy and environmental benefits of using insect meal in trout farming through a life-cycle approach.

The functional unit is defined as one ton of live fish weight, analyzed using a "cradle-to-farm gate" system boundary. Direct energy demands of the farm, as well as data on farm management and feed consumption for traditional trout farming, were collected through interviews with a major industry player. Sec-ondary data were used to estimate emissions from fuel use and nutrient emis-sions from fish metabolism. Data for the insect meal scenario were derived from primary experimental trials conducted within the newRIFF project.

The results reveal several trade-offs across the analyzed impact categories, driven in part by the differing scales of production between the compared systems. The study emphasizes the importance of considering both energy efficiency and environmental impacts when evaluating innovative feed alternatives, providing a robust framework for future comparisons and optimizations in sustainable aquaculture practices.

Keywords: Trout farming; Energy demand; Insect meal; Life Cycle Assessment; Environmental performance;

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Machine Learning and Big Data application for predicting sap flow fluxes: a case study on maize crop

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Abstract. This research focuses on the application of machine learning methods and big data analysis to estimate crop “internal variables” based on “external” variables for a smart and sustainable management of agricultural practices. The need for a prediction model arises from the invasiveness of internal measurements, which are more complex to obtain from sensors than the external ones. The study was applied to a silage maize irrigated by a hose-reel sprinkler supporting Variable Rate technology, to predict lymphatic flow (Sap flow) based on selected data. Meteorological features and soil-plant water status conditions were collected. Different models have been proposed, with satisfactory results. The most promising findings come from the application of a Multi-Layer Perceptron Regressor (MLPR), which showed high predictive performance using time sequences to capture complex dynamics. Data normalization and cyclic encoding techniques for time variables were crucial to ensure consistency and accuracy in predictive models. The suggested approach represents a remarkable step towards the adoption of AI technologies in agricultural management and highlights their effectiveness in improving the sustainability of agricultural practices, reducing environmental impact and optimizing the use of resources.

Keywords: Data-driven, crop transpiration, water requirement, water fluxes, SPAC models.

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Comfort and safety: the role of the seat in agricultural machinery

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Abstract. The seat is the device that minimizes vibrations transmitted to the tractor driver's body by the tractor platform, ensuring comfort and safety during operations. Furthermore, seats are essential to reduce whole-body vibration (WBV) to the drivers of agricultural and forestry machines, contributing significantly to their well-being and performance.

All seats for agricultural machines require homologation before their installation, in accordance with the Council Directive 78/764/EEC (Annex XIV), amended with Delegated Regulation 1322/2014 and Delegated Regulation 830/2018.

Furthermore, the seat ensures operator safety through the use of seat belts, which are part of the operator restraint systems that secure the driver within the vehicle. However, the weakest point in this system tends to be the attachment of the seat to the vehicle. Currently, the most common test used to assess seat attachment, especially when combined with ROPS (Roll-Over Protective Structures) tests, is the static test outlined in the OECD codes. This test evaluates the strength and stability of the seat anchorages, ensuring they can withstand the forces experienced during operation.

The aim of this study is to analyze these different approaches and evaluate the critical aspects of their testing procedures.

Keywords: Vibration, Comfort, Safety, Seats, Anchorage performance, Tractor

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Assessing the Impact of Seawater Intrusion in the Agricultural Soils of the Lazio Coast

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Abstract. In recent years, Mediterranean coastal areas have faced extreme climatic events, including salt wedge intrusion into freshwater systems, leading to increased salinization of agricultural soils. In Italy, the Lazio coast is particularly vulnerable. Historically reclaimed through landfills and drainage, this region relies heavily on agriculture as a key socioeconomic driver. This research aims to assess the extent of salinization in the coastal area around the Tevere River and its potential agricultural impact. Monitoring was carried out during the 2024 agricultural season through monthly sampling campaigns, measuring soil and surface water parameters. Special attention was given to analyzing salt wedge intrusion in water bodies and cultivated soils to understand its progression and effects on crops. Time domain reflectometry (TDR) was a key method for collecting spatial and temporal data on salt concentration variabil-ity. TDR measurements provided both volumetric water content (VWC%) and electrical con-ductivity (EC dS/m), with EC linked to soil properties such as water content, texture, and or-ganic matter. Alongside soil sampling, laboratory leaching tests assessed salt release from soil into water. Preliminary chemical analyses of major ions in leachates quantified the contribution of soil salinity to water salinization. Monthly soil samples from 10 monitoring points showed various salinity levels exceeding the FAO threshold of 2 dS/m, which can negatively affect crop growth and yields. The results emphasize the need for ongoing monitoring of electrical conductivity, temperature, and soil humidity to track salinization and inform strategies to safe-guard agriculture along the Lazio coast.

Keywords: Lazio Coast, Soil Salinization, Coastal Agriculture, Seawater Intrusion.

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Smart platform for efficient Treated Wastewater Reuse in crop irrigation

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Abstract. The growing demand for water and the impacts of climate change underscore the need for sustainable agricultural solutions. As conventional freshwater sources are overexploited, treated wastewater (TWW) offers a viable alternative for irrigation. TWW addresses water scarcity while providing essential nutrients, such as nitrogen, phosphorus, and potassium, which enhance crop growth and reduce the need for chemical fertilizers. This study conducted a three-year experimental trial (from 2021 to 2023) to investigate the smart fertigation of peach trees and processing tomatoes using secondary and tertiary treated wastewater, respectively, at the experimental platform near Cesena (Italy). TWW provided substantial savings of plant macro and micro-nutrients and overall no negative effects on soil, plant performances or fruit quality were observed. On the other hand, nutrients and organic material particles diluted in wastewater can enhance the formation of bacteria biofilm, responsible for drippers clogging. An innovative experimental platform equipped with grit filters and drip lines manufactured with a bacteriostatic effect additive, was set up in the same experimental platform. The system consists of three replicates to test the delivery performance of drip lines fed with three different water sources (e.g., freshwater, secondary and tertiary TWW). During the irrigation seasons, distribution uniformity monitoring and analyses for chemical, physical and mi-crobiological parameters were carried out on water samples collected at various sampling points and times during the seasons. This trial objective was to verify and quantify drip lines anti-bacterial additives effect on biofilm formation and therefore on drippers distribution uniformity maintenance over the irrigation cycle.

Keywords: Smart Fertigation, Treated Wastewater, Reclaimed Water, Water Reuse, Agricultural Irrigation, Circular Economy.

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Experimental results on rainwater permeability of agricultural nets

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Abstract. The need to protect crops, mainly orchards, from the extreme weather events such as heavy precipitation due to climate change is increasing. In recent years, innovative solutions such as rain-nets have been introduced to the market. The effectiveness of these protection systems may also depend, among many factors, on their specific techniques and deployment methods. At the University of Salento a research activity was carried out to assess the rainwater permeability of agricultural nets through an experimental setup positioned in an open field. This one is used to determine the Rainwater Permeability Index (Φ_{rw} [%]), a quantitative indicator of the nets' ability to allow rainwater to pass through to the crops towards the underlying soil. The setup simultaneously tests two nets having a porosity of 7% and 30%, respectively, each positioned at inclinations of 10°, 20°, and 30°. Measuring the water passing through the nets and the site's atmospheric precipitation allowed to define the Φ_{rw} values for the nets, considering variations in net inclination, rainfall data, and wind data. The results indicate that for the net with the lowest porosity positioned at a 10° inclination, Φ_{rw} is on average 39%, 36% at 20°, and 33% at 30°. The permeability index for the net with 30% porosity ranges from 58% to 64%, in relation to its inclination. The results of this study will provide valuable insights for defining the optimal characteristics of nets, aiming to minimize nets' rain permeability while ensuring good air permeability, thereby enhancing the resilience of crops to extreme climatic events.

Keywords: Climate change, Agricultural nets, Rainwater permeability, Crop protection, Extreme weather resilience, Net porosity

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Possibility of using an ozonized-solution sprayer in organic viticulture

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Abstract. The EU has set the target of a 50%-reduction of pesticides in agriculture by 2030, due to the increasing concerns about possible negative effects of these substances on the people (specif. the workers) and the environment. At the same time, organic farming techniques for the management of the vineyards are encouraged, even though maximum limits on the use of Copper-based substances are becoming increasingly stringent. To this end, a two-year field experimentation has been carried out in a vineyard near Udine (northern Italy) using an innovative sprayer able to instantaneously prepare and distribute ozonized water. The aim of these tests was to verify the effectiveness of this technical solution and the simultaneous possibility to limit the use of Copper or other pesticides in vineyards. The final yields of several theses in the same vineyard were hence quantified at the grape harvesting. The collected data evidenced a 100%-damage (hence the total loss of the grape production) within the untreated witness thesis. In the theses treated with different doses of Sulphur and Copper, it was also recorded a high damage, in this case characterized by an intensity decreasing with the used amount of those two substances, and, in any case, with production losses always exceeding 70%. Those results allow stating that even the defence techniques making use of different proportions of pesticides and ozonized water did not yield the desired results and led to an average decrease in the harvested crop of around 40%. The addition of ozonised solution to the treatments carried out, whatever the quantity used, was found to be completely ineffective, especially in a particularly difficult year for vineyard defence such as 2024, characterized by very frequent and intense rains. Concluding, the results referred to the observed year have evidenced that the application of ozonized water did not give any particular benefit, probably because the ozone, even if dissolved in an aqueous solution used to wet the vines' canopy and not in its gaseous state, has no sufficient persistence of action to effectively contrast the pathogens.

Keywords: Ozone sprayer, organic viticulture, pesticide reduction, sprayer performance, spraying application sustainability.

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Risk management approach for a safe and sustainable treated wastewater reuse at irrigation district scale

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Abstract. Climate change and water scarcity are affecting different sectors of our society, the agriculture being under a great risk since it is the production sector that consumes most water resources. Therefore, optimizing agricultural water reuse (e.g. reducing losses) and introducing alternative water resources (e.g. treated wastewater) in an imperative. Treated wastewater can be a sustainable way to reduce agricultural water scarcity, especially in the areas where agricultural fields are located in proximity of wastewater treatment plants (WWTPs). That resource has a constant volume and different valuable components (e.g. nutrients) that can bring different benefits. However, reuse of treated wastewater might mean a higher risk for farmers and consumers and therefore it is important to manage the risk related to the use of this resource. The new European regulation 741/2020 on wastewater reuse requires also risk management strategy to be made for every specific case of wastewater reuse in agriculture. While the regulation limits the system until the point of compliance (i.e. point where WWTP discharges treated effluent), it is also important to address the risks that may be present after that point (e.g. irrigation network, agricultural field). This research proposes a new methodology to address that aspect and applies that methodology on a specific case within the Metropolitan city of Bologna, where treated effluent from is currently being used for irrigation of different crops.

Keywords: Agricultural water scarcity, Pathogens, Risk management, Wastewater reuse.

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DSS-MOCOil - Decision Support System for Monitoring and Control of Olive Oil Production, a project funded by the European Eureka/Eurostars program

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Abstract. DSS-MOCOil project aims to develop and implement advanced monitoring and control strategies to optimize the olive oils production process from fruit maturation to bottled EVOO enhancing the quality and efficiency of industrial scale olive harvesting and processing in Italy (Puglia) and Spain (Ex-tremadura). The aim is to address the challenges posed by climate change on ol-ive cultivation and oil production, ensuring sustainable and high-quality outputs and maintain the competitiveness of European olive oil in the global market while promoting eco-friendly and more sustainable practices by gaining com-petitiveness. The project is supposed to monetize through increasing the effi-ciency and quality of EVOO production, reducing waste, optimizing resources, patenting and licensing to other producers the innovative solutions developed and creating consultancy services for other agricultural sectors facing similar challenges. The main approach is defined as “Monitoring-to-control” and is combined with “Optimized Harvesting and Processing Techniques” and “Sus-tainable Production Practices”. The project's focus on optimizing every stage of the production process, from fruit ripening to oil storage, ensures that the final product will have superior quality in terms of flavor, nutritional value, and shelf life. The project innovations represented are both incremental to enhance exist-ing processes, and breakthrough, such as Advanced Predictive Modeling and Real-time Data Integration. The project will assess the impact of its activities on local communities, ensuring that benefits are distributed equitably.

Keywords: Sustainable production practices, Optimized harvesting techniques, Advanced predictive modeling, Real-time data integration, Climate change ad-aptation, Resource optimization.

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Farm constructed wetland for the control of diffuse water pollution from agriculture

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Abstract. Agricultural production can have a negative impact on the environment and especially surface water quality through different substances used (e.g. nutrients, pesticides). Therefore, the non-point sources of pollution (agricultural drainage water) need to be monitored and their flow intercepted and treated before being discharged into the surface water network. Nature-based solutions, and especially constructed wetland can be particularly effective in this regard since they integrate well with the agricultural environment and since they are able to manage variable water and pollutant flows, typical of agricultural drainage water. This research focused on a full-scale farm wetland (i.e. surface flow constructed wetland) constructed in 2000 and located in an experimental farm within the Metropolitan City of Bologna. Its removal efficiency of different parameters (COD, TSS, TN, TP) as well as the water balance were monitored for two full years (2023 and 2024). As far as pollutant removal is concerned, the system, although a mature one, showed high performance (up to 83% for TSS and up to 90% for TP), underlining its role in the protection of environment and water quality. The water balance monitoring showed interesting results regarding the system's capacity to retain water. Depending on the period of year and the distribution of precipitation, the total retention during a specific rain event can be up to 100% and up to 70% on a yearly level. Moreover, the preliminary findings showed that the system can be very effective also in pesticides removal.

Keywords: Constructed Wetlands, Agricultural drainage water, Removal efficiency, Water balance.

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Energetic performance analysis of a plant factory in a Mediterranean climate

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Abstract. Plant Factories with Artificial Lighting (PFAL) are high-performance systems that can allow intensive production of fresh-cut vegetables, with continuous availability daily and seasonally, and benefiting from a short food supply chain. The plants grow on multi-level shelves, through hydroponic cultivation and with artificial lighting. PFAL are particularly energy-intensive, due to the artificial lighting system and the environmental conditioning system for cooling and heating. Controlled mechanical ventilation (CMV) with external air can help reduce the energy requirement of the cultivation room. Hence, it is important to analyse the energy requirements and thermal balance of this area considering the free thermal contributions by the CMV and the heat fluxes through the envelope. It is appropriate to focus on the heat pump's energy consumption for heating, sensible cooling, and dehumidification. This analysis needs to be on an hourly basis and over different seasons. For the purposes of this study, an existing reinforced concrete building, located in an Italian coastal area, was chosen to simulate a PFAL installation, and a building energy model was generated with the Design Builder-Energy Plus software. A configuration with high productivity (8800 m^2 of cultivation area) and very low thermal transmittance (0.10 W m^{-2} K^{-1}) was analysed with a ventilation flow rate ranging from 0 to 5 vol h^{-1} (~ 0 – 135000 m^3 h^{-1}) depending on the thermal requirements of the CMV. The paper describes the analysis and provides results over different seasons to offer guidance on minimising the energy requirements for a PFAL of this type.

Keywords: PFAL thermal performance, thermo-hygrometric parameters, mechanical ventilation, sensible and latent air conditioning, energy balance.

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Distribution of *Bactrocera oleae* in the territory based on biovariables and species distribution models

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Abstract. The olive tree (Olea europaea L.) agrosystems in Europe have been subject to numerous issues, including water scarcity, anomalous temperature, and increased pressure from phytophagous species. These factors have contributed to reduce production to 1.37 million tonnes in the 2023/2024 campaign. Therefore, research must focus on optimising resource use, including water, fertiliser, and pesticides. Among the various threats, *Bactrocera oleae* Rossi stands out as a predominant phytophagous species affecting olive quantity and quality. Advanced technologies, such as Geographic Information Systems (GIS) and climate models, combined with machine learning and statistical tools, have proven effective in assessing the territorial distribution of phytophagous. Based on the literature, the *Software for Assisted Habitat Modeling Package* (SAHM) has shown as a geostatistical tool for environmental monitoring. In this study, a methodology based on SAHM has been developed by integrating modelling approaches, including Maximum Entropy, Boosted Regression Tree, and Random Forest, and by performing comparisons of results and the analysis of accuracy measures. Therefore, the novelty in the proposed methodology was the application of this software to the identification of the areas under the greatest pressure from the phytophagous pest, both in the present and in the future, based on time series of the pedoclimatic conditions and forecasted climate data.
This study produced thematic maps highlighting the predicted presence of *Bactrocera oleae* under different bioclimatic conditions at the territorial level. These results provide valuable insights for companies and local authorities, supporting informed decision-making in land use planning and pest manage-ment.

Keywords: Species distribution models, GIS, biovariables, olive groves, bactrocera oleae, climate change

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Integrating Species Distribution Models and Climate Projections to estimate future citrus biomass potential distribution in the territory

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Abstract. Residual biomass from crop production and processing, such as citrus pulp, represents a valuable resource for green energy production. While traditional biomass estimates are based on actual production, recent research has considered Species Distribution Models (SDMs) to quantify the potential distribution of citrus biomass in the territory.

In a climate change context, making accurate projections of species distribution in the future is fundamental to effectively manage citrus biomass resources and properly locate processing plants and biorefineries in the territory.

VisTrail:SAHM (Software for Assisted Habitat Modelling) is a tool used for environmental analysis, capable of future predictions of species distribution. In this study, Boosted Regression Tree (BRT), Random Forest (RF), and Maximum Entropy (MaxEnt) models were utilised in VisTrails:SAHM and coupled to GIS analyses. The aim of the study was to investigate the potential future distribution of citrus crops in Syracuse province (Italy) in response to climate change. Current distributions were modelled by using pedoclimatic variables, and future projections were based on the bioclimatic variables from Euro-Mediterranean Center on Climate Change (CMCC) climate scenarios.

The results provided thematic maps showing the prediction of the crop presence, which highlighted the change in citrus distribution between presence and future due to climate change, and probability maps developed to identify the municipalities with the highest suitability for locating processing plants and biorefineries.

The integration of SDMs with future climate data simulations not only helps assessing the sustainability of biomass energy production but also provides valuable insights for agricultural planning and resource management.

Keywords: Citrus biomass, GIS, VisTrails:SAHM, Crop distribution modelling, Climate change, Biorefinery planning.

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Determination of vines water status using hyperspectral analysis

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Abstract. Water stress is an increasingly severe threat to crops due to global warming. Water stress can lead to substantial losses in summer-cycle crops, such as grapevine. Thus, developing monitoring protocols for determining grapevine water status is essential to provide quick and accurate information. We assessed the hyperspectral response of vines subjected to severe water stress (complete irrigation interruption). The experiment was conducted in a controlled environmental room where high-temperature conditions were imposed (T_{min} 30 °C – T_{max} 40 °C). The key physiological parameters to determine water stress and several vegetation indices derived from a portable high-resolution spectroradiometer were assessed. Then, we assessed the correlations between the physiological parameters and the spectral and vegetation indices to identify the best spectral indicators of water stress status. The results highlighted the best-performing vegetation indices and identified the near-infrared and green as the spectral regions more sensitive to determining water stress. The results provide valuable insights for developing instrumental approaches capable of supporting continuous vegetation monitoring in the field.

Keywords: spectral analysis, water stress, vegetation indices, portable spectroradiometer

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Preliminary laboratory tests for rain permeability evaluation of agricultural nets

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Abstract. In recent years, the meteo-climatic changes in the Mediterranean area stress the agricultural production, as they modify the natural growth regimes and negatively affect the productions. Therefore, covering crops with agro-textiles represents the main way to fight climate change, ensuring the replica-tion of the ideal microclimate for the growth of crop species, such as to maxim-ize production yields, even anticipating growth times, and optimize resource consumption. One of the most keenly felt issues is the orchard crop protection from the rain, which can lead to irreparable damages, and against which it is necessary to ensure adequate protection. Improved solution compared to cover-ing with plastic film could be the HDPE anti-rain nets covering, whereby a bet-ter aeration of the plant is allowed, less wind resistance is opposed, so that the supporting structure is not greatly stressed, which can be significantly simpli-fied, due to the lower mechanical strength requirements. The present research investigated some of the agro-textiles on the market, with special reference to rain permeability. Starting from the construction of a laboratory rainfall simula-tor, preliminary tests were carried out to identify the optimal rainfall duration to carry out the tests, which was found to be ten minutes. However, the first exper-iments, carried out at 10°, 20° and 30° nets' slope, showed that the analyzed an-ti-rain nets exhibited high permeabilities, in each case above 45% and with peaks of more than 90% for the anti-insect nets, regardless of the orientation of the weave with the slope and the intensity of the precipitation.

Keywords: Water-proof nets; rain protection; rainwater permeability; agricul-tural nets; climate change; HDPE nets

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Yet another open-source low-cost device for water level monitoring, but tested and clearly explained.

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Abstract. Effective monitoring of water bodies necessitates the use of specialized automated field instruments. A dense monitoring network is often critical for achieving a comprehensive characterization of the water systems. However, commercial monitoring devices typically entail substantial financial investments, with costs increasing proportionally to the number of parameters measured and additional functionalities (e.g., solar recharging, GSM connectivity). These financial constraints often limit the number of devices that can be employed in monitoring strategies. Moreover, commercial instruments are generally not modular, which can hinder their adaptability to diverse environmental conditions and varying monitoring objectives.
Open-source electronics platforms offer both low-cost components and modularity of the devices. Particularly, the Arduino platform, an open-source and low-cost prototyping platform allows for building and developing versatile and effective water monitoring loggers. In this work, we present an open-source, low-cost, easy-to-build device for monitoring superficial water bodies. The device was proved to be field resistant and requires very low power, thus free of solar power needs and perfect for battery application. Details about the functioning, assemblage and calibration are provided. The device is suited both for research applications and for schools' projects. Finally, given the low-cost it (about ~50 € per device) it can be built in multiple replicates for extensive water monitoring.

Keywords: Open-source water monitoring; Low-cost Arduino-based devices; DIY environmental monitoring; Modular monitoring systems.

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Specific machine for roadside overgrowth brushwood harvesting

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Abstract. Harvesting overgrowth brushwood is a valuable option for forest fuel production from roadside clearing, edge of arable lands, power line corridors and other infrastructural objects. Harvesting is mandatory in these areas mainly for safety reasons. When overgrowth brushwood, by a diameter exceeding 5 cm at a height of 1.3 meters, cannot be cleared by normal maintenance machines, and instead must be use harvesting machines and technologies developed for small tree harvesting. Previous studies on harvesting brushwood along road-sides were conducted, where different types of feller and harvester heads were tested The aim of this study were to define the performance of a specific ma-chine for harvesting brushwood along the roadside, compared to a conventional machine setup. The specific machine studied was capable to fell the overgrowth brushwood at 25 m distance, because of its specific configuration can reduce moving and stacking time by 66% and 37%, respectively, compared to a con-ventional configuration. While the differences in time consumption and produc-tivity between the two configurations were statistically insignificant, the specif-ic machine consistently performed well across various sites, including road em-bankments, where conventional machines faced accessibility challenges. Additionally, the tested machine reduced fuel consumption, minimized soil impact, and enhanced operational flexibility, enabling effective access to difficult terrain.

Keywords: harvesting, forestry, roadside maintenance, time consumption, productivity, fuel consumption

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Coupling EPANET with a FAO-56-based model for assessing irrigation network performance under variable conditions

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Abstract. This study presents an integrated modeling approach that combines EPANET with a crop water demand estimation model based on the FAO-56 methodology. The integrated model was defined and tested for an irrigation district of approximately 300 hectares in central Italy, where herbaceous crops are predominant, and the most common irrigation method is sprinkler. The hydraulic network consists of 23 delivery points equipped with smart monitoring systems that provide real-time data on pressure and flow.

The calibration of EPANET was carried out using flow and pressure measurements collected at specific network points during 2022-2023, ensuring that the hydraulic model accurately represents the observed operational conditions. Meanwhile, the crop water requirement model was calibrated using historical data from the period 2013-2023.

The integrated model enables the analysis of network behavior under different scenarios, including variations in crop types, climatic conditions, and irrigation methods. The results demonstrate how this approach can support decision-making processes related to both structural modifications of the irrigation system and agronomic management strategies. This study highlights the potential of such tools in optimizing water distribution efficiency and improving the overall management of irrigation resources.

Keywords: EPANET, irrigation network, digital twin, crop water requirements

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Soil loss under different agricultural management practices at the SERLAB monitoring site

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Abstract. Monitoring soil loss under different agricultural management practices is essential for developing effective soil conservation strategies. This study was conducted at the SERLAB plot-scale erosion monitoring site in central Italy, managed by the University of Perugia from 2023 to 2025. The experimental design included six plots (22 m long, 16% slope) under three soil management systems, each replicated twice: i) control (CTR), a traditional soil management approach with bare soil during the autumn-winter period and soil preparation in spring for sowing the cash crop (sunflower); ii) cover crop (CC) traditional management (CCT), where a mixture of hairy vetch (*Vicia villosa* Roth.) and rye (*Secale cereale* L.) is sown in autumn and incorporated by plowing in early spring before sowing the cash crop; iii) CC mulch-based no-tillage management (CCM), where the same CC mixture is sown in autumn and terminated by roller-crimping in spring, followed by direct sowing of the cash crop into the mulch. Meteorological and hydrological data were collected for several erosion events. While CC systems generally reduced soil loss (SL) compared to traditional management, the effectiveness varied. In some cases, such as during the establishment phase of CC in autumn 2023, results were contrary to expectations. However, the introduction of additional explanatory variables, such as the connectivity index and effective vegetative cover, improved the explained variance of SL. The study underscores the role of vegetative cover in soil conservation but also highlights the potential drawbacks of soil disturbance during CC establishment.

Keywords: Soil erosion, plot scale, cover crops, soil conservation

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Quantifying soil erosion and tracer-based characterization of overland flow from eroded hillslopes in eastern Italian Alps

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Abstract. Mountainous catchments in the European Alps are increasingly affected by shallow erosion processes. This study aims to: i) analyze recent morphological changes and quantify mass of soil removed from an experimental hillslope in the Bridge Creek Catchment (BCC) (eastern Italian Alps); and ii) evaluate overland flow (OVF) from eroded hillslopes, and compare it with other water sources using stable isotopes (δ^2H and $\delta^{18}O$), electrical conductivity and major ions. Unmanned Aerial Vehicle (UAV) based topographic surveys were conducted to build the Digital Surface Model (1x1 cm resolution) of the eroded hillslopes in BCC (Area 1 and Area 2). The mass of soil removed from the experimental hillslope (Area 1, 910 m^2) was quantified using three sediment collectors, each 2 m in length, 0.4 m in depth and 0.4 m in width, installed at the hillslope toe. Sediment data from the field was measured weekly or biweekly from summer to autumn of 2024, depending on rainfall conditions. Multiple water samples from different water bodies (stream water, spring water, shallow groundwater, OVF from the hillslope, rainfall, and saturated riparian zone) were collected between June 2023 and November 2024 for environmental tracer analysis. The total soil loss during the experimental period was estimated as 3.9 tons. The OVF from the eroded hillslope had isotopic signatures similar to recent precipitation events but showed more variability compared to precipitation. The results of this study can help to develop new monitoring systems of soil erosion and guide restoration plans in Alpine catchments.

Keywords: Italian Alps, Soil Erosion, UAV Survey, Overland Flow, Environmental Tracers.

Acknowledgements: This study was carried out within the Agritech National Research Center and received funding from the European Union Next-Generation EU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) - MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). This abstract reflects only the authors' views and opinions, neither the European Union nor the European Commission can be considered responsible for them.

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Climate change impacts and response of small and large reservoirs: insights from Val d'Orcia

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Abstract. Storing water for irrigation is key to ensuring future agricultural sustainability, given the more erratic rainfall patterns and the increased crop water demand expected in the future. Water managers and decision makers can rely on two different strategies, either storing huge amounts of water in large dams or promoting a diffuse network of small agricultural reservoirs. Here, we simulate the impacts of climate change on the characteristics of small and large reservoirs in Val d'Orcia, Central Italy. We use the Soil and Water Assessment Tool Plus to represent these two types of water storage. Forced with five climate models until the end of the century, model results show that future water storage will decrease in response to higher evaporation from the reservoirs and lower water flowing into the reservoirs. As a direct consequence of the predicted reduced area of the reservoirs, seepage from the bottom is also expected to decrease, hence reducing aquifer recharge. The trends evaluated with the Mann-Kendall test are found to be more significant during the summer season and for smaller reservoirs, which are therefore more susceptible to climate change compared to large dams.

Keywords: SWAT+, climate change, small agricultural reservoirs, irrigation.

Acknowledgements: This research was carried out within the AG-WaMED project, funded by the Partnership for Research and Innovation in the Mediterranean Area Programme (PRIMA), an Art.185 initiative supported and funded under Horizon 2020, the European Union's Frame-work Programme for Research and Innovation, Grant Agreement Number No. [Italy: 391 del 20/10/2022, Egypt: 45878, Tunisia: 0005874-004-18-2022-3, Greece: ΓΓΡ21-0474657, Spain:

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Improving Water Footprint reliability with a novel characterization factor at the local scale

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Abstract. ISO 14046:2014 is nowadays the international standard for measuring the Water Footprint (WF) of products, processes, and organizations, following a life cycle approach. The Available Water Remaining (AWARE) is an ISO 14046-compliant characterization model to measure the WF characterization factors (Cf) at national and sub-national levels. Despite being established on international consensus, AWARE is based on the use of global water balance models and does not incorporate knowledge of hydrological dynamics at high spatial resolution. Thus, the resulting WF values may be inaccurate for local studies. This work proposes an approach to estimate local Cfs with a municipality scale, using Tuscany Region (Italy) as a case study. Hydrological information (i.e. water availability) was retrieved from the Italian national water balance model with km^2 resolution (BIGBANG 7.0), and water consumption time series (2012-2021) were obtained at the municipality level. Results indicate that the yearly average Cf (~60 m^3 world eq / m^3i) is ~80% higher than the corresponding AWARE's Cf. WF results for two representative crops are influenced by the new Cf increasing between a range of 50% and 60%. The proposed approach can increase the reliability of WF assessments and can be extended to the entire Italian territory and other territories in the world.

Keywords Impact Assessment, Water Stress, Life Cycle Assessment, Water Use, Agricultural Water Consumption.

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Assessing rolling resistance of forest machines on steep terrain using CAN-BUS data under real-world operating conditions

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Abstract. Logging operations in mountainous environments pose unique challeng-es, particularly concerning machine-soil interactions. This study analyzes the rolling resistance coefficient (μr) of a forwarder during uphill logging operations in an alpine forest. Data were collected using a CAN-bus system that monitored the operational parameters of the forwarder in real-time, enabling a detailed analysis of μr under various environmental and operational conditions.

The results demonstrated a strong correlation between terrain slope and μr, with steeper slopes leading to higher rolling resistance values. Additionally, precipitation significantly increased μr by reducing soil-bearing capacity and increasing soil deformation. Linear regression models indicated that as the number of passes over the track increased, μr decreased, suggesting reduced soil compaction over time.

The study also found that winch assistance was primarily used on steeper slopes, but it did not result in a statistically significant reduction in μr. These findings high-light that μr is a valuable parameter for assessing soil trafficability and optimizing forest operations. The results have potential implications for forest management prac-tices and regulatory frameworks aimed at minimizing soil compaction and environ-mental impacts during logging activities.

Keywords: J1939; precision forestry; wood transportation; mountain forest

Paper ID: 107

The use of hemp residues in sustainable building materials: Mechanical performance and environmental benefits of *Cannabis Sativa*-based composites

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Abstract. This study investigates the potential of *Cannabis sativa* residues as a raw material for the production of innovative building elements. By integrating natural fibers derived from hemp residue, the research aims to evaluate the mechanical performance and ecological benefits of these materials. In line with the principles of the New European Bauhaus (NEB) - which represents a transformative vision, to make Europe the center of a new sustainable cultural and economic model - this study aims to combine technological innovation, circular bio-economy and environmental sustainability. Specifically, the influence of *Cannabis sativa* fibers on the tensile properties of concrete blocks has been analysed. The fibers were collected from the outer section of the stem of this plant. Mechanical tests were conducted on cylindrical concrete blocks with a constant amount of fibers (1% by weight) and different aspect ratios, to evaluate their tensile strength. With the aim to contribute to the analysis of the interaction of *Cannabis sativa* fibers with cementitious matrices and to evaluate the differences between various compositions, tensile tests were conducted on some raw fibers as well. The relevant results have been then even critically compared with tensile tests performed on recycled hemp sheets (thickness about 500 µm). The final results obtained have demonstrated how the use of agricultural by-products can contribute to more sustainable and resilient constructions, so embodying the core principles of the New European Bauhaus and conveniently contributing to support the implementation of sustainable bio-based solutions, as well as the European Green Deal in circular bioeconomy.

Keywords: Bioarchitecture, Circular bioeconomy, New European Bauhaus, Additivated concrete, Natural fibers, *Cannabis sativa*.

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Multitemporal analysis of soil erosion in a Sicilian *calanchi* basin

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Abstract. *Calanchi* are fragmented landforms characterized by intense soil erosion processes at a short temporal scale. The erosion rates in *calanchi* can be evaluated by UAV surveys combined with Structure from Motion and Multi-View Stereo technique application. This approach allows for obtaining 3D models of a site and evaluating its temporal evolution. The Sampria *calanchi* area is located in central Sicily and is characterized by wide spots of bare or sparsely-vegetated soil and intense erosion rates. Two surveys of the area were carried out using the UAV DJI-Mavic Air 2 in July 2023 and July 2024, extending a precedent investigation performed in May 2021 and April 2022. The aim of this paper is to perform a multitemporal analysis of the investigated area and measure the corresponding erosion processes (soil erosion and deposition) in a four-year monitoring period (2021-2024). The analysis highlighted that the *calanchi* area expanded by 6.5%, and this expansion mainly occurred in the 2022-2023 period, in which the highest annual rainfall and soil loss values occurred. Conversely, in the very arid period 2023-2024, with a total rainfall height of 350 mm, the extension of the *calanchi* area did not vary. Anyway, in the four-year monitoring period, annual soil loss was much higher than the tolerance.

Keywords: Calanchi, UAV, multitemporal evolution, erosion processes, soil loss.

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Use of graph theory, movement simulations and machine learning algorithms for the implementation of an Ecological Network. A study case in Reggio Calabria province, Italy.

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Abstract. Today, strategies centered on constructing ecological networks (ENs) are at the heart of scientific debate and are closely monitored by stakeholders and decision-makers worldwide. In this context, achieving the right balance between environmental and human needs is of utmost importance. This paper presents an approach to constructing an ecological network (EN) for the province of Reggio Calabria (Calabria, Italy). Analyses of ecological connectivity were conducted based on a map of habitats and the needs of 19 representative focal species selected from reptiles, amphibians, and mammals. The approach evaluated the strengths and weaknesses of graph theory, movement simulation models, and the Random Forest machine learning algorithm. Landscape connectivity was assessed by emphasizing the complexity of moving animals' behavior, specifically their inclination to exhibit both habitual (more easily predictable) and random behavior. The elaborations resulted in canonical elements of a network, such as patches and corridors, while a series of connectivity indices and movement predictions were generated. The connectivity indices provided both quantitative and qualitative information on the state of the network elements, thereby allowing for considerations regarding potential future restoration plans. By integrating the strengths of various established methods, this paper proposes a new and effective methodological approach for planners to implement an ecological network and enhance the robustness of provincial connectivity.

Keywords: Animal Behaviour, Movement Simulations, Ecological Network Implementation, Connectivity Evaluation, Landscape analysis.

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Valorisation analysis of chestnut (Castanea sativa) shell: an agro-waste biomass for energy and agronomic applications

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Abstract. The interest of the agri-food sector is increasingly closely related to sustainable use of resources and conversion of waste into by-products from a circular economy perspective. Residues from the chestnut production chain generate a large quantity of waste that is not exploited and is often unused. Large amounts of by-products are generated during chestnut processing such as inner shell, outer shell and peels, which represents approximately 10-15% by weight of the chestnut and are considered a precious source of bioactive compounds with multiple applications in the food, pharmaceutical and cosmetic industries. The work is aimed to investigate the energy and agronomic value of chestnut inner shell, the most significant fraction of peeling process. Following the drying and shredding of the sample, were determined the physico-chemical characteristics as moisture content, ash content, LHV, elemental composition, pH, content of micro and microelement, C/N ratio and Biochemical Methane Potential, to evaluate possible application of this material. In addition to the thermochemical conversion process, for the energy production from this agro-waste biomass, this study proposes to evaluate more conversion practices optimizing shell reuse in anaerobic digestion or as organic soil improver through composting and sustainable agriculture techniques. Using chestnut shell for energy production and agricultural applications helps reduce environmental impact, disposal problems about organic waste sent to landfills and promotes the use of renewable sources.

Keywords: by-products, chemical composition, sustainability, circular economy, waste recovery, energy conversion process.

Paper ID: 111

Deficit irrigation management and water stress assessment of Piedirosso cv on volcanic soils using HYDRUS-1D simulations

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Abstract. The challenges posed by climate change will necessitate important adjustments in agricultural water management practices, particularly in the wine sector, which holds significant strategic importance at the global level. Numerous wine-producing regions are either currently experiencing or are projected to face water shortages, which can influence both grape quality and wine characteristics. Within the framework of the CISAV project, supported by the University of Naples Research Funding (FRA), a three-year deficit irrigation management trial (2021-2023) was conducted in a vineyard of the local Piedirosso cultivar (*Vitis vinifera L.*) planted in volcanic soils, on the lower slopes of Vesuvius (Campania Region, southern Italy), characterized by a temperate Mediterranean climate. Analysis of the hydrological characteristics and soil properties of three soil profiles was carried out. During the experimentation conducted on three plots, two rainfed and one irrigated, continuous monitoring of the water availability variables was carried out, both on the soil (volumetric content and matric potential) and on the plant (leaf gas exchange rates and stem water potentials). The analysis of the correlations found over the observation period, supported by the knowledge of the other ancillary forcing variables, mainly linked to the meteorological trend, allowed us to interpret in terms of plant water stress the results of long-term simulations carried out using the HYDRUS-1D software.

Keywords: water stress, vineyard soils, Piedirosso, hydrological soil properties, volcanic environment, HYDRUS-1D modeling

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Coarse Particle Quality in Total Mixed Ration: Computer Vision vs. Operator Mixing

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Abstract. This study compares the physical quality and fibre length of the coarser fibres of total mixed ration (TMR) produced by a conventional mixing wagon and a mixing wagon equipped with a computer vision (CV) system. The trial was conducted on three dairy farms in Lombardy (Brescia, Cremona, and Milan districts) between October 2021 and November 2022.
Fresh TMR samples were analyzed using the Penn State Particle Separator (PSPS) method to determine particle size distribution, focusing on coarse particles retained by the PSPS 19 mm screen. In the laboratory, samples underwent moisture analysis and fibre length measurement.
The analysis revealed that the CV-assisted mixing wagon produced coarse particles more consistently aligned with the target fibre length (5 cm) compared to the operator-based mixing wagon. Regarding dry matter content per centimetre of fibre length, the results indicated that while the coarser TMR fibres from the operator-based mixing wagon were close to the target length, they exhibited a higher dry matter content per centimetre than those from the CV-assisted system.
Overall, computer vision systems enhance TMR consistency and offer significant advantages for animal farming, especially when operated by individuals with limited experience. At the same time, the findings also suggest that operator experience introduces a ration evaluation bias resulting in a TMR whose coarser particles have higher dry matter content.

Keywords: Dairy Farming, Penn State Particle Separator, Mixing Wagon, Livestock Automation, Animal Feeding.

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A Multicriteria Approach to Regional-Scale Planning of Water Harvesting in Arid Regions of Somalia

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Abstract. Somalia is one of the most arid countries in the world. Here, Water Harvesting (WH), namely the collection and storage of runoff water for productive use, can represent a suitable solution for enhancing the effect of erratic rainfall patterns. A major barrier to WH implementation is the difficulty of selecting suitable sites for such small- to medium-scale low-cost infrastructures, especially for large areas where it has not been implemented before. This study presents a Multi-Criteria analysis for selecting the best sites for WH Ponds and Sand Dams for seven regions of Northern Somalia (Awdal, Bari, Nugaal, Sanaag, Sool, Togdheer, and Woqooyi Galbeed). Criteria and weights for the analysis were based on existing literature and expert elicitation from interviews with FAO-SWALIM officers. The Analytical Hierarchy Process (AHP) was used to minimize the uncertainty in the weights selection; the analysis was validated using over 100 existing WH structures. Finally, the biophysical suitability to WH of different catchments in the study area was evaluated, showing good potential on the North-western side and some potential along the Eastern coast. This approach, covering half of the country, represents a cornerstone for any lower-scale investigation and can be replicated in any similar context, even if data is scarce. The study was funded by FAO LETTER OF AGREEMENT # 043/2024 - Desk study on “Best Siting of Water Harvesting Structures in Somalia with a focus on its arid parts”.

Keywords: Water Harvesting Ponds, Sand Dams, Multi-Criteria Decision Making, Analytical Hierarchy Process (AHP), Rainwater Harvesting.

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Biomethane as an alternative fuel: A Case of study on a crawler tractor

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Abstract. Over the past decade, the European Union has identified natural gas as a strate-gic fuel, investing heavily to expand its use, particularly in road transport. In It-aly, the government has supported biogas production, initially through incentives and now via the "Biomethane Decree."
At the same time, agriculture is increasingly focusing on sustainability, promot-ing environmentally friendly production processes and machinery. This shift enables opportunities for "CO2-free" branding, positioning biomethane-powered agricultural machinery as essential. Biogas plants, already common in agricul-ture, can be easily converted to biomethane for use as a renewable fuel.

The TOBIAS project, launched in 2020 and financially supported by the Pied-mont Region (Northwestern Italy), aims to establish a biomethane supply chain for agricultural tractors. Specifically, the project has developed two crawler tractors with natural gas engines designed for vineyard operations. The initial phase involved modifying an existing diesel-powered tractor by replacing its engine with a natural gas-powered F28 engine and integrating compressed natural gas tanks. A rigorous testing protocol was established to assess the performance of the modified tractors, including engine power, lifting and towing capabilities, and fuel consumption. Tests were conducted using specialized equipment and under real-world conditions at the CNR-STEMS experimental farm. The prototypes were evaluated with agricultural implements to simulate typical operations. The project highlights biomethane's potential as an alternative fuel to reduce environmental impacts in agriculture, emphasizing its role in enhancing sus-tainability and paving the way for broader adoption of renewable energy in farming practices.

Keywords: Stationary test, Field test, Vineyard, Engine performance

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Evaluating Drip Irrigation as a Sustainable Alternative to Flooded Cultivation for Rice in Northeast Italy: Preliminary results

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Abstract. On a plot in the Province of Verona (Northeast Italy), an area traditionally dedicated to rice cultivation, a trial was conducted in 2024 to compare the conventional flooded cultivation system with a drip irrigation system. Three different irrigation volumes were applied using drip tapes with varying flow rates. The primary aim of the study was to evaluate the productivity of the different methods and assess the potential for more sustainable alternatives that could support rice cultivation under drought conditions. Additionally, the study examined weed development and water losses through percolation.
Drip irrigation proved more efficient in meeting calculated water requirements, whereas the traditional flooding method used approximately 800 mm of water, with 55% lost to percolation. Biomass sampling across various phenological stages revealed no statistically significant differences between the treatments, indicating similar growth for both irrigation methods.
However, a significant difference was observed in the thousand-grain weight analysis. The conventional method yielded approximately 35 grams per thousand grains, while the best result from drip irrigation was 29 grams. Overall, total yield decreased by about 25% with drip irrigation compared to flooding. This reduction was likely due to very low irrigation volumes negatively affecting grain development. Despite the yield reduction, the comparable biomass growth suggests that drip irrigation can still support adequate crop development.
This preliminary study provides a basis for future research, emphasizing the need to recalibrate irrigation volumes. While the approach holds promise for maintaining production in the context of climate change and increasing water scarcity, challenges such as weed management remain to be addressed.

Keywords: Sustainable agriculture, Water management, Climate change adaptation.

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Development of an autonomous electric vehicle for greenhouse agriculture: the MAGA project

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Abstract. In recent years, agricultural robotics has received great attention in research studies, being considered a way to address some important issues of the agricul-tural sector, such as precision agriculture, resource saving, improvement of safety conditions and shortage of human labour. These issues are particularly critical in greenhouse production, where many repetitive and hazardous tasks still rely on human labor.
In this context, the Piedmont Region (Northwestern Italy), with support from European regional development funds, has sponsored the MAGA project, aimed at developing a self-driving electric machine for agricultural operations in greenhouses. The project involved both industrial and academic partners: Smartec srl, the project leader, focusing on the design, construction and produc-tion of advanced electronic systems and CNR-STEMS, drawing its attention on assessing the system sustainability and promoting the advancement and dissem-ination of knowledge and technologies.
MAGA has developed a multipurpose agricultural vehicle with specific fea-tures: autonomous driving, mobility on various terrains, the ability to spray ag-rochemicals, and collaboration with operators in tasks such as harvesting and transportation. The vehicle has a chassis approximately 1.2 meters long and 0.8 meters wide, with integrated batteries for propulsion. It is self-propelled by four wheels, each equipped with an internal electric motor. The autonomous driving system is based on RTK satellite guidance, featuring two antennas on the vehi-cle and a fixed ground reference receiver. A safety system with ultrasonic sen-sors detects obstacles within 30–40 cm, stopping all movements if necessary. The project outlines its framework, achieved results, and future implications for agricultural robotics in greenhouse environments.

Keywords: greenhouse robot, electrification, protected cultivation, sprayer

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Sound quality analysis of agricultural tire noise

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Abstract. Agricultural mechanization concerns occupational health and safety issues for workers, such as noise exposure. Professional drivers reported the troublesome noise of agricultural tires at the driver's position; nevertheless, measuring the sound pressure (in dB_A), the noise level did not show significant differences among different sets of tires, suggesting the hypothesis that the problem could be the perception of noise, therefore concerning aspects of psychoacoustics.

The science of psychoacoustics involves quantitatively evaluating subjective sensations using sound quality metrics (e.g., sound loudness). The application of sound quality metrics allows the representation of the relationship between the physical and perceptual acoustic quantities.

In this study, six different constitutive types of tires for agricultural tractors, all sized 650/65 R38, were fitted on a tractor's rear axle. The experimental tests focused on assessing the pass-by noise, noise measurement at the driver's position, and sound quality analysis of the noise measurement at the driver's position.

The research confirmed that the adoption of sound quality loudness could highlight the discomfort complained of by professional operators beyond certain speeds, a situation in which the use of sound pressure as dB_A cannot be helpful. The frequency analysis has shown that precise conditions characterize the onset of discomfort.

Keywords: Tractor; Psychoacoustics; Loudness.

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Landscape and environmental aspects in the design of the prevention of desertification and soil erosion. Forestry hypothesis in cultural heritage preservation.

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Abstract. The research is promoted by the growing attention paid by the Public Agenda on the multifunctionality of urban and extra-urban forests. The presence of forests contributes to the physiognomy of urban and extra-urban landscapes and provides benefits on economic, social and cultural levels. At a national level, the promotion of forestation initiatives is foreseen by the National Recovery and Resilience Plan which makes available the necessary funds for the interventions to be implemented especially in areas at risk of erosion and desertification in order to prevent phenomena of hydrogeological instability.
Forestry is also useful to improve cultural landscape fruition. Public urban forestation projects are going to be implemented due to reuse large abandoned areas (especially former military or industrial ones) but also to improve human well-being in fruition of archaeological Mediterranean sites.
The aim of this work is to propose a forestation hypothesis along the axis of an old historic road, probably from the Roman Era, in the municipality of Paternò (Province of Catania, Sicily). The methodology adopted is: Landscape Character Analysis, SWOT Analysis, Landscape strategy design.
The creation of a vegetation and ecological transect is hypothesized to mitigate the effects of soil erosion and desertification and to improve the fruition of the site. In this direction, funds are made available by the Sicily PSR 2020/2024 and 2021-2027 programs.
The first results are useful for Superintendencies and Archaeological Parks to improve protection and use of cultural heritage and for municipalities to shape sustainable governance strategies based on slow mobility.

Keywords: Landscape Analysis, Landscape protection, Landscape design, Forestry, Nature Based Solutions, heritage.

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Experimental analysis of the influence of different rim thicknesses on tractor operator comfort

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Abstract. The hypothesis that a lighter wheel can lead to fuel savings in road transport has led to consideration of the use of lighter rims. This led to an evaluation of whether this choice could have an impact on some of the performance characteristics of agricultural tractors such as operator's comfort. In this project an experimental test was carried out to evaluate the effects of lighter rims on the operator's whole body vibration.
Analyses were carried out in accordance with the requirements of the standard ISO 2631-1997 on the standard test track ISO 5008:2002 (100 m, smooth track), on vertical bumps and on flat track. Two sets of rims were mounted on a 250 hp 4WD tractor (MFWD) and tested at different tyre inflation pressures and forward speeds.
As the combination of tyre eccentricity and forward speed is a source of vibration when driving a tractor on a flat asphalt road, the same tyres were used for both rims and the high and low spot of the tires and rims were matched in the same position.
The results are reported according to the axis of solicitation at the driver's seat position: longitudinal (X), lateral (Y), vertical (Z) and in terms of the comfort index (CI).
The experimental activity showed that on the ISO track there were significant differences in the lateral acceleration of the driver, where the innovative rims were more comfortable.

Keywords: Energy Saving, Safety, Vehicle Dynamics.

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Managing unconventional water resources in the Mediterranean: insights from a participatory approach in four Living Labs

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Abstract. Non-conventional water (NCW) resources can contribute to ad-dressing the increasing water stress in the Mediterranean area, where water scarcity increases the risk of water and land resources degradation. Yet, the adoption of NCW in the region remains limited. Supporting the implementation of NCW resources shall also consider the social, economic, and institutional conditions that stimulate or deter the uptake of these solutions. We present a methodological framework developed within the AG-WaMED project to un-pack the multiple dimensions associated with the use, management, and regulation of NCW. The methodology combines hydrological and socio-economic modelling, 4 participatory workshops, stakeholder interviews, and multi-level governance assessment. Involving stakeholders is crucial to ensure the social acceptability of the proposed solutions and their successful implementation. In AG-WaMED, the participatory approach was based on the Responsible Re-search and Innovation (RRI) Roadmap©. The methodology is applied in four Mediterranean Living Labs (LL) in Italy, Spain, Egypt and a transboundary LL in Tunisia and Algeria. Four workshops were held in each LL. In the first one, the LL was established, and the main issues related to the NCW were assessed. Based on the outputs, specific models were developed, and they were presented in the second participatory workshop to obtain feedback on potential further analyses. However, most of the stakeholders' concerns relate to governance and legal aspects. Hence, the last two workshops led to the preparation of an Inte-grated Watershed Management Plan. The AG-WaMED's co-production ap-proach through the RRI Roadmap exemplifies how to actively involve stake-holders in sustainable water management.

Keywords: Non-Conventional waters, RRI Roadmap©TM, participatory ap-proach, knowledge co-production, rural living labs, Mediterranean.

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Relationship between Surface Water Content and Surface Reflectance in the Infrared Domain

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Abstract. Despite the considerable progress made in the last decade, the development of remote sensing techniques to monitor water content in soil-plant systems is still challenging. The strong correlation between water content and electromagnetic radiation in the optical, thermal and microwave domains has enabled the development of various approaches to characterize and monitor soil moisture dynamics in both surface and root zone layers. This study evaluates the capabilities of optical reflectance measurements – with special concern to the shortwave infrared region (SWIR) - for estimating soil water content in a controlled environment and in field conditions.

In the first case, soil samples were collected from a field with volcanic soil in the Campania region (Italy), divided into three subsets and placed into cylinders with standardized dimensions but different soil thicknesses. The samples were dried, watered to saturation, and subjected to daily gravimetric water content measurements, following the process of evaporation depletion over time. Concurrently, spectroradiometric reflectance curves were acquired in a darkroom using an SR2500 spectroradiometer. Reflectance data were transformed and integrated over spectral bands corresponding to the different optical satellite sensors. The results demonstrate a significant correlation between infrared bands and measured water content, highlighting the potential of spectroradiometric measurements for an accurate estimation of surface soil water content.

In open field conditions, remotely sensed infrared data were analysed in correspondence with precipitation and irrigation events. This test aimed to evaluate whether the infrared reflectance observations could capture spatio-temporal variability of the degree of saturation within the soil-plant system.

Keywords: Soil water content, Soil moisture dynamics, Remote sensing, Infrared re-gions, Optical satellites sensors, Surface reflectance.

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Effect of 3D-Printed Flexible Wheels on the Dynamic Behavior of Agricultural Soil Transit

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Abstract. Additive manufacturing is an industrial process that creates objects from 3D computer models by adding material layer by layer and allows the creation of flexible parts. Although its use is not widespread in agricultural equipment, it could be used to prototype complex components, such as wheels. In particular, using 3D-printed flexible wheels in agriculture is a novel approach with significant potential, as their adaptability to various terrains can address challenges like soil compaction caused by heavy machinery and vibrations that negatively impact processes such as fruit transport. This research focuses on how wheel flexibility affects vibration mitigation. Experimental tests were conducted in a controlled agricultural soil using a small trailer moved by a robot with a prototype of wheel geometry made of TPU materials vs a tube rubber tyre set in a varying velocity and weights. The results demonstrated the great feasibility of these prototypes with a proper manufacturing design for their application in areas such as robotic devices or fruit trailers.

Keywords: Flexible wheels, 3D printing, agricultural soil, wheel-soil interaction, vibration damping

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Connecting Nature, Enhancing Lives: A Regional-Scale Study on Green Infrastructure Planning

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Abstract. Green infrastructures (GIs) are among the most important tools used to contrast the adverse effects of landscape changes and fragmentation on bio-diversity and ecosystem services. They are defined as strategically planned networks of natural and semi-natural areas designed and managed to provide a wide range of ecosystem services. These services include improving air and wa-ter quality, mitigating climate change, conserving biodiversity, and enhancing quality of life.

The main objectives of the study presented here are: i) to identify the most crucial areas for green infrastructure (GI) planning at regional scale, focusing on core areas, restoration zones, sustainable land use zones, urban and peri-urban green spaces, and both natural and artificial connectivity elements as potential structural components; ii) study of GI potential in terms of ecosystem services (ES) considering hot spot and cold spot of ES captured by GI components.

As a case study, we focused on the Friuli Venezia Giulia region in Northern Italy, examining the proposed GI model, its potential relationships with ecosystem services (ES), and exploring feasible solutions for its implementation. Overall, this study contributes to the growing field of GI research, which recog-nizes the importance of strategically planned networks primarily based on natu-ral and semi-natural areas in providing ecosystem services and promoting sustainable development.

Keywords: Green infrastructure, landscape planning, GIS, network, ecosystem services.

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Assessing Carbon Stock in Small Landscape Features: a study case in Northeast Italy

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Abstract. Small landscape features (SLFs) are relevant but often overlooked components of ecosystems, playing a crucial yet poorly understood role in the global carbon cycle. Despite their ubiquity and potential significance, SLFs re-main largely understudied within ecosystem science. These features, encom-passing a diverse array of natural and semi-natural elements such as hedgerows and riparian buffers, intersect agricultural, urban, and natural landscapes, con-tributing to biodiversity conservation and carbon sequestration.

This study (PRIN 2020-EyeLand) aims to assess the carbon stock within SLF and its implications for ecosystem services within a case study in the Friuli Ve-nezia Giulia region. Through field surveys and remote sensing techniques, the research examines carbon density and distribution patterns in SLFs across di-verse landscape types and management practices. To this aim we adapted and applied the Random Forest model originally developed to estimate carbon stock in forests, trained on the 2015 INFC inventory points. It uses as covariates the Canopy Height Model, slope percentage, elevation, aspect, and spectral indices like NDVI, NDII, EVI, and GNDVI. The study reveals significant variations in carbon storage among different SLF vegetation types and land-use contexts. The average carbon stock in SLFs resulted 33,17 tC/ha. In comparison, the es-timated carbon stock in regional forests averages 70.95 tC/ha. This comparison provides context for understanding the relative contributions of SLFs to region-al carbon storage and productivity. By quantifying carbon stocks in these often-overlooked landscape features, val-uable data are provided for land managers and policymakers aiming to enhance carbon sequestration and biodiversity conservation in agricultural landscapes.

Keywords: Carbon Stock, Small Landscape Features, Agricultural Landscape, Ecosystem services.

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Paper ID: 125

High Nature Value Farmlands: Preserving Biodiversity and Ecosystem Services

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Abstract. Agroecosystems are often perceived as incompatible with natural resource conservation. However, High Nature Value Farmlands (HNVFs) challenge this notion by recognizing the crucial role of low-intensity agriculture in biodiversity preservation. The EU's integration of HNVFs into policy frameworks underscores their importance.

This study is part of the project "SICANSE-Development of an information system on the natural capital and ecosystem services of the agricultural and forestry sector" (Action 2.1.3). Our aim is to estimate the total extent of HNV farmland and monitor trends in its extent and condition at the regional scale. HNVFs are cultivated landscapes rich in biodiversity or supporting endangered species and habitats. They are categorized based on semi-natural vegetation, landscape diversity, and presence of protected species.

To map HNVFs, we combined available datasets, identified potential HNVF types, integrated weighted indices, and characterized the results. Analyses indicate that approximately 63.9% of identified HNVF areas consist of overlapping types, reflecting the multifunctionality and ecological complexity of these landscapes.

By preserving biodiversity and traditional farming practices, HNVF contribute to essential functions like pollination, water regulation, and soil health. Understanding their spatial distribution and evolution is crucial for effective conservation strategies and sustainable land management.

This study contributes to the growing body of knowledge on HNVFs. By quantifying their extent and monitoring their changes, we can inform policies and practices that safeguard these vital landscapes and the ecosystem services they provide. HNVFs emerge as key players in ensuring the balance between agricultural production and environmental conservation.

Keywords: Agroecosystems, High Nature Value Farmlands, Mapping techniques, Biodiversity conservation.

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A Critical Review of Terminologies in Soil and Water Bio-Engineering, Nature-based Solutions, and Related Fields

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Abstract. The fields of Soil and Water Bio-Engineering (SWBE), Nature-based Solutions (NbS), Ecological Engineering (EE), Green and Blue Infrastructure (GBI), and Engineering with Nature (EWN®) involve a variety of practices directed at sustainably and adaptively tackling environmental issues. However, the inconsistent and overlapping terminologies across these areas can create confusion, impeding effective communication among researchers, practitioners, and policymakers.
This review provides an in-depth examination of the current SWBE literature, thoroughly discussing its terminology, key applications, and thematic areas. The insights gleaned from these findings serve as a basis for assessing and contextualizing the outcomes of a meta-review related to NbS, GBI, EE, and EWN®. The study's objective is to explore how different practices are classified within these fields, discerning overlaps or exclusions and examining the reasons for these classifications. By synthesizing insights from these comparisons, the review emphasizes the differences and commonalities among these disciplines, revealing opportunities for enhanced alignment and collaboration.
The expected results include establishing a cohesive framework linking these fields, clarifying terminology to improve cross-disciplinary cooperation, and actionable suggestions to enhance the global discussion on sustainable and adaptive solutions. This initiative highlights the necessity of harmonizing terminology to boost the efficacy and scalability of strategies that address critical challenges such as climate resilience, ecosystem restoration, and the management of water resources.

Keywords: Soil and Water Bio-Engineering, Nature-based Solutions, Green and Blue Infrastructure, Terminologies, Standardization, Review Papers.

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Paper ID 127:

Assessment of emissions and air quality in naturally ventilated pig houses with different flooring systems

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Abstract. The uncontrolled presence of ammonia (NH_3), carbon dioxide (CO_2), particulate matter ($PM_{2.5}$ and PM_{10}) and hydrogen sulphide (H_2S) in pig houses is detrimental to animal health, farm workers and the environment. Within the EMILI project this study assessed the air quality and emissions over a 21-day period in two naturally ventilated piggeries, with different structures and management. Barn F had a fully slatted floor with a vacuum system; Barn S had a solid concrete floor in the indoor and outdoor areas. Monitoring was conducted using IoT sensor devices to continuously measure the concentration of NH_3, CO_2, H_2S, PM, temperature and humidity. An evaluation of several management aspects was conducted, with a subsequent comparison of these aspects with the daily mean values. The highest daily value of ammonia emission corresponded to feeding events that increased by 22% and 16% in barn S and F respectively. The feeding distribution also increased PM concentration in Barn F up to 32%. In Barn S, manure removal from the outdoor lane enhanced the emission of H_2S up to 1.9 ppm. In Barn F the vacuum opening led to an increase of NH_3 concentration of 57%, also the NH_3 emission factor increased of 55%. The automated window management system of Barn F, resulted in the accumulation of CO_2 and NH_3 during the night, specifically increasing up to 52% and 34%. On the contrary Barn S with access to an outdoor lane did not exhibit a similar increase.

Keywords: IoT sensors, Gas emission rates, Precision livestock farming, Livestock welfare and environment, Animal housing

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Electrification of Thermal Processing of Heterogeneous Food: Modeling of Ohmic Heating Effects

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Abstract. The electrification of food processing, particularly pasteurization, has emerged as a critical innovation to enhance energy efficiency, environmental sustainability, and process control. Among these technologies, ohmic heating (OH) stands out as a promising approach for the pasteurization of heterogeneous foods. This extended abstract outlines the principles, challenges, and modeling strategies involved in applying ohmic heating to the pasteurization of heterogeneous food matrices.

Traditional pasteurization methods rely heavily on conventional thermal technologies, which involve heat transfer from an external source. These methods often suffer from uneven heating, long processing times, and significant energy losses. Ohmic heating, by contrast, utilizes electrical current to generate heat directly within the food matrix. This technology has the potential to achieve rapid, uniform heating, particularly beneficial for heterogeneous food systems where conventional methods struggle with non-uniformity due to differences in thermal conductivity. Heterogeneous foods, which consist of multiple phases (e.g., solid particles suspended in liquid), present unique challenges for ohmic heating. Variations in electrical conductivity between phases can lead to uneven heating, impacting the efficiency and safety of the pasteurization process. In this work an heterogeneous system composed of meatballs in a puree, it was used to study the effects of the variation of electrical conductivity on volumetric heat sources through computational thermo-fluid dynamic models, integrated with experimental tests for the validation of the results.

Keywords: Modeling, Simulation, Ohmic Heating, Heterogeneous Food.

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Improving maize environmental sustainability by increasing fertilization efficiency

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Abstract. This study assess the environmental impact of maize cultivation under conventional and sustainable management practices using Life Cycle Assessment (LCA) approach. Eight farms located in Po Valley area and adopting conventional and sustainable practices were evaluated. The sustainable practice combines monitoring of soil characteristics with reduced nitrogen inputs, complemented by Corteva's innovative products, Instinct® and BlueN®.
Instinct® acts at the soil level and promotes stabilization of the ammonia nitrogen pool in the soil; BlueN® is a biostimulant, bacterial that diffuses into plant tissues and metabolizes atmospheric nitrogen by fixing it in a form that can be absorbed by the plant.
Sustainable practice presents better environmental results compared to the conventional one. Reductions in climate change impact (up to 56%), acidification (up to 84%), and ozone depletion (up to 83%) were achieved. These improvements are achieved thanks to optimized fertilization strategies that minimized greenhouse gas emissions, particularly nitrous oxide, and enhanced nitrogen use efficiency.
Despite the overall positive outcomes, an increase of marine eutrophication was observed in few cases due to the higher nitrogen leaching linked to biostimulant application. Mechanization also emerged as a significant contributor to impact categories such as photochemical ozone formation, ozone depletion and human toxicity, highlighting areas for potential improvement in machinery efficiency.
This work underscores the potential of integrating innovative agronomic strategies with LCA to achieve sustainable agricultural production. It offers a replicable model for enhancing productivity while reducing environmental footprints, advancing global efforts toward sustainable food systems.

Keywords: Maize cultivation; Biostimulant; Sustainable practices; Life Cycle Assessment; Environmental performance.

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Advances in the classification of behavioural activities of grazing cows by improving a statistical method based on accelerometer thresholds

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Abstract. Nowadays, great attention is paid to monitoring animals in intensive farms, both to ensure their well-being and to preserve the balance of the territory. Inappropriate grazing management could promote soil erosion, causing serious damage to vegetation. Therefore, classifying the behavioural activities of grazing cows in real time is a worthwhile challenge to limit such negative effects on the environment.

In this paper, a previously defined statistical-based method for classifying the behavioural activities of grazing cows was optimized.

The data collection system remained unchanged, consisting of collars equipped with triaxial accelerometers. Modifications were made to the algorithm for identifying behavioural classes, refining the accelerometer thresholds, previously determined, that identify each individual behavior. In detail, appropriate corrective statistical parameters were introduced, such as the Coefficient of Variation, useful for measuring the dispersion of the frequency distribution of the acquired accelerometer data relating to each behavioural class.

Following a testing campaign performed within experimental grazing farms, the main behavioural activities found to be reliably determined are: Feeding, Lying, Rumination in Lying Position, Standing and W

alking.

Keywords: Cow behavioural activities, Grazing cattle, Accelerometer thresholds, Coefficient of Variation

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Immersive and Interactive First-Person Navigation in Vineyards Using Neural Radiance Fields (NeRF and Gaussian Splatting

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Abstract. Extended Reality (XR), which encompasses Augmented Reality (AR), Virtual Reality (VR), and Mixed Reality (MR), offers transformative applications in vineyard management. These technologies can enhance decision-making, efficiency, and sustainability in viticulture. One key issue is the 3D reconstruction of the vineyard to integrate geo-localized sensor information. Neural Radiance Fields (NeRF) and Gaussian Splatting enable high-fidelity 3D reconstruction and real-time rendering in outdoor environments. This work presents an integrated approach for immersive first-person navigation in vineyards using these techniques. A multi-view dataset, captured with both a handheld high-resolution camera and a 360-degree video camera, is processed via structure-from-motion to estimate camera poses and generate sparse point clouds. NeRF can operate with extremely sparse inputs, sometimes even a single image, whereas Gaussian Splatting typically requires multiple input views; nevertheless, both methods enable real-time 3D environment reconstruction. Compared to standard photogrammetry, both NerF and Gaussian Splatting excel at rendering featureless areas and capturing extremely fine details such as small vine branches, water transparency and reflections, and frequent light changes. Users can navigate interactively through the virtual vineyard, facilitating remote crop monitoring, disease detection, and canopy structure analysis. To validate geometric quality, ground-truth data have been compared using Cloud-to-Cloud Distance (C2C), Chamfer Distance, Completeness, and Accuracy. Additional metrics include RMSE, reprojection error, and completeness curves (e.g., 90% of points with error < 2 cm). Rendering fidelity is assessed via PSNR and SSIM. Ongoing research aims to optimize training strategies, improve model scalability, and refine the distance calibration process, including integrating additional sensors or reference objects. Overall, this study demonstrates the feasibility of combining NeRF and Gaussian Splatting for precision viticulture, enhancing both scientific inquiry and practical vineyard management through advanced 3D visualization and analytics.

Keywords: NeRF, Gaussian Splatting, 3D Reconstruction, Vineyards, Precision Agriculture, Interactive Navigation.

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Mechanical and Physical Characterization of Mediterranean Wood Oaks for Sustainable Engineering Solutions

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Abstract. Wood, recognized as a sustainable building material, has seen a resurgence in modern construction due to its environmental advantages and mechanical properties. This growing interest justifies ongoing research into wood technology, particularly in assessing the mechanical and physical properties of key species. In this context, a combination of non-destructive and destructive testing methods was employed to characterize the Mediterranean oaks (*Quercus robur, Quercus cerris, Quercus pubescens, and Quercus ilex*), which are of significant interest for engineering applications. Non-destructive tests, using a microsecond timer, were utilized to estimate the dynamic modulus of elasticity (MOEd) of prepared speci-mens. Destructive tests, conducted at the Forest Mechanization and Wood Technology Labora-tory (AGRARIA, UNIRC) with a universal testing machine, included bending tests for the static modulus of elasticity (MOEs), parallel- and perpendicular-to-grain compression tests, Janka hardness, shrinkage and swelling analysis, and bulk density measurement.

Preliminary results highlighted notable differences in the mechanical performance of the species. *Quercus ilex* exhibited superior elasticity and dimensional stability, making it ideal for applications requiring durability and resistance to deformation. *Quercus cerris*, though pos-sessing good elasticity, showed higher shrinkage and swelling, which may limit its use in cer-tain environments. *Quercus robur* and *Quercus pubescens* displayed balanced properties, offer-ing versatility for various engineering applications.

This study emphasizes the growing role of Mediterranean oaks in sustainable construction and material innovation. It also underscores the value of non-destructive testing for efficient wood characterization, supporting optimized forest management and contributing to the ad-vancement of environmentally responsible building practices.

Keywords: Wood engineering applications, Non-destructive testing (NDT), Mechanical properties, Sustainable wood applications, Forest engineering

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Effects of ultrasonic riddling on the physical and sensory properties of sparkling wine

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Abstract. Riddling (remuage) is a crucial step in the production of sparkling wine obtained with Champenoise method. This step consists in systematically rotate and tilt the bottles for collecting the yeast lees in the bottle neck that are then removed by the disgorgement. Traditionally, the remuage has been manually per-formed by pupitres or using automated gyropalettes. However, this winemaking phase is labor-intensive and time-consuming, and requires experience, especially for the riddling by pupitres. Moreover, co-adjuvants (e.g., alginate and/or bentonite) are often added to facilitate yeast lees precipitation and aggregation con-equently ensuring the clarity of sparkling wine. This study explored the innovative application of ultrasound to shorten the riddling process while assessing the potential to avoid the use of co-adjuvants for commercial and sustainability benefits. To evaluate the sensory aspects, a triangular sensory test was conducted on an initial set of bottles. For chemical-physical analysis, a second batch of bottles was used to measure key parameters, in-cluding foam height and persistence, and turbidity. A custom-designed system for foam analysis incorporating an automated pouring mechanism, imaging software, and statistical tools was employed to assess foam characteristics. Turbidity was measured using a nephelometric turbidimeter for precise clarity evaluation.

Preliminary results indicated that ultrasonic riddling had no significant undesired effects on sensory properties. The use of ultrasounds led to potential advantages, as sediment collection facilitated by acoustic cavitation was faster, enhancing the yeast lees deposition efficiency. Moreover, the ultrasounds seemed to ensure the sparkling wine clarity even in the absence of co-adjuvants. However, further remuage tests are required to fully address the feasibility of co-adjuvants re-moval.

Keywords: Wine making, sparking wine, ultrasound, foam evaluation, Riddling

Paper ID: 134

First results of tests on the use of biolubricants on agricultural machinery

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Abstract: Most lubricants and hydraulic fluids used to operate agro-forestry machinery are mineral or synthetic fluids, both of fossil origin, with limited biodegradability. As such and given the high rate of dispersion due to leaks and failures, they have a negative impact on the environment and quality of agricultural products. A significant reduction of these effects could result from the replacement of these fluids with others of biological origin, appropriately developed to ensure high biodegradability and tribological properties comparable to those of the former. On purpose, since 2012 several experimental formulations have been studied at CREA to evaluate their attitude to be used as hydraulic fluids and/or lubricants for transmissions, by means of a specially designed fluid test rig (FTR), capable to accelerate their ageing by applying to small volumes of oil controlled work cycles characterized by high thermal and mechanic stress. Based on the FTR test results, some very promising fluids were selected to start the first tests on farm machines. One of these was loaded into a hydraulic reach mower with lateral first arm. During normal farm activities, the chemical-physical properties of the fluid were periodically monitored together with their performances. After several hundred hours of testing, the performances of both fluid and machine remained unvaried. Regarding the chemical-physical properties of the fluid, minimal physiological variations in dynamic viscosity, total acid number (TAN) and peroxide number were observed as all remaining parameters did not vary, confirming the good results of the tests at the FTR.

Keywords: Agricultural Machinery, Eco-sustainability, Biolubricants, Performance

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Irrigation management in an intensive olive grove in central Italy through the application of the SurEau-Ecos hydraulic model

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Abstract. Increases in the frequency and intensity of droughts caused by climate change are having a significant impact on agriculture, leading to a global decline in crop yields and serious implications for livelihoods and food security. The sustainable use of freshwater in agriculture requires highly effective irrigation management, which can be achieved by cleverly combining soil-plant-atmosphere continuum models with monitoring data. In this study, the hydraulic model SurEau-Ecos was first applied to the water management of an intensively drip-irrigated olive grove (Olea europea L. cv Maurino) located on a farm in central Italy (Perugia). The model requires the input of daily climatic data as well as plant and soil hydraulic properties. Continuous measurements of soil water potential and content, plant sap flow and sporadic observations of leaf water potential collected in 2023 and 2024 were used for calibration. The use of the model allows the determination of the temporal dynamics of plant water status under severe drought conditions, including the time courses of estimated embolism-induced xylem conductivity losses (PLC). The calibrated model will then be used to manage the irrigation of the olive grove throughout the summer of 2025, with the aim of saving water without seriously stressing the plants (as indicated by PLC values below 20%) and reducing production.

Keywords: plant water status, plant water stress, water management, SPAC models.

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Sparkling Wine Foamability Evaluation Using a Computer Vision-based Approach

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Abstract. The foamability of sparkling wine is traditionally assessed through visual evaluation by skilled experts or the Mosalux methodology. While the Mosalux device objectively measures foam stability, human evaluation provides aesthetic insights but lacks consistency.

This study employed an artificial intelligence (AI)-based image analysis technique to assess sparkling wine's key foamability characteristics, such as foam persistence and bubble chategorisation. A white, dealcoholized still wine served as the base, with 20 samples prepared by adding pure ethanol (0% to 12%) at varying temperatures (4°C to 25°C). Effervescence was induced by injecting carbon dioxide into a standard glass cylinder containing the wine. An RGB camera captured images above the cylinder after carbon dioxide injection, monitoring foam behaviour over several minutes. Foam and bubbles were manually labelled in part of the dataset for AI-model training. The collected data were analyzed in relation to Mosalux records and the wine's physical properties using response surface methodology. Results showed that lower ethanol concentrations promoted the formation of stable, compact foam while reducing the average bubble diameter. Maximum bubble production and detection kinetics were also strongly correlated with viscosity and surface tension, aligning with established scientific theories. These findings suggest that AI-based image analysis is a viable alternative for assessing sparkling wine foamability; therefore, labour is needed to label images. Beyond measuring foam collar persistence, as done with Mosalux, AI techniques offer additional insights by counting and classifying visible bubbles. These key features contribute to foamability potential and align with consumer perceptions.

Keywords: NoLo Wines; Foam Characterisation; Computer Vision; Sparkling Wines.

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Implementing Farm Design and Cooling System for High Producing Dairy Cows in Hot Weather

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Abstract. This study deals with the mitigation of the microclimate in a dairy farm in the Po Valley, during the summer, through the setting up of a combined cooling system of fans and sprinklers. It is well known that high temperatures, combined with high relative humidity values, Temperature Humidity Index (THI), have negative effects on high-production cows, leading to metabolic, productive and behavioral changes in dairy cows. The control of the microclimate of the farm structure plays an important role in microclimatic management, and the active heat mitigation systems improve the containment of the negative effects of thermal stress. Recent studies show that combining shade, intermittent showering and forced air movement is an effective method of cooling, able to reduce production losses in high yielding dairy cows when hot warm and humid weather occurs.

The farm involved in the study, with 200 dairy cows, is located in the province of Lodi. The farm produces corn, wheat, triticale, alfalfa, ryegrass and mixed meadow on 100 ha of cultivable surface. Recently the farm was renovated, with the installation of 2 automatic milking systems, an automatic microclimate control system, a heat recovery system and 3 automatic scrapers. The adoption of shade, a cooling system (sprinklers combined with fans on 3 different lines controlled by a monitoring climatic unit, working on THI) significantly improved milk production by 22.9% ($P<0.001$). Dry matter intake was increased 15.4 % ($P<0.01$) in the last summer in comparison with the previous 3 years mean value.

Keywords: Dairy farm, milk production, cooling system

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Evaluating a Commercial Agricultural Robot and a Conventional Tractor for Corn and Wheat Production: A Two-Year Field Trial

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Abstract. Commercial agricultural robots (CARs) have become available on the market, offering improved agricultural productivity by reducing manual labor requirements per hectare and enhancing the quality of farming operations through automation and artificial intelligence. This paper examines a two-year field trial that compared the Agrointelli Robotti 150D CAR and a conventional tractor in corn (maize) and wheat production. The study focused on secondary tillage, seeding/planting, mechanical weed control, and fertilizer application, while the same machinery was used for primary tillage and harvesting in both treatments. Performance indicators measured included working time, field capacity, operational quality, final yield, and soil compaction. Results show higher field capacity for the conventional tractor in tasks that benefit from larger working widths (e.g. fertilizer application). CAR excelled in narrow, slow-speed operations, such as mechanical weed control, while maintaining comparable quality (weed control efficiency of ~95%). Controlled traffic farming patterns adopted by CAR resulted in lower soil compaction across the experimental plots (reduction of ~0.6 MPa of soil penetration resistance). This reduction in compaction contributed to a slight increase in both corn and wheat yield. Findings highlight the potential benefits of CARs for precision tasks that require minimal soil disturbance, consistent operation quality, and labor efficiency.

Keywords: Commercial agricultural robots, Controlled traffic farming, Field capacity, Soil compaction, Mechanical weed control, Precision agriculture

This study was carried out within the Agritech National Research Center and received funding from the European Union Next-GenerationEU (PIANO NAZIONALE DI RIPRESA E RESILIENZA (PNRR) – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022).

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Field Test of a Somatic Cell Counter Performance by Support Vector Machine (SVM)

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Abstract. Bovine mastitis remains one of the most common and severe diseases affecting high-producing dairy cows, causing significant zootechnical and economic losses. These include compromised hygienic milk quality, reduced production, animal welfare issues, and ultimately, reduced profitability of dairy farms. The aim of this study was to evaluate the performance of a somatic cell count (SCC) sensor based on the instantaneous measurement of milk viscosity, which is known to vary with the number of somatic cells present.
The study was carried out on three farms in northern Italy, with 120, 110 and 255 lactating cows respectively, milked by Automatic Milking Systems (AMS) equipped with a built-in processor for milk viscosity detection. In total, viscosity SCC data from 1,050 milkings were obtained from the milking robots management system. An equivalent number of milk samples were sent to the Regional Breeders Association of Lombardy (ARAL) for detection of SCC by the reference method (fluoro-opto-electronic method). To evaluate the performance of the automated viscosity SCC method in detecting cows with high SCC (more than 200,000 cells · ml^{-1}) measured by the reference method, a Support Vector Machine (SVM) model was implemented. The SVM achieved a sensitivity of 69,2%, a specificity of 95,4%, apositive predictive value (PPV) of 50% and a negative predictive value (NPV) of 97,9%. These results seem to highlight that the viscosity SCC method is better at identifying cows that do not have mastitis and is good at excluding mastitis in cows that test negative.

Keywords: Bovine mastitis, Somatic cells counter, Milk viscosity, Automatic Milking System.

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Paper ID: 141

PEC Efficiency in Juveniles Rainbow Trout RAS

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Abstract. A recirculating aquaculture system (RAS) is an advanced inland fish farming method designed to minimize the environmental impacts often associated with traditional aquaculture practices. These systems are capable of maintaining stable chemical and physical water properties, which are crucial for the efficient operation of purification components. Any imbalance in water quality can hinder system functionality and negatively impact fish health, growth, and overall productivity.

This study assesses the performance of an advanced photo-electrocatalytic (PEC) purification system in tackling one of the main challenges faced by RAS: the buildup of nitrogen compounds, particularly ammonia, which is a byproduct of fish metabolism. High levels of ammonia can stress fish, impair their growth, and threaten the stability of the system. Trials were conducted using juvenile trout reared at two different densities: a low density of 5 kg/m³ and a high density of 10 kg/m³.

The study also examines the impact of Enteric Redmouth Disease (ERM), caused by *Yersinia ruckeri*, on system performance. ERM poses a significant challenge in aquaculture, as it disrupts system balance by increasing organic waste production, which can consequently reduce purification efficiency.
Juvenile trout cycles, even affected by *Yersinia ruckeri*, showed water mean ammonia concentrations of 1.48 mg/L and 2.27 mg/L, respectively for PEC and control tanks, at high density. These findings, with general high ammonia concentrations in water, highlight the relationship between pathogen presence and water purification technologies in RAS, and, at the same time, the ability of the PEC to contain nitrogen compounds.

Keywords: Recirculating Aquaculture System (RAS), Photo-Electrocatalytic Purification (PEC), Nitrogen Compounds, Ammonia Reduction, Enteric Redmouth Disease (ERM), Sustainable Aquaculture

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Developing a Demonstrative Model of Electric Trunk Shaker Head to Optimise Olive Harvesting

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Abstract. This paper focuses on developing a preliminary demonstrative model of a vibrating system designed to optimise olive harvesting. The core principle leverages natural resonance frequency, a phenomenon where an oscillating system experiences progressively amplified vibrations when subjected to periodic stress at its natural oscillation frequency. The system utilises an Arduino Uno microcontroller to power an electric motor, allowing for variable rotation frequencies. The Arduino Uno also controls a 3-axis accelerometer, which measures and transmits acceleration data to a PC at a rate of 200 times per second, providing quantitative measurements. An unbalanced mass attached to the motor generates a centrifugal force, applying vibrations to the branches of a small olive tree. The microcontroller precisely manages the electric motor's speed, gradually increasing it from zero. This incremental increase in speed consequently raises both the force and frequency of the vibrations transmitted through the unbalanced mass. The primary goal is to identify the natural frequency that maximally amplifies the olive tree's oscillation amplitude, enabling the system to operate at this optimal frequency for efficient harvesting. This innovative approach holds significant promise for agricultural advancements, offering an electrically controlled alternative to current hydraulic control systems for improved harvesting efficiency.

Keywords: Arduino, vibration, accelerometer, frequency, harvesting

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Heavy Metal Contamination: A Dual Opportunity for Soil Recovery and Renewable Energy Generation

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Abstract.
Human activities, particularly industrial and mining operations, release heavy metals that pose a significant threat to the environment and human health. These persistent pollutants degrade soil fertility, alter biodiversity, and contaminate groundwater, underscoring the immediate necessity for innovative and sustainable remediation strategies. One potential approach is phytoremediation, *in situ* biological remediation technique exploits the ability of plants to absorb and fix soil contaminants into their aerial parts. The purpose of this study is to compare two crops to assess their ability to absorb heavy metals and to analyze and quantify the environmental and energy benefits of green energy production from heavy metal-contaminated biomass. The methodology is based on life cycle assessment (LCA, using openLCA software to evaluate the energy and environmental impacts of the two crops ensuring a comprehensive assessment of environmental impacts. Eucalyptus (*Eucalyptus spp*., which is already used for land clearing in some areas of Sardinia, and Barley (*Hordeum vulgare* L. were evaluated for biomass production, heavy metal uptake capacity, energy output, and the environmental impact of cultivation inputs. The study revealed that barley produces higher biomass but requires more input for production than eucalyptus. From an energy perspective, the study revealed that barley produces 6.1 TJ of energy compared to eucalyptus (3.3 TJ. This study combines soil remediation with renewable energy production through phytoremediation, offering a sustainable solution to environmental degradation and energy challenges.

Keywords: Phytoremediation; Heavy metal; Soil contamination; Bioenergy; Biomass valorization; Renewable energy.

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Mapping Fine-Scale Soil Moisture Variability Using 3m Satellite Spectral Indices for Enhanced Weed Management

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Abstract. In the framework of precision agriculture, a key topic focuses on accurately estimating soil moisture for effective weed management, particularly for controlling black grass (*Alopecurus myosuroides* Huds.) in winter wheat fields across the United Kingdom. This study explores the potential of high-resolution satellite imagery from the Sentinel-2 (10m) and PlanetScope SuperDove constellations (3m) as an alternative to traditional soil sampling for soil moisture mapping. The study area encompasses 3 fields across England, providing a representative sample for assessing soil moisture variability. Three spectral indices; The Perpendicular Drought Index (PDI), Modified Perpendicular Drought Index (MPDI), and Drought Detection Index (DDI) were calculated from high-resolution satellite imagery. Field-collected soil moisture data, along with black grass abundance data, were used to assess correlations with these indices. Correlation analysis was conducted separately for each field, comparing spectral indices, soil moisture data, and abundance data for both the soil sampling date and the abundance sampling date. The indices were then used to develop machine learning models, including random forest, support vector machines, and gradient boosting, to estimate soil moisture variability and identify areas susceptible to black grass throughout the study area. Preliminary analysis indicates that specific spectral indices correlate strongly with soil moisture variability, suggesting the potential for high-resolution satellite imagery to act as a viable alternative to traditional soil sampling methods. This approach has the potential to offer valuable insights into water dynamics at the field level, supporting more sustainable land management practices and improving precision weed control strategies in winter wheat fields.

Keywords: Remote Sensing, Precision farming, Vegetation indices, PlanetScope SuperDove, Weed detection, Sustainability.

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Paper ID: 145

Forecasting NH_3 Concentrations from a Dairy Barn by Using Artificial Neural Networks

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Abstract. Evaluating gas concentrations represents an important objective to assess impacts from livestock production. Statistical models have partially con-tributed to gas monitoring and analysis, however the nonlinear interactions from the variables had stimulated the application of further approaches. Recently, Ar-tificial Neural Networks (ANNs) have been applied in agriculture and livestock context due to their understanding of large and complex datasets. This study aimed at assessing ANNs' models to predict ammonia (NH_3) con-centrations from a dairy barn and evaluate the minimum of data required to make accurate predictions. Data have been acquired in an open dairy barn lo-cated in Sicily (Italy) during different periods of the year. Nine variables have been included in the trials (i.e., internal and external temperature, humidity, wind direction and wind velocity, and hours of the day) to train the proposed models. The ANNs' structure was a Multi-Layer Perceptron (MLP), trained with Levenberg-Marquardt (LM) and Bayesian Regularization (BR) algorithms. Layers and Neurons were dimensioned according to the size of the datasets ap-plied. To evaluate the accuracy of each model and of each prediction, Coeffi-cient of Determination (R^2) and Mean Square Error (MSE) have been chosen as validation criteria. The obtained results provided specific information on how to predict NH_3 con-centrations under specific conditions in the barn, based on MLP models. There-fore, ANNs have potentialities for applications in livestock farming and, when combined with Precision Livestock Farming (PLF) approaches, can contribute to enhance environmental, animal and human health.

Keywords: artificial neural network, livestock production, concentration, am-monia, dairy housing, prediction.

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Evaluating the Impact in Livestock Production based on Artificial Neural Networks approach

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Abstract. Gaseous emissions from livestock production are a source of significant concern due to their contribution to environmental impacts. Monitoring gases and pollutant concentrations within these environments generates data that could be used to develop accurate prediction models. However, predicting gaseous concentrations is challenging for researchers due to the complexity of datasets and the nonlinear relationships among variables involved. Machine learning (ML) approaches, particularly Artificial Neural Networks (ANNs), have been applied in various fields of research, demonstrating their capacity to handle complex datasets, identify hidden patterns, and make predictions. Based on a wide literature analysis, this study investigated the application of ANN models in livestock farming, focusing on predicting gaseous concentra-tions from the livestock sector. The outcomes showed that ANNs provided significant improvement in livestock management, outperforming traditional statistical methods by better adapting to nonlinear data. However, critical gaps remain; these include defining and optimizing ANN structures, establishing validation criteria and training algorithms, mitigating models' overfitting, improving the transparency of decision-making processes, and developing sustainable solutions for farmers. Future research should be focused on the identification of the most suitable ANN structures for predictions in specific contexts and exploring approaches to reduce dataset bias.

Keywords: artificial neural network, livestock production, emission, machine learning, dairy housing

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Predictive analysis of electricity consumption of a mechanical biological waste treatment plant using machine learning techniques

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Abstract. The present work aims, in accordance with the goals number seven, twelve and thirteen introduced by the 2030 Agenda, to create a machine learning (ML) model for the prediction of energy consumption generated by a mechanical biological treatment (MBT) plant located in central Italy, given the distribution of incoming waste and the quantities of materials produced in the plant. This model is implemented in MATLAB and could be used to adjust the distribution of incoming waste to adapt the energy consumption of the plant to the capacity of the energy sources and can serve as a game model for other energy transformation plants. The result of this work is satisfactory with respect to the set objective, as a predictive model of electricity consumption has been achieved through Artificial Intelligence (AI) techniques, characterized by a prediction accuracy considered sufficient for the purposes of the paper ($R \geq 0.95$). The study findings, which feed into the literature on the application of artificial intelligence to real industrial plants, could be used to determine energy efficiency actions that could be incorporated into strategic property planning. Furthermore, the application of said model could contribute to the achievement of the objectives set by the main European and international policies on energy efficiency.

Keywords: Machine Learning; agricultural waste; predictive analysis; mechanical biological treatment waste plant; energy efficiency policies.

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MungiLUX: a Digital Twin to Improve Lighting Performance of Milking Parlours

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Abstract. Digital twins are an emerging technology widely used in the industrial sector. They create virtual environments by mirroring physical spaces enabling simulations to solve problems that are complex or costly to carry out in the real-world. Livestock farming is developing rapidly with the introduction of various information and communication technologies, and it is one of the perspective areas where digital twins can provide benefits for livestock management and operational efficiency. However, to the best of our knowledge, no studies have investigated the use of digital twins to improve the lighting performance of milking parlours. In this study, carried out within the MungiLUX project funded by Regione Lombardia (FEASR - Rural Development Programme 2014-2020), we propose a novel digital twin framework for livestock management, focusing on milking parlours and their lighting. In order to validate the impact of the proposed framework in two milking parlours involved in the project, we performed different lighting simulations based on real data sets, aiming to meet the illuminance requirements of the UNI EN 12464-1:2021 standard for the visual task areas of milkers. As a result, different and alternative combinations of luminaires were found, representing many potential lighting scenarios to improve the lighting performance of milking parlours and make the milking process more energy efficient and sustainable from an economic and environmental point of view.

Keywords: Digital Dairy Farming, Lighting Scenarios, Visual Task Area, Milking Process

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Assessment of environmental impact of an experimental vertical farm in Greece through LCA

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Abstract. Vertical Farms could be an innovative solution to the challenges of sustainable food production, reducing land consumption and optimizing production. This technology is outlined as a highly controlled system to grow plants in urban environments and is characterized by a high level energy consumption. However, to assess its actual sustainability, it is essential to apply a systemic approach such as Life Cycle Assessment (LCA). LCA analyzes the environmental impact throughout the entire life cycle, including production, transportation, energy, and product disposal. This study primarily considers the LCA of a productive pilot site at the Agricultural University of Athens which has research purposes. The LCA analysis takes in consideration the comparison of lettuce production in an experimental vertical farm and in open field in Greece. Thus, the study shows that, despite the high energy consumption for lighting and climate control, that undermines the sustainability of this type of production, vertical farms can significantly reduce other types of environmental impacts for food production, such as water consumption, pesticide use and land consumption. The, the integration between Vertical Farms and LCA allows identifying optimization strategies, promoting technological and policy innovations that favor resilient and sustainable urban agriculture.

Keywords: Vertical farm; Food production; Sustainability; Life cycle Assessment.

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Environmental assessment of a Photovoltaic and battery system for Olive Oil mills

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Abstract. This study evaluated the environmental performance of a photovoltaic (PV) system integrated with a battery energy storage system (BESS) installed on the rooftop of an olive oil mill. Based on a Carbon Footprint (CF) methodology, the study quantified the potential reduction in greenhouse gas emissions and other key environmental impacts associated with the adoption of this renewable energy solution.
Based on the Life Cycle Assessment (LCA) methodology, a cradle-to-gate approach was applied, considering the environmental impacts of olive cultivation, harvesting, milling, and extra-virgin olive oil (EVOO) packaging.
The research methodology involved the formulation of an algorithm to optimise the energy management of the interaction among the energy produced by the PV system, the energy stored in BESS, the energy required from the national grid, and the load of energy consumption required by the mill.
The results demonstrated a significant reduction in CO_2-equivalent emissions of the mill equipped with the PV and BESS, achieving an 80% decrease compared to grid-supplied energy. Notably, the cradle-to-gate analysis, revealed reduced environmental impacts even within the agricultural phase, despite the primary focus was on energy generation at the mill.
These findings, described through the energy consumption profiles and an overview of the environmental impacts, provided specific information on the environmental benefits of integrating renewable energy technologies into the EVOO industry.

Keywords: olive oil mill, agrisolar, photovoltaic, battery energy storage system, greenhouse gases, life cycle assessment.

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Nature-based scenarios for urban climate neutrality

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Abstract. The challenge of achieving climate neutrality is particularly critical in urban settings. Cities often struggle to develop effective strategies, especially in densely built-up contexts where new solutions must integrate with the existing urban fabric. In this regard, urban green design proposals should prioritize providing proximity ecosystem services to improve citizens' quality of life while contributing to global climate change mitigation and adaptation efforts. In this research, we developed a scenario analysis that compares the potential ecosystem services (air quality improvement and carbon sequestration) provided by alternative vegetation enhancement solutions in dense urban environments. The study area is the San Sisto district in Perugia, a densely populated neighborhood in central Italy. Using GIS software (QGIS) and the i-Tree Eco model, we compared various scenarios simulating the increasing tree-lined streets, enhancing canopy density in pre-existing green areas, converting interstitial agricultural areas into parks, and introducing vegetation in open impermeable urban spaces. The findings indicate that no universally optimal solution exists for densely built-up neighborhoods. Indeed, each proposal offers distinct benefits while introducing new challenges, such as maintaining the functionality of existing urban services. These evaluations provide critical insights to assist public administrations and urban green space planners in designing tailored solutions and ensuring transparency regarding the overall impacts of their choices.

Keywords: Urban green infrastructures, ecosystem services, proximity ser-vices, scenario analysis, i-Tree Eco, GIS

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Advanced Agrivoltaics in Super-Intensive Olive Orchards: A Case Study Aligning with Italian Guidelines

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Abstract. The Italian Ministry of the Environment and Energy Security (Ministero dell'Ambiente e della Sicurezza Energetica - MASE) has published guidelines on agri-voltaic plants (APV), defined as a symbiotic system comprising agricultural crops or livestock and photovoltaic (PV) plants. The guidelines categorise APV systems into two types: Basic APVs, which are designed to optimise agricultural and renewable energy production; and Advanced APVs, which must be innovative and include a monitoring plan. Furthermore, the guidelines emphasise innovative technological and agricultural solutions in plant design, such as elevated module mounting and rotation, to ensure minimal disruption to agricultural activities while maximising energy production.
This study investigated the practical implementation of the guidelines established by MASE within a case study: an advanced APV in a super-intensive olive orchard in Sicily (Italy). In detail, the research assessed the feasibility of the APV application in super-intensive olive cultivation.
To investigate the performance of APV, some metrics have been extrapolated from MEES guidelines and have been compared to design data from the case study: area for agricultural on total area; percentage of total area covered by modules; PV energy production, soil fertility; micro-climate; climate change resiliency.
Based on the analysis, the results showed valuable insights into the potential of advanced APV to enhance agricultural sustainability and profitability while contributing to Italy's renewable energy goals.

Keywords: advanced agri-voltaic, photovoltaic, agricultural activities, super-intensive olive orchard, Italian ministry guidelines, agrivoltaics performance metrics.

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Antecedent conditions and riparian tree water uptake control stream network dynamics in a Mediterranean forested catchment

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Abstract. The drivers on stream network expansion and contraction in headwater Mediterranean catchments are still not well understood. In this research, we use a simple time-lapse photography approach to investigate the main controls on the seasonal dynamics of the stream network in a small mountain forested catchment. The Re della Pietra experimental catchment (2 km2) is located in the Tuscan Apennines, Central Italy and is characterized by a Mediterranean climate with a strong seasonality in the meteorological forcing leading to intermittency in flow. Time-lapse cameras were installed by four tributaries to monitor the frequency of hydrological connection/disconnection between the tributaries and the main stream. Soil moisture probes at two depths were installed in two locations.

Preliminary results show a gradual disconnection of the tributaries from the main stream with decreasing soil moisture during middle and late summer. On the contrary, the wetting-up period in early fall was quicker and more erratic with tributaries responding to rainfall events at different times. Cumulative antecedent precipitation from 1 hour to 7 days played a clear role on disconnection of the tributaries from the main stream at all monitored locations. The influence of antecedent conditions from 1 hour to 7 days was weaker although dependent on the location in the catchment. The combination of antecedent precipitation and soil moisture explained most of the variability of flow/no-flow conditions in the stream network but, in addition, an important role was played by water uptake of the riparian trees that led to diel appearance and disappearance dynamics of water in small tributaries, affecting hydrological connection.

Keywords: ecohydrological response; vegetation; catchment dynamics.

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Management of Green Roofs: Evaluating Green Manure for Low-maintenance, Herbaceous Plant Species to Increase Sustainability

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Abstract. Research on spatial and landscape planning has highlighted the benefits of ecosystem services provided by urban green systems; at the same time, adaptation to climate change has pushed for an integrated approach to urban green planning able to increase urban climate mitigation and urban resilience. Research about the most important performances of urban green systems, like urban heat reduction, air quality improvement, stormwater management, and building thermal insulation, shows the importance of plant selection and substrate management for their optimization. In local urban climates it is essential to study the growth potential of multi-purpose, low-maintenance forbs adapted to thermal and water stress on specific substrates as a sustainable management solution for green systems. This study evaluated the performance of multi-purpose, low-maintenance herbaceous plants on experimental green system modules under controlled conditions, comparing chemical fertilization and treatments with biomass from catch crops used as green manure. The results are expressed according to key metrics such as fresh and dry biomass, plant cover ratio, and chlorophyll content. Results show that the plants treated with green manure produced significantly higher values of cover and biomass in comparison to treatment with chemical fertilization suggesting the catch crops as useful sources of green manure for green system management. Overall, the results were consistent with the research goals of finding sustainable solutions for green systems management, since low-maintenance species and green manure contribute to the elimination of chemicals in urban green.

Keywords: urban green systems; green manure; herbaceous plants; urban heat island effect; impact mitigation; nature-based solutions

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Integration of RGB and Thermal Imaging Techniques for Non-Destructive Analysis of Toasting Dynamics and Acrylamide Level in Whole-Grain Bread

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Abstract. This study explored the feasibility of using non-destructive imaging techniques combining RGB and Thermal (RGB-T) data to analyze the level of acrylamide in whole-grain bread after toasting. Bread samples were toasted at various temperatures, and RGB-T imaging captured their appearance and surface temperature over post-toasting. Advanced image-processing algorithms and machine learning models, including multiple linear regression, partial least squares regression, random forest regression, and LSTM Neural Networks, were utilized to analyze the relationship between imaging features and acrylamide formation. Chemical measures were used as ground truth.

The analysis demonstrated that combining color and thermal data provided significantly more robust insights into the bread's toasting dynamics than color analysis alone for detecting acrylamide. The cooling curves derived from thermal imaging contributed essential data for understanding temperature distribution and its impact on physical and chemical changes during and after toasting. This highlights RGB-T and RGB imaging as a promising tool for monitoring acrylamide formation in real-time, offering applications in food safety, quality control, and nutritional optimization.

This technique offers a novel, non-invasive approach to improving food quality control by assessing key attributes such as toasting uniformity, crust characteristics, and surface browning. Its potential applications extend to optimizing the nutritional properties of baked products and ensuring consistent product quality. RGB-T imaging represents a step forward in integrating advanced sensing and computational analysis in food science, with significant implications for industrial-scale monitoring and control.

Keywords: Acrylamide, Bread, Computer vision, Thermal camera

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Upcycling Gin Distillation By-Products through Ultra-sound-Assisted Extraction of Juniper Berries

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Abstract. Ultrasound-assisted Extraction (UAE) is an emerging technology in the food industry, that leverages cavitation to enhance extraction processes. By reducing operational times and temperature, UAE not only increases the yield but also improves extract quality. This study evaluates the potential of ultrasound technology for extracting bioactive compounds from spent juniper berries, a by-product of gin distillation, to maximise the value of this expensive raw material. UAE and classical maceration were applied to extract compounds from whole and crushed juniper berries, with several key process parameters, including Brix, pH, Oxidation-Reduction Potential (ORP), and colour (CIELAB colour space), analysed. Extractions were performed in triplicate. Results show that grinding the berries significantly improved extraction yield and efficiency, achieving a higher quantity of extract in a shorter time. Ultrasound extraction demonstrated a potential for higher efficiency in extracting bioactive com-pounds compared to classical maceration. This technology may produce ex-tracts with higher quality in terms of colour and physicochemical properties, although further research is needed to optimise the process fully, thus offering a sustainable approach for enhancing the gin industry's circular economy and re-ducing waste.

Keywords: Green extraction, Hydroalcoholic maceration, Spirits, Circular economy, Sustainable Food Processing.

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Sap flow – VPD dynamics at the hillslope scale under water stress conditions.

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Abstract. Tree response to water stress may be exacerbated in steep hillslope forests, where topography plays an important role both in the redistribution of water in the soil and in promoting different microclimates. However, very few studies have been conducted to investigate how trees react to climatic stress in steep forested hillslopes.
In this study, sap flow velocity was measured from May to October 2021 in nine European beech trees (*Fagus sylvatica*) in a north-faced steep hillslope in the Re della Pietra experimental catchment, Tuscany Apennines, central Italy. Three sensors were placed at the bottom of the hillslope, three at midslope, and three in the upper part. Meteorological variables (rainfall, air temperature, air humidity, solar radiation) were measured by a weather station in a flat area at the top of the hillslope. Soil moisture was measured by six probes in three positions along the maximum slope of the same hillslope. Sap flow velocity showed no trend related to hillslope position until mid-August, when the upper hillslope trees experienced a notable decrease, whereas no change occurred in the lower part. The hysteresis area between sap flow velocity and vapour pressure deficit varied seasonally. In the midslope and upper hillslope, the hysteresis area increased with solar radiation, temperature, and soil moisture but decreased with increasing air humidity. In the lower hillslope, where trees were not stressed, these relations were erratic without a specific pattern.
This reveals that the topographic position of trees interacts with temperature, air humidity, solar radiation, and soil moisture in regulating tree defense mechanisms against excessive water loss.

Keywords: Hillslope topography, Sap flow velocity, VPD, Hysteresis, Drought.

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Agricultural building design: BIM-AI integration for energy optimisation

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Abstract. Achieving energy-efficient building design is a necessary objective in the context of global environmental challenges, a priority to be addressed also in the field of agricultural buildings in order to ensure their long-term sustainability and economic viability. Conventional design methodologies, often based on fragmented datasets and oversimplified models, fail to capture the dynamic and complex factors that influence a building's energy performance. This limitation is particularly significant during the early stage of the design process. The integration of Building Information Modeling (BIM) and Artificial Intelligence (AI) offers a solution to these challenges, with several studies highlighting their potential to enhance efficiency, precision, and sustainability.

This study investigates how the optimisation of building energy performance has been explored in the existing literature, through the integration of BIM and AI. It evaluates the factors influencing energy efficiency, such as envelope characteristics (including wall and roof assemblies, window-to-wall ratio, and orientation), material properties, and building systems. By leveraging BIM-AI integration, predictive modelling can be conducted in the pre-design phase to assess the performance of various design alternatives. These models enable data-driven decision-making, guiding energy optimisation strategies and improving their accuracy and effectiveness during the design process.

The findings of the analysis suggest that the integration of BIM and AI offers the potential to enhance building energy performance and highlight the need for future research aimed at prioritising a simplification of BIM integration processes by expanding the scope of training data for AI models and validating the applicability of these technologies for agricultural buildings.

Keywords: Building Information Modeling, Artificial Intelligence, Digital Construction, Energy efficiency.

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Paper ID: 160

Mitigation strategies for Livestock farming Air Pollution: Green Wall System Design

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Abstract. Livestock farming significantly contributes to atmospheric pollution, releasing greenhouse gases and particulate matter. The consequent environmental degradation poses health risks to both humans and animals, necessitating effective mitigation strategies. Among various approaches for mitigating this kind of pollution, green systems employing plants for air filtration and purification, have demonstrated to be an effective solution. While these systems have been extensively integrated in civil buildings, few studies have explored their application in livestock farms.

This study focuse on designing a green wall system to function as a biofilter, specifically engineered to capture and reduce pollutant particles within a livestock barn, where it will be field-tested to evaluate its effectiveness in reducing pollutant particles. The system has been designed for its application in an open free-stall barn, for dairy cattle breeding, located in the Province of Ragusa, Italy.

The design process started by assessing existing green systems to select both the best technology for the specific conditions of the dairy barn and non-toxic and animal-safe plant species with effective air-filtering properties.

The proposed system is a modular, mobile green wall that maximises flexibility in positioning within the barn's open sides. This approach allows evaluating the biofilter performance across varying environmental conditions within the structure. The plant species selected was *Nephrolepis exaltata* for its air-purifying properties; the system also include an automated drip irrigation connected to water storage.

Future research is necessary to evaluate the effectiveness of the designed system, providing empirical evidence to validate its performance and potential scalability.

Keywords: Green Wall Systems, Biofilter Design, Livestock Emissions, Air Pollution Reduction.

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Paper ID: 161

Assessment of Horse Behaviors using Deep Learning Techniques

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Abstract. Horse behavior can provide valuable insight into their current subjective state, thus being a good indicator of their current welfare and the daily time spent for the different behaviors can be a useful monitoring strategy. Lying has been reported as an effective animal-based indicator of the welfare of stabled horse. On the other hand, the monitoring of the access to the drinking trough or evaluating the feeding time can be useful measures for the establishment of the welfare state. However, measuring this behavior in animals by direct or video observations can be a time-consuming process, especially in horses which spend a relatively small proportion of their day in lying down behavior or for drinking. To help the daily management, computer vision can permit automated systems to interpret and understand visual information in animal environments. By drawing on methodologies from image processing and machine learning, computer vision facilitates the analysis, interpretation, and extraction of valuable information from visual data. This paper explores the application of a deep learning-based computer vision system for the identification of the behavior of individual stabled horse. Object detection techniques were applied to identify behaviors like lying and standing, while pose estimation was used to detect drinking. Performance evaluation of the network involves the use of precision-recall curves, and accuracy of identification by comparison with the human labelling performed on the same video. The system achieved accuracy value of 86% in behavior classification compared to manual annotation. The application of the technology tested here can provide real-time recognition and information about the current welfare of the monitored animal and the results of the paper shows the valuable insights into the monitoring of horse behavior.

Keywords: computer vision; horse; welfare; YOLO; pose estimation; animal behavior.

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Delving into the environmental benefits of precision viticulture applications for crop protection

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Abstract. Precision Viticulture (PV) is a cyclical management strategy for field operations that leverages information and technology to utilize various sources of vineyard data. This approach supports targeted decision-making with the goal of optimizing production processes. Despite PV is more and more applied, there is still a lack of knowledge about the main environmental benefits related to its application. In this context, the aim of the project Winery Farming 4.0 (Farming Data Imple-mentation: definition of smart solutions for the effective implementation of Ag-riculture 4.0 in winery production) is to evaluate the main barriers that still limit the implementation of PV solutions and, finally, to assess the potential sustainability benefits related to the application of some PV solutions in different Italian viticulture area. In this study, the environmental benefits related to the adoption of different PV technologies mainly focused on crop protection optimization are presented. In detail, after definition of stability maps and reference variability thresholds, Var-iable Rate Application (VRA) based on sensors or prescription maps, drone ap-plications as well as the adoption of *smart* applications providing risks alert and application doses were evaluated thanks to the application of the Life Cycle Assessment (LCA) approach. 1 ton of grape was selected as functional unit while a "from cradle to farm gate" perspective was considered about the system bound-ary. Primary data were collected during field trials carried out in different Italian viticulture areas. Thanks to the PV solutions application, interesting environmental impact reduc-tions were achieved for the toxicity-related impact categories while smaller ben-efits occur for all the other environmental indicators (e.g., climate change).

Keywords: Precision agriculture, Environmental sustainability, Pesticide, Vine-yard.

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Assessment by machine learning of the energy consumption for cooling ventilation in livestock buildings

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Abstract. In livestock buildings appropriate ventilation is an essential requirement to ensure both animal welfare and efficient and sustainable production. On the other hand, natural airflow usually presents high variability with time, and it is rather difficult to estimate because of the presence and interaction of the animals. To guarantee optimal indoor microclimate conditions in hot and temperate regions, ventilation systems are usually implemented in the barn coupled to cow shower systems. In these facilities, energy load for ventilation systems can account for more than 30% of the total energy consumption of the farm. This paper presents a machine learning model, set in the framework of NeuralProphet, for the forecast of the energy need from the cooling ventilation system. By leveraging the advanced capabilities of NeuralProphet in handling both seasonality and trends inherent in time-series data, this paper aims to provide precise estimation of future energy demands based on historical data. Integration of a predictive model within the farm management systems will further enable farmers to know the energy amounts expected to be consumed in the days ahead, which provides an invaluable source of information for decision-making.
Keywords: machine learning; NeuralProphet; energy need; livestock; dairy cow; ventilation.

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Integration of a geothermal system in a winery: preliminary assessment

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Abstract. The wine-production sector is characterised by the need, at certain stages of the vinification process, to keep temperatures that are constant and different from the ambient temperature, to control the biological fermentation processes that take place in the must. One of the possibilities for making the entire sector more sustainable from the energy point of view is to use, as far as possible, renewable sources in the process stages that require thermostatation. The present study investigates the effective possibility of using a low-enthalpy geothermal system (i.e., with a horizontal development) as an integrative thermal system, drawing some conclusions on its concrete applicability to a medium-small experimental winery (total volume of fermenters: 2800 L) and the possible scale effect(s) occurring for larger installation sizes. What emerges from this study is the need to have at disposal a site of at least 54 m^2 to be excavated to a depth of 3 m in order to guarantee a thermal power integration of 20 kW in cooling mode, against an installed nominal pumping power of only 550 W (hence granting a useful effect 36 times higher, i.e. a COP equal to 36). The preliminary evaluation concerned also the precise quantification of the costs for investments (materials/components purchase, ground excavation, pipe-laying/installation of components), resulting in an interesting overall investment cost coefficient of 1.273 EUR/W.

Keywords: Geothermal energy, wine-making cycle, thermostatation of fermentation processes, thermal integration, sustainable primary sector.

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Estimated specific CO_2 production of agricultural tractor over the years

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Abstract. In the current context of increasing focus on environmental sustainability, there is a constant effort to reduce pollutant emissions across all sectors, including agriculture. Over the years, European and international regulations, defined by the "Stage" standards, have progressively limited pollutant emissions such as hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO). These standards, from Stage I introduced in the late 1990s to Stage V implemented in 2019, have successfully reduced regulated pollutants. However, no specific regulations currently address CO_2 emissions in tractors. In this work, CO_2 emissions are assessed through their direct correlation with fuel consumption, and both hourly CO_2 and specific CO_2 production in terms of $kg_{CO_2}\,(kWh)^{-1}$ are calculated. This study refers to the power performance and fuel consumption of tractors tested under OECD Code 2 standards from the 1990s to the present day. The analysis is divided into two categories: open field tractors (T1) and narrow-track tractors for orchards and vineyards (T2). The results highlight the lack of substantial progress in reducing carbon emissions over the years. These findings underline the need for future strategies targeting the carbon footprint of agricultural machinery alongside traditional pollutants.

Keywords: Greenhouse effect, Environmental sustainability, Fuel consumption, Pollutant emissions.

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Paper ID: 165

Estimated specific CO_2 production of agricultural tractor over the years

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Abstract. In the current context of increasing focus on environmental sustainability, there is a constant effort to reduce pollutant emissions across all sectors, including agriculture. Over the years, European and international regulations, defined by the "Stage" standards, have progressively limited pollutant emissions such as hydrocarbons (HC), nitrogen oxides (NOx), particulate matter (PM), and carbon monoxide (CO). These standards, from Stage I introduced in the late 1990s to Stage V implemented in 2019, have successfully reduced regulated pollutants. However, no specific regulations currently address CO_2 emissions in tractors. In this work, CO_2 emissions are assessed through their direct correlation with fuel consumption, and both hourly CO_2 and specific CO_2 production in terms of $kg_{CO_2}\,(kWh)^{-1}$ are calculated. This study refers to the power performance and fuel consumption of tractors tested under OECD Code 2 standards from the 1990s to the present day. The analysis is divided into two categories: open field tractors (T1) and narrow-track tractors for orchards and vineyards (T2). The results highlight the lack of substantial progress in reducing carbon emissions over the years. These findings underline the need for future strategies targeting the carbon footprint of agricultural machinery alongside traditional pollutants.

Keywords: Greenhouse effect, Environmental sustainability, Fuel consumption, Pollutant emissions.

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Exploitation of Renewable Sources for the Energy Needs of Farm Buildings: an Application in the Swine Sector

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Abstract. Livestock farms and agricultural facilities offer various potentials for the production and utilization of renewable energy, thanks to the availability of spaces on building roofs and open courtyards. At the same time, the livestock sector is characterized by high energy demands required for operating numerous types of equipment and for building climate control. The latter aspect is increasingly critical due to the growing awareness of the importance of animal welfare, both for meeting ethical considerations and achieving high production standards in terms of quantity, quality, and food safety.

This study presents the development and implementation of an integrated system for utilizing solar thermal and photovoltaic energy, along with low-enthalpy geothermal exchange, aimed at ensuring renewable energy production in a farrow-to-nursery swine farm with 500 sows located in the Po Valley (Italy). The system was designed to meet the energy needs for heating areas in the weaning building. Designed and sized based on farm-specific parameters, the system was completed in 2023 as part of the European Horizon 2020 project RES4LIVE.

The plant also includes a smart monitoring system for key internal and external environmental parameters, as well as the energy metrics of the involved buildings, which also works as a control system for the facilities. The results of one year of system operation and monitoring are presented, focusing on energy production, efficiency, and the control of indoor thermo-hygrometric conditions in the livestock building.

Keywords: Pig Barn, Smart Monitoring, Energy Efficiency, Animal Welfare, Geothermal Storage, Data Analysis.

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Rollover stability evaluation of a tractor with suspended front axle

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Abstract. Many of the agriculture-related accidents involve vehicle rollovers, which are most often fatal. In Italy there is an average of 140 fatal accidents per year. This although since 1974 the integration of passive safety systems (i.e. ROPS and seat belts) has been mandatory in new machines (after 2008, integration is mandatory in any vehicle for professional use, thus including older tractors that must be retrofitted). The study of the rollover stability of vehicles according to their configuration and the implements they are mounting becomes very important. In particular to develop and integrate new tractor active/passive safety systems and to characterize and select the best machine according to the expected operating scenario.

In recent years, many tractors have been equipped with a suspended front axle to enhance the operator comfort. Generally, these systems present a certain degree of regulation through hydraulic actuators in order to obtain different behaviors (i.e. softer or harder suspension, limitation of oscillations, etc.). While this innovation improves the user experience, it necessitates thorough analysis and validation from a stability perspective.

In this work the digital-twin model for determining the stability of a tractor with suspended front axle through simulations is presented. The model has been tuned and validated through a series of experimental tests on a real machine by exploiting a novel rotating and tilting test-rig for tractor rollover evaluation available at the Agroforestry Innovation LABoratory (AFILAB) of the Free University of Bolzano. The result of the work consists in a series of stability maps that represent the behavior of the machine in all the defined scenarios.

Keywords: Rollover stability, Tractor Stability, Rotating test-rig, Centre of Gravity determination, rollover stability maps, twin-model.

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Some considerations on the use of steam in industrial wine-making processes

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Abstract. Industrial wine production, a key EU-sector, exhibits significant en-ergy consumption, whose reduction is crucial to achieve the 2050 climate goals. The main energy source in wineries is electricity, while steam is still commonly used as heat carrier, even if its convenience in wine-making has never really been explored in the literature. Thus, the objective of this study is to investigate whether steam as energy carrier is really the ideal solution in wineries. After a detailed characterization of process thermal requirements and related equip-ment, an energetic model of a winery was developed. Different possible plant configurations in terms of combinations of thermal power generation technolo-gies were identified and their energy performance analysed, including both gas-fired steam and hot water boilers. The developed model was validated thanks to a case-study constituted by a winery in north-eastern Italy, specialized in spar-kling wines. Results show that a very common solution, involving a steam boil-er serving all different process utilities, entails significant energy inefficiencies. Indeed, only very few low-energy-demanding utilities require thermal energy in this form. The more energy-efficient solution is, instead, supplying thermal needs through hot water at different temperatures, able also to minimize pro-duction costs from a life-cycle perspective. Other interesting benefits lie in the adoption of heat recovery systems e.g. from air compression units, to meet part of the loads related to heating needs. These research findings, pursuing efficien-cy and sustainability performance improvement, are applicable when designing new wine-production plants or replacing existing steam boilers at the end of their technical life.

Keywords: Industrial thermal needs, Energy efficiency, Thermal energy carri-er, Sparkling wine production, Bottling process, Energy-supply enthalpy levels.

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Valorisation of Forest By-products by Steam Distillation: Influence of Conservation Conditions

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Abstract. Due to their rapid colonisation of marginal Alpine areas, the conifers *Pinus mugo Turra* subsp. *mugo* and *Picea abies* (L.) H. Karst. require regu-lar containment interventions. Steam distillation for essential oil extraction is a common valorization method for by-products from these operations. This study evaluates the impact of five conservation treatments on steam distillation pa-rameters. Biomass was collected in the "Altopiano dei Sette Comuni" (Asiago Plateau) and subjected to different conservation conditions: room temperature vs. refrigerated storage of whole vs. shredded material, alongside immediate distillation.
Steam distillation was performed on 4 kg of plant material, for one hour, in triplicate. Essential oil (EO) was measured and chemical composition was analysed by GC/MS. Moisture content, heating value, ash content and bulk density of both material states (fresh and post-distillation spent) were tested.
Higher EO yields resulted from distillation of plant materials subjected to immediate extraction and stored as whole branches. Chemical composition complied with the available ISO reference and previous literature. The Principal Component Analysis effectively differentiated the samples primarily based on plant species and the shredding treatment. Moisture content and bulk density varied significantly in relation to plant species, material state and conservation treatment. Heating value and ash content were not affected by conservation treatment and distillation, with a higher heating value for *Pinus mugo* and a higher ash content for *Picea abies*. Valorising *Pinus mugo* and *Picea abies* by-products enhances the feasibility of containment interventions, but careful con-sideration of logistical and economic factors remains essential.

Keywords: Conifers, Essential Oils, Forest Management, Extraction.

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Paper ID: 170

Milker Performance Analysis using Herd Management Software Integrated with Multivariate Control Chart and Support Vector Machine

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Abstract. Modern milking machines equipped with milk meters and sensors provide detailed data on milk production, milking time, flow rate, electrical conductivity, etc. at both individual and herd levels, enabling precise management of the milking process. This study evaluated whether the milking process in a small dairy farm in central Italy was in- or out-of-control using a statistical model combining multivariate control charts and support vector machines (SVM). Milking in this farm is carried out by a striking and variable number of milkers rotating in monthly shifts. In a parallel milking parlour with five stalls in a single row an average of 25 dairy cows, identified by RF-ID technology and managed by DeLaval DelPro Farm Manager, are milked twice a day. Analysis of 2,600 milking batches from October 2023 to August 2024 revealed that 9% were out of control, primarily due to prolonged animal loading times and post-milking routines. The proposed model demonstrated exceptional performance, with 100% sensitivity and 99.8% specificity, effectively detecting out-of-control milking conditions. These results underscore the effectiveness of integrating multivariate control charts with SVM to identify anomalies and implement corrective measures, ultimately improving milking efficiency and consistency.

Keywords: Milking Process Monitoring, Dairy Herd Management, Milking Data Analytics

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Mapping Unmanned Aerial Spraying System Efficiency: A Methodological Approach for Vineyard Plant Protection Product Application

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Abstract. Unmanned Aerial Spraying Systems (UASSs) present a promising approach for Plant Protection Products (PPPs) application in vineyards, offering solutions with reduced health risks and operational costs. This study evaluates the UASS spraying performance on a Vermentino vineyard in Sardinia (Italy) during the 2024 season, focusing on canopy penetration efficacy through the analysis of Water Sensitive Papers (WSPs). The UASS operated at 2 m/s, spraying 50 L ha-1 across three replicates at 2 m above ground level. The trial covered a 50 × 30 m area comprising 12 vineyard rows and utilized 72 WSPs arranged in a regular grid across two canopy height layers. Kriging maps were generated to visualize distribution performance and compare it with canopy volume variability derived from the Canopy Height Model (CHM) technique. Penetration rates were calculated for each sampling point and correlated with canopy volume. Contrary to the experimental hypothesis, the findings indicated no correlation between canopy volume and penetration rates. Distribution maps corroborated these results, showing no spatial correlation for the penetration rate variable. The significance of this study lies not in the correlation findings but in establishing a robust methodology to evaluate UASS distribution performance, essential to validate the potential of UASS applications in viticulture as a viable alternative for PPP distribution. Furthermore, the lack of correlation highlights the need to investigate other factors influencing the performance, crucial for UASS distribution optimization.

Keywords: Precision Aerial Spraying, Canopy Penetration Efficacy, Viticultural Spraying Technology, Spatial Variability Assessment, Agricultural Spray Mapping.

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Identifying the dynamic response and acclimatization to wind of a poplar plantation based on operational modal analysis

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Abstract. The overall area dedicated to poplar cultivation in Italy is estimated to be around 45,000 to 50,000 hectares. This represents a substantial portion of the country's agri-cultural land utilized for specialized tree plantations and continues to play a vital role in the country's wood production sector.

Nowadays, due to the more and more frequent extreme meteorological events char-acterized by strong winds, the stem breakage and consequent loss of biomass causes important issue to the production and the whole chain.
Poplar plantations, while economically important, face significant risks, particularly from strong wind events. These events can cause substantial damage, including up-rooted or broken trees, leading to significant biomass loss and economic hardship for growers. The dense, uniform structure of many poplar plantations can increase their vulnerability to wind damage by channeling strong winds through the stand.
This study explores the different dynamic response of the same clone in a single stand which can be derived due to a different acclimatization process on the samples growing on the edges with respect to the ones growing in the inner rows. A novel as-sessing method exploit high-sensitivity accelerometers are able to capture the variation of the dynamic response of a tree within a very limited time-frame and low wind speed conditions. Although not yet easily linked to the phenological traits of poplars the ob-served significant differences in the tree geometry in key parameters such as fundamen-tal frequency and damping ratio are linked to the growing conditions (i.e., crown size and stem height), that reflects into the tree geometry sharing original data on the com-prehension of the acclimatization process.

Keywords: tree architecture, stability, plantations, poplar, wind

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GIS-based multi-criteria spatial analysis model to support planning and implementation of green infrastructure

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Abstract. Land use change and urbanization processes are causing increasingly severe environmental challenges, further exacerbated by climate change. Heat island effect, poor environmental quality and reduced exposure to nature are having remark-able effects on the quality of our ecosystems and on people's health and wellbeing. Green infrastructure has proven capable of mitigating the above-mentioned critical issues, providing a wide range of ecosystem services, including reduction in heat stress and improvement of many health-related environmental factors, for the benefit of all inhabitants, and more fragile population in particular. Geospatial technologies can provide a sophisticated understanding of drivers of environmental critical issues and support the implementation of green infrastructure to maximize their effective-ness. The study proposes a methodology based on the analysis of time series of satel-lite data that allows the quantification of the relationships between land use changes and green cover evolution on thermal stress. The method is tested on a case study and has quantified the contribution of green infrastructure to the reduction of heat island phenomena. Moreover, the study proposes a framework to highlight the hotspots with critical environmental issues, based on a comprehensive approach that incorporates key criteria such as the heat island intensity, air quality and vegetation cover for envi-ronmental stress magnitude, and population exposure and vulnerability, by means of an analytic hierarchy process implemented in a GIS environment. The framework's effectiveness has been demonstrated in a case study in Italy, proving the usefulness in supporting spatial planning policies with evidence-based information and facilitating targeted nature-based solutions implementation.

Keywords: green infrastructure planning; geospatial technologies; environmental quality; heat island effect; AHP; spatio-temporal analysis.

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Paper ID: 174

Hemp Seed Oil Extraction With A Portable Field Press

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Abstract. The adoption of sustainable post-harvest techniques and product traceability has highlighted the need for extraction methods that reduce energy consumption and avoid the use of solvents. Mechanical pressing represents an eco-friendly solution for extracting oils from plants and seeds, widely used in the food industry due to its simplicity and sustainability. In the case of hemp seed oil extraction, this technique is preferable to solvent extraction as it preserves the qualitative properties of the extracted oil (antioxidants, essential fatty acids) while generating reusable by-products suitable for animal feed or energy pellet production. In this study, a direct field extraction method for oil from hemp seeds of the Italian *Cannabis sativa* Codimono variety was evaluated using a portable mechanical press prototype. The main operational parameters assessed during the extraction trials included seed quality characteristics, seed cleanliness, pretreatment conditions (moisture and temperature), oil yield, and by-product recovery. Preliminary results indicate promising oil yields and significant recovery of spent oilcake that can be valorized as a by-product, particularly for producing fuel pellets using simple, low-cost equipment. This strategy promotes sustainability and efficiency, providing producers with tools to optimize cultivation practices, oil production, and by-product recovery.

Keywords: *Cannabis sativa*, Mechanical pressing, Circular economy, prototype press, extraction parameters

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Evaluating supplemental irrigation strategies to address climate change: a case study from the Veneto region (Northeast Italy)

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Abstract: This research examines the impact of climate change and the increasing scarcity of water resources on agriculture, with a specific focus on the management of supplemental irrigation within three Land Reclamation Consortia located in Veneto region (Italy). These consortia operate within an intercon-nected network of water bodies belonging to the Piave river watershed. Data collection for this research involved administering a questionnaire to the partic-ipating consortia, addressing topics such as irrigation scheduling, emergency management, and water supply methods. The effectiveness of current manage-ment practices employed by the consortia was then evaluated using the Aqua-Crop model. The aim was to determine, under two distinct agro-climatic scenar-ios, whether existing management frameworks could meet the irrigation needs of local farmers.

The survey revealed how the consortia adopt different strategies to cope with drought, such as irrigation scheduling, the use of predictive models, and the implementation of more efficient irrigation systems. The analysis highlights a progressive adaptation in water resource management, driven by the increasing intensification of the effects of climate change. The adoption of advanced technologies, such as drip irrigation and the digital management platform Irriframe, is crucial to optimizing water efficiency. The preliminary results of this study also indicate the need to promote greater collaboration between the Consortia in order to respond more effectively to the increasingly evident impacts on agri-culture related to water scarcity.

Keywords: Water resource management, Land Reclamation Consortia, Agriculture, Advanced irrigation technologies

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Green infrastructure and adaptation to climate change in European cities: an investigation on the municipality of Sassari, Sardinia (Italy

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Abstract. This study is part of ongoing research that involves a cluster of European states and cities: the aim is to compare how key instruments regarding spatial and climate policy consider green areas (including green infrastructure, GI) to face the effects of climate changes. At local scale, we focus on Sassari, Italy, which is characterized by quite high flooding risk and hazard. Future climate scenarios point out that Sassari will be affected by an increase in average temperature, temperature extremes, and periods with high temperatures. Furthermore, Sassari is expected to deal with an increase in daily cumulative precipitation, daily precipitation intensity and frequency of extreme precipitation events. The method consisted of retrieving and examining local documents relevant to adaptation to climate changes (ACC) based on the use of GI (or green areas at least). According to the findings, the municipality approved three instruments regarding spatial and climate policy: a local Climate Change Adaptation Plan for Flooding Risk; a municipal master plan, which is compliant with the Regional Landscape Plan and the Regional Hydrogeological Plan; a Municipal Code for the Protection of Urban Green Areas. We found out that the three tools set objectives and actions related to the protection/formation of green spaces/green areas, which could be useful also in terms of ACC (e.g., promotion of policies for the protection, conservation and redevelopment of the coastal areas; protection, preservation, improvement and increase of the plant heritage of the municipality, by establishing rules to ensure the protection and rational management of green areas).

Keywords: green infrastructure, green areas, green spaces, adaptation to climate change.

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Unveiling the Interdependencies of eco-hydro-eteorological variables in a Mediterranean Forested catchment

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Abstract. Eco-hydro-meteorological variables (EHM) are vital for evaluating climate change effects on ecosystems and hydrology. Meteorological factors like precipitation and vapor pressure deficit influence soil moisture variability, affecting tree transpiration and sap flow, which impacts soil moisture. Understanding these interactions is essential for effective water resource management and accurate drought predictions. Nonetheless, research on EHM feedback mechanisms in mountain forested catchments, especially in Mediterranean regions, is lacking.

We monitored EHMs for two years at the mountain forested Re della Pietra catchment (Central Italy), and we performed wavelet transform analysis to assess EHM variability over time, frequency, and space and wavelet coherence to examine factors influencing EHM feedback dynamics.

The wavelet transform analysis highlights rainy periods exceeding the 1024-hour frequency and a clear seasonality of vapor pressure deficit, marking the dry-wet seasons' transition. Soil moisture variability in the bottom slope significantly differs from uphill areas, where recovery periods after dry seasons are more pronounced. High daily transpiration for sap flow is shown at 12/24-hour frequencies, varying by location. A high coherence between sap flow and soil moisture at 12/24-hour frequencies suggests that soil moisture influences sap flow. Conversely, the rapid soil moisture decline in the upslope promotes the early cessation of tree transpiration, leading to low coherence. Sap flow influences soil moisture above 24 hours and strongly correlates with vapor pressure deficit in all frequencies and precipitation only above 64 hours. This study thoroughly explores complex eco-hydro-meteorological dynamics within forest catchments through wavelet analysis.

Keywords: Forested Catchment, Eco-hydro-meteorological interaction, Wavelet Analysis, Led-Lag Dynamics

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Carbon Balance Assessment of a Golf Course: The Case Study of the Golf Club Ca' Amata

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Abstract. This study analyzed the role of a golf course as a potential sink or source of CO_2, evaluating the balance between carbon emissions and absorption. As is known, a golf course represents a vast green area that has the potential to guarantee many ecosystem services such as carbon sinks. The research focused on the management of trees, shrubs, and turfgrass, alongside other maintenance activities at Golf Club Ca' Amata in Castelfranco Veneto (North Eastern Italy). Emissions were estimated using data from collaboration with the golf course's superintendent and collaborators, including those generated by machinery and fertilizers. Simultaneously, carbon absorption was calculated using the i-Tree Eco software, a widely used tool for urban forest management, for 7,119 inventoried individuals, including trees, shrubs, hedges, and vines. For the turfgrass-soil system, average values from a literature review were applied.

The total emissions amounted to approximately 73 Mg of CO_2 per year, primarily originating from mowing operations on fairways and roughs. Fertilizers applications contributed to N_2O emissions equivalent to 11.5 Mg of CO_2e annually. However, the total carbon absorption was estimated at 525 Mg of CO_2 per year, with over 360 Mg attributed to turfgrass. This resulted in a reassuring positive carbon balance for the case study, with a surplus absorption of 440 Mg of CO_2.

These findings can be instrumental in developing sustainable management strategies that reduce emissions and maximize CO_2 absorption.

Keywords: Golf course management, Sustainability, i-Tree ECO, Ecosystem services, Turfgrass.

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An autonomous UAV-based monitoring device for precision viticulture

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Abstract. Current advancements in proximal sensing for sustainable viticulture focus on integrating autonomous systems, such as UAVs, with miniaturized sensors and machine learning to enhance the efficiency of vineyard monitoring. The study, part of the COLIBRI' project (Collaborative integration of mini-UAV, miniaturized sensors, and machine learning for proximal sensing towards sustainable viticulture), developing an autonomous drone system equipped with advanced sensors to automate vine monitoring. The drone carries a thermal camera to assess leaf water stress and a hyperspectral camera to evaluate grape ripening. The on-board integration of a companion computer (Raspberry Pi) enables real-time data analysis using machine learning models. This approach facilitates instant classification of ripening conditions and water stress levels, supporting vineyard management decisions.

The UAV autonomously collects data from specified targets, processes inputs externally, and executes assigned missions reliably. It is equipped with a flight controller to stabilise flight and control engine functions and a companion computer to manage software and instruct the flight controller. A ground station monitors the mission via telemetry and uploads data to the UAV. The system uses a GPS receiver for navigation, while the object approach relies on artificial vision with Aruco fiducial markers and the OpenCV2 library. Test flights demonstrated reliable mission execution with potential for the future.

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Keywords: Drone, Companion Computer, Optical sensors, Grape quality, Water status, Machine Learning, Agriculture 4.0

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Exploring Suspended Sediment Sources and Transport Pathways in Forested Catchments

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Abstract. Suspended sediment transport in mountain catchments plays a crucial role in shaping stream morphology and ecology, yet the processes governing sediment dynamics in forested areas remain scarcely understood. This study investigates the sources and drivers of suspended sediment transport within a densely forested catchment. The study area is the *Re della Pietra* experimental catchment (2 km^2) located in Tuscany(Central Italy). The catchment is characterized by a Mediterranean climate with significant seasonal variations, given by cold, wet winters and warm, dry summers. The elevation ranges between 643 m and 1320 m a.s.l.., with a dense vegetation cover mainly composed of beech, oak, and pine trees. Meteorological parameters are recorded from a weather station at the upper part of the catchment, while turbidity, stream stage, and soil moisture are monitored at the catchment outlet.

Turbidity is continuously recorded at the catchment outlet, alongside stream stage, soil moisture at two depths and the main meteorological variables data.

Preliminary results indicate a strong correlation between turbidity, stream stage variation, and rainfall intensity triggering large runoff events; significant turbidity peaks appear to occur mainly during moderate to intense storms during the wet season. Hysteresis analysis revealed that 15% of the loops were clockwise, representing the most recurring figure and indicating that suspended sediment primarily originates from local sources. Future work will imply the conversion of raw turbidity data into suspended sediment concentration, the conversion of water level data in discharge, and further hysteresis analysis

Keywords: turbidity, suspended sediment, sediment transport, sediment mobility, sediment dynamics, forested catchment

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From Hyperspectral to Multispectral and RGB Imaging in vineyard management

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Abstract. One of the latest approaches to vineyard monitoring and management is the use of optical sensors. Previous studies have explored the possibility of monitoring grape quality parameters using hyperspectral cameras in the Vis/NIR range. However, these cameras are expensive and unsuitable for the acquisition speeds required in the field. In order to make this monitoring technology applicable to wine-growing practices and more appropriate to the budgets of small growers, a first step could be to move from hyperspectral cameras to multispectral and RGB cameras. Spectral reconstruction - also known as spectral estimation and spectral super-resolution - is an alternative approach to acquiring hyperspectral information from a multispectral or RGB camera. Three main approaches are investigated: regression, sparse coding and DNN. Specifically, the aim of this study is to evaluate algorithms available in the literature and apply them to our case to determine if a visible spectral signature can provide the same qualitative information about the fruit as hyperspectral and multispectral systems.

Keywords: Multispectral, imaging, in-field, precision viticulture.

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Assessment of forest wildfire hydrological effects: the case-study of three Calabrian catchments

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Abstract. High-intensity wildfires can alter the hydrological response of small mountain catchments, especially in the peculiar conditions of the semi-arid Mediterranean environment, where the combination of geomorphologic and climatic factors determines the formation of flash floods.

The paper aims to draw some quantitative indications about the hydrological effects of forest wildfires at the catchment scale. Among those, most burned by the extreme wildfires that occurred in August 2021 in the Aspromonte massif (southern Calabria), three catchments (Amendolea, Melito, and Valanidi) were chosen. The Curve Number variations were estimated between pre- and post-fire conditions, and the resulting hydrological response was evaluated using the Soil Conservation Service Curve Number model (SCS-CN) incorporated in the HEC-HMS software. The model was applied assuming the basins are subject to the same rainfall event (in pre- and post-fire conditions), both simulated and real. As simulated rainfall events, those with return periods ranging from 2 to 200 years were analyzed to evaluate both frequent and rare events. As a real event, the extreme event of October 21, 1953, was analyzed. This is an extreme rainfall event (1,000 mm in 3 days, high-point intensities of 83 mm/h with 50-year return time) generated an extreme flood (with flow value up to 20 m^3/km^2 for the Valanidi catchment, indirectly estimated by some authors), which, moving downstream, caused tens of victims. To verify this value, a dendrochronological approach was also used.

The investigation shows how the drastic elimination of large forested areas due to the wildfire intensifies the hydrological response of the catchments examined, with notable increases in flow values. Furthermore, the paper seems to confirm how after the wildfire even ordinary rainfall events (e.g. the first autumn rains) can hydrologically put the basin in crisis. On the other hand, the incremental values of peak flow rates tend to significantly decrease above a maximum rainfall intensity threshold, highlighting a lower protective effectiveness of the forest during rainfall events with a high return time.

Keywords: Wildfires, hydrological response, Fiumare, Curve Number, rainfall events.

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Analysis of Tractor Rollover Risks: A Comparison of Simulation and Experimental Methods

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Abstract. Tractors are considered as a basic mechanization tool in many countries due to their ability to be used with various attachments. However, their operation on generally sloping, rough and soft terrains bring serious safety risks such as rollover accidents. Rollover is one of the most common causes of tractor accidents in agricultural fields and caused 1490 deaths globally in 2022 alone. In this study, both standard test methodologies required by international regulations and computer-aided approaches were used to understand the stability behavior of tractors and to improve safety. Two different methods were applied on a narrow-tracked vineyard tractor: 1. multi-body dynamic (MBD) simulations and 2. rollover tests performed on a rotatable tilt table. The MBD model developed using Adams/View predicted rollover angles by taking into account the physical properties and dynamic behaviors of the tractor. These predictions were verified by tests performed on the specially designed test-rig. On the test platform, the center of gravity (CoG) location and stability limits of the tractor were measured using gravity sensors. As a result, a stability map was composed with the methods used. These approaches contribute to the development of more effective safety systems by analyzing the stability of tractors in different terrain and operating conditions.

Keywords: Tractor Stability, Stability Map, Rollover Accidents, Multi-body Dynamics, Tilting Platform, Agricultural Vehicles.

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A low-cost 3D camera-based system for non-contact weight estimation in dairy calves

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Abstract. Calf body growth is typically monitored using mechanical or electronic scales, however such manual measurements are labor-intensive and can cause stress to young animals. Despite the advances in precision technologies and research focussed on adult cattle, there is a significant gap in solutions specifically designed to estimate the weight and the growth rate of young calves.
Hence, this study aimed to develop a system for non-contact evaluation of the calf body weight, using a low-cost 3D camera and an associated algorithm to enable fully automated weight estimate. A total of 230 measurements were carried out on 110 female Italian Holstein calves, aged between 1 to 121 days. 3D images of each calf's back were acquired from a top-view configuration.
3D images were analysed using custom-developed software to extract two key morphological parameters for each individual calf, namely the maximum width of the abdomen (WA) and the height (HM) measured at the same position. Simultaneously, each imaged calf was weighed on a mechanical scale. In addition, its abdomen width and height at the withers were manually measured, for further validation of the system accuracy.
The image-extracted parameters were finally used to train a simple prediction model for calf body weight, which demonstrated a fairly good prediction capability (R2 = 0.87, mean relative error = 6.6 %) when applied to a validation set of calves weighing between 24 and 88 kg.
The obtained results, the simplicity and low-cost of the measurement setup, highlight the potential of implementing daily monitoring of individual calf growth using such a system, with significant advantages over traditional, labor-intensive weighing method based on scales.

Keywords: Dairy calf, Animal weight, Body weight estimation, 3D-camera, 3D image analysis.

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Catastrophic events in the Mediterranean Area: multi-risk and multi-level approach.

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Abstract. Catastrophic phenomena generally trigger natural hazards which may lead to damage and destruction of territories, structures, and infrastructure; but the most important consequence is loss of human lives. Therefore, it is of the utmost relevance the assessment, planning, and management concerning the design phases by applying appropriate sustainable mitigation measures. To do so, the fundamental step is the knowledge of trigger mechanisms and the modeling of natural hazards.

Following the previous considerations, Calabria represents a remarkable case study due to its geomorphological, climatic, hydrological, and anthropic characteristics since they lead it to be largely subject to natural disasters that could be either single or overlapping. The region may experience simultaneous events, e.g. earthquakes together with extreme rainfall events, or consequential, e.g. a landslide along the coastline, triggered by an earthquake, that generates a tsunami. The paper analyses the typical catastrophic phenomena that affect the Mediterranean area, such as earthquakes, tsunamis, sea storms, floods, and wildfires, also considering climate change that could modify their frequency and intensity.

A multi-hazard and multi-level approach was used to carry out the analysis. Levels 0 and 1 regard the reconstruction of historical catastrophic events that affected the Calabria region. In level 2 hypothetical event scenarios are considered: e.g., anthropization and erosion processes during the occurrence of tsunamis or historical floods. Levels 3 and 4 provide rapid and detailed analysis concerning the effects that follow these scenarios. In the end, level 5 analyses the probability of joint events occurring.

Keywords: Natural hazard events, multi-level analysis, multi-hazard analysis, earthquakes, tsunamis, floods, wildfires.

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Reduction of ecosystem services provided by green infrastructure due to land take. The case of the Province of Monza and Brianza (Italy

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Abstract. Non-urbanized areas, including residual urban green areas, urban parks, agricultural lands, natural and semi-natural areas, are a fundamental part of the green infrastructure. They are essential in sustaining life and future development, providing a series of ecosystem services (ESs) vital to human society. However, the rapid expansion of urban areas has led to a significant reduction of green spaces, driving the European Union to set the ambitious goal of achieving zero net land take by 2050. Land take, reducing available land resources, impacts ecosystem functionality, making it crucial to preserve high-quality territories and the relative Ess provided.

In this context, the aim of this study was to evaluate the reduction of ESs due to the land take occurred in the last 20 years in the Province of Monza and Brianza, the Italian province with the highest land take (ISPRA, 2024). To achieve this goal, authors used the official data of land use/cover of the Lombardy Region, with three time-thresholds (1999–2003, 2012–2013, 2021) and applied a methodology for ESs assessment originally developed for the municipal level (Senes et al., 2023), adapting it to the provincial scale.

The study analyses land take and land-use changes trend and assesses how these changes have led to variations in ESs provision. The approach involves calculating multiple indices reflecting different aspects of green areas: agricultural land use, landscape value, and natural resource distribution. Findings reveal that urban expansion has decreased agricultural and landscape quality indices, reflecting farmland loss and visual degradation. However, because the natural quality index has improved, likely due to conservation policies, despite the high land-take recorded, there has not been an equally high reduction in ESs provision. Anyway, although regional policies have mitigated some negative effects, the overall reduction of green spaces remains a critical issue.

Keywords: green infrastructure, land take, land planning, ecosystem services, rural territory.

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Study for improving the extraction capacity of pod espresso machines

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Abstract. The use of single-dose espresso pods has seen rapid growth in recent years, thanks to their convenience and the consistent quality ensured by the packaging and extraction system. However, pod-based espresso machines often deliver lower performance compared to other methods, particularly in terms of foam quality and aroma persistence. This study aims to ana-lyze and improve the extraction capacity of pod machines, focusing on foam quality and other chemical-physical parameters of the extracted coffee. For this study, two different types of coffee and two pod espresso machines were used, and the quality of the extracted coffee was evaluated. The machines tested are both for single-serve pods, and have different operating parameters, especially in terms of extraction temperature settings and ease of use. The parame-ters assessed in the samples included the beverage yield in grams, the percentage height of foam relative to the total beverage, caffeine content (mg/mL), the percentage of dissolved sol-ids in the beverage, pH, and aromas. The extraction temperature was also monitored. The re-sults revealed significant differences for the analyzed parameters, particularly a reduction in foam height as the temperature increased. The best foam formation was observed at tempera-tures between 80° C and 83°C.

Keywords: espresso pods, extraction capacity, foam quality, chemical-physical parameters, extraction temperature.

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Development of digital technologies for promoting good agricultural practices in Lebanon's dairy farms

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Abstract. The adoption of digital technologies in agriculture, particularly in dairy farm-ing, remains limited in Lebanon due to a significant knowledge gap regarding their benefits and applications. This knowledge gap prevents farmers from fully understanding the benefits offered by digital technologies. Therefore, to support good agricultural practices through the implementation of digital technologies on dairy farms in Lebanon, it is crucial to bridge the knowledge gap through in-vestments in training, technical assistance and information dissemination. This would enable dairy farmers to fully understand the opportunities offered by dig-ital technologies, fostering their adoption and contributing to a more sustainable and resilient development of rural areas. Therefore, the aim of this study was to develop a dedicated application to support the dissemination of best practices for using and maintaining milking technologies and installations in the Bekaa Valley region of Lebanon. A preliminary online questionnaire was distributed to 30 dairy farms within the cooperative to collect key characteristic and identi-fy 10 representative farms for the implementation of the developed technology. The developed mobile applications offer interactive, multimedia guides on milking equipment, specifically tailored for novice operators. Created for An-droid devices using Android Studio, the applications leverage the Flutter framework and Firebase technology to deliver a user-friendly experience. The results indicated that the most adopted equipment for milking animals, about 90% of the investigated farms, was the mobile milking machine system. This research demonstrates the potential of digital technologies to drive socio-economic development in rural Lebanon and establish stronger synergies be-tween local governance and international stakeholders.

Keywords: Mobile app, milking, data analytics, Android studio, Digital Tech-nologies

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A new index for the ecological quality assessment of Fiumare: example of application in Calabria and Sicily (Southern Italy

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Abstract. The fiumara environments are typical intermittent/ephemeral streams within the semi-arid Mediterranean environment.
The persistent "non-equilibrium" condition of the fiumara context (concerning high spatial and temporal variability of physical and biotic factors), makes it hard to define a reference condition to assess its ecological status.
Several fluvial indexes, used for evaluating river ecological quality with respect to an optimum (reference condition), have been proposed in the last decades. Most of them, however, have been developed for a specific geographical and environmental region, or in a particular river context and it is not uncommon that these indexes give negative or incorrect ecological evaluation even in the presence of high levels of naturalness.
To help the recognition of more adherent reference conditions for these ephemeral streams, a multi-disciplinary analysis of both hydro-geomorphologic features and their interaction with the fluvial ecosystem has been carried out. Consequently, a set of representative case studies with (disturbed) and without (undisturbed) hydraulic engineering control works are chosen in Calabria and Sicily. Finally, a new modified index, specifically developed for fiumara environment to improve the performance and effectiveness of an existing index commonly used in the literature, was applied.
The new modified index, which is able to detect the reference condition of fiumare, provides an appropriate assessment of their ecological and morphological status even in the absence of human intervention.

Keywords: Semi-arid Environment, Hydrological Processes, Reference Condition, Riparian Habitats.

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Impact of Agrochemicals Active Ingredients on the Degradation and Mechanical Integrity of Agricultural Plastic Nets

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Abstract. The increasing use of agrochemicals for crop protection has raised concerns about their persistence in the environment and their interaction with agrotextiles. Previous studies state that specific chemicals are responsible for the polymers' degradation process and that significant reductions in terms of mechanical performance over time have to be expected. This study investigates on the impact of commonly used agrochemicals on the degradation of agricultural plastics. Laboratory tests have been performed on yarns composing PE-HD agrotextiles for greenhouse cover and protection, artificially aged for given durations and treated with different regularly registered and commercially available agrochemicals (fungicides and insecticides). Using a combination of accelerated aging and mechanical tensile testing, the structural integrity degradation of plastic threads that make up agrotextiles exposed to different formulations and different agrochemicals has been evaluated. The influence of environmental factors, such as UV and temperature on the interaction between agrochemicals and plastics has been underlined as well. The found experimental outcomes highlight the need for farmers to consider these interactions when selecting pesticides for agricultural applications, as right choices may be the key to meet the sustainability and environmental needs in agricultural practices. In addition, a contribution is given to the knowledge of the real lifetime under actual operating conditions and of the environmental concerns of the agrotextiles use. This potentially represent a base for future drafting of guidelines for a mature and aware use of agrotextiles and agrochemicals to mitigate environmental impacts of the agricultural operation.

Keywords: Agrotextiles, Mechanical test, Agrochemicals, Plastic degradation, Environmental impact.

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A multidisciplinary approach for vineyard monitoring on regional scale

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Abstract. Fungal diseases of grapevines cause significant damage to the quality and productivity of viticultural crops. To study the inter-play between grape diseases, environmental and management factors is essential for developing sustainable and quality of grape production. In particular the “mal dell’esca” disease, attributed to a complex of fungi of the genera *Fusarium, Phaeoacremonium, and Phaeomoniella* is attracting interest at the national and international level. The aims of this study are: i) to map the disease distribution on the region-al scale, ii) to study the agronomic and environmental factors that can influence the spread of the pathogen. Outbreaks of infection detected in the period 2012-2022 were mapped and the relationships between the spread of the pathogen and specific vineyard characteristics were analyzed. The results show a widespread distribution of the pathogen in all viticultural areas of the region, with a particular incidence in white-berried varieties. Statistical analysis revealed a strong correla-ion with the variety, the amount of organic carbon in the soil, and with the vine growing system adopted. Specific interactions between the considered factors have emerged, providing useful indications for a more targeted and sustainable management of viticultural crops.

Keywords: viticultural crops, GIS, precision farming, vineyard, spatial analysis

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Performance enhancement of constructed wetlands for dairy and livestock wastewater treatment by aeration and alternative substrates

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Abstract. Dairy and livestock farms generate substantial quantities of wastewater, which, if not managed properly, can pose a serious threat to the ecosystem. A sustainable solution for the treatment of these effluents could be Constructed Wetland (CW) systems. Nevertheless, the main weakness for the full-scale implementation of CW systems is the substantial land area required. The main objective of this research activity was to optimize constructed wetlands (CWs) for wastewater treatment and reuse in small to medium-sized dairy and livestock farms, thereby minimizing the spatial footprint. In this regard, a lab-scale CW system was designed to enhance removal efficiencies (REs) of the main pollutants (e.g. nutrients and organic matter) by using innovative substrates, aeration techniques and recirculation strategies. The lab-scale system is composed of four identical hybrid CWs, each one consists of two treatment units functioning in series: vertical flow (VF) followed by a horizontal flow (HF). The VFs are filled with five substrates (from top to bottom): dolomite (13 cm), perlite (12 cm), zeolite (21 cm), expanded clay (21 cm) and plastic balls (26 cm). The HFs are filled with gravel and expanded clay (inlet of the system). The VFs are fed with a peristaltic pump, while the HFs are fed by gravity. Assessments of the hydraulic behaviour of the substrates and the evaluation of REs were conducted.

Keywords: lab-scale hybrid constructed wetland; substrates; synthetic dairy wastewater; synthetic livestock wastewater; removal efficiencies; hydraulic behavior.

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A participatory evaluation of a large-scale landscape restoration project in steep-slope areas of Central Africa

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Abstract. Landscape restoration projects are among the most extensive conservation actions at the global level that have been promoted in the last three decades. Such projects, however, cannot exclusively be based on the restoration of natural and semi-natural ecosystems but should be based on a cultural landscape approach balancing environmental and socio-economic needs. One of the largest restoration projects realized in the last five years was the World Bank's Burundi Landscape Restoration and Resilience Project (PRRPB). PRRPB utilized an integrated approach to restore the social-ecological systems in the target steep-slope areas of intervention, adopting a mix of landscape restoration solutions (slow-forming terraces, reforestation, etc.) and socio-economic measures. With a large-sample questionnaire, realized on the field with the local population, the following work aimed at assessing the impact at the local level of one of the largest landscape restoration projects carried out in a developing country. The most perceived vulnerabilities in the study areas were "Soil erosion and degradation" followed by "Reduction of agricultural production and/or food security". Most of the interviewed perceived that the project was successful in combating soil erosion, and around 60% perceived an improvement in socio-economic conditions. These and other insights will be informative for similar projects in the region.

Keywords: Burundi, terraces, slow-forming terraces, participation, project evaluation, land and water management.

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Investment in irrigation infrastructure for more efficient water resource management

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Abstract. The aim of this paper is to highlight how the investments financed by the Italian Ministry of Agriculture and Food Sovereignty from 2017 to the present to irrigation entities for the efficiency of irrigation infrastructures through the modernisation of distribution networks, and the installation of technologies such as meters and remote control systems, in order to improve the management of water resources, can contribute in the Green Transition to increase the resilience of agricultural systems and the ecosystem in gene-ral to drought and water scarcity.

Through the use of DANIA (National Database on Investments for Irrigation and the Environment), managed by CREA Politiche e Bioeconomia, an on-line database (https://dania.crea.gov.it/) that collects all the financial and physical monitoring data of the projects on the irrigation networks, it will be possible to assess the effectiveness of the investments, and thus the contribution to the sustainable water resource management under climate change scenarios, through the quantification of appropriate indicators in terms of water savings and efficient area. Therefore, water savings are expected to exceed 1 billion cubic metres for the efficiency of irrigation systems, of which the reduction of losses for the modernisation of the network alone is estimated to exceed 300 million cubic metres, a reduction of the withdrawal at source (river, spring, etc.) of more than 280 million cubic metres, as a con-sequence of the efficiency of the areas served by distribution networks of more than 1.3 million hectares.

Keywords: DANIA, investments for the efficiency of irrigation infrastructures, resilience of agricultural systems, water scarcity, water resource management, water saving.

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Experimental tests of a microwave pilot system used for callosobruchus maculatus inhibition in legumes. evaluation of treatment and energy efficiency

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Abstract. The purpose of this paper was to carry out a first study evaluating, through experimental tests on a pilot plant, the performance of the microwave (MW) treatment on chickpeas infested by Callosobruchus maculatus. The operating parameters useful for proposing it on an industrial scale as an alternative to traditional chemical treatments were studied, taking into consideration both treatment and energy efficiency. The MW treatment is particularly effective at the lowest operating yields, which correspond to the longer residence times of the product in the plant (25 and 21 min/100kg of product) and the lowest temperatures (55 °C and 46 °C). In fact, at the operating capacities of 2.3592 q/h and 2.8746 q/h were obtained, respectively, an egg mortality of 96.6% and 90% and an individual mortality of 90%. Finally, in the test carried out with adult C. maculatus, all individuals survived the treatment; however, the individuals subjected to the treatment with lower flow rates showed an inhibitory effect on egg production.
With all studied working conditions the MW process is carried out with very low energy consumption: from 0.0316 to 0.0251 Wh/kg; the relatively higher values correspond to the lowest operating capacities, which provided the best sanitation results.

Keywords: Microwave, Chickpeas infestation, Callosobruchus maculatus.

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Precision Weed project: site-specific weed management in maize using advanced sensing technologies

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Abstract. Effective weed management is crucial for agriculture, as weeds significantly reduce crop yields and innovative solutions based on precision agriculture can support the shift to low-chemical methods, aligning with European sustainable farming strategies.
In 2024, a field trial was conducted at UniMI experimental farm in Landriano, Italy. Two adjacent maize fields were established: one treated in the pre-emergence phase and the other intentionally left untreated.
To investigate the spatial and temporal variability of weeds, two detection methods, i.e. Proximal Sensing (PS) and Remote Sensing (RS), were employed at the V3–V4 growth stage of maize. The PS system utilized three RGB cameras mounted on a tractor, capturing high-resolution georeferenced images from 2 meters above the ground. The RS system used a quadcopter (DJI Mavic 3) flying at 40 meters to collect georeferenced RGB and multispectral images. The data were processed to compute vegetation indices, particularly the Excess Green index and Fractional Green Canopy Cover, to create weed infestation maps.From weed infestation maps, prescription maps were generated to assign treatments to each plot conducted with precision spraying of herbicide with a Kverneland iXter B16biXtra boom sprayer, equipped with RTK-GPS and individually controlled nozzles.
Detection accuracy was evaluated by comparing PS and RS systems, while the effectiveness of site-specific spraying was assessed by analyzing maize yields across treatments. Preliminary findings suggest that site-specific management reduced herbicide use without compromising yields, compared to uniform management. Pre-emergence treatment was the most effective weed control strategy, irrespective of post-emergence methods. The study also highlights the challenges of matching the spatial resolution used for weed detection to the optimal resolution required for precision spraying.

Keywords: Site specific weed management (SSWM), Precision Agriculture, Precision spraying, Proximal sensing, Prescription map.

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Strategies for Sustainable Recovery in the Case Study of a Historic Farmhouse in the Agro Romano. A Preliminary Methodological Development

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Abstract. The research focuses on the reuse and recovery of a farmhouse in the Capo Due Rami area, located in the Agro Romano, with particular attention to its historical, architectural, landscape, and sustainability transformations. The study integrates historical and documentary sources, cartographic analysis, and field surveys to reconstruct the development of the area, including agricultural and infrastructural changes occurred between the end of the 19th and the beginning of the 20th century. The analysis highlights the evolution of rural architecture and identifies the architectural typologies of farmhouses, designed to support agricultural activities such as cereal cultivation and livestock breeding. The conservation interventions aim to preserve the remaining structures that have survived the various transformations of the area. The project also includes sustainable solutions, such as the installation of photovoltaic panels and other low-impact technologies, to ensure the functionality and sustainability of the structures, preserving the historical and environmental heritage while addressing the needs of contemporary agricultural practices and urban pressures.

Keywords: Sustainable recovery, Historic farmhouse, Agro Romano, Architectural transformation, Rural architecture, Conservation interventions

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Environmental-tracer behavior in a pre-Alpine catchment: insights from a temporary stream network

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Abstract. Geochemical tracers can be particularly useful to study the hydrological connectivity of temporary streams during different wetness conditions. Understanding the behavior of such streams is of paramount importance in the Mediterranean region, where temporary watercourses represent a significant portion of the hydrological network. In this work, we exploited environmental tracers (i.e., stable water isotopes, major ions, and electrical conductivity (EC)) to i) investigate the relation between discharge and tracer concentration at different spatial and temporal scales, ii) analyze the effect of antecedent conditions on tracer temporal variability at different spatial scales, and iii) identify the main topographic and lithological controls on the geochemical signature of surface waters. This study relies on a database of isotopic and geochemical compositions of surface waters integrated with hydrometeorological data, collected in the 116-km² Posina catchment in the Italian pre-Alps.

Preliminary results show that $\delta^{18}O$ increases with discharge (reflecting the enriched isotopic composition of rain water), whereas EC shows a negative relation with discharge. Positive correlations are found between average tracer concentration ($\delta^{18}O$ and nitrates) and peak antecedent discharge, while negative correlations exist for EC, chloride, sulphates, sodium, magnesium and calcium. Antecedent precipitation positively correlates with $\delta^{2}H$ and nitrates but negatively with sulphates and sodium. Overall, the tracer composition of surface waters seems strongly influenced by the main catchment lithology and not related to the topographic characteristics. By enhancing our understanding of the processes governing temporary streams, this research contributes to a better man-agement of water resources in the pre-Alpine region.

Keywords: Temporary streams, geochemical tracers, pre-Alpine catchment, isotopic composition.

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Experimental Study on Agricultural Tractor Emissions and Fuel Consumption through Laboratory Testing

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Abstract. Agricultural tractors, being involved in every field activity, play a fundamental role in modern agriculture. However, their engines require a high consumption of diesel fuel, which generates polluting emissions that are harmful to the environment. These armful gases could affect the quality of the agricultural products and the men health. This work reports the experimental results performed at the Agro-Forestry Innovation Laboratory (AFILab) of the Free University of Bolzano on a narrow-track vineyard tractor, more than 20 years old and with over 5000 working hours, representative of the average age of tractors used in agriculture. The aim of the study is to analyze the performance, consumption and emissions of the engine. Tests were performed at different speeds and engine loads, with a subsequent statistical analysis of the data. The results, presented through maps of braking specific fuel consumption (BSFC) and emissions (BSEL), can provide crucial information for assessing the environmental impact of tractors, and for developing new strategies in reducing emissions.

Keywords: Tractors, pollutions, consumption, agriculture dynamometer.

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An RCNN-based Image Processing Method for Adhesive Droplets on Water-sensitive Papers

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Abstract. As an efficient, low-cost and farmer-friendly tool, water-sensitive paper has been widely used for assessing droplet deposition over the past few decades. Although various algorithms and software for droplet analysis have been developed, dealing with adhesive droplets remains a major challenge. In recent years, several methods have been proposed to tackle this issue, but there remains a need for a solution that is both efficient and straightforward. In this study, a novel image-processing method for water-sensitive paper is proposed. This method utilizes two branches of the Region-based Convolutional Neural Network (RCNN), Mask-RCNN and Keypoint-RCNN, to perform instance segmentation and keypoint detection, respectively. Instance segmentation identifies the contours of all droplets, while keypoint detection locates the intersection points of individual droplet contours within the adhesive droplets. The adhesive droplet contours are then segmented at these intersection points, ensuring that each contour segment corresponds to only one droplet. The complete contours of individual droplets are reconstructed by fitting these segments using the least squares method, enabling the extraction of droplet size parameters. An experiment was conducted to evaluate the accuracy of both instance segmentation and individual droplet reconstruction. Three water-sensitive paper samples with different droplet coverage levels, specifically 31.36%, 19.82% and 11.07%, were manually annotated to serve as ground truth. These samples contained 152, 91 and 51 adhesive droplets, respectively. In the trial, the proposed method achieved pixel-level segmentation accuracies of 95.35%, 97.47% and 98.81%, and successfully reconstructed 108, 60 and 33 individual droplets, respectively. Results demonstrate that the method can accurately segment droplets from water-sensitive papers and reconstruct the individual contours of adhesive droplets.

Keywords: droplet deposition analysis, image processing, convolutional neural network, instance segmentation, keypoint detection.

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Meteorological conditions and soil management practices affect grapevine canopy segmentation through remote sensing technologies

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Abstract. Green transition of agriculture promotes certain management practices, as the use of cover crops, intended to achieve the goals of the European Green Deal. However, the adoption of these strategies involves some methodological difficulties for crop monitoring using remote sensing, as the case of crop segmentation. The objective of this work was to evaluate the influence of meteorological conditions and soil management strategies on grapevine canopies segmentation. The experimental vineyard (Requena, Spain) considered two soil management practices: use of spontaneous cover crops and soil tillage. Multispectral images were acquired at two contrasted meteorological conditions from a multispectral sensor on board a UAV. Vines canopies were segmented using QGIS applying a variable NDVI threshold approach. The NDVI threshold varied depending on the meteorological conditions, being 0.18-0.22 and 0.46-0.50 under drought and without drought conditions, respectively. Without water stress conditions, the segmentation methodology identified the 98 % of plants, with an average fraction cover (Fc) of 10 % regardless the soil management. Under drought conditions, plants under soil tillage conditions presented a higher Fc in comparison to those with cover crops (7 % vs 5%, respectively), and the segmentation methodology performance resulted more accurate for the soil tillage than for the cover crop treatment (missing plants of 9 % and 18 %, respectively).

In conclusion, the application of variable NDVI threshold segmentation has been shown to be significantly influenced by meteorological conditions and soil management practices.

Keywords: multispectral imagery, vineyard, NDVI, cover crops, drought, stress.

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Innovative vacuum-conveying plant for grape marc handling in winery: operative evaluations and health and safety aspects

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Abstract. In winemaking, grape marc represents the largest fraction on byproducts and can be handled differently within the cellar. Currently, the most commonly used conventional transport systems for marc are not optimized and hold several health and safety issues.
The conventional transfer of grape marc using bins may pose hazards due to mechanical lifting and the use of forklifts; furthermore, they are unsuitable on large distances. Transfer by pumps is also critical for work safety; in addition, marc to be transferred must be wet enough. This is achieved by draining away less of the liquid from the solid fraction at racking, resulting in a loss of free-run wine (higher quality), which is retained in the marc, and extracted as press-wine (lower quality).
The use of vacuum conveying systems provides safer workplaces by allowing operators to work outside the vat (low CO_2 exposure), no moving mechanical parts, as well as quali-quantitative advantages.
Comparative trials were carried out on an industrial scale transferring grape marc from the vat to the press according to two systems: an innovative continuous vacuum conveyor vs a conventional hopper pump. Results obtained from wine analysis and mass balances, showed that the vacuum conveyor has a mild treatment on marc, ensuring the full recovery of potential free-run wine and preventing the 50% from being collected as press-wine. Hence, the added commercial value of the products allows a quick return on investment. Moreover, the vacuum transport ensures greater safety and equal or higher working capacity than conventional systems.

Keywords: Winemaking, Byproducts, Workplace Safety, Grape Marc, Vacuum Transport, Racking.

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A survey to analyse stakeholder perception on Unmanned Ground Vehicles in agriculture

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Abstract. Unmanned Ground Vehicles (UGVs) in agriculture are autonomous or remotely operated machines equipped with GPS, vision systems, sensors, and actuators to navigate and process the work environment for managing specific tasks in open field, orchard, vineyard and greenhouse. They enhance automation, efficiency, and safety while reducing labor costs and promoting sustainability. However, their adoption is hindered by a lack of knowledge, trust in technology, and unclear European regulations. Additionally, many UGVs remain prototypes requiring specialized adjustments with respect to the specific area of operation.

To assess stakeholder perceptions and promote UGV adoption, a survey was conducted at the International Agricultural and Gardening Machinery Exhibition (EIMA) in Bologna in November 2024. The survey, available both in-person and via QR code, involved approximately 350 participants. It focused on farmers' generalities and background, expectation, concerns, and key features of agricultural UGVs. Questions were structured as closed-ended, with single or multiple-choice answer options.

Results indicate that UGVs are widely perceived as innovative and beneficial for improving safety. However, reliability and high cost remain major concerns and represent the main obstacle to the widespread adoption. Vehicles features include 24/7 working capability and flexibility in terms of environmental conditions together with the ability to perform multiple agricultural tasks. Despite the current challenges, UGVs are expected to play an increasing role in agriculture, if cost, reliability and safety will be addressed.

Keywords: Sustainable agriculture, Robot, Automation, Autonomous vehicle, Agricultural field robot

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UAV spot spraying in the traditional cultivation of olive trees in Tuscany

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Abstract. The unmanned aerial vehicles (UAVs) for agricultural spraying are advantageous system for successfully solving operational challenges in crop protection, including complex high-slope scenarios or low-dosage application of plant protection products (PPPs) or spot spraying. In Tuscany, traditional olive cultivation often involves a combination of these factors for the purpose of spraying PPP against *Bactrocera oleae*. This study aimed to analyse the spot spraying performance of the DJI Agras T10 UAV in traditional terraced olive cultivation. To this end, four trials were carried out varying the application volume (0.1 and 3 L tree^{-1}) and the nozzle type (AIXR11002VS and XR11002VS). The spraying analysis focused on the evaluation of spray coverage and deposition on canopy and on ground. The findings demonstrated a significant impact of wind direction on droplet deposition, both for the AIXR11002VS and the XR11002VS nozzles, and for both canopy and ground deposition. This is due to the elevated application height of the UAV (6-7 m above ground level). The XR11002VS nozzles ensure the presence of droplets on the downside of the leaves for both low and high dosage applications. The low-dosage application (0.1 L tree-1) facilitates the localisation of spraying to a single side of the olive tree, as recommended by some pest control baits. In conclusion, the utilisation of low-dosage UAV spot spraying ensures optimal performance in terms of spraying deposition. Conversely, the implementation of high-dosage application needs a distinct strategy for the plan-ning of the spraying path to ensure sufficient coverage of the entire canopy.

Keywords: Drone, Low dosage, Plant Protection Products, Precision Agriculture, UAV.

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European Artificial Intelligence Act: potential effects on agricultural autonomous tractors and vehicles

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Abstract. Artificial Intelligence (AI) represents one of the most important frontiers of contemporary innovation, with increasingly transversal applications that are redefining the production, decision-making and operational paradigms in the agricultural sector. Faced with the difficulties involved in defining artificial intelligence and regulate its practical applications, the European Commission has accomplished, in recent years, a regulatory path to provide a framework for developers and users. This led to the adoption of the 2024/1689 European Regulation, also known as AI Act. In the light of the AI Act, the implementation of artificial intelligence systems in the design of autonomous tractors and vehicles is considered a high-risk application in terms of safety. Consequently, a certification process delegated to a third party is deemed a needful approach.
Nowadays in Europe agricultural tractors and vehicles are covered by dedicated regulations outlying the requirements and paths for the certification.
An analysis of the current regulations for agricultural tractors and vehicles is performed with respect to the AI Act provisions to understand how to address the design and trade of autonomous agricultural tractors and vehicles in the European countries. In the light of this, by cross-referencing and interpreting the current regulations, it appears feasible to adapt both autonomous tractors and vehicles integrated with artificial intelligence systems to the safety requirements.

Keywords: Artificial Intelligence; Unmanned Ground Vehicles; European Regulation; Safety performance

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Farm machinery fleet management through a new generation of ag-software: a case study

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Abstract. Acquiring data on the activities performed by agricultural machinery has become a critically important opportunity to improve performance and detect critical situations and anomalies at an early stage that can affect farmers' income, quality of work and thus safety, health and leisure.
Native connection of farm equipment to dedicated software, in addition to the CANBUS and ISOBUS connection systems, enables the full range of possibilities related to telemetry, integrating and translating data from tractors connected to operating machinery to make farms more economically competitive and more environmentally sustainable.
In this way, work activities can be planned in advance with the dedicated software so as to reduce the setup time in the field while tasks will automatically appear on the tractor monitor as soon as the machine with connectivity enters the field.
The objective of this work is to acquire data from tractors equipped with Agriculture 4.0 technology and monitor all field operations, road travel and downtime to obtain accurate reporting on work and travel times, worked areas, productivity, fuel consumption and other engine and emissions metrics. The ultimate goal is to determine the costs of crop operations, energy uses and emissions. Data were collected on a tractor used for one crop-year and included harrowing with three different harrows and seeding operations with a pneumatic seeder. The farm is located in Pietraperzia territory, Enna province in the internal areas of Sicily (Italy), characterised by a Mediterranean climate, where cereals and legumes are cultivated.
The acquired data set allows for the evaluation and improvement of worksite logistics on a per-crop operation basis.

Keywords: Data acquisition, Precision Agriculture, Emission reduction, Crop management, Telemetry

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Design and Development of an Innovative Furrow Opener for Sustainable and Efficient Seeding

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Abstract. Innovation in mechanical component design is crucial for improving agricultural machinery efficiency and sustainability. This study presents the development of the "New Furrow Opener," designed to optimize performance in no-till and conventional seeding systems.

In a no-till seeder, the furrow opener creates precise soil grooves for seed placement while minimizing disturbance. It ensures optimal seed-to-soil contact, enhancing germination and plant growth. Its adaptability allows effective performance across various soil types, improving efficiency and preserving soil structure. The main objectives are reducing energy losses, enhancing adaptability, increasing durability, and lowering production costs. The "New Furrow Opener" features a modular design integrating advanced materials and optimized geometries through numerical simulations. It consists of multiple metal plates, assembled with pins and nuts for quick replacement in case of damage or wear. The manufacturing process uses advanced technologies to ensure precision, quality, and sustainability. Components were produced using CO_2 laser cutting and steel alloys to reduce weight while improving strength and abrasion resistance. A comprehensive validation process was conducted through laboratory and field tests. Virtual simulations confirmed design optimization, followed by field tests comparing performance with a standard furrow opener. Three-dimensional laser scanner images highlighted differences, and tests across various soil types demonstrated its versatility.

This study represents a significant advancement in mechanical component design, combining sustainability, energy efficiency, and adaptability. The "New Furrow Opener" meets current agricultural needs and provides a foundation for future mechanical systems.

Keywords: Furrow Opener, No-Till Seeding, Agricultural Machinery, Sustainable Design

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Comparison of four types of skidders: performance and production costs

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Abstract. Cable skidders are the most used timber extraction machines in Central and Eastern Europe. Cable skidders and many adapted skidders were used to increase productivity and to reduce labor. This work compared the work cycles, productivity and costs of four types of skidders investigated in similar coniferous stands: a dedicated cable skidder, a dedicated cable-grapple skidder, a dedicated grapple skidder and an adapted skidder. The comparison of delay-free work cycles of the four skidders showed the largest share is occupied by travel loaded. The cable-grapple skidder demonstrates the highest average speed of 5.6 km h^{-1}, followed by the grapple skidder at 3.97 km h^{-1}, the cable skidder at 3.79 km h^{-1}, and the adapted skidder with an average speed of 3.31 km h^{-1}. The average delay-free productivity of the studied skidders is highest for adapted skidder (17.93 m^3·PMH^{-1}), followed by grapple skidder with a slightly lower rate (17.90 m^3·PMH^{-1}), the cable-grapple skidder (17.25 m^3·PMH^{-1}), and cable skidder (14.53 m^3·PMH^{-1}). In conclusion, the average payload of the grapple skidder and the cable grapple skidder is less than the maximum payload of the machine. This is due to the narrow skidding roads and because these skidders are not suitable for the specific site-selective felling with marked single and small groups of trees. The dedicated cable skidder and the adapted cable skidders are very close in productivity.

Keywords: forest operations; mechanization; productivity; time-motion study.

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Semi-anechoic chamber to assess the Electromagnetic Compatibility of Tractors and Unmanned Ground Vehicles for agriculture

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Abstract. The recent revolution in agricultural mechanization is integrating advanced robotics into crop management, including the use of Unmanned Ground Vehicles (UGVs). Additionally, the new European directives aimed at reducing pollutant emissions from internal combustion engines and promoting environmental sustainability are driving the introduction of electrically propelled tractors and agricultural machinery, as well as the replacement of hydraulic actuation systems with electric actuators on attached implements.

These technological innovations require increased attention in terms of electromagnetic prevention and protection for sensitive equipment, as the electromagnetic emissions generated can be transferred to other devices and electronic systems on the machine via conduction or radiation, as well as to the external environment. Moreover, during the normal operation of the vehicle, electromagnetic interference immunity must be ensured, as such interference can disrupt electrical and electronic devices, causing malfunctions or operational failures. In agricultural autonomous vehicles, electromagnetic emissions and immunity to interference are even more critical as they could compromise proper operation within the designated working area.

The Laboratorio di Meccanica Agraria of the University of Bologna is expanding its testing equipment with a semi-anechoic chamber, financed by the PNRR Agritech project, for measuring radio disturbance levels in agricultural tractors and UGVs. The existing testing procedures for ensuring compliance with electromagnet-ic compatibility (EMC) requirements (i.e. RVFSR 2015/208 and UN/ECE R10 rev.6) assessed for conventional agricultural tractors will be evaluated, in terms of applicability and suitability to the integrated electrical systems and devices of autonomous agricultural vehicles in order to define updating actions if required.

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Agrivoltaics to power electric tractors: first results from an energy farm

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Abstract. Agrivoltaics and electric tractors represent an innovative combination to address climate challenges and improve agricultural sustainability.
Agrivoltaic structures allows the renewable energy production on farmland, and to feed electric power for tractors and other farm machinery. The combination of agrivoltaic power and electric tractor was experimented in a plant located in the territory of Borgo Virgilio (Mantua). The experimentation was done in cooperation with New Holland, REM Tec, Hubfarm and XFarm. The agrivoltaic parcel covers 14 hectares entirely dedicated to rotational herbaceous crops. The plant is featuring a bi-axial solar-tracking photovoltaic modules designed to maximize solar power production while keeping agricultural land full available for cultivation. The results show that the use of a 55 kW New Holland T4 electric tractor, powered by a 110 kWh battery that is charged via an agrivoltaic system, not only contributes to the reduction of greenhouse gas emissions in cultivation operations by improving the overall energy efficiency compared to a tractor powered by an internal combustion engine, but also achieves energy self-sufficiency on the farm. However, some limitations emerge, such as battery loading cycles, which can be critical during energy-intensive farming operations. At present, the upfront cost of electric tractors, which is closely linked to the use of lithium-ion battery could represents another obstacle, necessitating the development of cheaper and more suitable battery technologies. Despite these challenges, the integration of agrovoltaic systems and electric tractors offer further potential like carbon credit to support energy transition in farming.

Keywords: Agrivoltaics, Sustainability, Solar Panels, Zero Emissions, Renewable energy, Electric agriculture, Electric tractor.

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Automated Detection of Grapevine Leafhopper Infestations Using YOLO: Balancing Dataset Diversity and Real-World Performance

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Abstract. This work focuses on the development of an automated system for detecting grapevine leafhopper infestations, emphasizing the role of data diversity and partitioning strategies in achieving reliable model performance. Leveraging advanced deep learning techniques, specifically the YOLO (You Only Look Once) object detection model, the study aimed to deliver a practical tool for vineyard pest management, supporting optimized crop protection and promoting sustainable agricultural practices. Over, a comprehensive dataset was created, featuring over 2,500 expertly annotated images of symptoms categorized by berry color (red or white) and symptom severity (early or severe), resulting in four distinct classes: "red_severe", "red_early", "white_severe", and "white_early." The YOLO model demonstrated strong detection capabilities, achieving a mean Average Precision (mAP) of up to 0.988 for specific classes (namely "red_severe"), although challenges remained for symptoms like "white_early" that are often barely visible. A critical contribution of this study lies in highlighting the importance of dataset diversity, showing that proper data partitioning across different grape varieties and locations ensures realistic assessments of model performance. In contrast, random partitioning overestimates model accuracy and reduces generalizability. Furthermore, merging early symptom classes improved detection rates, offering timely identification of infestations to enable earlier interventions. This research underscores the potential of YOLO-based object detection systems to enhance vineyard pest management by enabling precise, efficient detection of leafhopper infestations under real-world conditions. By addressing the importance of dataset diversity and partitioning, this work contributes to the development of scalable, reliable solutions for sustainable and precision-viticulture.

Keywords: Precision Agriculture, Leafhopper Infestation Detection, Deep Learning, Object Detection.

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Hydrological response of green roof microcosms under Mediterranean climatic conditions

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Abstract. Green roofs are multi-layered systems that significantly reduce the runoff volume and mitigate the flow peaks entering the sewer system through hydrological processes of rainfall retention and runoff detention. This study aimed to quantify and model the hydrological response of different combinations of substrate and drain in terms of retention, detention capacities, and delay in peak flow. Three commercial substrates manufactured by HARPO Verdepensile® and three drainage layers (preformed plastic system, expanded clay, and expanded perlite) were considered. The outflow drainage and the volume of water retained by the multi-layered system were measured during simulated rain experiments at rainfall intensities of 30, 60, and 100 mm h^{-1}. Two initially substrate moisture conditions were investigated: *i*) air-dried substrate, D and *ii*) substrate wetted to field capacity, W. Independently of the considered substrate-drain combination, green roof retention, detention and peak delay for D conditions were statistically higher than for W one (P = 0.05), thus suggesting that the initial substrate moisture condition affects the hydrological response. For a given initial condition (i.e., D or W) significant differences in retention, detention, and peak delay were found between the tests conducted at 30 mm h^{-1} and those at 60 and 100 mm h^{-1}, while no differences were observed between tests conducted at 60 and 100 mm h^{-1}. This indicates that beyond a certain rainfall intensity, the green roof hydrological response is unaffected. A simple reservoir model was applied to the experimental data to obtain a set of functional parameters calibrated for Mediterranean climate conditions.

Keywords: Rainfall retention, runoff detention, green roof, substrate, drainage layer, rainfall intensity.

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Fluorimetric survey on Sardinian artichoke ecotype: a comparison between organic and conventional management

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Abstract. The evolution of innovative techniques, particularly through Precision Agriculture methods, are vital for enhancing crop yield and quality. Crop management is a critical aspect of the horticultural sector due to the complexities and costs associated with producing commercially viable products. To preserve the commercial value of crops under sustainable management, it is essential to manage plants rationally, especially in organic management, which requires special attention in distributing nutritional inputs and cultivation techniques. The study investigates the Spinoso sardo globe artichoke varietal type on a multitemporal survey, analysing the physiological differences between the conventional crop management and two different organic management systems: one including a catch crop between two main artichoke cropping cycles, and the other adopting a biennial rotation of artichoke with cauliflower, through a Multiplex Force-A (MFA) fluorometer. The study identified physiological and nutritional variations during the artichoke's growth cycle across different cultivation systems. The MFA analysis identified a high physiological variability between the managements. The study of fluorimetric indices revealed significant differences among the theses monitored through ANOVA statistical analysis and the Tukey test, observing higher values on the conventional system in chlorophyll and nitrogen content despite the organic systems, which showed higher values on stress index, especially during the final survey. The MFA application in the three different crop management systems demonstrates the sensor reliability and its capability to indicate physiological differences between plots, making the MFA a suitable tool for the fluorimetry application as a fast response tool to support monitoring and control operations in horticulture.

Keywords: Precision Agriculture; Multitemporal Survey; Fluorescence Indices; Organic and Conventional Management.

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Developing equations to estimate rainfall erosivity from coarse time resolution precipitation data in southern Italy

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Abstract. Rainfall erosivity represents a pivotal element of the Revised Universal Soil Loss Equation (RUSLE) and its precursor, i.e. the Universal Soil Loss Equation (USLE). In the present study, two new empirical relationships were developed and compared with eight existing empirical equations. The analysis was carried out using 10-minute rainfall data from 2004 to 2023, available at 335 automatic rain gauge stations across three pilot regions in southern Italy (Campania, Sardinia, and Sicily), which allowed the calculation of 132,609 benchmark values of mean annual rainfall erosivity. The first proposed model is parsimonious and exploits two compound meteorological predictors, namely the rainfall episodicity index and the rainfall concentration ratio, obtained from daily aggregated rainfall data (i.e., mean annual rainfall, Gini's coefficient of daily rainfall distribution, mean annual number of rainy days). The second model is multi-parametric and includes geographic and topographic covariates. The two proposed models outperformed the eight existing equations based on several statistical performance metrics, including the root mean square error, the mean error, the adjusted coefficient of determination, the Kling-Gupta efficiency, and the Akaike information criterion. The findings yielded significant insights, paving the way for future studies to assess the transferability of the models to other areas of the Mediterranean Belt.

Keywords: Soil erosion, RUSLE, R factor, Daily rainfall erosivity models, Gini's coefficient

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Environmental impacts assessment of gaseous emissions from livestock farms for meat production in Italy

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Abstract. It is widely recognised that livestock farming is one of the most environmentally impactful agricultural activities. The livestock buildings are a significant source of pollutants and gases, such as methane, ammonia, and particulate matter. This study focused on the pollutant emissions from livestock farming for meat production in Italy. The examined livestock farms included cattle, buffalo, sheep, goats, fattening pigs, and sows. Starting from emission estimation based on the guidelines provided by the Intergovernmental Panel on Climate Change (IPCC), Life Cycle Impact Assessment (LCIA) was applied with the aim of assessing the environmental impacts (EIs) of gaseous emissions at the territorial level in each region of Italy. The research findings indicated that the most significant EIs associated with gaseous emissions are Global warming and Photochemical oxidation. Other significant EIs include Human toxicity, Acidification, and Eutrophication. In detail, EIs have been quantified for each gas and species, and the results have been presented through thematic maps produced by using Geographical Information System (GIS) tools.

Keywords: livestock farms, life cycle impact assessment, emission estimation, global warming, environmental impacts, Geographical Information System

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Ammonia spatial variability and estimation of yearly emission factor in a naturally ventilated dairy barn in Sicily

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Abstract. Ammonia (NH_3) and greenhouse gas emissions from naturally ventilated dairy barns are generally estimated by using indirect methods, where the selection of sampling points is relevant both at horizontal and vertical locations. This study aimed at evaluating spatial variability of gas concentrations to estimate NH_3 emissions in a naturally ventilated dairy barn located in Sicily (Italy). Data were acquired from September 2021 to September 2022 in a cubicle free-stall dairy barn at different horizontal and vertical sampling locations. Concentrations of NH_3 and carbon dioxide (CO_2) were continuously measured by measurement devices based on the photoacoustic spectroscopy method. In addition, microclimatic variables (i.e., temperature, relative humidity, wind speed, and wind direction) were recorded by sensors installed inside the barn. Data were organised in a dataset to statistically analyse gas concentrations and, then, based on CO_2 mass balance method, emissions were estimated.

Results of the study increased knowledge on the spatial variability of gas concentrations in Mediterranean barns with statistical differences between sampling locations. In addition, this study also provided the yearly ammonia emission factor for this barn typology, based on the estimation of emissions.

Keywords: dairy farm, carbon dioxide mass balance method, ammonia, emissions, concentrations

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Potential biomethane generation from frass in insect-based protein production systems

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Abstract. Insect-based protein production has rapidly gained popularity, resulting in the increased generation of frass - the residual substrate from insect farming. Despite its theoretical potential, the energetic value of frass remains underexplored. This study investigates the feasibility of biomethane production via anaerobic digestion from the frass of *Tenebrio molitor* (TM) and *Hermetia illucens* (BSF), two of the most widely farmed insect species for food and feed. Frass derived from eleven rice by-product diets (six for TM and five for BSF) was analyzed for physicochemical composition and biochemical methane potential (BMP). BMP tests were conducted under mesophilic conditions (40°C) in 5 l plexiglass bioreactors over 23–34 days. Reaction tanks were loaded with a 1:1 mixture of inoculum and substrate based on total solids. The BMP values for TM and BSF frass were ~230 $l \cdot kg^{-1}$ VS and ~170 $l \cdot kg^{-1}$ VS, respectively, which is comparable to commonly digested substrates such as livestock manure, fruit and vegetable waste, and organic fractions of municipal solid waste. Statistical analysis revealed no significant differences in BMP among the eleven diets, indicating that anaerobic digestion is a viable method for valorizing frass from TM and BSF, independent of the insects' diet.

Keywords: Anaerobic Digestion, Biomethane, Black Soldier Fly, Mealworm, Bioenergy Production.

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Effectiveness of physical and enzymatic pre-treatments on biogas production and struvite precipitation from digestate

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Abstract. The use of pre-treatments on input feedstock before anaerobic digestion process is a common strategy to enhance biogas production or improve the chemical properties of the obtained digestate. When mechanically separated, phosphorous (P) and nitrogen (N) tend to accumulate, respectively, in the digestate solid and liquid fraction, contributing to soil and water pollution when land applied. In this context, one of the most promising methods of recovering P and N from livestock waste is the precipitation of struvite ($NH_4PO_4Mg \cdot 6H_2O$), a natural mineral used as a slow-release fertilizer. To be recovered in form of struvite, organic P must be solubilized and transferred from the digestate solid part to the liquid part. This study aims to investigate the effect of various physical and enzymatic pretreatments on biogas production and organic P solubilization to improve the precipitation of struvite and maximize P and N recovery from digestate. Hydrodynamic cavitation, enzymes for organic matter degradation and organic phosphate hydrolysis enzymes (phosphatase and phytase) have been tested. Laboratory experimental batch trials have been performed according to UNI/TS 11703:2018 official guidelines. After struvite precipitation from the liquid fraction of the obtained digestates, the different derived minerals have been chemically characterized in terms of purity and carbon content. Experimental results will be presented to identify the best options for digestate pretreatment. This work was financed by the European Union´s Horizon Europe research and innovation program for the ECONUTRI project (Grant Agreement number 101081858).

Keywords: Anaerobic digestion, hydrodynamic cavitation, enzymes, phosphorous, nitrogen.

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On the environmental impact of lawn mowing operation in urban area, a case-study in Florence (Italy)

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Abstract. It is beyond a shadow of a doubt that urban greening plays a major role in providing ecosystem services. It can afford both regulating service, such as air filtering, noise reduction, microclimate regulation, and cultural services, such as recreation, aesthetic, spiritual services, and so on. Thus, urban green areas greatly contribute to the human well-being. Within this framework the environmental sustainability of the maintenance operations of these spaces is a crucial aspect, so that without sustainability most of the above services would disappear or be fictitious. Lawns are a vital component of parks, residential garden, green streets and more in general of the green infrastructure belonging to a metropolitan district. Lawns maintenance mainly relies on mowing operation which almost always entails using of fossil fuel driven lawn mowers. This depict a potentially trouble scenario if understood under the perspective of climate change and related issues. In the present paper, data from some field trials about lawn mowing performance (field capacity, efficiency, unit energy requirement) in the municipality of Florence (Italy) are presented. Based on these data, a simplified Carbon Footprint Model was built with the aim of better understand the environmental load of mowing practice in urban context.

Keywords: LCA; GWP; garden machinery; turf mowing; self-propelled mower; sustainable city.

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Evaluating the Environmental Benefits of Agricultural Robots: Insights from Effective Implementation Practices

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Abstract. The agricultural sector is facing a growing pressure to balance increasing food demands with the urgent need for sustainable resource management. In response, agricultural robots (AgBot) are emerging as an interesting technology to address this challenge. AgBot are designed to perform various tasks in the agricultural field, such as data collection for field monitoring and agricultural practices for soil and crop management, with high precision and minimal human intervention. This study aims to review and analyze research on the potential of agricultural robots to enhance sustainability and evaluate the environmental trade-offs associated with their use compared to traditional agricultural practices. A systematic and critical review of the literature was carried out following PRISMA guidelines. The Scopus and Web of Science databases were used to find relevant research studies on the AgBot sustainable implementation in agriculture.

Recent studies reveal that AgBot, especially if powered by electric or hybrid system, can reduce greenhouse gas emission while minimizing resource waste such as fertilizer and water. Moreover, the benefits provided by environmentally friendly powering systems could be partially reduced by the energy intensive production of batteries and the limited recyclability of their components. The finding emphasizes that adopting AgBot can contribute significantly to enhancing agriculture sustainability, provided that their design and deployment are guided by comprehensive sustainability evaluations.

Keywords: Autonomous Ground Vehicle, Agriculture sustainability, Agricultural robots, Terrestrial drones, Unmanned Vehicle

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Energetic valorization of olive oil industry residues

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Abstract. Olive oil extraction process generates huge amounts of wastes in short periods of time, representing a relevant environmental problem in Mediterranean areas. The three-phase system generates two by-products: dry olive pomace (DOP), a solid residue, and olive mill wastewater (OMWW), an efflu-ent generally spread in olive grove. The two-phase system produces wet olive pomace (WOP) exclusively. All olive mill biowastes have chemical properties (low pH, high volatile solids and polyphenols content) which can negatively impact soil properties and water quality if improperly managed. In this context, the anaerobic digestion process (AD) is an interesting method for olive oil bio-wastes upcycling, allowing energy recovery, biogas and digestate production. This study focused on the energetic valorization of different samples of OMWW, DOP and WOP via AD process to investigate the Biological Methane Potential (BMP) and biogas production dynamics. Laboratory batch trials were performed according to UNI/TS 11703:2018 official guidelines under mesophilic conditions for 40 days, by using a typical digestate liquid fraction as inoculum. Each trial was performed in quadruple and was composed of a mixture of biomass and inoculum with 1:2 ratio on volatile solids content. Experimental results showed that WOP without olive stones and OMWW reported the highest BMP values (576 L_N kg_{VS}^{-1} and 541 L_N kg_{VS}^{-1}) with an average methane con-tent of 58% for both biomasses.

Keywords: Dry olive pomace, olive mill wastewater, wet olive pomace, anaerobic digestion, Biochemical Methane Potential.

Acknowledgements: This research is funded by Next Generation EU - National Recovery and Resilience Plan (PNRR) - Mission 4, Component 2, Investment 1.4, National Research Centre for Agricultural Technologies-AGRITECH, identification code: CN00000022, CUP: D13C22001330005.

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Evaluating Droplet Size from Spray Nozzles Using Grayscale and RGB Image Processing Techniques

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Abstract. Image analysis is widely applied across various fields, including agriculture, where it plays a crucial role in studying the spray application of plant protection products (PPPs). Regardless of the field of application, image analysis must address the challenge of separating objects of interest from the background through segmentation. This process can be facilitated by selecting appropriate thresholding algorithms or applying suitable image enhancement techniques. Among these techniques is the decomposition of an image into its individual red, green, and blue channels, followed by the analysis of each channel to improve contrast, reduce noise, and optimize image segmentation overall.

The aim of this study was to compare the information extracted from grayscale, green channel, and blue channel images for measuring droplet size of spray nozzles. Four nozzle-pressure combinations were considered: TP11001 at 0.45 MPa, TP11003 at 0.30 MPa, TP11006 at 0.22 MPa, and TP8008 at 0.20 MPa. Droplet RGB images were obtained using the Liquid Immersion procedure: Petri dishes containing silicone oil were sprayed with a mixture of water and Red Ponceau food dye and then photographed with a high-resolution DSLR camera. Images were analyzed using ImageJ software, considering grayscale as well as green and blue channel images. The red channel was excluded due to its poor performance. All images were binarized using the Otsu's thresholding algorithm and processed to extract the information necessary to determine the droplet size distribution.

Although data analysis is ongoing, preliminary observations suggest that differences in characteristic diameters may be observed depending on the type of the image analyzed (RGB or single channel).

Keywords: Phytosanitary treatment, Spray, Drop size spectrum, Image analysis, ImageJ, RGB Channel Splitting.

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Energy performances of a building-plant system equipped with a hybrid configuration of living wall

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Abstract. Natural ecosystems integrated into building envelopes enhance energy savings and environmental sustainability by promoting urban transformation. The abundant availability of surfaces on the building facades suggests the implementation of living walls to address these targets. The paper introduces the energy performance of a building-plant system in which façades are equipped with greenery and alternated PV panels to take advantage of the limitation of the surrounding air temperature and increase the power output. Using real climatic data, energy performances for a reference building-plant system located in the Mediterranean area will be determined assuming the employment of an electric heat pump in the TRNSYS environment. The model will be able to consider the evapotranspiration of vegetal species, the thermal drift of PV cells and real power absorbed from the heat pump in order to quantify the benefits in terms of energy-building labelling. This paper aims to provide significant information for the design of highly efficient buildings by the application of the proposed hybrid solution and when implemented as a renovation intervention in existing structures.

Keywords: Natural ecosystem, living walls, hybrid configuration, BIPV, building energy performance, TRNSYS simulations.

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An open-source platform for tracking carbon dioxide levels in soil: proof of concept and prototype

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Abstract. Carbon dioxide monitoring sensor technology has found applications in many sectors, including environmental monitoring. Its development and dissemina-tion have been driven by the potential danger of carbon dioxide in enclosed, poorly ventilated, and crowded spaces. This need has led to the development a wide range of low-cost sensors. In this study, an open platform based on open-source hardware was created using the Sensirion SCD30 sensor to monitor car-bon dioxide emissions from agricultural soils, with the aim of correlating emis-sions with microbial activity. The first objective was to verify the sensor's relia-bility at concentrations higher than those for which it is designed. To achieve this, the experimental design shown in Figure 1 was followed, generating in-cremental levels of CO_2 from 100 to 20000 ppm through the controlled intro-duction of pure gas. As further validation, the levels were also measured by the Innova 1512 from LumaSense Technologies. After validation, a comparative performance test between the two sensors was conducted. For the experiment, 18 pots with a diameter of 260 mm and a volume of 12 L containing 6 soil sam-ples each, for 3 replicates, were used. Static chambers were used to allow gas accumulation, as shown in Figure 2. The low-cost open-source prototype demonstrates the potential of a new tool in agricultural research, with high ver-satility, adaptability, and user-friendly functionality. The collected data opens the possibility for a microbiological study.

Keywords: CO_2, Environmental monitoring, Soil health, Microcontrollers, Precision agriculture, Static chamber.

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Development of a Monitoring System for Food Waste Assessment based on Computer Vision

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Abstract. In collective restoration, automated food waste assessment is essential for effective waste reduction since manual weighing and surveys are time-consuming and imprecise. A device was created to systematically track food waste on trays in real-time by combining artificial intelligence with RGB-D image processing. Food remnants were photographed in RGB-D using a depth camera. After that, each image is processed by a deep learning model that uses visual and spatial features like texture, color, and shape to reliably classify each pixel into food categories. This process is known as semantic segmentation. Depth information was used to calculate the amount of food that is left over the tray. High overall precision in trash recognition was attained by this automated approach, with improved outcomes for more represented categories. Direct measurements of tray leftovers were used to quantify waste, and the results were calibrated against standards for the more represented waste categories. Sensitivity analysis assessed the reliability of the gathered information. This technology offers the chance to analyze waste drivers, discover patterns, and uncover inefficiencies in food consumption by facilitating precise and systematic food waste monitoring. In line with more general sustainability objectives, these insights enable collective food services to carry out focused interventions, maximize resource allocation, and eventually help achieve notable decreases in food waste.

Keywords: Semantic Segmentation, Deep Learning, RGB-D images, Food Waste Assessment

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Thermodynamic Study of an Integrated Pyrolytic Process Aimed at Enhancing Overall Energy Efficiency and Reducing Environmental Impact

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Abstract. In traditional industrial pyrolytic systems, heating is achieved by burning a portion of the material in a highly exothermic process that reaches temperatures exceeding 1000 °C. This approach results in: an initial gasification process leading to the formation of toxic compounds; the establishment of an inert hot gas flow, generally nitrogen (N_2), within the system, which tends to dilute the syngas, reducing its calorific value and increasing the risk of undesirable byproducts.
In the low-environmental-impact pyrolytic process patented in Italy (Patent No. 102017000092437), a pretreatment involving micronization and the use of a continuous plug-flow reactor are proposed. In this reactor, combustion gases from a syngas engine circulate externally at temperatures exceeding 550 °C, maintaining the internal system temperature at 500 °C. Along the reactor's axis, and in every section of it, a steady-state "pyrolytic" condition is established. The heating of micronized biomass occurs through the recirculation of syngas mixed with superheated steam. Solar energy, concentrated by a paraboloid, is split into two wavelength fractions: IR and UV. The IR fraction is used to superheat the steam, while the UV fraction, together with microwaves (MW) generated by a magnetron powered by electricity from a generator connected to the syngas-purified internal combustion engine, is utilized in high-reactivity zones (heating zone and material input zone).
In this study, a mass and energy balance of the process was conducted to demonstrate the superior efficiency of the proposed system.

Keywords: Pyrolysis, Modelling, Energy saving.

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An attempt to assess *Vitis vinifera* (L.) water status by integrating stomatal conductance and UAV imagery

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Abstract. In the Mediterranean basin, drought and irrigation might significantly impact viticulture, grape composition and wine quality. Therefore, the assessment of the vine water status and its spatial variability is crucial to optimise the water management. This study aimed to evaluate the spatial variability of vine water status assessed by using (i) imagery from an unmanned aerial vehicle (UAV), equipped with a multispectral camera, and (ii) vine-based leaf stomatal conductance (gs) (Li-600 porometer). Trials were performed in Basilicata (Southern Italy) during the 2024 growing season in a flat, drip-irrigated vineyard (*cv* Primitivo / 157-11 C – 2.5 × 1.1 m). Vines were trained at vertical shoot positioned trellis and Guyot-pruned. The soil homogeneity was preliminarly checked using an electro-magnetic induction sensor ensuring that potential confounding variables were not affecting results. Two irrigation treatments were imposed: well-watered (WW) and drought-stressed (DS). The UAV flight was conducted on 2nd of August, and gs was measured on 29th of July on 93 leaves and 2nd of August on 119 leaves. On 29th of July, gs was 0.203 ± 0.014 and 0.162 ± 0.011 mol m^{-2} s^{-1} in WW and DS, respectively. On 9th of August, the gs was 0.227 ± 0.021 and 0.151 ± 0.011 mol m^{-2} s^{-1} in WW and DS, respectively. Vegetation indices (e.g. NDVI or NDRE) from UAV imagery were also evaluated and correlated to gs and field data.
This study was supported by the Agritech National Research Center, founded from the European Union Next-Generation EU, CN00000022, CUP: C33C22000250001.

Keywords: UAV, drought stress, EMI, porometer, soil, precision viticulture.

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Environmental Monitoring for Contamination Risk Assessment in Food-Handling Facilities: A Sensor-Based Approach

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Abstract. Contamination in food-related environments poses significant challenges, necessitating innovative new strategies for its detection, monitoring, and prevention. Ensuring food safety environment within manufacturing or storage buildings requires the development of advanced preventive technologies capable of minimizing contamination risks. This study focuses on the development of a novel approach aimed at monitoring critical environmental parameters, such as temperature, humidity, and airborne gases, which can dissolve into food solutions and compromise both their safety and organoleptic properties. The proposed approach features an output capable of delivering clear, real-time feedback on the environmental conditions, enabling prompt corrective actions. By integrating precise detection with user-friendly communication, this system bridges the gap between environmental monitoring and operational decision-making in food-handling facilities. This research not only contributes to enhancing contamination assessment techniques but also offers valuable insights into the dynamic relationship between environmental factors and food safety, advancing the field of contamination prevention in food production and storage environments.

Keywords: Food, sensor, safety, buildings, contamination, prevention.

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Groundwater Recharge in the Padana Plain: Irrigation as a Driving Force

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Abstract. Historically, the Padan Plain has been characterised by extensive agricultural expansion and intensification of production, relying heavily on intensive irrigation supported by widespread traditional surface irrigation systems. These systems draw water mainly from rivers and distribute it through an extensive network of canals. In addition to increasing and securing crop yields, they contribute to groundwater recharge, which mitigates river droughts and seasonal fluctuations in surface water availability. Accurate estimation of irrigation-related groundwater recharge is therefore crucial but remains under-studied due to the complex hydrology of the region and lack of data.

Within the framework of the MidAS-Po project, a methodological approach was developed and applied for estimating the groundwater recharge. On the one hand, the agro-hydrological model IdrAgra-Po was implemented to simulate daily soil water balance, obtaining the recharge from agricultural fields and open surfaces; the model incorporates inputs like agro-meteorological data, soil hydro-pedological properties, land use and water table depth. On the other hand, groundwater recharge due to seepage from the extensive networks of irrigation canals was estimated using a simplified methodology based on data on irrigation networks and seasonal water volumes from the national agricultural information system SIGRIAN.

Preliminary estimate of groundwater recharge associated with irrigation practices highlights the important role of irrigation on aquifer replenishment in the Padana Plain. However, further efforts are needed, involving stakeholders, to enhance the quality of input data, particularly regarding local irrigation methods and practices, land use, and the volumes of water diverted from rivers or extracted from aquifers.

Keywords: Irrigation systems, Groundwater recharge, Agricultural water bal-ance, Agro-hydrological model, Padan Plain

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Correlation between agrometeorological variables measured inside and outside greenhouse and spatialization through remote sensing imagery

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Abstract: Agrometeorology has been demonstrated to play a critical role in several aspects regarding the crop management. Meteorological stations are mostly located outdoor, thus they do not measure the actual conditions need to the management of crops growth under greenhouses. The aim of this work was to develop a model that correlates the agrometeorological conditions inside and outside a greenhouse planted with tomato.

For this purpose, two agrometeorological stations were installed, one inside and the other one outside a greenhouse located at Santa Croce Camerina (RG). Data was collected over three months at a 15-min frequency. The model was trained on two-thirds of the data, randomly sampled from the entire dataset, and validated on the remaining one-third. The obtained model was spatialized using the agrometeorological data from ERA5, applying it uniquely to the greenhouses identified from the classification of remote sensing imagery from PRISMA satellite.

Main results showed a good correlation in terms of solar radiation and air temperature measured inside and outside the greenhouse. A lower performance was obtained for relative humidity and especially wind speed. From the spatialization of the above-obtained relationships, distribution maps of the agrometeorological variables were generated thus simulating the expected conditions under greenhouse with similar conditions to the one utilized to create the model.

In conclusion, this study has allowed to estimate the main agrometeorological variables inside the greenhouse from the external conditions, providing a useful tool for crop management applications. Future effort should be paid to better characterize the model including additional co-variables (e.g., crop type, type and status of greenhouse cover material).

Keywords: Tomato greenhouse, Crop management, Solar radiation, Plant disease, Spatial modeling.

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A novel green wall system for high sustainable buildings

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Abstract. In recent decades, there has been a significant increase in energy consumption related to buildings, with energy saving becoming a priority and a fundamental element of environmental sustainability. This increase can be at-tributed to atmospheric phenomena that are becoming increasingly extreme, with average temperatures significantly high in summer and extremely low in winter. Moreover, most of the rural building heritage is characterized by con-structions with criteria that are not suitable for passively maintaining internal thermal comfort. One of the most viable solutions for new and existing build-ings is the installation of heat-insulating cladding to the building envelope. Among the various existing types of such cladding, those that are most envi-ronmentally sustainable are green walls system. This paper proposes a new type of green wall system that adds the excellent thermal insulation characteristics of cork to the thermal benefits associated with the effects due to vegetation. The structure of the green wall is made of cork, with pots containing the growth substrate for a wide variety of plants. The system is designed to allow for ex-cess water to be recovered, and it is equipped with a watering system for the plants irrigation. In this paper an evaluation was conducted to analyze the main properties, of the green wall system proposed, the results highlighted the system performance to moderate the building thermal behavior during both cold and hot weather conditions.

Keywords: Green wall; sustainability; cork; heat-insulating; thermal comfort.

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Potential Use of Digestate and Biochar as Biofertilizers for Mitigating Land Degradation in Rural Areas: A GIS and Remote Sensing-Based Approach

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Abstract. Every year, approximately 20 million hectares of fertile land are subjected to degradation: land degradation is a complex phenomenon which includes geographical, ecological, climatical, and socio-economic aspects, whose total economic cost has been estimated to value USD 6.3–10.6 trillion annually.
Monitoring degradation as well as identifying viable solutions is urgently needed to prevent further deterioration costs.
Among potential restoration strategies, biochar and digestate application produced respectively from pyrolysis and anaerobic digestion may offer a promising solution, due to their ability to enhance soil properties physically, chemically, and biologically.
The aim of this study is to evaluate the potential production for biochar and digestate to restore identified degraded areas. By integrating satellite data with Geographic Information Systems (GIS), degraded lands in rural areas of the Veneto Region (Italy) were identified and mapped. Residual biofertilizers was assessed to estimate the spatial production of biochar, while digestate production was analysed based on the output of regional biogas plants. Lastly, a spatial analysis was conducted to determine optimal locations for pyrolysis plants, ensuring sufficient feedstock availability and proximity to vulnerable areas.

Keywords: Rural Landscape, Land degradation, Biochar, Digestate, Spatial Analysis, GIS, Remote Sensing.

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Agricultural by-products valorization for buildings materials purposes in a circular economy framework

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Abstract. Globally, approximately 1 billion tons of agricultural waste (AW) are generated annually, posing significant challenges to environmental quality and contributing to pollution, particularly in rural areas. Shifting towards circular agricultural models that prioritize the reuse of biowaste and by-products offers a sustainable and effective solution. This research introduces an innovative insulation construction material, developed by combining clay soil with agricultural by-products (ABP), such as straw, grape pomace and stalk. The study evaluates the influence of various types and concentrations of ABP on the material's thermophysical and mechanical properties. The results revealed that the addition of ABP improved both flexural strength and thermal resistance, while compression strength remains almost unaffected. As a final step, a tailored matrix was developed for rural buildings, such as flour mills, olive mills, barns, and wineries, addressing their unique challenges and offering targeted solutions. These rural buildings require optimal microclimatic conditions to support efficient agro-industrial processes, and the proposed material provides a sustainable means to achieve this goal.

Keywords: agricultural waste valorization, rural buildings, biobased material, thermal insulation, circular economy

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Comparing gas concentrations from different livestock dairy farms in the Mediterranean area

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Abstract. Agriculture and livestock farming are responsible for emitting relevant quantities of ammonia and greenhouse gases that produce negative impacts on the environment (e.g., global warming, eutrophication, soil acidification) and human health (e.g., respiratory disease). The present study investigates pollutants emissions from livestock dairy farms, with a particular focus on the monitoring of gas concentrations in the breeding environment. The measurement campaign was carried out in two different dairy farms with an open envelop located in the province of Ragusa (Italy). These farms have been selected based on specific features such as construction typology, ventilation system, floor type, heard management. Gas concentrations (e.g., ammonia, methane) were measured using portable devices based on the Fourier-Transform-Infrared (FTIR) technology. Data acquired during the investigation period have been analysed using a comparative approach. The results quantified gas concentrations from the different dairy farms. In detail, gas concentrations have been evaluated analysing the effect of different barn typology and heard management on gas concentrations.

Keywords: dairy farms, ammonia, greenhouse gas, heard management, building typology

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Multi-temporal hyperspectral analysis of downy mildew symptoms on vine leaves

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Abstract. Downy mildew (DM), caused by *Plasmopara viticola*, is one of the most destructive fungal diseases affecting grapevines. Traditional methods for detecting DM in vineyards rely on visual inspections, which are time-consuming, error-prone, and often result in late detection of infections, as the human eye cannot detect low disease severity. This entails ineffective disease control, reducing fruit quality and causing significant yield losses. In recent years, optical sensor technologies have shown promise to evaluate plant physio-logical status and to detect crop diseases at an early stage, thereby facilitating strategic interventions with timely and targeted actions. However, the use of advanced hyperspectral sensors and imaging techniques has been poorly inves-tigated, especially in viticulture. Therefore, this study aimed to explore the potential of hyperspectral imaging to (i) identify the presence of DM symptoms on grapevine leaves and (ii) monitor the temporal and spatial evolution of DM severity.

Under laboratory conditions, hyperspectral images of vine leaves inoculated with *Plasmopara viticola* and placed in Petri dishes were collected. Acquisitions were performed from 0 to 12 days post-inoculation using a hyperspectral imaging system (HSI) operating in the 400–1000 nm spectral range.

Hyperspectral images were analysed to identify characteristic wavelengths associated with DM infection and to monitor the spatial distribution of symp-toms over time.

Results confirmed the potential of using HSI to distinguish between healthy and diseased leaves and demonstrated that the growth of symptoms on the leaf surface was detected more accurately than through visual assessments, allowing for a more precise evaluation of disease severity.

Keywords: Downy mildew, Grapevine diseases, Disease detection, Hyperspectral imaging (HSI), Spectral analysis.

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Species Selection for Nature-Based Green Facades Design in the Mediterranean Area

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Abstract. Using native species in the design and construction of green walls is a nature-based solution that harnesses spontaneous flora to optimize infrastructure and safeguard biodiversity for the future. The Mediterranean region is a biodiversity hotspot that hosts native flora exhibiting a high biodiversity, which can be selected based on their morphological and ecological characteristics, as well as their adaptability to environmental stresses, to ensure the success of green infrastructures. For this purpose, the selection process involved all 7759 taxa listed in the new Flora d'Italia by Pignatti, with the selection criteria encompassing life form, chorological type, Ellenberg ecological indices, altitude, and habitat. The selection process was carried out in several stages, starting with the identification of 4296 taxa of Mediterranean and Southern European species based on chorological type, including 1760 endemic taxa. Subsequently, 2226 taxa were identified as suitable for incorporation into green facades, categorised as Chamaephytes (Ch), Nanophanerophytes (NP) and Hemicryptophytes (H). Subsequent analysis, informed by the mean Ellenberg ecological indices values for 20 target species representatives of vertical or sub-vertical habitats, resulted in the delineation of specific ranges for Temperature (T), Humidity (U), Light (L), Nutrients (N), and Continentality (C), encompassing 1308 taxa. Finally, considerations of habitat, altitude and allergenicity of species led to the selection of 694 taxa. Of the remaining 55 families, Asteraceae (137 taxa) and Fabaceae (76 taxa) were found to be the most significant, with predominant habitats on rocks, rubble and walls. The most common life form occurring was Chamaephytes (Ch), with 399 taxa. The selection carried out provides a list of taxa which could be suitable for green facades design, with specific characteristics for a variety of ecological and climatic contexts.

Keywords: Biodiversity Conservation**,** Ecological Indices, Green Walls, Mediterranean Flora, Native Species.

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Cost-Effective Image Analysis for Soil Erosion Monitoring

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Abstract. Soil erosion is a significant environmental concern, requiring accurate and efficient monitoring methods. Traditional techniques, such as sediment traps and erosion pins, provide reliable data but are labor-intensive and costly. In recent years, remote sensing and image analysis have emerged as alternatives, yet their high expense remains a barrier to widespread use. This study explores a more accessible, cost-effective approach by employing image analysis for erosion assessment. A proof-of-concept was conducted on a semi-natural hillslope at Tuscia University in Viterbo, Italy, where artificial rainfall was simulated, and digital surface models (DSMs) were created using low-cost equipment. By comparing pre- and post-event DSMs, soil displacement was estimated and evaluated against traditional measurement methods. While some discrepancies were observed, the findings highlight the potential of this technique for erosion monitoring. The results suggest that with further refinement, this approach could provide a practical and scalable solution for assessing soil erosion in various environmental and agricultural settings.

Keywords: Image analysis, Soil erosion, Monitoring, Inexpensive method.

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Growth performance, microbiological safety and environmental impact of *H. illucens* larvae reared in a mass-scale prototype

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Abstract. The black soldier fly larvae (BSFL) is an emerging insect species gaining significant attention for its dual potential in addressing feed and waste management challenges. Recognized for its ability to transform low-quality organic residues into nutrient-dense biomass, BSFL offers a promising strategy to enhance the sustainability of agri-food production chains. However, the commercial-scale production and bioconversion of BSFL face technological, environmental, safety, and economic challenges that must be addressed to ensure long-term viability. This study evaluates the growth performance of BSFL reared on diverse agri-food industrial residues. In this study, the test conducted on liquid digestate is considered. Additionally, a life cycle assessment (LCA) was conducted to identify key environmental hotspots in BSFL production and microbial quality assessments were performed to ensure safety. The trials were conducted in a dedicated prototype facility (shipping container) with dimensions of 13 m (length) × 2.5 m (width) × 2.7 m (height) and a capacity to process about 200 kg of residue daily. The results indicate promising bioconversion efficiency, with a bioconversion ratio of 15%, feed conversion ratio of 4.47, and substrate reduction of 74%. However, the LCA revealed that climate control energy consumption accounted for 90% of the climate change impact, with a total emission of 4.17 kg CO_2/kg of fresh larvae. Microbial safety assessments detected pathogenic bacteria like the Enterobacteriaceae group and fecal streptococci in both the larvae and substrate, underscoring the need for robust microbial control measures. In conclusion, while BSFL production demonstrates significant potential for sustainable waste valorization and feed production, addressing environmental hotspots and microbial safety challenges is critical for scaling up operations effectively and sustainably.

Keywords: Black soldier fly larvae, sustainability, residue valorisation, microbial safety, insect rearing.

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Chemical, physical and energetic characterization of food pellets

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Abstract. The pelletization process is one of the most applied biomass standardization processes. Whether it is biomass for soil improver use (manure), biomass for energy use, or zootechnical food biomass, the densification process makes the product homogeneous, stable, and easy to use. One of the most recent applications of pelletized biomass (especially wood) in Italy concerns food pellets. Food pellets are pellets for energy use where the combustion products (heat and smoke) are used to cook and smoke foods. This sector is expanding in Italy but lacks in-depth studies on the biofuels used. This study characterized five pellet samples of various origins following the UNI EN ISO 17225-2 reference standard. The results show that for various parameters, pellets are compliant with the standard (such as diameter-dimensional parameters and some physical parameters), while for others, which are crucial according to the standard, they are of poor quality or even unclassifiable. However, for some reference parameters, such as ash content, it should be specified that these do not constitute a technical or economic limit for food pellets. High values (over 2%), as recorded in an analyzed sample, do not hinder a correct valorization of the pellet. In conclusion, it can be stated that the analyzed pellets reflect a compositional and analytical variability typical of residual or virgin woody biomasses from broadleaf trees (the only ones usable for food pellets) variability that, in this case, is more an added value than a defect as it is related to a greater spectrum of possible aromatic profiles that are the true target of food pellets.

Keywords: Pellet, Wood, Broadleaf, Biomass, Food, Smoking.

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Training needs in the crop protection sector: first outcomes of the RENOVATE project

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Abstract. The EU Horizon project RENOVATE (Training experiences and networking for farmers in the field of sustainable crop management, funded by the European Union under Grant Agreement 101134024) aims to provide farmers and farm advisors with a complete digital platform for improving their knowledge and practices about the correct management of Plant Protection Products application with special regards to arboreal crops. Namely, the platform will include innovative training paths configured as serious games to be more attractive and interesting for the end-users. Through exercises made in a virtual reproduction of the farm context, the end-users will learn the most adequate practices to follow and the more advanced techniques for achieving a full sustainable management of crop protection activities. Besides, a digital library of conventional training materials will be available as well. To identify the key topics, practical information and guidance that are more interesting for the operators, some Focus Groups were established in different EU countries involved in the project, aimed at getting suggestions and recommendations from stakeholders (e.g. representatives of farmers, farmers unions, technical support services, PPP industries, public authorities). The outcomes of the first FG meetings are contributing in defining the contents of the training platform.

Keywords: Crop Protection, Sustainability, Training Platform, Serious Game.

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Implementing variable rate application sprayer algorithm: how to identify the spray application rate according to canopy density?

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Abstract. Reliable sensors for measuring canopy features and technologies for obtaining precise real-time Variable Rate Application (VRA) spraying are currently available. The most challenging task remains the development of algorithms that relate sensor outputs to the appropriate amount of spray to deliver, without compromising crop protection efficacy. In this context, the objective of the research was to determine, through field experiments, the optimal spray application rate according to different vine canopy densities. The identified spray application rate would be then implemented in the control algorithm of a VRA prototype smart sprayer developed within the AGRITECH project (PNRR – MISSIONE 4 COMPONENTE 2, INVESTIMENTO 1.4 – D.D. 1032 17/06/2022, CN00000022). The prototype is a conventional tower-shaped sprayer equipped with PWM (Pulse Width Modulation) valves, capable of continuously varying spray application rate according to real-time canopy density data measured by a stereoscopic camera. To this end, by varying the PWM duty cycle, four fixed spray volumes were tested (67, 218, 330, and 448 L ha^{-1}) across two vineyard parcels characterized by different canopy densities (0.57 and 1.2 leaf area index - LAI). The assessment was based on spray coverage and spot density, measured using water-sensitive paper (WSP) placed at various canopy positions and leaf sides. Data analysis showed that in low and high vineyard canopy density the adequate spray application rate is lower than 200 and around 250 L ha^{-1} respectively. The latter values ensure the highest spray efficiency in terms of minimum amount of over- and under-sprayed WSPs.

Keywords: Precision Agriculture, Smart Sprayer, Sensor, Stereoscopic Camera Sensor, Pulse Width Modulation Valves.

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Environmental Benefits of Urban Food Hubs: A Life Cycle Assessment of Surplus Food Redistribution in Milan

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Abstract. Urban food hubs for surplus food redistribution are a promising solution to mitigate food waste and its associated environmental impacts. However, their environmental sustainability remains underexplored. This study conducts a life cycle impact assessment of two food hubs in Milan, a leading city in implementing innovative food policies. The analysis reveals that a single food hub generates significant environmental benefits, including net yearly savings of 107 tons of $CO_{2,eq.}$ and the recovery of around 140,000 meals. These efforts reduce the environmental burdens linked to excess food production and disposal, including greenhouse gas emissions, resource depletion, biodiversity loss, and pollution.
By diverting surplus food from waste streams, food hubs align with global sustainability goals, particularly SDG 12 (Responsible Consumption and Production) and Target 12.3, which seeks to halve global food waste by 2030. The findings also highlight the potential of food hubs to integrate environmental benefits into broader urban sustainability frameworks.
This study provides a structured approach to quantifying the environmental impacts of surplus food redistribution, offering actionable insights for policymakers, urban food actors, and nonprofit organizations. It strengthens the case for food hubs as key instruments in climate change mitigation, resource conservation, and sustainable food systems, emphasizing their transformative role in urban waste management and policy innovation.

Keywords: Surplus food redistribution; food waste mitigation; Environmental sustainability; Life cycle assessment.

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Autonomous navigation systems for agricultural machines and robots: development, performances and future scenarios

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Abstract.
Autonomous machines will be one of the most effective solutions to face the reduction of agricultural workers and tractor drivers in the next future. Autonomous systems will enhance the features of automatic driving systems, adding sensors, cameras and radars to gain awareness of the working area and achieve the ability to complete defined tasks without operator interaction.
This paper presents the development of an automatic guidance system, specifically conceived for agricultural robots, and based on a dual GPS-RTK, compass, and IMU. The system has been implemented and tested on a tracked agricultural robot (AlpiRobot Level 38.12) to evaluate its performances both in flat and sloped vineyards. The paper also discusses possible solutions to upgrade the robot to a fully autonomous system to fulfil international standards (e.g. ISO18497 and ISO25119). In particular, a solution based on 3D point-cloud analysis has been studied for guidance assistance, precision enhancement, and obstacle detection.
This study was partially funded by the European Union - NextGenerationEU, Mission 4 Component 1.5 - ECS00000036 - CUP D17G22000150001. This work is part of the project EVA which has received funding from Cascade funding calls of NODES Program, supported by the MUR - M4C2 1.5 of PNRR funded by the European Union – NextGenerationEU.

Keywords: Autonomous systems, Agricultural robots, Navigation, GPS-RTK, Precision agriculture.

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Energy efficiency and carbon footprint of three biogas valorization strategies

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Abstract. The European Union aims to achieve carbon neutrality by 2050, targeting a significant reduction in greenhouse gas (GHG) emissions. Directive (EU) 2018/2001 mandates that renewable energy constitutes at least 32% of gross energy consumption by 2030, with 14% specifically from renewable transport fuels. The emissions from agriculture activity, which represent over 10% of EU GHG emissions, can be reduced via anaerobic digestion of biomass, producing biogas and digestate. Biogas, composed mainly of methane (CH_4) and carbon dioxide (CO_2), can be used for producing electricity and heat, or upgraded to bioCH_4.

This study is part of the Life Clinmed-Farm project (Towards a Mediterranean Climate Neutral Farm Model), which promotes sustainable farming practices to reduce emissions and optimize resource efficiency. Three biogas valorization strategies were evaluated:

1. A biogas plant with a cryogenic CH_4 upgrading unit to produce liquid bio-CH_4 for heavy trucks, with recovered CO_2 supplied to the food and beverage sector. Excess heat is supplied to a nearby industrial facility in winter and converted into cooling energy via an absorption refrigeration system in summer.
2. A biogas plant connected to a combined heat and power engine for heat and power generation, with surplus heat used by a glass industry in winter only.
3. A biogas plant using a membrane upgrading unit to produce bio-CH_4 for injection into the national gas grid, without valorizing excess heat.

Scenario 1 achieved the highest energy efficiency and lowest carbon footprint, highlighting the potential of agricultural biogas plants to support carbon neutrality through biofuels production.

Keywords: Greenhouse gases, emissions, energy, decarbonization, biomethane

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Natural based solution for habitants well-being: proposed of a novel indoor living wall system

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Abstract. Indoor living walls are regarded as a highly regarded architectural solution. They have been adopted to enhance the aesthetic quality of a variety of building types, including office buildings, restaurants and, on occasion, residential structures. While it is evident that plants provide a positive visual impact to the environment, the knowledge of the other benefits of this natural-based solution is not yet well disseminated. The scientific literature addresses several aspects, including classification, the effects on air quality and indoor temperature, the greater aesthetic and psychological impact, and the improved acoustic treatment of indoor spaces. The phenomenon of indoor house environment pollution is increasing. This is attributable not only to external air contamination, but also to internal factors such as the types of building materials used, the prolonged presence of occupants, and insufficient air renovation due to the high performance of window sealing. The main indoor building contaminants are dust and airborne particles possible vehicles of toxic elements and CO_2. The flora of the living wall has been demonstrated to possess the capacity to mitigate the repercussions of air contamination and enhance indoor air quality (IAQ). This paper proffers a novel technical system solution for an indoor living wall. The solution is predicated on a modular interlocking system that integrates the plant pots, the droplet irrigation, and an electronic control apparatus. The proposed system enables the reuse of grey water on site, exhibiting a low energy consumption.

Keywords: Living wall, Indoor environment, IAQ, Air phytoremediation

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Effect of the soil storage period on saturated hydraulic conductivity

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Abstract. The soil storage period, which is the period that the soil remains in the laboratory before carrying out the experiment, can induce changes in soil hydrodynamic properties such as saturated hydraulic conductivity, K_s. Some studies have reported an increase in K_s with longer storage periods, while others have observed the opposite effect.

This paper describes a study performed to investigate the effect of the storage period on repacked soil columns.

The K_s was measured in the laboratory with the simplified falling head (SFH) technique. A total of 90 repacked soil columns were prepared using two loam soils and one sandy clay loam soil, each stored for short and long periods.

The results show that longer storage periods lead to higher means of K_s values for all tested soils. The increase in mean K_s values between short and long storage periods was statistically significant for the two loam soils (+28.8 and +49.7%), whereas no significant difference was observed for the sandy clay loam soil (+7.9%). These results can be attributed to the stabilization of soil aggregates and structure caused by the aging effect.

This study confirms that, in the experiment performed on repacked soil columns, a potential increase of the measured K_s must be considered if the laboratory experiments are not carried out within a short time frame.

This study was carried out within the RETURN Extended Partnership and received funding from the European Union Next-GenerationEU (National Recovery and Resilience Plan – NRRP, Mission 4, Component 2, Investment 1.3 – D.D. 1243 2/8/2022, PE0000005)

Keywords: Saturated hydraulic conductivity, Soil column, Soil storage period, Simplified falling head, Laboratory experiments.

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Preliminary assessment of requirements for simulator-based precision farming driver training

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Abstract. The introduction of technologies such as auto-guidance, geo-positioning and ISOBUS implements has led to new ways of organizing and carrying out agricultural tasks. Although there have been problems with the acceptance and uptake of these technologies, only straight-line driving and the associated correct spacing between passes seems to have affected farmers.
The availability of a simulator that reproduces the practicalities of a real agricultural tractor and its implements is a strategic resource. It allows the operator to manage the main technologies that characterize the precision farming scenario, such as automatic guidance systems, geopositioning tools and ISOBUS communication protocols.
In addition, familiarization with these technologies using a simulator ensures a controlled, risk-free environment, especially as complex, expensive and safety-critical machines are used by practitioners in a real-life scenario.
The tractor driving simulator adopted for this research is classified as a Human in the Loop Digital Model, focusing on the main tasks for which digital technologies are adopted: sowing, fertilizing and weeding. By promoting adoption rather than diffusion of precision agriculture, this research also fits into the current trend of using the idea of "gamification". The aim of this research is to define the requirements for simulator training for operators of precision farming machinery. The trial of this study was focused on simulated fertilization and showed that undesirable fertilization was affected by the high average maximum speed (peaks) and the high average cruise (mean) speed.

Keywords: Tractor; digital innovations; efficiency; gamification; realism; virtualization

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Paper ID: 252

Nature-based solutions to mitigate the impact of floods and soil erosion on the dam siltation in southern Italy

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Abstract. Dams are important infrastructures to regulate water for multi-purpose uses in the Mediterranean region. Nevertheless, global warming is intensifying the water cycle and raising the probability of extreme climate events in the Mediterranean region. Altered rainfall patterns, particularly intense rainstorms, trigger floods and exacerbate soil erosion and subsequent reservoir siltation, reducing dams' storage capacity and lifespan. This study investigates the impact of runoff floods and soil erosion on siltation in a multi-purpose earthen dam built in 1994 on the Alento River (Campania, Southern Italy). Using the Hydrologic Engineering Center's Hydrologic Modeling System (HEC-HMS) and the Modified Universal Soil Loss Equation (MUSLE), driven by observed rainfall, a 30-m DEM, and land use/soil data, we simulated runoff and soil erosion. The model was calibrated against observed daily water yield. Two scenarios were analyzed: (1) current bio-climatic conditions, and (2) the implementation of nature- and engineering-based solutions (e.g., a diversion weir and terraces) to mitigate flood impacts and soil erosion. By assessing these scenarios, we aim to quantify the contribution of runoff and erosion to siltation and downstream flooding, and to demonstrate how these mitigation strategies can enhance dam resilience and ensure the long-term provision of essential water resources in a changing climate.

Keywords: Runoff, Soil-erosion, MUSLE, HEC-HMS, Alento river catchment, Italy.

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Paper ID: 253

SmartWT: an IoT device for the remote monitoring of water levels in rice paddies

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Abstract. This study proposes a remote monitoring system for the ponding water level in flooded rice fields. The system is based on a completely open-source architecture, with the data acquisition and transmission operations realised using an Arduino Nano in conjunction with a GSM board. The data is measured by an ultrasonic distance measuring sensor installed on a tube inserted into the soil, perforated below the soil surface and continuous above (i.e. Water Tube). The entire system has been optimised for the environment in which it operates, with a waterproof sensor and container, and the device has been designed to require low power to operate, making it easy the installation in the field and minimising maintenance requirements. The device is designed to run on batteries alone, with a life of approximately 3 months when transmitting every 2 hours. For longer transmissions, the batteries must be replaced, or a photovoltaic panel can be connected. Several tests have been carried out in the laboratory and in the field to verify the actual accuracy of the sensor used, to assess any problems in using an ultrasonic sensor inside a pipe in a field application, and to study the influence of pipe diameter and environmental temperature. These tests have shown that precautions are needed to obtain accurate measurements.
Based on this research, the SmartWT was used in the 2023 and 2024 agricultural seasons to monitor the ponding water level in five fields of three productive rice farms and, based on these measurements, to manage the AWD (Alternate Wetting and Drying) irrigation technique in the fields.

Keywords: Ponding Water Level, IoT, AWD, Water Tube, Smart Agriculture

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Paper ID: 254

Novel covering system to contain greenhouse indoor overheating

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Abstract. Greenhouse cultivation is a form of modern agriculture in which crops grow in a controlled environment and the most important factor influencing plant growth is solar radiation. In addition, the most important process that requires solar radiation and regulates plant growth and development, is photosynthesis. Therefore, it is important to consider the characteristics of greenhouse covering materials, which can affect the quality and level of radiation transmitted indoors and are of primary importance for greenhouse cultivation.

The overheating of the indoor air temperature in greenhouses in the Mediterranean region is a significant problem. The most common solution to this problem is the use of shading techniques, such as screens, temporary coatings or nets. However, these techniques are not optimal because screens do not allow for smooth regulation of light (slow reac-tion to changing light conditions) and coatings also absorb light in the presence of low radiation.

The application of electrochromic filters to the greenhouse covering could be a smart solution because it would allow for continuous control of light intensity, which would improve crop growth. In this paper, a new smart greenhouse with an electrochromic covering system is pro-posed to limit the overheating that causes damage to plants.

Keywords: overheating in greenhouses, shading in greenhouse, shading materials, light intensity; electrochromic filters, air temperature.

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Paper ID: 255

Estimation of the irrigation needs of the Franciacorta wine-growing area in northern Italy for the construction of a new collective irrigation network

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Abstract. The aim of the study is to quantify the irrigation needs of the Franciacorta wine area (province of Brescia, Italy) using the IdrAgra simulation model (https://idragra.unimi.it/). Due to climate change and, in particular, following the drought recorded in 2022, the Lombardy region, the Irrigation Consortium Oglio-Mella (which governs the collective irrigation networks in the territory) and the Franciacorta Consortium (association of Franciacorta winemakers) have reported the need for the Franciacorta vineyard areas to be irrigated in the future. To estimate the necessary irrigation needs, the IdrAgra model was used, which is a conceptual model with distributed parameters capable of estimating water flow rates and volumes needed to irrigate large agricultural areas. In a first phase of the study, the model was calibrated considering flow rates delivered by the Oglio-Mella Consortium to a specific irrigation district in Franciacorta irrigated by sprinkler irrigation. To parameterize irrigation management in the case of drip-irrigated vineyards, a questionnaire was designed and distributed to vine growers having private farm wells and therefore irrigated vineyards. Once the model was calibrated, it was possible to estimate the flow rates needed to irrigate the vineyard area in Franciacorta alone (3350 ha irrigated by drip irrigation) and the total agricultural area (drip irrigated vineyards + sprinkler irrigated arable land, for a total of 6700 ha) in a current scenario (2008-2022), and in a future scenario (2035-2064) built based on the 5th IPCC report. The results show that the water flow rates needed in the medium-term future scenario are comparable to the current ones, while the water volumes increase and the irrigation needs are anticipated in the season. The results are currently being used to evaluate the feasibility of a collective irrigation network to irrigate the Franciacorta area that would be managed by the Oglio-Mella Consortium.

Keywords: Irrigation need, IdrAgra model, Grape, Climate change scenario, Model simulation, Collective irrigation network.

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Using Microtensiometers for Irrigation Management in a Citrus Orchard Irrigated with Subsurface Drip System

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Abstract. Plant water status serves as a key indicator for effective irrigation management. Crop water status is commonly assessed by measuring the stem water potential, Ψ_{stem}, using the Scholander pressure chamber, PC, making continuous monitoring of plant status impractical. Recently, microtensiometers, MT, have been developed for continuous monitoring of trunk water potential, Ψ_{trunk}, overcoming the limitations of PC measurements. The effectiveness of MT in continuously monitoring Ψ_{trunk} was tested in 30-year-old mandarin trees equipped with subsurface drip irrigation during the 2022 and 2023 seasons. The Ψ_{trunk} data were compared with Ψ_{stem} values simultaneously measured by the PC. Shade trials were conducted in the 2023 season to assess Ψ_{trunk} and Ψ_{stem} response to external disturbances. Additionally, the potential of MTs for citrus irrigation scheduling was evaluated by comparing Ψ_{trunk} with weather variables. Results showed that in citrus orchards, MTs recorded higher Ψ_{trunk} values than Ψ_{stem}, especially in the afternoon, with a significant correlation (R^2= 0.62). Moreover, Ψ_{trunk} was also less sensitive than Ψ_{stem} to external disturbances, during shade trials. The correlation between Ψ_{trunk} and vapor pressure deficit was also significant (R^2= 0.57). The cross-correlation analysis between Ψ_{trunk} and ETo, showed stronger links in the summer peak, decreasing over the season and emphasizing environmental influences on plant water status. These results demonstrate the potential of using Ψ_{trunk} as an indicator to optimize irrigation in citrus groves. However, specific irrigation thresholds need to be established for Ψ_{trunk}, in addition to the well-defined thresholds for Ψ_{stem}.

Keywords: Microtensiometer, Pressure chamber, Citrus orchard, Stem water potential, Trunk water potential, Subsurface drip irrigation.

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Optimizing Citrus Orchard Identification and Distribution: A Data-Driven Approach Using Machine Learning and Spectral Indices. Preliminary results.

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Abstract. Species Distribution Models (SDMs) aim to identify the relationship between environmental conditions and species presence. These models analyse environmental data and species occurrence records to identify suitable habitats and have been widely used in ecological applications such as invasive species management and climate change impact assessment.
In the literature, despite the utilization of SDMs, challenges remain regarding the quality and quantity of input data, which are required for accurate modelling. Traditional field surveys, required for species identification, are often expensive and time-consuming, and for this, satellite image classification is offering an efficient alternative.
This study focuses on data fusion from multiple satellite constellations to identify and map citrus orchards in Sicily, the leading citrus-producing region in Italy. Sicily accounts for 63% of the national orange production and provides a vital socio-economic resource for local communities.
The thematic maps produced in this study integrate composite spectral bands and semantic segmentation techniques. The analysis is optimised using GIS tools and advanced statistical models, including machine learning algorithms. Furthermore, the integration of geometric and textural information, in addition to vegetation indices and water/non-vegetation indices, will serve to enhance the data processing process. This approach improves the identification and management of citrus orchards and provides an understanding of agricultural planning.
The results of this work will support the development of sustainable agricultural policies, enabling more efficient resource management. Besides, they will contribute to monitoring the productivity of citrus orchards and promoting a key crop for Sicily's economy.

Keywords: Remote sensing, Citrus orchards, GIS, Land-use change prediction, Spatial analysis, Sentinel-2 satellite imagery

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Novel and practical methodology for UASS spray mixture sloshing reduction evaluation

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Abstract. Within unmanned aerial spray system (UASS), tank spray mixture sloshing can significantly impact trajectory accuracy, spray precision and energy consumption. Within the framework of the PRIN 2022 PNRR 3E-UAVspray project, a 10 L volumetric capacity diamond-shaped tank was selected. Two configurations of the selected tank: standard and partitioned (featuring internal plates to dampen sloshing) were tested. The aim was to compare partitioned configuration effectiveness in reducing sloshing with respect to standard one. Per each tank configuration were tested four mixture volumes corresponding to 20, 40, 60, and 80% of the full tank capacity. An innovative methodology was developed to assess sloshing effect, combining a custom test bench and image analysis. The test bench consisted of a suspended 7 m slide where the tank was fixed to a sliding support that allowed controlled acceleration, deceleration, and braking. A high-resolution camera captured internal liquid dynamics during the braking phase. Key performance indicators, including settling time and maximum overshoot, were analyzed using image processing software. Results demonstrated the effectiveness of the partitioned tank in minimizing sloshing, with a general marked reduction in settling time (five times) and overshoot (two times) compared to the standard configuration. These findings suggest that partitioned tanks can significantly enhance UASS stability, enabling more precise spray applications and reducing energy consumption. Further trials are ongoing to implement the assessment and pertinent results will be included in the final paper. This methodology and design approach lay the groundwork for further advancements in UASSs, addressing critical challenges in precision spraying operations.

Keywords: Unmanned Aerial Spray System, Anti-sloshing Tank, Pesticide Tank, Anti-sway Performance Test, Tank Partitioning, Sloshing Damping.

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Paper ID: 259

Geospatial databases for the evaluation of agroenergy supply chains

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Abstract. Biomass is a key resource for the renewable energy sector, with its availability and energy potential assessed in tons of dry matter per year. The SOFAST project, funded by PNRR and coordinated by the University of Pisa, aims to develop a smart agroenergy supply chain for Central Italy. In this con-text, CREA is establishing a scientific-technological hub to optimize the energy conversion of agroforestry residues through thermochemical and biochemical processes. A crucial aspect of this study is the integration of geospatial data-bases to enhance decision-making in agroenergy planning. The Biomass Atlas by ENEA, accessible via WEBGIS, provides detailed spatial information on bi-omass availability and its classification. Complementary datasets, such as land use maps, the SINFOR forestry database, AGEA administrative data, and Co-pernicus satellite imagery, enable high-resolution assessments down to the par-cel level.Despite challenges in integrating heterogeneous data sources and up-date frequencies, these databases support sustainable biomass management, contributing to the ecological transition and optimized energy production strat-egies. This study proposes to build a database for the classification of the avail-ability of agroforestry residual biomass in the Lazio region and to evaluate the energy input that these can produce in short-supply thermochemical processes.

Keywords: Biomass, Database, Prunings, Bioenergy.

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The Connectivity, Climate, and Land use/cover change (CCL) Nexus: A Landscape-Scale Scenario Evaluation

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Abstract. This study reviews the current scientific literature on the Connectivity, Climate, and Land use/cover change (CCL) Nexus, emphasizing how landscape connectivity is shaped by climate change and land use transformations. The review assesses the application of scenario-based modelling approaches in evaluating landscape-scale dynamics, with a particular focus on the PANDORA model. This model, grounded in landscape thermodynamics and bio-energy flux principles, provides a structured framework for simulating the impacts of climate and land use changes on ecological connectivity. Through the analysis of Business-as-Usual (BAU) and intervention-based scenarios, the study explores the role of urbanization and naturalization in shaping connectivity patterns of Traponzo River watershed in Central Italy. Findings indicate that while climate change introduces moderate alterations to landscape connectivity, urban expansion remains the dominant disruptor, with naturalization efforts proving insufficient to fully counteract its effects. The evaluation of bio-energy landscape connectivity (BELC) across diverse climate models and land use scenarios further highlights the need for integrated landscape planning strategies. By synthesizing advancements in scenario-based modeling and connectivity assessment, this review underscores the importance of adaptive land management approaches. It advocates for the use of plausible scenario modelling and planning frameworks to enhance ecological resilience, connectivity, and sustainable development in complex socio-ecological systems.

Keywords: environmental planning, land abandonment, urban planning, climate change, fragmentation.

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Crop protection in heroic viticulture: comparison between traditional and aerial spray application techniques

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Abstract. Crop protection operations in heroic viticulture are mainly manually made. Noteworthy, plant protection products (PPP) manual applications are inefficient exposing the operators to PPP contamination with health-adverse effects. In this context, the Torino Chamber of Commerce (Punto Impresa Digitale - Piano Nazionale Impresa 4.0 project) funded experimental trials aimed to compare PPP traditional and aerial spray application techniques for their effects on i) canopy spray deposit, ii) ground losses and iii) operator dermal exposure. Trials were conducted in sloped terraced vineyard featured by isolated vines. The traditional spray application was carried out by operator using an Ausonia knapsack sprayer featured by lance with single brass-nozzle providing on average 1,359 L ha^{-1}. The advanced technique foresees the use of DJI-AGRAS_MG-1P Unmanned Aerial Spray System (UASS) equipped with four flat-fan nozzles providing 100 L ha^{-1}. The canopy and ground losses deposit were measured using filter papers affixed in different positions to the leaves and on the ground, respectively. The dermal exposure was evaluated using a coverall worn by operators. To determine the collector spray deposit Tartrazine E102 water solution was applied. The dataset was standardized to 100 L ha^{-1} spray application rate. Average canopy deposit (0.13 *vs.* 0.11 µL cm^{-2}) as well as ground losses (0.35 *vs.* 0.40 µL cm^{-2}) were not significantly different between knapsack and UASS. The operator exposure for manual and UASS spray application techniques reached average values equal to 8.58 and 0.14 µL $body^{-1}$ (after 1,000 m^2 of vineyard surface applied), respectively. UASS can be an effective alternative for PPP spray applications in heroic viticulture.

Keywords: Precision Agriculture, Aerial Drone, Knapsack Sprayer, Spray Canopy Deposit, Spray Ground Losses, Operator Dermal Exposure.

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Moringa oleifera Lam. cultivation monitoring through remote and proximal sensing in Sicily

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Abstract. *Moringa oleifera* Lam. is a tree native to north-west India, known for its resilience in arid and semiarid regions and its nutritional benefits. This study evaluated the growth rates of four different *M. oleifera* genotypes in a semiarid Mediterranean environment, in Sicily, southern Italy. On July 3, 2024, the transplantation of one-month-old Moringa seedlings was carried out at the experimental field located in Santa Flavia (Palermo, Italy) at the Cooperativa Agricola Primo Sole. Four different genotypes of *M. oleifera* were planted with a planting density of 1.5 meters between plants and 3 meters between rows. The four *M. oleifera* genotypes origin utilised were: 1) African (A); 2) Indian (I); 3) Pakistani (PKM1); 4) Pakistani (PKM2). The field was divided into four plots, each containing thirty plants of each genotype. Moringa plants were monitored throughout the entire growing cycle using Precision Agriculture (PA) technologies. Periodic flights were conducted monthly with an Unmanned Aerial Vehicle (UAV) equipped with a multispectral and thermal camera. Additionally, LiDAR was used as a handheld scanner Proximal Sensing for biomass estimation. During the peak vegetative vigour period, identified through NDVI index calculation, *M. oleifera* leaves were harvested on December 3, 2024. The average biomass production per plant, including the main stem, was as follows for each genotype: 6.300 kg (A), 2.700 kg (I), 2.600 kg (PKM1), and 5.010 kg (PKM2). The production of dry biomass was equivalent to 20% of fresh biomass, comprising 14% leaves and 6% stems for genotypes (I), (PKM1), and (PKM2), and 13% leaves and 7% stems for genotype (A). The LiDAR biomass measurements was significantly correlated with biomass derived from vegetation harvest with R^2 value of 0.87. The comparison carried out resulted in an error rate of 3.3% (precision of 96.7%), which testifies to the reliability of the method used.

Keywords: UAV, Smart Farming; Precision Agriculture, Drones, Vegetation Indices (VIs), LiDar.

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Precision Agriculture Technologies in Sicilian Saffron Cultivation

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Abstract. The cultivation of *Crocus sativus* is an ancient tradition that has seen a true resurgence in Sicily in recent years. According to the Economic Observatory of the Italian Saffron Association, various cooperative realities and individual producers have emerged in our region in recent years, thanks to the profitability of the spice, which can cost up to 30,000 euros per kilogram abroad. Saffron is extremely rich in nutraceutical compounds and is used as an antiseptic, antidepressant, antioxidant, digestive, and anticonvulsant. It is a source of numerous nutrients and phytocompounds with antioxidant action that help protect health from oxidative stress, the risk of cancer, and infections. The application of Precision Agriculture technologies in saffron cultivation aims to improve and enhance the saffron production chain by optimizing the harvest timing, the most delicate phase of the vegetative cycle. In order to determine the right flower harvesting time, Unmanned Aerial Vehicle (UAV) flights, using a Dji Mavic 3 Multispectral drone equipped with a multispectral camera were conducted on the experimental saffron fields located in Sicily (Italy). UAV imagery plays a crucial role in monitoring saffron flower growth by offering a systematic approach to track pre-harvest conditions. The UAV system calculates the area covered by saffron flowers, creating a detailed database for analysis. This data is used in classification models to accurately differentiate saffron flowers from others, improving the precision of growth tracking and predictions. The use of precision agriculture can also allow for the counting of plants and the estimation of flowers, in order to valorise the part of the flower not usually used, by minimizing resource waste and reducing environmental impacts. UAV imagery systems improve crop management by offering real-time data and insights, enabling farmers to make informed decisions.

Keywords: Smart Farming, Remote Sensing, UAV, Medicinal and Aromatic Crops (MAPs), photogrammetry, Decision Support System (DSS).

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Assessing the spatial and temporal patterns of sediment and nutrient transport from catchment to sea

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Abstract. Intermittent rivers account for 30% of the global river network, their flow and sediment regime are important for river ecosystems. During floods, a large amount of sediment and pollutants may be delivered to the river reaching the coastal zone and forming plumes that impact coastal water bodies. Hydrological models like the Soil & Water Assessment Tool (SWAT) are widely used to simulate sediment and nutrient loads to the sea. Remote sensing tools, using indices such as the Normalized Difference Turbidity Index (NDTI), allow us to assess water turbidity and identify the plume area. This study, coupling SWAT and NDTI, aims to assess the fate of sediment and nutrients in the Canale d'Aiedda basin and the plume of deposition into the Mar Piccolo Sea (Apulia, Southern Italy). The SWAT model, calibrated using daily flow and discrete sediment and nutrient concentrations, was run from 2017 to 2023. NDTI was determined using Sentinel-2 imagery, processed on Google Earth Engine. A flood event was analysed during which 95 kg of nitrogen, 37 kg of phosphorus, and 121 t of sediment were delivered into the Mar Piccolo, highlighting the impact of hydrological events on nutrient and sediment fluxes. Post-event NDTI mapping showed increased turbidity near the D'Aiedda estuary, with high values along the coast. This study showed that Sentinel-2 satellite data and cloud computing enhanced turbidity monitoring, complementing the SWAT results.

Keywords: SWAT model, Sentinel-2, sediment load, nutrient transport, plume deposition, Intermittent river

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Improving Pulse Logistics: Big-Bag Transport and Controlled Atmosphere for Traceability

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Abstract. In recent years, human diets have increasingly incorporated plant-based proteins. Pulse seeds, such as lentils, chickpeas, and beans, serve as a key protein source. However, their quality deteriorates during storage and transport due to mold growth and insect infestations, compromising nutritional value and marketability. Hermetic storage and modified atmosphere techniques have proven effective in preserving quality attributes and preventing pest-related losses in stored grains.

Large-capacity flexible containers, like big bags (1 m^3), are widely used by specialty grain producers and exporters for their convenience and cost efficiency. This study examines an innovative approach that employs big bags internally lined with polyethylene to create a CO_2-enriched controlled atmosphere, aimed at pest control, reducing grain moisture fluctuations, and maintaining pulse quality.

The experiment was conducted at the Grain Postharvest Pilot Plant of INTA (Argentina) over 60 days, as part of the VALPRO Path project. Six big bags, each containing approximately 700 kg of pulses, were heat-sealed and injected with CO_2 until reaching 90% internal concentration. Gas composition (O_2 and CO_2), temperature, and relative humidity were continuously monitored. Additionally, live Sitophilus oryzae insects were placed in vials inside the bags, with mortality assessed at 30 and 60 days. Grain moisture content was also measured to ensure stability during storage.

This study highlights the potential of hermetic big bag technology as an effective solution for postharvest pulse management, supporting food security and sustainability in grain storage systems.

Keywords: big bags, controlled atmosphere, pulses, VALPROpath.

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Developing high-resolution Nitrogen prescription maps using UAV-based multispectral data and dilution curve approach

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Abstract. Effective nitrogen (N) management is essential for maximizing potato yields while promoting sustainable farming practices. The Nitrogen Nutrition Index (NNI), a widely recognized indicator of plant N status, plays a crucial role in optimizing fertilization strategies. Conventional methods estimate NNI through destructive field-based measurements, but advancements in remote sensing (RS) now offer a more efficient and comprehensive way to assess crop N variability across agricultural fields.

This study leverages multispectral data acquired via Unmanned Aerial Vehicle (UAV) and machine learning (ML) models to predict potato NNI and generate prescription maps for site-specific N fertilization. The UAV-captured multispectral imagery was processed to extract spectral bands and a wide range of vegetation indices, with a feature selection algorithm identifying the most relevant predictors to enhance model performance. These selected features were then used to train and evaluate multiple ML models. The framework used provided accurate NNI predictions comparable to ground-based estimates. Using these predictions, the nitrogen requirement (NR) of the plants was calculated, allowing the generation of prescription maps for optimized fertilization. This integration of UAV multispectral data and ML effectively captured spatial variations in crop N status over time, enabling a targeted approach to nitrogen application and consenting to improving the efficiency of N fertilization.

Overall, this approach offers a robust framework for precision N management, supporting data-driven decision-making for optimizing fertilization and enhancing resource efficiency in potato production.

Keywords: Precision Agriculture, UAV, Nitrogen Use Efficiency, Machine Learning, Nitrogen Nutrition Index.

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Biostimulant and fertilization effect evaluation through drone-based multispectral and thermal images

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Abstract. Input management in agriculture is a key factor to increased economic and environmental sustainability. The aim of the study was the application of a remote platform equipped with multispectral and thermal cameras in order to evaluate the use of biostimulants in olive groves under different irrigation regimes. The trial was conducted during the 2023 growing season in an experimental olive grove with a 5 x 5.5 m training system, located in Segesta (Italy). A randomised block experimental design was adopted. Four treatment were performed: Control (C), Fertilised (F), Biostimulated (B) and Fertilised + Biostimulated (FB). Each treatment was replicated in three blocks with 12 plants each. Each block was divided into two separate sub-blocks to perform different irrigation treatments. Specifically, deficit irrigation (DI) received no water treatment across season, while irrigated plants (IP) received two irrigation interventions. Mineral NPK fertilisation was carried out by distributing 400 g plant-1, as well as, 72 gN*plant-1 based on the fertiliser titration (18%). Biostimulant treatments were applied in the B and FB treatment, applying 300g hl-1 of foliar algae-based biostimulant (SWE), at three different phenological stages (BBCH 54, 71, 73). Multispectral and thermal flights were conducted from the beginning to the end of the growth status. Two-factor ANOVA analysis of variance (irrigation and treatment) showed that treatment had a statically significant effect on plant NDVI (Pvalue<0.001), and a statistically significant interaction between Treatment and Irrigation (Pvalue=0.005). Irrigation had an effect on canopy temperature despite the treatment, showing smaller values in irrigated canopies.

Keywords: Precision farming, NDVI, Olive groves.

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Analysis of multispectral and geometric features of six olive cultivars using UAVs in different training systems

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Abstract. The knowledge of vegetative and spectral parameters in different environmental contexts is a key aspect to increase the use efficiency of various inputs and to recreate cultivar-specific models able to determine real field conditions. The aim of this study was to detect the canopy geometric and spectral differences of six olive cultivars, cultivated with different training systems and shapes, using a drone equipped with a multispectral camera. The experimental olive orchard was located in Sciacca (Italy) in a Mediterranean soil-climatic climate. In the experimentation, five local cultivars (Abunara, Calatina, Cerasuola, N. del Belice and Nasitana) and one international cultivar (Arbequina) were used. In the plot, there were hedgerow (central axis, T1) and volume (polyconic vase, T2) training system. In the hedgerow systems (T1), there were two intra-row distances of 6 x 2 m (T1_1) and 6 x 3 m (T1_2), while the volume systems (T2) were 6 x 4 m (T2_1) and 6 x 6 m (T2_2). The surveys were carried out using a multispectral camera mounted on a drone (Phantom 4, DJI). The images were processed using GIS software to obtain the spatial and geometric information of each individual plant. All hedgerow cultivars showed higher values of fraction cover, although the highest values of area and canopy volume were observed in the 6x4 and 6x6 systems. Local cv. Calatina showed similar behaviour to the cv. Arbequina used in the high-density plants. The fraction cover obtained by applying various equations showed that the relative vegetation abundance algorithms are able to effectively estimate the degree of vegetation cover ($r^2 = 0.97$***).

Keywords: Precision oliviculture, Unmanned Aerial Vehicle, NDVI

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LiDAR application in *Moringa oleifera* Lam. for Precision Agriculture

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Abstract. Precision agriculture utilizes advanced techniques to optimize resource management, minimize yield losses, reduce environmental impacts, and enhance agricultural profitability and sustainability. A key innovation in this field is the integration of LiDAR (light detection and ranging) technology, which employs laser pulses to generate detailed 3D models for remote sensing applications in agriculture. LiDAR offers high-resolution data on crop metrics such as height, canopy cover, and biomass, enabling farmers to monitor crop growth and make data-driven decisions regarding irrigation, nutrient management, and harvest planning. The experimental site is located in Grotte (Agrigento, Italy) in which LiDAR technology was used in precision agriculture, detailing terrestrial systems along with their specialized applications in the field. The article focuses on the application of LiDAR in the cultivation and harvesting of *Moringa oleifera* Lam. It highlights how LiDAR technology allows for precise assessments of crop health and growth patterns, as well as the estimation of yield and maturity. The use of terrestrial LiDAR systems (TLSs) provides high-resolution, ground-level data. LiDAR's capability to create accurate 3D models facilitates the calculation of crop volume and biomass, correlating well with crop maturity indicators. While LiDAR technology shows promise in optimizing agricultural practices, further research is needed to enhance its integration with other remote sensing methods and improve data processing efficiency.

Keywords: Smart Farming, Precision Agriculture, LiDAR technology, crop management, yield estimation, canopy volume.

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Comparison of Satellite-Derived Soil Moisture Estimates and Ground-Based Measurements in Agricultural Sites of the Piedmont Region

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Abstract. Accurate soil moisture estimation is essential for agricultural management and hydrological modeling studies. In this regard, many regions at the National and International level have established a soil moisture monitoring network. Nevertheless, a uniformly distributed soil moisture monitoring network is still lacking in the Piedmont region, thus limiting the establishment of a comprehensive ground truth for validating hydrological models. Consequently, for regional-scale studies, it is necessary to rely on other types of measurements/estimates, such as those derived from gridded products.

This study evaluates the consistence of soil moisture estimates derived from three satellite-based products - ERA5, SMAP, and Sentinel-1 - against in situ measurements from soil moisture probes and a Cosmic Ray Neutron Sensor (CRNS) at some agricultural sites in the Piedmont region. The comparison is conducted across different soil types, land cover conditions, and irrigation practices to assess the reliability of each dataset in capturing soil moisture at different spatial and temporal scales.

Despite the measurements/estimates refer to different spatial and temporal scales, results indicate that the soil moisture dynamics of gridded products are overall consistent with the dynamics observed in ground-based measurements. Some discrepancies are noted and preliminary explanations for these discrepancies are investigated.

Keywords: Soil moisture, SMAP, ERA5, Sentinel-1, Cosmic rays, Capacitive probes

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Olive Paste Malaxation at Different O_2 Levels and Extra Virgin Olive Oil Quality

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Abstract. The presence of oxygen during malaxation plays a key role in improving the quality of extra virgin olive oil (EVOO) in terms of volatile and phenolic components. The research aimed to implement a new digital malaxer to perform malaxation in a controlled environment. The system was designed by the mechanical section of the Department of Agricultural, Food and Forestry Sciences of the University of Palermo. The main objective was to monitor and control in real time the oxygen within the mixing head space during malaxation. The application developed allowed the definition of advanced procedures for controlling gas concentration (O_2 and also N2) inside the malaxation machine. Olives of cultivar Biancolilla were processed in October 2024 to carry out the experimental tests. Three tests were performed: the control, consisting in malaxation in unmodified atmosphere; test T_1, where the malaxation chamber was inert by filling N2 before the olive paste entry, then O_2 was introduced at 15 min; and test T_2 where O_2 was inserted in two times, i.e. at 10 min and 20 min. Chemical analyses were performed on the EVOOs obtained to assess their main quality parameters, including phenolic and volatile composition.

Keywords: malaxation, phenolic compounds, real time, technology, volatile compounds.

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Bridging the Theory-Practice Divide: New Skills for Sustainable Precision Viticulture

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Abstract. The optimal use of Sustainable Precision Viticulture (SPV) solutions requires new knowledge and skills for those working in the field, revolutionizing previous organizational and production systems. Literature highlights the need for different technical, technological, ecological, and entrepreneurial capabilities. However, these identified skills clash with the skills perceived to be needed by practitioners. A research study was carried out to determine this gap. The first step was a data-driven approach consisting of a text mining analysis (part of speech tagging and chunking) of three databases (Erre Quadro's patent database, OPERNAIRE, and CORDIS-founded project) to extract the most recurring and emerging concepts related to technologies and drivers of change in SPV. Then, the clustered terms were compared to standardized occupational profiles in ESCO, O*NET and Lightcast's Open-Skills databases to extract the skills needed for the identified profiles. The above databases classified the skills extracted as green, digital, and entrepreneurial skills. In the second phase, an expert-driven approach was implemented. The resulting skills were used to design a questionnaire to be submitted as an interview to key stakeholders, including farmers, uni-versity students, trainers, and technicians, to validate the founding of the first step. The interviews took place in Belgium, France, Greece, Italy, and Spain. From the first step, 113 green skills, 73 digital skills, and 55 entrepreneurial skills were screened and validated. The survey results revealed a significant gap be-tween the needed and the perceived competence in the digital skills section, where a limited understanding of the added values of the technology application was evident. According to the findings, practitioners are more interested in en-trepreneurial and green skills than digital abilities.

Keywords: smart farming, digital training, data-mining, practitioners, interview, entrepreneurship.

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Exploring new approaches to mechanize cereal production in mountain areas

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Abstract. Diversification of agricultural production in mountain areas is a highly debated topic in research, politics and rural communities alike. In the Alps, there has been a history and constant interest in the cultivation of cereals as way to complement animal husbandry for instance. Due to the lack of suitable machinery, cereal production in mountain areas takes place on the few favorable areas or is pursued on very small land plots by farmers that belong to the category "heroic agriculture". Nevertheless, surveys indicate farmers inter-est in cereals and geostatistical data shows the availability of appropriate areas for crop cultivation. To boost the cereal value chain in mountain areas, thor-ough mechanization of the central production steps is necessary. The mecha-nized sowing and harvesting of cereals on slopes is currently a major challenge. Following various previous approaches, the University of Bolzano is launching a new project to assess which technologies are suitable for growing cereals on steep slopes. The aim of this paper is to give first insights into the results of this research and provide an overview of the profile of producers interested in cereal production. How many hectares are available? What are the characteristics of the plots? Which varieties are in demand? What plans are there for post-production? Have the farmers already gained experience? With this knowledge, it will be possible to carry out an initial multi-criteria analysis of farmers' op-tions and potential benefits.

Keywords: Mountain agriculture, cereal production, mechanization, high-tech, retrofit, niche production, multi-criteria analysis

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A GIS Method for Evaluating Built Heritage in Marginal Regions

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Abstract.
Marginal areas are peripheral regions with a rural vocation, generally characterized by economic and demographic decline, with direct consequences on land use and territorial management. Identifying these areas is a key element for their strategic planning. In Italy, the National Strategy for Internal Areas (SNAI) classifies the territory at the municipal level based on the degree of marginality, considering the distance from key service-providing centers, such as complete secondary schools, hospitals with a first-level DEA, and Silver category railway stations. However, using municipal boundaries as a unit of analysis can be limiting for the formulation of more effective management strategies, which would require a more detailed scale representation.

In these areas, depopulation affects not only land use but also the condition of the built heritage, which may require conservation and recovery interventions. However, studies on the built environment, mostly conducted in recent years, rarely focus on the dating of buildings.

This study aims to develop a rapid and low-cost GIS-based methodology for dating of rural buildings, applied in some rural areas of the Lazio region, with the goal of updating the geodatabase and providing a useful tool for the management, maintenance, and recovery of the built heritage in marginal areas.

Keywords: Marginal areas, Rural buildings, GIS.

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Development of a territorial Decision Support System (DSS) for the Sustainable Management of Livestock Waste for the Lazio Region

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Abstract. The optimal management of livestock waste represents a crucial challenge for ensuring agricultural sustainability, environmental protection, and compliance with current regulations. In response to these demands, this research aims to develop a Decision Support System (DSS) at a territorial scale for the Lazio region, designed to enable the sustainable management of livestock effluents.

The DSS integrates GIS technologies with multicriteria analysis methodologies to identify the most suitable areas for manure application. The approach relies on a precise and integrated selection of spatial data layers, considering agronomic, environmental, and socioeconomic factors. This system is designed to meet both regulatory compliance requirements and the growing need for the adoption of more environmentally responsible agricultural practices.

Among the key benefits this DSS seeks to achieve are the reduction of water pollution, the mitigation of greenhouse gas emissions, and the minimization of negative impacts on ecosystems and biodiversity. Additionally, the system enhances the efficient recovery and reuse of nutrients contained in livestock waste, promoting sustainable and effective fertilization practices while incorporating the principles of circular economy within the agricultural sector.

This tool represents a significant step forward an agricultural model that redefines livestock waste as a resource, transforming a critical issue into an opportunity to integrate technological innovation, environmental protection, and economic competitiveness.

Keywords: Decision Support System (DSS), Multicriteria Analysis, GIS Technologies, Livestock Waste Management, Agricultural Sustainability, Circular Economy

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Integrated and Participatory Landscape Protection and Restoration Planning for Water Ecosystems: The Case Study of Lake Vico

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Abstract. Freshwater ecosystems face growing threats, such as eutrophication, soil erosion, and biodiversity loss, which compromise their ecological resilience. While protection and restoration are essential, their success often depends on the involvement of local communities, and the exclusion of key stakeholders from the decision-making processes undermines the effectiveness of these initiatives.

Lake Vico exemplifies these challenges, exacerbated by the presence of intensive hazelnut cropping systems and the inherent fragility of aquatic ecosystems. The lake currently faces environmental issues such as soil erosion and nutrient pollution, which threaten its ecological balance and water quality. Tackling these problems requires an integrated and participatory approach that actively engages diverse stakeholders, including local authorities, farmers, NGOs, and residents. The "4 Returns Framework" (4RF) for landscape restoration is a practical methodology for fostering collaboration and achieving long-term solutions. The 4RF aims to deliver four key returns—inspiration, social, natural, and financial—through five core elements: (1) landscape collaboration, (2) shared understanding, (3) participatory visioning and planning, (4) implementation of concrete actions, and (5) continuous monitoring and learning. Its participatory nature strengthens territorial management, enhances stakeholder collaboration, and deepens the connection between communities and their environment.

Within the Horizon Europe EUROLakes Project, this contribution presents the first analysis and results of the 4RF conducted at Lake Vico, highlighting the challenges and barriers to implementing protection and restoration interventions based on Nature-based Solutions. The goal is to provide a replicable model for sustainable restoration that delivers both ecological and socio-economic benefits for lake ecosystems and communities.

Keywords: NBS, Socio-ecological systems, Hazelnuts, Eutrophication, Environmental planning

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Analysis of Irrigation Systems at a Sub-District Level

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Abstract. Recent years have shown how climate change is leading to an increase in drought events in the Po Valley, severely affecting irrigation and hence the agricultural sector. In this study, the agro-hydrological model IdrAgra was applied to a number of irrigation sub-districts in the Po valley, incorporating detailed land use and soil information and local agro-meteorological data. The sub-districts were selected among those with available data to represent the variability on irrigation system characteristics. The daily crop water requirements estimated by the model were compared with the water supplies for the period 2016-2022, including wet, average and dry years, enabling the assessment of the efficiency of the analysed irrigation systems.

The initial analysis focused on seven sub-districts in the Lombardy region characterised by pressurised distribution networks and irrigation methods. In addition to the boundary conditions (e.g. presence of shallow groundwater table), important variables affecting the mismatch between the actual irrigation needs and the delivered irrigation volumes include the rigidity of the distribution system (e.g. rotational distribution) and the limitations of current field water application practices.

The analyses were aimed at investigating the relative role of the different components of the irrigation system on the overall efficiency of water use. The results indicate that improved distribution and application practices can increase the efficiency of irrigation systems quite significantly in the context of the Po valley and supposedly in other irrigation contexts.

Keywords: irrigation efficiency, sub-district scale, agro-hydrological model, monitoring irrigation volume.

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Analysis of Potential Energy Supply to a Greenhouse through Shallow Geothermal Heat Exchange

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Abstract. Greenhouse crop production is one of the most energy-intensive activities in the agricultural sector and a significant portion of the energy required for climate control in these structures is derived from fossil fuels. To achieve the decarbonization of the greenhouse sector and mitigate the rising costs of food products, underground heat exchange represents a particularly effective solution, given the availability of land that can be allocated for this purpose in agricultural facilities.

This study aims to develop an analysis procedure for the design and optimization of systems harnessing shallow geothermal energy coupled with heat pumps to heat and cool interior spaces for controlled environment agriculture. The study is carried out with reference to the study case of an experimental greenhouse in Bologna. The procedure developed led to the evaluation of the geothermal heat and cooling potential of a site and the analysis of energy flows achievable for a given technical configuration.

The study is carried out in the framework of the research project PRIN 2022 DiAGreen "Digital twin of Agricultural Greenhouses: a multi-domain tool for energy efficiency, decarbonization, enhanced production and cost reduction of intensive greenhouse cropping systems". The resulting tool can support the design of optimal shallow geothermal system configurations, considering space constraints, while integrating with indoor environmental control systems for agricultural productions. Additionally, the results are suitable to usefully inform the process of modeling and simulation of renewable energy utilization.

Keywords: Controlled Environment Agriculture, Renewable Energy, Ground Source Heat Pump, Low Enthalpy.

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Development of a land use intensity index in Google Earth Engine

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Abstract.

Increased food demand, driven by population growth, has led to the expansion of cultivated areas and the intensification of agricultural activities, posing significant risks to biodiversity and the environment. Globally, contrasting trends are observed: in the Southern Hemisphere, agricultural expansion often occurs at the expense of forests, while in Europe, agricultural land abandonment is more prevalent, with an estimated 11% of farmland at risk of abandonment by 2030. Simultaneously, existing cultivated areas are experiencing increased agricultural intensification.

This study develops a methodology for assessing the Agricultural Land Use Intensity Index on a large scale, using cloud computing platforms and remote sensing techniques. By leveraging Google Earth Engine and Sentinel-2 multispectral time-series data, the study analyzes vegetation phenology and agricultural disturbances. Crop growth cycle profiles and peak NDVI values were extracted and validated against the 2020-2021 Land Parcel Identification System (LPIS) dataset, using 100 randomly selected pixels per crop. Optimizing peak detection thresholds resulted in an overall accuracy over 80%.

This research explores the potential of combining Sentinel-2 data, phenological analysis, and cloud computing for high spatio-temporal resolution land use intensity assessment.

Keywords: Google Earth Engine, Time Series Analysis, Agricultural Land Use Intesity.

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Assessing Wildfire Damage by UAV on Forest Areas: a Case Study

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Abstract. In July 2023, the mountains of Palermo, and in particular the area of Monte Grifone, located southeast of the Conca d'Oro and the city, were affected by devastating fires that also damaged the famous "cypress of San Benedetto il Moro". It is one of the oldest cypress trees in Italy, belonging to the species *Cupressus sempervirens* L. included in the list of monumental trees of Italy. In the following months, aerial monitoring was conducted using a drone, model DJI Phantom 4 Multispectral, equipped with a six-sensor multispectral imaging system, which includes five sensors for specific bands of the electromagnetic spectrum (blue, green, red, red edge and near infrared) and a standard RGB camera for visible images. The drone, flying at a height of 60 meters, captured detailed images of the top of the cypress, allowing to observe the entire crown and identify any signs of regeneration. The collected multispectral images were processed using the photogrammetry software Agisoft Metashape Professional and the open source software QGIS for GIS analysis. This phase allowed to evaluate the health status of the cypress through specific vegetation indices. The collected data were used to plan targeted interventions for the conservation and recovery of the cypress. The research activity also involved the area surrounding the cypress and the nearby Convent of Santa Maria di Gesù on Monte Grifone in order to evaluate the impact of the large forest fire in the area one year after the event.

Keywords: cypress, drone, environmental risk, forest fire.

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Leveraging Sentinel-2 and Pléiades Data for Sustainable Management of Urban Forestry: A Case Study of Historic Parks in Rome

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Abstract. Urban green spaces play a crucial role in mitigating the impacts of urbanization and climate change, yet their management poses significant challenges. This study examines the application of multispectral data for monitoring urban forestry in three historic parks in Rome: Villa Borghese, Villa Doria Pamphilj, and Villa Ada Savoia. By leveraging satellite imagery from Sentinel-2 and Pléiades platforms, we quantified the vegetative vigor of Pinus pinea specimens over three timeframes: 2015, 2018, and 2021. The Normalized Difference Vegetation Index (NDVI) was calculated to evaluate tree health, focusing on diachronic variations.

The comparative analysis highlights the strengths of Sentinel-2's temporal resolution and Pléiades' high spatial detail, emphasizing their complementary roles in vegetation monitoring. Results underscore a significant decline in vegetative vigor by 2021, linked to environmental stressors. This research provides critical insights into sustainable management strategies for urban green heritage, ensuring their resilience against evolving climatic and anthropogenic pressures.

Keywords: Urban forest, Sentinel-2, Pléiades, OBIA

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Unmanned Aerial Spraying Systems application in vineyard: preliminary results

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Abstract. Optimization of agricultural resources involves the adoption of innovative technologies and embedding precision farming strategies. Unmanned aerial spraying systems (UASS) represent a promising solution for the targeted application of treatments. The aim of the study is to evaluate the spraying efficiency of a UASS in a vineyard (cv. Catarratto) according to two droplet size and three terrain orographic conditions. The spraying system was a four-rotor UASS (ABZ L30) with a tank capacity of 30 L, equipped with 2 centrifugal nozzles. UASS flight was carried out at 2 m above canopy level with a speed of 2m s^{-1} in the inter-row position. The effectiveness of the treatment was evaluated using Water Sensitive Papers (WSP). These were placed in the bunch zone and in the upper part of the canopies. In addition, WSPs were positioned at ground level in the inter-row and under the plants to assess ground deposition. The average droplet size was set according to the nozzle rotation speed, resulting in values of 330 µm and 530 µm. The distribution was carried out on three subplots with different slopes: smaller than 10%, between 10% - 15% and greater than 15% respectively. Deposition analysis was performed using ImageJ software with the DepositScan plugin. The results showed that % coverage was higher in the upper part of the canopy than in the bunch zone regardless of the set droplet size. Overall, the results obtained suggest that the adoption of spraying technology using UASS in vineyards could be improved. The adoption of these systems can effective reduce the environmental impact.

Keywords: Precision viticulture, Aerial spraying, WSP analysis.

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Climate Change Impacts on Hydrology and Soil Erosion in a Mediterranean River Basin

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Abstract. This research investigates climate change impacts on streamflow and sediment yield in the Carapelle basin, a Mediterranean watershed in Apulia, Italy. Employing three climate model projections (CMCC, MPI, and EC-EARTH) after comprehensive bias correction, the study used the Soil and Water Assessment Tool (SWAT) to simulate hydrological processes and sediment transport through calibration and validation for the period 2004-2011 data. Projections for the period 2030-2050 reveal significant environmental transformations, including anticipated temperature increases up to 1.3°C and rainfall reductions approaching 38% compared to baseline conditions. Model predictions showed considerable variability: the CMCC model forecast the most dramatic changes with a 67% reduction in mean annual flow and 52.8% sediment load decrease, while the EC-EARTH model projected more moderate 7% flow reduction and 18.1% sediment load decline. Spatial analysis unveiled persistent erosion risks in areas with steep slopes and wheat cultivation, where sediment yields are expected to exceed 10 t ha^{-1}. These findings highlight the complex, spatially heterogeneous impacts of climate change on Mediterranean watersheds and underscore the urgent need for proactive water resource management and sustainable agricultural practices to mitigate potential environmental degradation.

Keywords: Global Climate Models (GCMs), Bias Correction, Climate Change, SWAT Model, Runoff, Sediment Yield.

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Application of Vegetation Indices to Precision Aromatic Crops

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Abstract. Remote sensing from Unmanned Aerial Vehicles (UAVs) allows to efficiently gather field data for precision agriculture. The aim of this paper is to analyse multispectral data related to aromatic crops, i.e. oregano, rosemary and sage. A DJI Mavic 3 Multispectral quadcopter was used to capture the images, which were subsequently processed by means of Agsoft Metashape software, in order to create two ortho-mosaics: RGB and monochromatic images. By means of GIS software several Vegetation Indices (VIs) were computed. These indices, e.g. Normalised Difference Vegetation Index (NDVI), Green Normalised Difference Vegetation Index (GNDVI), Soil Adjusted Vegetation Index (SAVI) and Transformed Chlorophyll Absorption in Reflectance Index/Optimised Soil Adjusted Vegetation Index (TCARI/OSAVI), allow to assess the spatial and temporal variability of vegetation vigour and chlorophyll concentration for each crop. Among the VIs, NDVI is currently the most widely used, as it leverages the reflectance differences between red and near-infrared (NIR) wavelengths. For each crop it was possible to produce vegetation vigour maps, where the NDVI values resulted 0.75 to 0.8 for rosemary, 0.6 to 0.7 for sage and 0.5 to 0.6 for oregano. The findings of this study indicate that UAV-based remote sensing is an optimal technique for managing the spatial and temporal variability of vegetation vigour in Medicinal and Aromatic Plants (MAPs) within the marginal hilly areas of inland Sicily. This paper also demonstrates that high-resolution UAV data and photogrammetric methods are fast, reliable and cost-effective tools, constituting a Decision Support System (DSS) that allows crop assessment in precision agriculture.

Keywords: Chlorophyll Concentration, NDVI, Remote Sensing, UAV, Vigour Maps, Decision Support System (DSS).

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UAV vs. Ground-Based LiDAR Systems Comparison for 3D Modelling in Precision Oliviculture

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Abstract. The applications of Precision Agriculture (PA) have grown considerably in recent years, providing innovative tools for sustainable olive orchard management. This study compared two LiDAR-based systems to enhance three-dimensional canopy reconstruction while assessing survey efficiency and output quality. The experiment took place in an intensive olive orchard in the Mediterranean area. The first system employed a DJI Matrix 350 UAV equipped with a Hovermap ST-X LiDAR, flown in automatic mode at an altitude of 40 m above ground level. The second system used a track-based LiDAR sensor that moved within the orchard. LiDAR devices incorporate a cutting-edge technology, boasting a detection range of up to 300 m and capturing over two million points per second with advanced SLAM processing. The Emesent Aura software was used to generate the point clouds and the digital elevation models. The outputs generated were evaluated by comparing point cloud density and biomass estimation accuracy. Preliminary results show that both LiDAR approaches effectively delineate tree geometry and quantify canopy attributes. The UAV-based system proved fast, enabling a broad coverage and consistent data quality. The ground-based platform demanded a significant operational effort and provided enhanced local resolution in complex tree structures. Both systems can support robust canopy characterization and their integration may favor more precise and sustainable olive orchard management.

Keywords: Olive orchard, Precision Agriculture, sustainability, 3D model reconstruction.

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EYE-LAND a Crowd-Sensing Geospatial Database for the Monitoring of Rural Areas

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Abstract.

In recent years, data collection has become increasingly accessible, thanks to the widespread use of everyday tools such as smartphones. In addition to simplifying data acquisition, these devices facilitate the rapid and large-scale exchange of information, opening up new perspectives for landscape and spatial analyses.
The main objective of the Eyeland project is to develop a smartphone app that adopts a participatory approach, such as Crowd Sensing and Citizen Science, to collect information in various fields related to agricultural, forests and rural lands.
The app is designed to facilitate easy and intuitive surveying, engaging farmers, technicians, and trained citizens. Moreover, thanks to preconfigured tabs that provide guidelines for data collection, the acquisitions remain consistent and easily processable.
The project employs a multidisciplinary approach to the study of the territory, with different research units involved in defining mapping strategies for various elements useful for spatial planning and for ground truth validation in remote sensing applications.
The aim of the research project is to develop a geodatabase that integrates in situ data as observations, addressing the disparity between the demand for geospatial information and its accessibility. To achieve this, a WebGIS infrastructure has been developed to enable data visualization and sharing among end users.

Keywords: Spatial Planning, Data Collection, Citizen Science, Crowd Sensing, Remote Sensing

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Spectral and thermal canopy characterization of different grapevine varieties

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Abstract. Classification of vine varieties is essential for precision viticulture, as it enables the identification of distinct growth patterns and targeted management strategies based on the bio-agronomic characteristics of each variety. Remote and proximal sensors used in precision viticulture offer methods to assess growing conditions by exploiting hyperspectral, multispectral and thermal data collected in the field. This study aimed to assess spectral and thermal variations in the canopies of five grapevine varieties using both proximal and remote sensing techniques. The trial was conducted in the 2024 growing season in Sicily, Italy, in experimental fields where vineyards are managed according to ordinary practices of the area. Grapevine varieties examined were Catarratto, Grillo, Müller Thurgau, Pinot gris and Trebbiano Toscano, trained using vertical trellises and pruned using the Guyot technique. Multispectral data were acquired using the DJI Mavic UAV, while thermal data were provided by the sensor H20T mounted on the Matrice 350 UAV. The multispectral and thermal images were processed using Geographic Information System software to extract spectral and thermal features from canopies. Hyperspectral acquisitions were made with a FieldSpec® HandHeld 2™ spectroradiometer in sunlight canopy exposure. The hyperspectral data showed clear canopy signature differences of the examined varieties in specific spectrum regions. The multispectral data allowed to obtain continuous maps of crop variability, highlighting the vigor and health status of each variety. Thermal conditions were correlated with canopy area and vegetation reflectance.

Keywords: Remote sensing, Spectral signature, Phenotyping.

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Monitoring and Energy Optimization of Agricultural Shelters: Case Study of Poultry Tunnels in the Province of Viterbo, Italy

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Abstract. The ultimate goal of this research is to identify advanced techniques and practices for improving the energy efficiency of agricultural buildings for livestock, with a specific focus on two poultry tunnels located in the province of Viterbo. To thoroughly understand the environmental determinants affecting the area and to appropriately evaluate energy efficiency scenarios best suited to the site, a series of sensors has been installed within the buildings to monitor climatic parameters such as air pressure, temperature, solar radiation, and humidity.
The monitoring activity, conducted continuously with recordings at 15-minute intervals, aims to capture thermo-hygrometric parameters, solar radiation, and the thermal transmittance of the building envelope. This process seeks to identify critical issues related to thermal dispersion and quantify the energy performance characteristics of the structures.
Additionally, the energy performance of the two tunnels, equipped with internal heating and cooling systems, is assessed through the installation of heat flux sensors, pyranometers, and sensors for temperature, humidity, and wind speed.
The data collected are utilized to evaluate potential intervention strategies, with the goal of identifying objective and measurable criteria within the fra-mework of environmental and constructive sustainability for livestock buil-dings.

Keywords: Energy Efficiency, Environmental Monitoring, Sustainability, Building Performance Analysis, Poultry Tunnels, Efficiency improvement of livestock buildings.

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Calibration of the airflow from a multirow vineyard sprayer by automated ultrasonic anemometry

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Abstract. The importance of air distribution in the efficacy of treatments from air-assisted sprayers demands a precise characterisation of the entity and spatial distribution of air flows from this type of machine. Ultrasonic anemometry is widely used for this type of investigation, with commercially available test benches being used in sprayer inspection workshops and research institutes.
This paper summarises the recent experiences in evaluating and calibrating a multirow vineyard sprayer (Rafal Pro 6 Sides, Caffini S.P.A., Palù, VR, Italy) with a commercial test bench (WP5000, Ernst Herbst Prüftechnik e.K., Hirschbach, Germany). The instrument is based on an array of ultrasonic anemometers. This type of sensor can produce accurate, time-resolved measurements of the airflows. This allows to quantify the turbulence generated, which seems to play a role on coverage in dense vine canopies. However, the test bench only produces time-averaged measurements, losing some degree of detail. The experiments aimed at assessing the repeatability of the trials and at calibrating the sprayer to obtain a uniform distribution. The tests showed that a minimum of three repetitions is required to produce a reliable result: based on previous experiences with more conventional sprayer architectures, it would seem that this variability is due to the higher degree of turbulence generated. The calibration attempts were successful.
Further experiments are underway to access the turbulence data, in order to understand whether this aspect of the machine's performance plays a significant role in the repeatability of the measurement.

Keywords: Plant Protection, Airblast Sprayer, Sprayer Calibration, Air Distribution, Test Bench.

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Sustainable farm buildings in a mountain area of Southern Italy. Study of site-specific building types and construction systems in Nebrodi Mountains, (Sicily).

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Abstract. In most farm buildings, animal houses, and dairy barns, indoor microclimate control greatly influences animal well-being and productivity. An appropriate choice of building envelope characteristics - in terms of size, shape, building materials, and construction system – is essential to obtaining effective control of microclimate through passive systems, thus reducing energy consumption and related carbon emissions. Moreover, the need to achieve the strategic goal of having zero energy and zero embodied carbon building stock by 2050 requires a site-specific approach to farm building design and greater attention to the appropriate choice of sustainable building materials and components. Timber and other materials derived from plants and vegetable-fibers and agri-food byproducts, appear as an efficient and sustainable alternative vs. the conventional building systems employing reinforced concrete and steel. Most vegetable-fiber-based materials are from renewable resources and often allow obtaining carbon-negative components, presenting good insulating properties. Moreover, the animal housing needs should be preferably answered rehabilitating the present farm building stock and improving its potential performance rather than new building facilities. New buildings, in turn, should be conceived considering their characteristic cycles, either as whole buildings or concerning their subsystems, components, and materials. This work presents the first results of a study on a mountain area in Nebrodi Mountains (Sicily). We aimed improving the functional performance of the present farm building stock using sustainable building systems and materials. Guidelines, reference building layouts and constructional schemes, were also proposed for new buildings by re-interpreting and innovating the traditional approach, and valorising local resources and skills.

Keywords: Farm buildings, sustainable architecture, building construction systems, rural building rehabilitation.

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YOLOv11 for Crop Variety and Plant Part Recognition in Greenhouse

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Abstract. This study explores the application of YOLO11, a deep learning-based object detection model, for the recognition of plant parts, crop varieties, and developmental stages in agricultural imagery. The model was trained on a dataset comprising 561 instances across nine crop classes, including peppers, tomatoes, and eggplants, with a focus on identifying parts such as flowers, fruits, and various growth stages. Evaluation results demonstrated a mean average precision (mAP) of 0.639 at IoU=0.5 and 0.376 at IoU=0.5:0.95, highlighting the model's capability in detecting and classifying diverse plant features. Key performance metrics, including precision, recall, and F1-score, were analyzed for each crop class. The results revealed significant performance variations across classes, with some, such as "Ppr_Fl," achieving high precision (0.83) but lower recall, while others, like "Tom_Frt," exhibited lower precision but higher recall. These variations underscore the challenges in accurately detecting and classifying agricultural crop parts across different developmental stages, influenced by factors such as visual diversity and class imbalance. Additionally, the study emphasizes the computational efficiency of YOLO11, with an inference time of 2.0ms per image, enabling real-time applicability in field conditions. These findings highlight the potential of YOLO11 in precision agriculture, offering a robust solution for automated recognition of plant parts, crop varieties, and growth stages, with significant implications for crop monitoring and yield prediction.

Keywords: YOLOv11, Object detection, Crop variety recognition, Plant part classification, horticulture.

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Evaluation of vineyard health status through UAV with multispectral camera

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Abstract. The use of Unmanned Aerial Vehicles (UAVs) with multispectral camera enables the assessment of vegetative vigour in field crops. Vineyards have become a key focus of precision agriculture, leveraging these technologies for agronomic optimization and plant disease monitoring. The high geometric resolution of UAV-derived images enhances disease detection, which is challenging due to the irregular presence of symptoms. Consequently, seasonal and annual monitoring is essential, and automated symptom detection can greatly assist grape growers. Spectral sensors provide non-destructive, objective, and rapid disease identification. This study evaluates the feasibility of UAV-based multispectral imaging for detecting foliar disease symptoms in vineyards. The study was conducted in a vineyard in western Sicily (Italy) trained with a vertical trellis system and Guyot pruning. The experiment was carried out in June 2023 using a UAV equipped with a multispectral camera. Using Digital Elevation Model (DEM) and spectral bands features such as the Canopy Surface Model (CSM) and vigour maps were extracted to detect the presence of diseased vines. These maps highlighted critical vines based on spectral responses, which were georeferenced and monitored throughout the season. Samples from these vines were analyzed at the laboratory, revealing that plants appearing asymptomatic upon visual observation were affected by diseases that could compromise vineyard health. This approach underscores the potential of UAV-based multispectral imaging for early disease detection in viticulture.

Keywords: Disease detection, Spectral imaging, Precision viticulture

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Vineyard vegetative characteristics evaluation through UAV-based LiDAR SLAM technology

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Abstract. Evaluation of vegetative characteristics is an important aspect in determining vineyard vigor. Traditional methods of evaluating these parameters are often time-consuming and labor-intensive. This study addresses the need for high-throughput phenotypic data by employing a UAV-based LiDAR system integrated with simultaneous localization and mapping (SLAM) technology. Experimental vineyards located in western Sicily were monitored during key phenological stages to determine vigor parameters. A DJI Matrice 350 equipped with a Hovermap ST-X LiDAR was flown over the experimental field. This system provides high-density point clouds with a detection range of up to 300 m and more than two million points per second with advanced SLAM technology for processing. Concurrent video capture with an action camera enabled RGB color assignment to the dense point cloud. Data processing was performed in Emesent Aura.

The resulting georeferenced 3D models effectively separated the vines from the background elements, allowing detailed partitioning of vineyard structures and vegetative parameters. Preliminary findings demonstrate the feasibility of using UAV-based LiDAR to accurately derive vegetative characteristics measurements, thereby reducing the problems derived from manual data collection. This approach offers a promising solution for vineyard management practices, improving the efficiency and precision of structural assessments. Overall, the proposed framework leverages advanced LiDAR-SLAM technology to provide robust phenotypic information, potentially advancing machine vision applications in viticulture.

Keywords: LiDAR, High-throughput phenotyping, UAV, Precision Agriculture

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Pasta with balanced aminoacidic profile enriched with pro-teins from pulses

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Abstract.
Italy is the world's largest pasta producer alongside the United States, Brazil, and Turkey. Italians are also the biggest pasta consumers, as it is a staple in their culture. Pasta's global popularity is due to its chemical, physical, and nutritional properties. It is a dry food with long shelf life, easy preparation, and high carbohydrate content. However, traditional semolina pasta lacks high-quality protein, particularly lysine and methionine. Egg pasta offers a better amino acid profile but relies on less sustainable animal proteins.

The European project ValPro Path aims to enhance plant-based proteins, especially from legumes, through innovative farming and processing techniques. The project, supported by the University of Turin, Aarhus University, Pastificio Antignano, and Molino Peila, developed a new plant-based pasta. This tagliatelle includes semolina fortified with red lentil, chickpea, and green pea flours. The goal was to create a high-protein pasta with a balanced amino acid profile following FAO/WHO guidelines.

Three pasta formulations (20%, 30%, and 40% semolina with legume flour) were tested against egg and gluten-free corn pasta. Analyses included cooking time, water absorption, texture, and sensory evaluation. The 40% legume-fortified pasta showed the best balance between nutrition, texture, and consumer preference, making it a viable alternative to traditional pasta.

Keywords: enriched protein pasta, controlled atmosphere, pulses, VALPRO-path.

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Dynamic social network analysis of a group of dairy cows allowed free access to the pasture

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Abstract. Dairy cows are known to be social animals but little is still known about their social behavior. In this study, we investigated the social network of a dynamic group of dairy cows during the dry period. The experiment lasted 5 months and a total of 35 Holstein cows have been included. The cows were fitted with radio frequency identification (RFID) tags and were allowed free access to the pasture through a gate which automatically recorded when a cow exited or entered the barn. Dyadic social interactions were monitored based on the temporal association of cow passages through the gate. A k-means algorithm was applied to the log of the frequency of dyadic time intervals between subsequent passages. Two normal distribution curves intersecting at x = 3.39 (corresponding to 30 seconds) were identified. This value was used as a threshold to determine whether consecutive passages were associated. A leader-follower matrix of associated passages was built and examined using dynamic social network analysis (DSNA). This approach provided a detailed view of interactions and hierarchies, enabling the identification of key animals and association patterns and allowed understanding how the social dynamics evolved over time. The DSNA produced three key findings: i) individual cows have different roles and importance in the herd social network, which do not seem to depend on cow physical characteristics such as age or body weight; ii) the most socially active cows established preferential relationships with specific members of the herd; iii) when key animals leave or enter the group, the structure of the social network changes deeply and significant bonds need to be re-established to maintain social stability.

Keywords: Dairy cows, social network, pasture, behaviour.

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Design and Development of a Test Bench for Measuring Vibrations from Portable Olive Harvesters

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Abstract. Hand-held vibrating harvesters are widely used where full mechanization is not feasible. These machines increase operators' productivity and reduce harvesting costs, but also expose users to high vibration risks for the hand-arm system, potentially leading to vascular issues such as the Raynaud's syndrome and the vibration-induced white finger.

The vibration transmitted to the operator's hand-arm system depends on both machine characteristics (e.g., materials and kinematics) and the interaction with branches. Therefore, assessing the actual risk requires direct measurements of vibration under real working conditions, making the comparison between different harvester models challenging. Moreover, idle mode measurements are not reliable, as vibration are often higher than during harvesting.

To address this, a test bench was designed and built to standardize vibration measurements, as no unified regulation currently exists. The test bench simulates the resistance exerted by branches during harvesting and allows testing various type of hand-held harvesters, including combo, beater, and flap models.

The test bench consists of an aluminum frame with a working area of approximately 1.5 m × 1.5 m, featuring vertical and horizontal nylon wires with adjustable spacing. These wires are tensioned using springs to ensure a consistent load during testing. Load resistance can be adjusted by moving a vertical and a horizontal bar that stretches the springs. Three parallel frames, spaced 10 cm apart, simulates a 3D tree crown.

A beater harvester, operated by three researchers, was used to evaluate the functionality of the test bench and its capacity to simulate the tree crown. The recorded data are still being processed.

Keywords: Safety, Health, Acceleration, HAV, Hand-arm systems

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Proximal Hyperspectral Imaging May Support Decisions on Irrigation Strategy on Tomatoes

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Abstract. Sustainable irrigation benefits the environment by reducing water consumption and contributes to the long-term viability of agriculture by balancing resource utilization and preservation. This study employed a hyperspectral camera to capture high-resolution images (range: 400–1000 nm; bandwidth: ~3.2 nm) to distinguish among tomato fields subjected to three irrigation treatments: (T1) time-based irrigation managed by the farmer, (T2) sensor-based irrigation supplying 100% of the plant's water needs, and (T3) deficit irrigation providing 70% of the plant's water requirements. Approximately 60 fruits were randomly collected from each treatment, and quality parameters, including firmness, total soluble solids (TSS), total acidity (TA), dry mass (DM), total polyphenols, total antioxidant activity, and total carotenoids, were evaluated. Vegetation indices, such as Normalized Difference Vegetation Index (NDVI) and Water Band Index (WB), were assessed. No significant differences were found among treatments for WB; however, T1 showed the highest NDVI value (0.6 ± 0.02), followed by T2 (0.5 ± 0.02) and T3 (0.41 ± 0.02). These trends were further supported by partial least square discriminant analysis (PLS-DA), which successfully classified both plant and fruit images across treatments, achieving cross-validation sensitivity and specificity of 0.89 and 0.90 for plant, and slightly lower values of 0.78 and 0.77 for fruits. While differences were observed in vegetation indices, no significant differences were found among treatments on fruits for firmness, DM, TSS, acidity, or total antioxidant activity. However, differences were observed in other parameters, such as total carotenoids, which were 0.73 ± 0.02 g/kg, 0.80 ± 0.02 g/kg, and 0.82 ± 0.04 g/kg for T1, T2, and T3, respectively. Total polyphenols were 0.09 ± 0.00 GAE g/kg for T1 and T2, and 0.08 ± 0.01 GAE g/kg for T3. These results demonstrate that proximal hyperspectral imaging can support agriculture by providing information on irrigation treatment and fruit quality, promoting the diffusion of sustainable irrigation practices. Sustainable irrigation management can be, in fact, adopted without compromising fruit quality.

Keywords: proximal sensing, irrigation, hyperspectral, quality

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The Use of VIS-NIR Hyperspectral Imaging to Assess Pulp Redness Level of Blood Oranges (cv. Tarocco Sant'Alfio)

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Abstract. The global fruit industry continually faces technological challenges to meet the increasing consumer demand for high-quality produce. For hiqh quality blood oranges it's very critical the insurance of intensity and uniformity of the pulp red color, not discernible from the external surface. Nowadays color can be assessed only cutting the fruit and on a limited number of randomly selected fruit, but non-destructive techniques have proved to be effective in predicting internal quality and composition of fruit and vegetables. This study aimed to investigate the potential of VIS-NIR (400-1000 nm) and NIR (900-1800 nm) hyperspectral imaging combined with Partial Least Squares Discriminant Analysis (PLS-DA) to classify Tarocco Sant'Alfio oranges into two classes of redness, namely Red and Non-Red. A total of 400 oranges were scanned using a hyperspectral imaging system. Following image acquisition, the fruits were longitudinally cut and RGB image of the internal section was taken to assess redness index. PLS-DA models were developed using various spectral preprocessing techniques, with the dataset partitioned into two subsets: 70% for calibration and 30% for validation. The best classification performance was achieved using first derivative preprocessing combined with mean centering, resulting in classification accuracies of 80% and 87% for calibration and prediction, respectively. These results demonstrate the potential of hyperspectral imaging as an effective, non-destructive method for assessing internal color variations in Tarocco Sant'Alfio oranges which can be implemented on selection line for fruit classification.

Keywords: Hyperspectral images, Oranges, VIS-NIR, PLS-DA, Machine Learning.

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Detection of Pesticide Residues in Table Grapes by mean of Hyperspectral Imaging

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Abstract. The detection of pesticide residue levels is critical for food safety assessment. The traditional detection methods are time-consuming and laborious while non-destructive detection makes the process rapid and ensures quality. This research focuses on the time-series hyperspectral imaging of red grapes to classify pesticide residue levels with the passage of days. A combined solution of two pesticides, "Flint" (Bayer) and "Switch" (Syngenta) was used in a ratio of 1:5.33 in water; the initial solution was then diluted into the required low levels of concentration. The pesticide solution was applied in the lab, by spray, simulating the field conditions. Five concentrations were prepared diluting the initial solution 100 % (T1), by 80% (T2), 60% (T3), 40% (T4) and 20% (T5). After the spray, the grapes were stored at 0˚C. The hyperspectral images were taken with the hyperspectral line-scan scanner (Version 1.4, DV srl, Padova, Italy) with two sensors, in the visible near-infrared (Vis-NIR) range from 400 to 1000 nm and near-infrared (NIR)from 900 to 1700 nm. The hyperspectral images were taken 24 hours, 8 days, 15 days and 19 days after treatment. For each day 10 grape berries were taken from each treatment so 200 samples were imaged. After that berries were frozen for further chemical analysis of residues. For classification, the data set was divided into five classes according to treatments, 100% (class1), 80% (class2), 60%(class3), 40% (class4) and 20% (class5). The partial least square discriminant analysis (PLSDA) method was used for each sampling. The Vis-NIR spectra didn't discriminate well among classes and showed accuracy for most classes lower than 70%, while the NIR spectra showed better discrimination for most classes. The cross-validation (CV) accuracy for treatments after 24 hours was lower than 70% while for the remaining days the average CV accuracies for T1, T2, T3, T4 and T5, were 98%, 88%, 75%, 70 and 94%, respectively. Pesticide analysis is still running but the results show that the pesticide residue could be detected at very low concentrations, even after 19 days from the application, suggesting that prediction may also be achievable. This research could enhance the non-destructive detection of pesticide levels on grapes and the regression models for the degradation of pesticide residue over time would help the quality assessment for industries and the market.

Keywords: pesticide residue, hyperspectral imaging, grapes quality assessment, non-destructive detection, Vis-NIR and NIR spectroscopy

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The Development of Yolov8 Algorithm for A Real-time Model of Grapes Cutting Point Detection

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Agriculture has gone through transformational changes because of the rapid growth of artificial intelligence (AI) technologies. To overcome the difficulties associated with using conventional fruit harvesting techniques, automated robotic fruit harvesting has become a ground-breaking alternative. This study aims to design machine learning model of grape detection and optimal picking point determination on peduncle that can be integrated into robotic harvesting system. The RGB images were taken in the field near Foggia, Italy using iPhone 13 mobile camera with the resolution of 3024 × 4032 pixels. The images were taken at different angles and under varying natural lighting conditions to make the model more robust. Then these images were annotated using bounding boxes algorithm. The two classes were labelled in each image i.e. Picking Point and Grapes. The 165 annotated images then divided into training and validation set in ratio 70:30. The YOLOv8 deep learning architecture was used to train the object detection model. The performance efficiency of model was evaluated using 100 epochs. The results show the model achieves a maximum of mean Average Precession (mAP) of 90 %. The precession curve steadily improves across training while recall curve remains lower. This showed that model is detecting object with good accuracy and could be improved to be adapted to any vison system.

Keywords: robotic harvesting, picking point detection, YOLOv8, precision agriculture

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Techno-economic and environmental assessment of biogas production from ensiled orange peel waste (OPW)

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Abstract. The use of agro-industrial by-products to generate energy is a valid approach to improve the sustainability levels of production processes. Within the agro-industrial sector the citrus pro-cessing generates a significant amount of by-products known as orange peel waste (OPW). Recent researches on the valorisation of OPW yielded promising results, especially regarding biogas production. However, the availability of OPW is limited to a few months each year due to the seasonality of the product and processing variables. This limits the continuous operation of biogas plants using OPW. In this context, the objective of the present study is to analyse the technological feasibility of storing OPW through the ensiling process and to assess the econom-ic and environmental sustainability of biogas production for two different scenarios: "Ensiled" scenario and "Business as usual" scenario. The economic sustainability analysis, conducted with the Life Cycle Costing (LCC) methodology, highlighted the investments necessary for the ensiling process, by revealing that both scenarios are potentially profitable. With regard to environmental performance, measured using the Life Cycle Assessment (LCA) methodology, the "Ensiled" scenario had a slightly higher impact than the "Business as usual" scenario for almost all impact categories. However, even in this scenario, the overall process remains highly sustainable, especially since in many areas, the alternative to storing OPW would be the dis-posal. The results obtained could have important policy implications to incentivise business-oriented strategies for new ecological transition pathways.

Keywords: By-product valorisation; Life Cycle Costing (LCC); Life Cycle Assessment (LCA); Orange peel waste (OPW); Biogas; Assessment of invest-ments;

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The effect of wetting cycles on the moisture behaviour of thermally treated ayous wood at two different temperatures in an industrial plant

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Abstract. Wood is a highly attractive material, yet it is also susceptible to degradation, mainly in outdoor environments. Thermal modification is a viable alternative to enhance the durability of wood, especially when used in contexts where the use of preservatives is not recommended.

This study investigates the behaviour of ayous wood untreated (UT) and thermally modified at two different temperatures (TM190 and TM215) when subjected to consecutive soaking-drying cycles. The thermal modification was conducted on planks in an industrial system that used a slight initial vacuum in an autoclave Maspell WDE Model TVS 6000 and a treatment temperature of 190 °C and of 215 °C for three hours, respectively. Some selected physical properties (radial, tangential, volumetric swelling and anti-swelling efficiency) were determined at each soaking-drying cycle.

The application of thermal modification resulted in a reduction of swelling from the untreated, for TM190 and for TM215.However, after exposure to consecutive soaking-drying cycles, the swelling of the control samples exhibited a slight decrease, while the thermally modified samples demonstrated an increase in swelling. The findings of this study offer a more comprehensive understanding of the thermal modification of wood and its behaviour under cyclic wetting-drying conditions, particularly considering that thermally modified wood is used for external flooring and facades.

Keywords: *Triplochiton sleroxylon* K. Schum, soaking-drying cycles, physical properties.

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Urban land cover mapping utilizing Sentinel 2 data for the strategic planning and management of the available green spaces

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Abstract. The emphasis on planning urban green spaces has increased significantly due to the ongoing global scarcity of metropolitan areas. Landcover mapping has been a crucial management tool for decades, ensuring an efficient system. This research aims to assess the feasibility and potential of the applied methodology. Sentinel 2 data has been employed to depict green space patterns in two megacities. The Geographic Object-Based Image Analysis (GEOBIA) approach has been used to classify the intricate urban morphology considering the existing green spaces. Results have been generated for the study area in central Italy, mainly covering the Marche region. The findings accurately reveal the green space patterns in both cities, affirming the applicability of the Copernicus data. The accuracy has been assessed based on the available field data and the data extracted from Google Earth. This will also illustrate the necessity of strategic planning to excel in the existing management system. This type of green space pattern mapping will be readily available to policymakers, either public or private entities.

Keywords: GEOBIA, Sentinel2, eCognition.

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Agroecological practices to increase farm resilience: A measurement of economic-environmental sustainability through a life cycle approach

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Abstract. The effects of climate change and global geopolitical turbulence are increasingly driving the need for sustainable and resilient agri-food production systems. Shock events affect the food availability, which in the case of commodities, has a direct impact on consumers' purchasing power. Innovations that facilitate the reduction of raw materials, e.g. chemical fertilizers, can provide effective solu-tions to emerging challenges. Nevertheless, for large-scale efficacy, such innovations must prove to be cost-effective and low environmental impactful. In this regard, the present study analysed the economic and environmental perfor-mance of agronomic trials of wheat-legume temporary intercropping. Accord-ing to this practice, a functional group of crops, such as legumes, was terminat-ed and incorporated into the soil when wheat was at the tillering stage. This was done to avoid interspecific competition but facilitate the uptake of nutrients such as nitrogen (N) and phosphorus (P) by the wheat. Sustainability assess-ments were carried out using life cycle thinking (LCT) methodologies, which allow to account all input and output in all phases of production process to be analysed. In more detail, conventional life cycle costing (LCC) was used to assess economic aspects, while life cycle assessment (LCA) to consider environmental impacts. Results demonstrate the overall economic and environmental efficacy of the innovative models, which enhance business resilience and reduce environmental loads, while underscoring certain constraints for large-scale implementation. The study's findings bear significant business and policy implications and can inform the formulation of incentives to promote more sustainable agroecological practices.

Keywords: Resilience and sustainability; Investment and profitability analysis Life cycle costing (LCC); Life cycle assessment (LCA); Agroecology.

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Evaluating Rainfall Erosivity Using a Convection-Permitting Model Ensemble Across an Alpine Transect

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Abstract. Alpine regions are highly vulnerable to rainfall-induced soil erosion, which is expected to change in a warming climate. Recently developed convection-permitting climate models (CPMs) outperform coarser-resolution regional models in capturing intense sub-daily rainfall, thanks to their high spatio-temporal resolution and ability of explicitly resolving convection. As a result, CPMs hold great potential for assessing rainfall erosivity and projecting its future changes under climate change scenarios in complex orography regions.
This study assesses the ability of a multi-model CPM ensemble to provide reliable rainfall data for the evaluation rainfall erosivity, an essential step in analyzing erosivity projections. The study focuses on a transect in the Italian eastern Alps, an ideal case study due to its complex topography and high rainfall variability. Data from 174 rain gauges at sub-hourly resolution are used as benchmark to evaluate the CPM ensemble's performance.
Preliminary results indicate that the CPM ensemble slightly overestimates the number of erosive events and underestimates the mean annual rainfall erosivity in the region. Whereas these biases are relatively minor when considered globally in the area, it is shown that the accuracy of CPM-based simulations is significantly influenced by terrain elevation. In lowland areas, the models tend to underestimate both the number of erosive events and average rainfall erosivity, whereas at higher elevations, they overestimate both the metrics. Furthermore, topography strongly affects the spread of erosivity simulations among the CPM models.
These findings highlight the need for bias adjustments that account for topographic influences when investigating future changes in rainfall erosivity patterns.

Keywords: Rainfall erosivity, Erosivity, Convection Permitting Models.

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Digital Tools and Practices in Cable Yarder Line Design and Tracking: A Survey-Based Analysis

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Abstract. The use of cable yarders in forestry operations requires precise planning, careful design, and accurate installation of cable lines. This study presents a structured questionnaire aimed at collecting insights from professionals with different levels of expertise in cable yarder operations, ranging from technical designers to field operators. The survey explores key aspects such as surveying methodologies, tool usage, and the potential role of digital technologies in optimizing line planning, design, and installation.
The expected outcomes include a deeper understanding of the balance between traditional tools (e.g., compass, inclinometer) and emerging digital technologies (e.g., GPS, GIS-based software, mobile app). Additionally, the study evaluates the perceived benefits and challenges of integrating digital solutions into forestry operations. The research will provide valuable insights into how digital tools can enhance operational efficiency, improve safety, and influence training requirements. Furthermore, it will assess professionals' familiarity with digital tools and their openness to adopting mobile applications for real-time data collection and decision-making.
By analyzing these factors, the study aims to support the development of more effective and user-friendly technological solutions for cable yarder operations. Ultimately, these advancements will contribute to safer, more efficient forestry practices and promote the adoption of digital innovations in the field.

Keywords: Cable yarder, Forestry, Technology acceptance, Design, Operators, IT

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Modular Robotic Platform for Precision Agriculture

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Abstract. A modular robotic platform enhances precision agriculture by improving crop row detection and management. Autonomous movement capabilities, combined with the YOLOv8 model, enable real-time crop row recognition, optimizing efficiency and reducing resource waste. The integration of machine learning algorithms and robotics ensures increased accuracy in agricultural operations.

Tested in real-world conditions, the system demonstrates significant improvements in precision and recall metrics, validating its effectiveness in crop row detection. Designed for scalability, the platform adapts to various agricultural tasks, offering a cost-effective and sustainable solution. By leveraging AI-powered vision systems and modular robotics, it contributes to the advancement of automation in modern farming.

Keywords: Precision Agriculture, Modular Robotics, Crop Row Detection, Autonomous Systems, Machine Learning, YOLOv8 model.

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Next-Generation Robotic Weed Management: Enhancing Precision Agriculture through Computer Vision, CNNs, and Vision Transformers for Accurate Detection and Classification

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Abstract. Weeds pose a significant threat to agricultural productivity by competing with crops for essential resources such as water, nutrients, and sunlight. Traditional management methods, such as manual labor and chemical herbicides, are costly, labor-intensive, and environmentally harmful, leading to soil degradation, water pollution, and herbicide resistance. This study explores integrating computer vision techniques, convolutional neural networks (CNNs), and vision transformers (ViTs) into robotic systems for precise weed detection and classification.

Using state-of-the-art deep learning models, we develop an autonomous robotic platform capable of identifying weeds at various growth stages, distinguishing them from crops, and implementing targeted interventions in real time. The framework relies on large-scale datasets of high-resolution images captured under diverse conditions to train robust models. CNNs, known for hierarchical feature extraction, provide a strong baseline for weed recognition, while ViTs, using self-attention mechanisms, enhance performance in complex scenes with overlapping plants or varying backgrounds.

Field trials demonstrate a significant reduction in weed biomass and a substantial increase in crop yield compared to conventional herbicide-based methods. These models are integrated into a mobile robotic platform equipped with cameras, GPS, and actuation systems designed for mechanical or localized chemical weed control. This research highlights the transformative potential of AI-driven robotics in weed management, advancing sustainable and scalable precision agriculture while minimizing ecological impact.

Keywords: Weed detection, Precision agriculture, CNNs, ViTs, Mobile robotics, Mobile robotics.

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The effects of automation and digitalization on managers and employees in horticulture – a mixed methods study in Germany

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Abstract. The lack of skilled labor, rising input prices and structural change are challenging horticulture in Germany. Technological innovations can contribute to solving these problems. So far, most research on agricultural innovation focuses on the farmer's perspective. However, the adaptation of new technologies directly affects and changes the working environment and daily tasks of employees. Our study focuses on both horticultural operations managers and employees, and aims to answer the research question of how digitalization and automation affect them and their work. We have adopted a mixed methods approach, combining qualitative and quantitative empirical fieldwork in the horticultural sector.

For the qualitative study, we visited eight horticultural companies mainly producing ornamental plants and interviewed both managers and employees. We found that managers and workers have similar and generally positive views on the impact of digitalization and automation on their sector. For example, they expect an increase in efficiency, a reduction in injuries and a decrease in the need for (mainly) unskilled labor.

A quantitative online survey of n = 288 people from the whole horticultural sector provided data for a regression analysis in the style of a technology acceptance model. The intention to use a new technology is strongly influenced by whether or not it is perceived to be useful. Managers and employees of horticultural companies show the same attitude. Our study provides insights into how the sector can deal with ongoing technological change in terms of the organization of management and work processes.

Keywords: Technology acceptance, qualitative content analysis, regression, horticulture

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Carbon Footprint of Vermicompost Production

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Abstract. Vermicomposting is a method for treating food waste, producing both organic amendments and earthworms. These amendments are used in agroecological contexts to increase organic matter content in the soil, which in turn improves soil structure, aeration, and water-holding capacity and prevents soil erosion. In addition, it contributes to the circular economy by reintroducing food waste into food production.

This study aims to estimate the carbon footprint of vermicompost. The functional unit is 1 kg of vermicompost and the system boundaries are from cradle to factory gate. Process inputs include earthworms, organic waste (food waste, straw, or other substances to have an optimal carbon-to-nitrogen ratio), water to maintain moisture, and plastic for packaging. The outputs are vermicompost, earthworms, and emissions to the atmosphere, namely biogenic CO_2, CH_4, N_2O, and NH_3. Background inventory data are obtained from Ecoinvent and GaBi databases, whereas the emissions released are gathered from the literature. These emissions exhibited a broad variability depending on the substrate and composting conditions. For example, CH_4 ranges from 0.003 to 0.08 g C/kg of waste. Therefore, a variability assessment is carried out using Monte Carlo simulation, and the average carbon footprint of vermicompost and a confidence interval is calculated. The results of this study aim to fill the data gap on the carbon footprint of biofertilizers and amendments. These data are crucial to show the real sustainability of agroecological practices.

Keywords: vermicomposting, emissions, Carbon footprint, Organic waste, Organic amendment, Agroecology.

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Carbon Footprint of Powdered Smoothies Developed Using Pulse Spray Drying (PSD)

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Abstract. Fruits and vegetables are essential for maintaining a healthy diet because they contain antioxidants, vitamins, minerals and fiber. On the other hand, fruit and vegetable surplus represents an environmental problem, and alternatives to valorize them are required. Pulse spray drying (PSD) is an emerging drying technology that could contribute to use this surplus to produce food powders, such as smoothies. These smoothies could be easily integrated into the daily diet or used as an ingredient in the food industry. PSD equipment consists of one or more pulse combustors to produce high-temperature and high-velocity pulsating jets that increase heat/mass transfer rates. PSD works with direct heating, has a better energy efficiency than spray drying, and the powders obtained have better characteristics and lower particle denaturation. PSD is still under development, and scientific studies are needed to understand and corroborate its potential benefits. This study assesses the prospective carbon footprint of powdered smoothies from fruit and vegetable surplus dehydrated with PSD. The functional unit is 1 kg of powdered smoothie, and the system boundaries from cradle to factory gate. From pilot plant data, a scale-up is made to provide inventory data at the industrial scale. Mass and energy balances are carried out for that purpose, considering an input of 3000 kg/h of liquid smoothie. Aspects such as the allocation between fresh juice and residues, as well as a forecast of energy production in the future, are considered. This analysis contributes to developing more sustainable and energy-efficient fruit and vegetable products.

Keywords: Carbon footprint, Pulse spray drying, Powdered smoothie, Fruit and vegetable surplus.

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Operating Parameters of Sprayers and Functional Control in Olive Growing in Calabria

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Abstract. Sprayers are the most commonly used agricultural machines for applying crop protection products. In conventional sprayers, the liquid mixture is atomised by pressure and directed into an air stream generated by an axial fan. A crucial aspect of their optimal functioning is the so-called "functional check". Directive 2009/128/EC has made it compulsory to carry out functional checks on equipment used to distribute plant protection products. The functional check is carried out exclusively by test centres authorised by the regional authorities and staffed by qualified personnel.

A functional check is a series of checks carried out using specialised equipment and standardised procedures to assess the correct functioning of sprayer components. To be authorised to carry out functional checks and adjustments on sprayers, test centres must meet specific requirements, including employing at least one qualified technician, having equipment that meets established standards and being able to carry out simple mechanical interventions.

This study aims to analyse the data collected between 2022 and 2024 by the accredited test centres of the Regional Agency for the Development of Agriculture in Calabria (ARSAC) for olive cultivation. By evaluating these parameters, it will be possible to gain valuable insights into sprayer performance and identify opportunities to improve treatment efficiency.

Keywords: Functional Check, Test Centre, Equipment, Systems Monitoring.

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Protecting olive trees from pests and diseases: Comparing laboratory and field spraying effectiveness

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Abstract. Olive growing is one of the most emblematic agricultural practices in the Mediterranean. Its protection is a fundamental intervention, without which it would be difficult to achieve high productivity in the field. Although significant technological advances have been made in active formulation development, mechanical distribution requires increasing attention. Low application efficiency is often due to outdated, malfunctioning or incorrectly calibrated and set equipment. In this context, the PRIN 2022 PNRRR project "Implementation of a Digital Tree to Optimise Technical and Environmental Performance of Crop Protection Equipment (IM GROOT)" aims to investigate the quality and sustainability of mechanical agrochemical application in olive orchards, focusing on spray distribution uniformity, environmental impact and worker and bystander safety. This study presents the results of the first year of the project. It discusses preliminary laboratory tests to assess leaf deposition and surface coverage under controlled conditions, and initial field tests to determine application quality under common working conditions. The laboratory tests were carried out using a test bench designed to measure the droplet size spectrum produced by crop spray nozzles. On the other hand, field trials simulated applications to determine foliar deposition and soil losses. The results show the need to optimise the use of machinery and equipment in the field to meet both production and environmental objectives.

Keywords: Test bench, sprayer, food dye, Petri dishes, water sensitive papers

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Olive Oil Booster replaces malaxers to improve yield, quality and energy efficiency of virgin olive oil extraction process

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Abstract. The malaxation phase in the olive oil extraction process has always played a crucial role in achieving yield and quality. With the introduction of the centrifugation method for solid-liquid separation, the importance of malaxation has become even greater. From the mid-1900s to the present, technological development of malaxation has seen improvements aimed at improving oil quality while maintaining unchanged performance in improving extraction yield. Malaxation at atmospheric pressure can improve extraction yield by increasing time and temperature, but only to the detriment of the quality of the resulting oil. Alfa Laval's introduction of the Olive Oil Booster (OOB) represents an innovation for simultaneously improving quality and extraction yield. The OOB system replaces traditional malaxation with vacuum malaxation at 50-70 mbar a, reducing oxidative phenomena, preserving the aromatic fraction, increasing the migration of phenolic compounds to the oily fraction, and increasing the extraction yield in the decanter centrifuge, thanks to the breaking of the emulsion and the disintegration of the microgels produced by the pectin content in the olive paste. Furthermore, the possibility of reducing malaxation temperature and time, simultaneously with an increase in extraction yield, allows OOB to guarantee a reduction in the specific energy required for the extraction process.

Keywords: Vacuum, Quality, Centrifuge, Malaxation, Oil yield, Phenols, Volatile compounds, Energy consumption.

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Recovering livestock and dairy by-products for biomethane production through anaerobic co-digestion process

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Abstract. This work aims at recovering livestock and dairy by-products for energy purposes. Particularly, experimental trails focused on the evaluation of the Biochemical Methane Potential (BMP) of the aforementioned by-products, through batch discontinuous anaerobic co-digestion process under mesophilic conditions at 37 °C. The samples, i.e. bovine manure and slurry and milk whey, were provided by a private farm located in the Province of Reggio Calabria. Before performing BMP tests, it was necessary to characterize the matrices considering physical-chemical parameters, particularly: pH, total solids content, volatile solids content and the chemical oxygen demand, to determine the composition of the mixtures to be subjected to an anaerobic digestion process, avoiding any inhibitory phenomena. Hence, the considered theses were: T1: 100% bovine manure, T2: 50% bovine manure + 50% bovine slurry, T3: 45% bovine slurry + 45% bovine manure + 10% milk whey and T4: 40% bovine manure + 40% bovine manure + 20% milk whey. The BMP tests were performed in a fermentation system equipped with 18 reactors incubated in a heating oven. The reactors are individually connected to milligas counters for the quantitative and continuous evaluation of the produced biogas. The milligas counters are hermetically connected to CO2 absorption bottles. The gas coming out from the CO2 absorption bottles was periodically analysed to quantify the methane contained in it. The obtained results are promising, as biogas production reached 7 L/Lsubstrate for thesis T2, with methane percentages up to 99% of the biogas excluding CO2..

Keywords: Biochemical Methane Potential (BMP), Biogas, Mesophilic conditions, Renewable energy, Sustainability.

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