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11<sup>th</sup> AIAA 2017 Conference  
**Biosystems Engineering Addressing  
the Human Challenges  
of the 21<sup>st</sup> Century**

# BOOK OF ABSTRACTS

Bari (Italy), 5-8 July 2017

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*Welcome to the 11th AIIA Conference in Bari, Italy!*

*I am very pleased to welcome all the participants of the 11th AIIA 2017 Conference, jointly organized by the Italian Society of Agricultural Engineering (AIIA) and the University of Bari Aldo Moro.*

*The AIIA2017 Conference “Biosystems engineering addressing the human challenges of the 21st century” has a multidisciplinary approach, framed in 10 thematic areas concerning the aspects currently shared by the Agricultural and Biosystems Engineering:*

- 1. Cultural heritage preservation and rural landscape protection, planning and management*
- 2. ICT, precision systems and new technologies for land, farm and forestry management*
- 3. Energy, waste and by-products smart use*
- 4. Challenges in water and soil conservation and management*
- 5. Hydrology, debris flow, sediment-large wood connectivity in a changing environment: processes, control and consequences*
- 6. Post harvest, logistics and food chain equipments and structures*
- 7. Organic farming, sustainable plant and livestock production processes and technologies*
- 8. Safety, health, ergonomics, management and standardization for agriculture and forestry machines, equipment and structures*
- 9. Natural resources and environmental systems monitoring and assessment*
- 10. Biosystems engineering at urban and suburban scale*

*We received approximately 230 papers from 10 different countries. The Conference consists of three days of scientific paper presentations, including 3 invited lecturers, 135 oral presentations and 92 e-posters.*

*I am confident that all the papers that will be presented during the oral and poster sessions, along with the relative discussions, will contribute to increase the development and dissemination of Agricultural and Biosystems Engineering. I believe that AIIA2017 will highlight new routes for the cooperation among different research teams.*

*On behalf of the Organizing Committee, I wish you a fruitful and interesting Conference and a pleasant stay in Bari.*

Prof. Giacomo Scarascia-Mugnozza  
Convenor Department of Agricultural and Environmental Science  
University of Bari “Aldo Moro”, Italy



## **TOPIC 1**

Cultural heritage preservation and rural landscape protection, planning and management..... 2

## **TOPIC 2**

ICT, precision systems and new technologies for land, farm and forestry management..... 24

## **TOPIC 3**

Energy, waste and by-products smart use ..... 57

## **TOPIC 4**

Challenges in water and soil conservation and management ..... 85

## **TOPIC 5**

Hydrology, debris flow, sediment-large wood connectivity in changing environment: process, control and consequences..... 118

## **TOPIC 6**

Post harvest, logistics and food chain equipments and structures ..... 132

## **TOPIC 7**

Organic farming, sustainable plant and livestock production processes and technologies..... 165

## **TOPIC 8**

Safety, health, ergonomics, management and standardization for agriculture and forestry machines, equipment and structures ..... 190

## **TOPIC 9**

Natural resources and environmental systems monitoring and assessment ..... 229

## **TOPIC 10**

Biosystems engineering at urban and suburban scale ..... 254



*11<sup>th</sup> International AIAA Conference: July 5-8, 2017 Bari - Italy*  
*"Biosystems Engineering addressing the human challenges of the 21<sup>st</sup> century"*

# **TOPIC 1**

## ***CULTURAL HERITAGE PRESERVATION AND RURAL LANDSCAPE PROTECTION, PLANNING AND MANAGEMENT***



Monitoring and modelling for dry-stone walls terracement maintenance <i>Preti F., Dani A., Errico A., Giambastiani Y., Guastini E., Penna D.</i> .....	5
Assessing volumetric and geomorphologic changes of terraces in Amalfi Coast using photogrammetric technique. <i>Capolupo A., Cervelli E. Pindozi S., Boccia L.</i> .....	6
Could the environmental issues in agricultural areas be an effective driver to set up a participatory and sustainable management? The experience of the Rural Observatory in the Municipality of Corinaldo (Province of Ancona, Italy) <i>Galli A., Tiberi S., Marcheggiani E.</i> .....	7
Farm buildings and rural landscape quality: FarmBuiLD as a method to link rural heritage and new constructions. A pilot study in the Emilia-Romagna Region (Italy) <i>Maino E., Torreggiani D., Benni S., Tassinari P.</i> .....	8
Valorization of key buildings of the rural traditional landscape in central Italy: the case of the "Casa Colonica" <i>Menconi M.E., Grohmann D. Rocchi L., Paolotti L.</i> .....	10
Coping with species' perception of barriers: an assessment of landscape fragmentation <i>De Montis A., Ledda A., Serra V., Peddio V.</i> .....	11
Rural buildings and landscape fragmentation: measure and interpretation <i>De Montis A., Ledda A., Serra V.</i> .....	12
Stone artifacts of the Sicilian mountain landscape: a cultural heritage to be protected <i>Lanteri P., Tomaselli G., Quattrone M., Vindigni V., Russo P.</i> .....	13
Integrated geomatics techniques for historical agricultural building surveying <i>Modica G., Tirella V., Tripodi R., Merlino A., Praticò S., Di Fazio S., Fichera R.C.</i> .....	14
Characterisation of the historical agricultural terraces of Costa Viola (Calabria – Italy) at landscape and architectural scale <i>Praticò S., Modica G., Tirella V., Tripodi R., Laudari L., Di Fazio S.</i> .....	15
A Geographical Information System for agriculture plastic waste mapping <i>Schettini E., Blanco I., Loisi R.V., Scarascia Mugnozza G., Vox G.</i> .....	16
A simplified ecological network model for mapping and evaluating structural connectivity in agricultural and urban landscapes <i>Sigura M., Boscutti F.</i> .....	17
Design criteria for safety and organization of teaching farms <i>Sigura M., Cividino S.R.S., Taffon B., Gubiani R.</i> .....	18
Cultural quality of landscape: an expert-based multicriteria approach to integrate functional integrity and spatial accessibility <i>Vizzari M., Antognelli S., Robert S.</i> .....	19



The study of green areas in the farm with agriturismo <i>Borghi P.</i> .....	20
The role of DTM/DSM and RGB/CIR digital aerial orthoimages in landscape planning: a case study in Valsesia (Piedmont) <i>Drusi B., Borgogno Mondino E.</i> .....	21
Tensegrity greenhouses: light structures, technologically advanced and durable. <i>Fuina S., Marano G. C., Scarascia Mugnozza G.</i> .....	22
The melting pot of habitats <i>Tarantino F.</i> .....	23



## **Monitoring and modelling for dry-stone walls terracement maintenance**

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**Keywords: dry-stone wall, terrace, water concentration, piping**

### **Abstract**

An analysis of dry-stone walls stability in agricultural areas based on innovative monitoring and modeling is here presented. The field test took place in Lamole, a terraced rural area located in the province of Florence, Tuscany, central Italy, where wine production is the most important agricultural activity business. Results show a good capability of the model to predict the time-space distribution and the intensity of stresses on the instrumented dry-stone wall and to describe the bulging of the ancient ones. We obtained significant information on how the terrace failure in Lamole resulted mainly related to the water concentration pathways at specific portions of the walls. An accurate drainage of the terraced slopes, even by means of simple ditches, could reduce the concentration factor at the critical parts of terraces strongly reducing the water pressures on the walls. The analysis of the effects caused by high return time events has been carried out by means of artificially reproduced severe rainfalls on the presented experimental area.



## Assessing volumetric and geomorphologic changes of terraces in Amalfi Coast using photogrammetric technique.

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**Keywords: photogrammetry, soil loss, terraces, terrain morphology**

### Objectives

Terraced landscapes are the most distinctive sign of human influence on territory modelling and a peculiar feature of cultural heritage worldwide. Indeed their construction has been essential to make mountain or steep slope areas habitable and arable, reducing the slope gradient and increasing soil permeability. Recently, they are barely sights and commonly abandoned due to their inadequate and insufficient competitiveness. This trend is causing serious problems of hydrogeological instability and, therefore, both European and Italian agricultural and environmental policy is focusing on the promotion of the protection of these areas. In particular, terraced landscapes wrap Amalfi Coast becoming a typical shape and enhancing its beauty. Moreover, they are a proof of the past and, for this reason, they are involved in UNESCO World Heritage List. In view of the above, the safeguard of this place and the development of a management and maintenance plan of these areas should be a priority. Understanding their evolution over the years is a prerequisite to implement a rescue plan suitable to the study area. Hence, the volumetric and geo-morphology changes of terraced landscapes in Amalfi Coast have been performed by analysing different photogrammetric Digital Elevation Models (DEMs), obtained by historical series of aerial photos.

### Methods

The assessment of volumetric and geomorphologic changes have been implemented in Amalfi Coast, a stretch of coastline on the southern coast of Salerno Province in Southern Italy. To achieve this purpose, some historical series of aerial photos related to the area of interest over a fifty – year period have been taken into account and processed using Agisoft Photoscan Professional in order to generate a fine photogrammetric DEM for each year considered. Subsequently, the volumetric changes ( $m^3$ ) between the different DEMs have been evaluated by multiplying their horizontal grid resolution ( $m^2$ ) with their slope differences. Instead, also the slope degree differences have been analyzed. Eventually, the influence of terraces on the surface flow path have been estimated by the Relative Path Impact Index (RPII), computed on a smoothed DEM, purified of roads, trails and terraces. These indices have been computed using ArcGis.

### Results

This research shows that the photogrammetric technique is a promising method to analyze the volumetric and geomorphological changes of terraced landscapes in Amalfi Coast. In particular, it allows to compare DEMs of different years and to quantify study area changes, which are significant because of the abandonment of this place and their insufficient maintenance.



## **Could the environmental issues in agricultural areas be an effective driver to set up a participatory and sustainable management? The experience of the Rural Observatory in the Municipality of Corinaldo (Province of Ancona, Italy)**

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**Keywords: landscape degradation, participatory GIS, rural observatories.**

### **Objectives**

Considerable portions of agricultural land in the undulating landscape of the Marche, where the Municipality of Corinaldo is located, are subject to soil erosion and landslides. These events, often damaging peri-urban and rural roads also, are distributed within micro-basins in such a way that the challenge of sustainable management of landscape by farmers represents a very crucial node. Many actors are involved in and affected by this process of landscape degradation: farmers, administrative bodies, public services, citizens. To tackle this situation, the Municipality of Corinaldo and the Landscape Research Center (CIRP) of Polytechnic University of Marche have recently implemented a specific initiative. Main goal of this collaboration has been to experiment a participatory model, based on the institution of a Rural Observatory, for mapping agricultural areas under degradation and improving their sustainable management.

### **Methods**

The Rural Observatory has been set up like an open institution inspired at the Guidelines of the Committee of Ministers of Members States of Council of Europe (CM/2008-Art.10), his role was to improve territorial knowledge and involve administrators and private farmers together to share new approaches able to prevent landscape degradation. Headquartered in the observatory, a special office, to which farmers and common people have had the opportunity to signal critical sites affected by hydrological degradation, was set up as first step of the experimental model. Based on these information, a series of field surveys aiming to collect technical data and geo-localise sites under degradation were performed by specialists. All collected data were entered in a dedicated GIS, very useful tool finalised to map and monitor all the criticalities in the rural areas of the studied territory therefore the core of the project.

### **Results**

The "special office" at the observatory was visited by seventy farmers, their contribution allowed to survey more than one hundred critical sites. All collected information for every site were then processed and analysed in the GIS environment. The obtained results have given more light on the origins and main degradation typologies that occurred in the studied area. A series of Focus Groups, with the involvement of farmers and administrators, were organised as final step of the project. These meetings allowed to focalise on remedies to be implemented for a more sustainable land management.



## **Farm buildings and rural landscape quality: FarmBuiLD as a method to link rural heritage and new constructions. A pilot study in the Emilia-Romagna Region (Italy)**

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**Keywords: farm building design, rural heritage, building parameters, physiognomic characterization.**

Land use, rural development and life styles over time have led to “isotropic” and disorienting landscapes, where often new rural buildings have been created through serial design and globalized formal criteria, independently of their surroundings. In those landscapes, unlisted traditional buildings are often degraded and abandoned. Over the last years, citizens, stakeholders, technicians and administrators have been gaining increasing awareness of the cultural and environmental values of rural landscape as a common good. In such context, the quality of rural building is an integral part of the environment, and one of the essential elements for local and national identity. This new cultural attitude is accompanied by new needs and requirements. On the one hand, those related to regulations and planning, which increasingly call for holistic management tools, considering both outstanding rural buildings and farms in compromised environmental and cultural conditions, thus going beyond constraint-related approaches. On the other hand, stakeholders see the quality of the rural settlement and of the surrounding landscape as an essential element for rural productivity in a multifunctional perspective.

To improve the quality of rural landscape, the design and evaluation of new rural buildings, as well as building management processes (maintenance, restoration, extension, change in use, etc.), should consider many aspects in terms of environmental integration and formal relations with the built context. In addition to building surfaces, such as colour, form, lines, texture, scale, and spatial character, the perception of formal features, such as the dimensional proportions, and the articulation of forms, hollow and solid volumes, play a crucial role in landscape consistency, in terms of visual and aesthetic quality.

In this paper we focus on a part of FarmBuiLD (Farm Building Landscape Design), a research programme aimed at the analysis of farm buildings and definition of meta-design criteria for the improvement of their landscape quality. This method is based on a set of parameters for the physiognomic characterization of both historical and contemporary rural buildings. The study focuses on a pilot area and the selection of a sample of historic rural buildings and another sample of contemporary rural buildings, selected within a study area of the Emilia-Romagna Region (Italy), the Imola District, in the metropolitan city of Bologna. In particular, in this paper, based on the findings of previous research works focused on a first validation of the methodology applied to a set of contemporary rural buildings, the authors show how the FarmBuiLD model can be applied to the analysis of the peculiar building characters of a place, whether historical or contemporary, in order to derive quantitative indications about the relationships between the formal features of heritage and contemporary buildings. In particular, the joint interpretation of the parametric results about the dimensional aspects



(height-width-length), volumetric characteristics, openness/closure of perimeter surfaces, and articulation of volumes, has allowed to identify concordant and discordant elements. A further development of the research presented in this paper is currently ongoing, with the aim to investigate the consistency level between the objective findings derived from the FarmBuiLD method and a survey of the subjective interpretation of the rural built landscape by defined target categories.



## Valorization of key buildings of the rural traditional landscape in central Italy: the case of the "Casa Colonica"

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**Keywords: vernacular building, traditional farmhouse, life cycle assessment, life cycle costing, dynamic thermal simulation, retrofitting solutions**

### Objectives

Traditional farmhouses are landscape resources of great value as elements of identity that can "narrate" different space-time modality of land management and social organization. The typical farmhouse of central Italy is called "casa colonica". The "colono" is the farmer who lives and works in the house but who does not have the property of the fields and of the building. The original functions of these buildings were lost with the transition from a traditional rural society to the modern industrial one, but their high aesthetic values have allowed them to find new life as country houses.

A meaningful objective is to merge the need of preservation of these historic buildings and the need to increase their energy efficiency.

This paper is part of a broader research with this aim.

The objective of this work is to develop a model to evaluate the overall sustainability of different coating materials for increasing the thermal inertia of these typical farmhouses.

### Methods

We developed an energy simulation model integrated with a life cycle costing and a life-assessment approach. Furthermore, the outputs of the model were combined with a multiple-criteria approach aimed to rank the overall sustainability of the insulating materials. The criteria resulting from the simulation engine are the "discomfort degree hours" and the "CO2 avoided". About the life cycle approach, the criteria used are the net present value, the human health, the ecosystem quality, and the consumed resources.

Ten insulating materials were tested and the model was applied to retrofit a traditional "casa colonica" through the insulation of the roof.

### Results

The results of the simulation process showed that in these buildings, only with the addition of an insulation material with low conductivity internally to the roof, the perceived discomfort from residents can be reduced by 74% and the energy consumption related to air conditioning can be reduced by 66%.

From the multiple-criteria approach, the resulting best materials are the polyurethane, the rock wool, the polystyrene foam, the hemp and kenaf fibres. These materials have a good life cycle assessment performance, a good energy, and thermal performances.

The worst materials are the mineralized wood, the gypsum fiber board and the plywood. In fact, while presenting a good life cycle costing performance, these materials have a low life cycle assessment performance and a low efficiency in increasing the comfort and the energy saving of the building.



## Coping with species' perception of barriers: an assessment of landscape fragmentation

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**Keywords: landscape fragmentation, transport and mobility infrastructure, barrier effect, sensitivity**

### Objectives

Ecosystem continuity is becoming a crucial issue at the international and national level, and some policies have been proposed in order to maintain ecological coherence and connectivity. The European Landscape Convention has opened new perspectives on landscape analysis and planning, by focussing not only -as usual- on high quality but also on degraded landscapes across Europe. In the last decades, landscape quality has been strongly affected by human actions, as a continuous demand of settlements has had negative effects on habitats with a considerable biodiversity loss. A major consequence of this is landscape fragmentation (LF).

### Methods

Transport and mobility infrastructures (TMIs) are the main causes of LF, since they have effects on ecosystem continuity, flora, and fauna. TMI-driven LF can be assessed using indices, such as the infrastructural fragmentation index (IFI). IFI takes into account elements, such as perimeter and extension of the study area, number of patches, length of TMIs' traits, and a dimensionless occlusion coefficient, which varies in the range 0.3-1.0 depending on TMI's type. However, TMIs are perceived in different way by animals, according to a 'barrier effect', which is well-known in scientific literature. At the moment, the formulation of the IFI does not fully consider real fauna perception of TMIs.

We aim at building and applying a new index, namely the barrier fragmentation index (BFI), which allows us to quantify the LF as perceived by target species. In order to obtain the BFI, we modify the IFI equation by replacing the occlusion coefficient with another coefficient, which takes into account the probability of barrier effect for given target species. In particular, we choose the hedgehog (*Erinaceus europaeus italicus*), as it is a common and well-known species in Sardinia.

### Results

Outcomes show that BFI varies with lower absolute values with respect to IFI. By contrast, we verify that BFI and IFI display similar trend lines with a different sensitivity to the changes of their components.



## **Rural buildings and landscape fragmentation: measure and interpretation**

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**Keywords: rural landscapes, rural buildings, landscape fragmentation, fragmentation index**

### **Objectives**

Urbanization has effects on ecological networks and causes fragmentation processes and soil consumption, which produce qualitative and quantitative effects on habitat, flora, and fauna.

Also rural buildings have negative ecological consequences, increasing the level of landscape fragmentation and decreasing the extension of natural and semi-natural habitat areas. Landscape fragmentation due to exurban development has some relevance in international scientific literature.

In this study, we aim to measure landscape fragmentation caused by rural buildings. We start from the revision of the urban fragmentation index (UFI) in the perspective of the construction of an rural buildings fragmentation index (RBFi).

### **Methods**

Landscape fragmentation caused by urban development can be assessed through indices such as the UFI, which is encountering some interest in scientific research. We apply the UFI in six landscape units defined by the Regional Landscape Plan of Sardinia, in a modified version – namely the RBFi- able to quantify the landscape fragmentation due to rural buildings.

The study is developed using regional land cover maps data freely disseminated on-line in shapefile format by the Autonomous Region of Sardinia and the ortho-photos accessible through the regional Web Map Service.

### **Results**

Preliminary results show the highest RBFi values in 'Piana del Rio Mannu di Ozieri' and 'Golfo dell'Asinara'. 'Gennargentu and Mandrolisai' shows the least values of RBFi. 'Regione delle Giare Basaltiche', 'Gennargentu and Mandrolisai', and 'Golfo dell'Asinara' have the highest increase of landscape fragmentation from 2003 to 2008, while 'Massiccio del Limbara' has the least one.



## **Stone artifacts of the Sicilian mountain landscape: a cultural heritage to be protected**

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**Keywords: Stone buildings, Rural landscape, Remarkable architectural**

### **Objectives**

The present work reports the results of a survey carried out in a town situated in the mountain area of Syracuse, Buccheri, where there is a high concentration of "Neviere" of particular architectural merit. "Neviere" are original stone buildings, probably made between mid-1600 and early 1700, symbol of ancient and sophisticated construction techniques, placed in several agricultural sites near Mount Lauro, mount of south-east Sicily that belongs to the chain of Mounts "Iblei", which is the highest peak reaching the 987 metres. Moreover, Mount "Lauro", is part of an underwater volcanic complex of the Miocene, no more functional. They are elements that must be protected for the great value that they take both the recognized role in maintaining biodiversity, both for the cultural, witnesses and landscape importance.

Today, these artifacts are in state of neglect or are gradually disappearing due to the absence of crops or the conversion of agricultural land into building areas.

### **Methods**

The "Neviere" studied are located within agricultural funds, in forested public lands of the City of Buccheri. Their identification is complex because of the poor state of repair, or because completely buried, or hidden by the dense vegetation.

Therefore, the survey took advantage of historical documents, of census cards of Neviere's character and of surveys made on fields. In the municipal area were identified three areas and in each one were detected artifacts with a clearly identifiable structure (17 totally). The survey of the artifacts has been directed to identify the formal type, the specificity of construction techniques and the metric relations between the parties, so as to highlight the intrinsic testimonial value and cultural. At the same time, in order to describe their relationship with the context, some thematic maps that show the current state of the landscape and the potential and the risks of damage were considered.

### **Results**

The direct surveys have shown a remarkable architectural complexity that we can see in interesting metric reports and special construction techniques.

In relation to formal and constructive features four types of "Neviere" have been identified. In addition, the study highlighted that the cultural, historic and landscape value of manufactured goods requires adequate and urgent forms of public intervention.



## **Integrated geomatics techniques for historical agricultural building surveying**

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**Keywords: 3D advanced surveying techniques, Integrated Survey, Terrestrial Laser Scanner (TLS), Unmanned Aerial Vehicles (UAV), Handheld Scanner, Point-Clouds, GIS.**

### **Objectives**

The research objectives are referable to the general theme of monitoring, recovery, and protection of the historical agricultural built heritage. In that direction, a thorough knowledge of its current condition is needed as a pre-requisite to implement planning and management actions for their sustainable valorization. To this end, we developed a method for agricultural building surveying based on advanced 3D surveying techniques that allow to obtain a highly accurate geometric model both of buildings and their surrounding.

### **Methods**

The proposed method is based on the integrated use of the following equipment: Unmanned Aerial Vehicles (UAV) for the survey of surroundings, roofs and not easily accessible areas; Terrestrial Laser Scanner (TLS) and Handheld Scanner (HS) for outdoor and indoor building components, global navigation satellite system (GNSS). Three methodological steps can be singled out: survey planning and data-collection, pre-processing and processing of the data obtained. In terms of interoperability, all surveyed data are shared as 3D cloud-points. The survey planning represents a key-part of the whole process considering that it affects the duration of the field work and the accuracy and completeness of the obtained data-sets. The pre-processing step, basically involves the co-registration of all the surveyed data. To this end, all surveys and the obtained datasets are georeferenced in a common coordinate reference system (CRS), usually the WGS84/ETRF1989 UTM33N (EPSG 32633). Processing is the last step: the whole 3D point-clouds are managed and converted into parametric elements in order to generate the so-called 'as-built' or Historic Building Information Modeling (HBIM).

### **Results**

The proposed method allows to obtain a highly accurate and quick survey of historical agricultural building compared to conventional instrumentation and methods. The obtained positional accuracy is  $\pm 1.5$  cm of Root-Mean-Square Error (RMSE) in planimetric (X,Y) and  $\pm 5$  cm in altimetry (Z). The obtained 3D point-clouds coming from the integrated survey (UAV, TLS, HS, GNSS) allow to derive an accurate parametric modeling through HBIM. Moreover, the obtained model appears as more significant than the simple geometric model, since it is a "smart" 3D model containing a wide range of useful information.



## Characterisation of the historical agricultural terraces of Costa Viola (Calabria – Italy) at landscape and architectural scale

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**Keywords: Terraced agricultural landscape, Land Use / Land Cover (LU/LC), Change detection, Dry-stone walls**

### Objectives

The aim of this research is the characterisation of the historical agricultural terraced landscape of 'Costa Viola', at landscape and architectural scale. The investigated area is a coastal strip, in the Calabria Region, in the South of Italy, about 1÷2 km large and 20 km long with an area of 24 km<sup>2</sup>. The altitude is variable between 0 and 600 m a.s.l. with very steep slopes (the most representative range is between 30° and 45°). The area is characterised by the presence of dry-stone walls terraces, built from the 18<sup>th</sup> century and used to allow agricultural practices, mostly for vineyards and other crops such olive and citrus for a lesser extent. The resulted terraced landscape is today recognised as worthy of protection because of its high cultural and scenic value. In recent years, the terraced system of Costa Viola has undergone progressive abandonment due to the general loss of economic competitiveness of the agricultural activities, mainly in those areas most difficult to cultivate. This abandonment, followed by a degradation of the characteristic terraced landscape, is also a major cause of the increase of landslides and, more in general, hydrogeological risk. Therefore, it has emerged, both for stakeholders and decision makers, the need to have a precise picture of the current extent and state of the terraced areas.

### Methods

The terraced system was investigated under two main aspects and two different scales. An historic characterisation of the evolutionary trends of terraced areas at a landscape scale was carried out comparing Land Use/Land Cover (LU/LC) maps obtained by digitalisation in GIS environment starting by historical aerial photographs and orthophotos for three different years: 1955, 1976 and 2015. On the other hand, a characterisation of dry-stone walls, at an architectural scale, was carried out using Handheld Scanner (HS) and photogrammetry surveys using Structure from Motion (SfM) techniques.

### Results

A geodatabase of terraced areas, both active and abandoned, a set of change detection matrices and a classification scheme of the main constructional features of dry-stone walls have been produced as main results. In particular, dry-stone walls and the other built elements of the terraced system were considered by distinguishing two main classes of features, one concerning the building elements and techniques (e.g., stones dimension, stone layers, vertically conjunction elements, drainage elements, etc.) and the other concerning the observed maintenance status (e.g., vegetation cover, wall collapse, etc.).



## **A Geographical Information System for agriculture plastic waste mapping**

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**Keywords: land analysis, plastic film, environment, waste valorization.**

### **Objectives**

Plastic materials are widely used for agricultural applications: covering films and nets for greenhouse, low or medium tunnel; soil mulching and solarisation films; irrigation and drainage pipes; bags, containers; and pots. These materials need to be properly disposed of, due to the high volumes of waste generated at the end of their lifetime. A non suitable disposal system for agricultural plastic waste could provoke economical and environmental damages; besides an optimized process of collection, transport and final disposal permits the re-use of agricultural plastic wastes for other different applications or for generating energy. The management of plastic waste flux coming from agricultural activities is still far to be adequately implemented in some Italian areas. The Province of Barletta-Andria-Trani is characterized by high densities of greenhouses, tunnels, protected vineyards and mulching films for vegetable cultivation. Aim of this study is to identify the points of waste generation and to quantify the waste in a restricted area of the municipalities of Trani and Barletta.

### **Methods**

The research is based on the application of a Geographical Information System, in order to create a geo-referenced database able to map and provide the complete data on the agricultural plastic waste quantities in a restricted area of the municipalities of Trani and Barletta. The land use map of the Region of Apulia was geo-processed and enriched with detailed data on the typology of selected crops and on the plastic materials used for their cultivation.

### **Results**

A dedicated geo-referenced database was created; waste density in the study area varied in the range from 3.3 kg ha<sup>-1</sup>yr<sup>-1</sup> to 861 kg ha<sup>-1</sup>yr<sup>-1</sup>. The availability of updated data on the spatial distribution and amount of the plastic materials employed for the cultivations supplies a suitable tool for the decision makers in the evaluation of different development scenarios rural planning strategies. This tool could be useful for an efficient allocation of waste collection sites in an agricultural area in order to help farmers during the phase of disposal of the plastic materials.



## **A simplified ecological network model for mapping and evaluating structural connectivity in agricultural and urban landscapes**

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**Keywords: Landscape analysis; Ecological network mapping; Connectivity indices; Graph analysis; GIS.**

### **Objectives**

This research aims to evaluate the ecological connectivity in intensive cultivated and urbanized landscapes with particular consideration on the roles of anthropogenic land uses in the construction of ecological corridors. In these landscapes ecological network model is optimal to measure basic aspects (structural and functional) of connectivity as permeability of landscape matrix (barrier effect), continuous or discontinuous connections (stepping stones) intrapatch and interpatch connectivity.

### **Methods**

A network modeling approach is developed to incorporate in a GIS environment (I) natural and anthropogenic habitats; (II) the barrier effect related to a set of species target (flora and fauna); (III) effective paths (continuous or discontinuous corridors) between patches. Graph Theory (Graphab) and vector-buffer based mapping procedure (QGIS) are proposed for mapping corridors. A set of connectivity indices are applied. The indices of Effective Mesh Size (MESH), Node degree (ND), Probability of connectivity (PC) and Corridor Area Potential (CAP) are applied to measure the interpatch connectivity and the contribution of anthropogenic land uses in the construction of ecological corridors.

To test the methodology on different landscapes and compare the results, three study areas (Friuli Venezia Giulia plane, North east of Italy) with different agriculture and urban intensity are chosen

### **Results**

Connectivity (MESH) is effected by extension and diversity of functional habitats characterizing core areas. ND and PC show a great contribution of isolated core areas to interpatch connectivity, giving a measure of the role of small natural habitats to the overall connectivity. CAP allows the characterization of ecological corridors in terms of gaps and barriers due to less "permeable" land uses to species (e.i. urbanized and industrial areas) where environmental improvement is more difficult.

The obtained network model can support local and regional authorities in the process of ecological connectivity implementation, improving the ecological landscape planning at the local scale. The model is developed in the framework of the Regional Environmental Landscape Plan of Friuli Venezia Giulia Region.



## Design criteria for safety and organization of teaching farms

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**Keywords: Multifunctional farm; Safety; Farm layout; Workspaces; Teaching farms**

### Objectives

The research focus is on farm organization and safety for users in teaching farms. Specific aims are: i) definition of state of the art on quality requirements for teaching farms; ii) identification of critical issues in work spaces for educational activities and iii) definition of the spatial layout for farms involved in agro-environmental learning.

### Methods

A check-list on the base of reference standard and literature was created to get a detailed analysis of the work-place risk and the spatial layout of educational activities. A *Model Rules* regarding risks incidence and choerence of layout was obtained by a set of rules defined on the base of reference standard and farm surveys. The model was tested on a sample of teaching farms in the Friuli Venezia Giulia region.

### Results

Around 2000 teaching farms are active in Italy where regional situations are very different. Nearly 30 items was considered in the check-list on farm structure, including for example anti-slip solutions for floors of internal spaces, safe paths for pedestrians separated from traffic of agricultural vehicles, sufficient number of toilets, ecc. The check list used to analyse the spatial layout of educational activities detected aspects as the appropriate ration operators/users, suitable information on the risks in the farm, availability of teaching materials, ecc.

The results of the model application highlighted that safety requirements vary according to the different work spaces. In particular, the sections at highest risk are those linked with stock of tractors and *farm machinery*. Educational activities involving the users showed less critical items. This difference seems to be related both to the poor perception of risks associated with farm activities and to the increasing attention on interactions between childrens and farming during learning activities.

The spatial layout of educational activities must provide adequate space identified in the following broad categories: access area, reception area, path-ways dedicated to agro-environmental learning, area and facilities for laboratory activities, picnic area, play areas, areas for the farm animals.

Results highlighted how analysis of farm resources, identification of users target and specific formation for farmers on safety and layout organization are crucial steps for a proper organization of teaching farms.



## **Cultural quality of landscape: an expert-based multicriteria approach to integrate functional integrity and spatial accessibility**

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**Keywords: Landscape quality, functional integrity, landscape cultural services, ecosystem services, cultural functions, spatial multicriteria decision analysis.**

### **Objectives**

Landscape quality assumes a central role in the contemporary processes aimed at landscape analysis, planning, and management. It is strongly bound to landscape elements and features and to their spatial and functional interrelationships. The cultural quality, in particular, is related to the functional integrity, spatial accessibility and visibility of elements of value (natural or man-made). These characteristics influence the capability of a landscape to produce cultural functions that, if actually used, provide services and related benefits to different categories of stakeholders. In this framework, the research was aimed at quantifying the potential and actual cultural quality of a landscape in central Italy featured by the presence of a great extension of historical olive yards and many landscape elements of value.

### **Methods**

The first phase was focused on the identification of existing quality components within the landscape under investigation. Geographic data was collected for all the selected components and published through a webGIS interface (accessible from <http://maps.agr.unipg.it/>). For each element of the selected components, five specific cultural functions, derived from ecosystem services and functions literature, were analysed: recreational, educational in-situ, symbolic, religious, and aesthetical. Each function was measured by an index of functional integrity quantifying the potential capability of landscape elements to provide cultural functions. For recreational and religious services quali-quantitative indicators were used to quantify the functional integrity, while for educational, symbolic, and aesthetical functions an expert-based assessment was performed. The scores given to each element were spatialised and aggregated by a weighted sum, according to a multicriteria spatial analysis procedure, to calculate function-specific integrity indices and, finally, an overall potential cultural quality index. The weights were calculated using the Incomplete Pairwise Comparison Matrices method filled by the experts. Spatial accessibility and visibility of each element was also assessed and then compared with the functional integrity indices to assess the actual cultural quality.

### **Results**

Results show how the functional integrity, the spatial accessibility and visibility to elements can be effective for quantifying the potential and actual cultural quality of a landscape. These information can support decision making within landscape planning and management processes.



## **The study of green areas in the farm with agriturismo**

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**Keywords: agriturismo, green areas, design.**

### **Objectives**

The agriturismo is an activity that has undergone extensive development in many agricultural farms and that, today, requires the presence, in contiguous with the building structures utilized (adequately renovated annexes), of a specific areal context that characterizes and contributes to the success of the business itself.

This area (which becomes the farmyard) is generally developed in a natural-green arrangement of the land; its prevalent characteristics tend to be reflected in the development of the surface, in part in relation to the site itself and orography of the terrain where the enterprise is located, and, in part, in relation to the direction and management of the company itself.

### **Methods**

In this paper, we will consider the general characteristics of projectual elements on a theoretical level. These studies were conducted by examining existing or newly renovated rural characteristics of some agrarian activities that are present in the territory of Perugia.

From the study conducted, regarding the number of sites taken into consideration, a general picture emerges that, in its entirety is very precise and detailed, and describes the contemporary presence of common elements, in almost all companies, and their own specific characteristics. All the companies, for example, show the same scheme of division of the contiguous space characterized by the presence of the reception, agricultural, recreational and park areas.

### **Results**

Furthermore, the study shows as during the design phase of the new elements, the businesses followed the PAC/PSR indications and they have also seriously considered the needs and expectations of their guests and users. Thus, as the final result, in most of the cases, is revealed a complete harmony in the connection between the building and the court yard.

Nevertheless, in some cases, despite the valuable work that was done, the connection between the structures, the courtyard and the territory is lost. Therefore, in these cases, there is a great expectation about the overall rural development of the territory but, the growth of the purely agricultural activity practiced in the company loses importance.



## The role of DTM/DSM and RGB/CIR digital aerial orthoimages in landscape planning: a case study in Valsesia (Piedmont)

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**Keywords:** Aerial Orthoimages, DSM, DTM, Landscape planning

### Objectives

Landscape management relies on accurate and up to date spatial information concerning any recurrent structural configurations having the character of a permanence and needing effective safeguard policies. Such landscape invariants relate to physical and ecological characteristics, lithological typologies, morphological aspects, ecosystem characters, settlement frames and infrastructure facilities, agroforestry systems and cultural heritage. It is widely recognized that obtaining that information through ground surveys is time consuming and much expensive, so high resolution aerial orthoimages and laser scanner-derived products can be a valid alternative. Administrative bodies have recently promoted onerous survey campaigns and made available for free a huge amount of new geographical datasets, often remaining underused owing to a widespread lack of knowledge within administrators and technicians. The Piedmont Landscape Plan recognizes regional landscapes as essential cultural and economic resources and defines both protection and enhancement measures. Furthermore, according to the Rural Development Program 2014-2020, municipalities ought to adopt both technical and operating guidelines as a supplement to local town-planning regulations.

In this work we suggest an integrated approach based on different data sources to support landscape analysis in the aim of improving territory planning by reducing field survey time. New available regional data, such as high resolution digital RGB and CIR aerial orthoimages and Digital Terrain and Surface Models, can effectively be used for such task.

### Methods

The proposed methodology has been applied to a test area in Valsesia (NE Piedmont). It relies on the adoption of the above mentioned data and their processing within GIS environment. CIR aerial orthoimages have been used to characterize vegetation and roofs materials. DTM and DSM have been derived from the LiDAR acquisition achieved during the ICE aerial-photogrammetric survey. DTM has been used to describe the area morphology (height, slope, curvature, etc.). DSM and DTM has been jointly used to derive information concerning trees and buildings heights. We have mapped grasslands/pastures, forests, rural settlements, paths/roads, screes and terracing walls. Landscape concerns have then been related to cadastral maps and some synthetic statistics computed.

### Results

New digital geographical data proved to be useful for landscape reading and planning. The underlying technologies seem to finally inaugurate new perspectives for wide area and sectorial landscape planning, reducing circumscribed, targeted ground surveys, which normally represent town-planning primary costs. Both planimetric (orthoimages) and altimetric (DTM/DSM) information from new free geographical data, if jointly and properly used, demonstrate to generate a meaningful added value to planning ordinary approach. Through intersecting accurate landscape analysis with random field surveys we have elaborated roof mantle, urban texture, degradation and cover land maps on a cadastral support, describing characterizing features and fringe transitional landscapes. From such a deep knowledge of landscape safeguard recommendations can just arise, finalized to ensure a sustainable balance between conservation of existing production activities and preservation of both landscape and environment integrity.



## **Tensegrity greenhouses: light structures, technologically advanced and durable.**

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**Keywords: greenhouse structures, tensegrity, structural design.**

### **Objectives**

The greenhouse structures represent an important part of the Italian production of both vegetable and flower products. This paper aims to investigate new types of structures for greenhouses focusing on a new structural typology: the "tensegrity". The tensegrity structures can cover large spans with a low structural weight. One of the more interesting applications is the covering of the Georgia Dome Stadium in Atlanta and these constructions make it possible to change their configuration as needed, or also make themselves folding structures. The objectives of this paper are the analysis and design of this new structural type of greenhouse in order to achieve the reduction of structural elements weight, the reduction of structural shading, adequate resistance to environmental actions and economic feasibility.

### **Methods**

The research is carried out by means of analytical models and structural design software, considering all the loads acting on the structure related to its function. The used methodologies mainly concern the procedures: UNI EN ISO 13031-1 2004 "Greenhouses: Design and construction. Technical standards for construction" and the Italian law D.M. January 14, 2008. The standardized procedures followed in all aspects of the research ensure that the results are acceptable under the scientific and structural point of view. The "tensegrity" structures employ compression elements included in a network of tensioned cables. The modular configuration of the system, called "T-bar", has four cables subjected to tension  $t(s_1)$  and two bars subjected to compression  $f(l_0)$ . In a system of this type, the relation that rules the principle of mass reduction is the following:

$$f(l_0)/l_0^2 < (\rho_b^2/E\pi)(\sigma_s/\rho_s)^2 \quad \text{with} \quad \hat{t}(s_1) = t(s_1)/f(l_0)$$

### **Results**

The tensegrity structures enable: a reduced use of steel used for compressed elements; no bending in the covering structural components exclusively subjected to tension or compression; stabilization of the structure to the external actions through the imposition of a state of internal pretension of the cables. The use lightweight roofing materials with high durability, such as plastic films, is compatible with the characteristics of the structure. For these features, this new type of structures have the advantage of being lighter, than the traditional greenhouses structures, and have an higher resistance to exceptional weather conditions, compared to the tunnel greenhouses.



## The melting pot of habitats

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**Keywords: the history 1, the naturalness 2, the agriculture 3, the sustainability 4.**

The mission of the agronomist is to lead the transformation of the territory, especially now that the phenomenon of urbanisation is bringing the landscape to the loss of naturalness in the first place, and then reduction of countryside areas too.

In Salento, in a very degraded space of 250.000 square meters around the city centre, activities have been undertaken in order to retrieve naturalness, lost in the last century, but also to restore the urban agriculture, mainstay of the European cities in the 90s. This regeneration is to bring back significant benefits to the urban population living nearby.

Through a newly created wooded band, it has been recreated the ideal environment for a social, recreational and didactic agriculture; this is productive for the local markets and the farm's guests as well. Thanks to the landscape project, naturalness was reformed in some of the natural habitats typical of Salento areas: the Garigue, the Maquis, the Mediterranean forest, the marshy habitat.

Finally, attention has been paid in retrieving rainwater to be used for irrigation, and in the energetic self-sustainability of the industry thus bringing a positive, ecological balance, with a net profit of the oxygen produced. It is a melting pot of habitats and activities, all in harmony with the territory, the environment and the local community, which can easily enjoy the place's activities and values.

Hereafter is a concise schedule of the interventions that have been done.

Parameter	UM	Values
The wood and the Mediterranean forest	mq	110.000
The maquis and the garigue	mq	8.000
The marshy habitat	mq	11.000
The agricultural area	mq	120.000
Agricultural productions: olives, grapes, vegetables, cereals, legumes, honey, minor fruits.	N°	5.000
Area used as allotments and social orchard of autochthonous species	mq	2.500
Cycle-pedestrians tracks	m	6.000
New trees	N°	27.500
New types of shrubs	N°	32.000
New faunal species that have reappeared	N°	15
The use of resources H <sub>2</sub> O, energy, soil, etc.	N°	0



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## **TOPIC 2**

***ICT, PRECISION SYSTEMS AND NEW TECHNOLOGIES  
FOR LAND, FARM AND FORESTRY MANAGEMENT***



Sentinel-2 spectral indexes for estimating canopy nitrogen in durum wheat and tomato <i>D’Urso G., Napoli R., Vanino S., Nino P., De Michele C., Anzano E.</i> .....	28
Prototype of an expert system for the management of irrigation in a greenhouse for ready-to-use vegetables. <i>D’Urso G., Tedeschi A., Monaco E., Basile A.</i> .....	29
Thermal imaging and EMI data fusion to delineate homogeneous management zones based on the variability of soil hydraulic properties <i>Ortuani B., Mezzanzanica M., Sona G., Facchi A.</i> .....	30
Soft path water management adaptations to climate change: the SO-WATCH project <i>Castelletti A., Gandolfi C., Giuliani M., Buarnè F., Borghi A., Facchi A., Sali G., Li Y., Giudici F.</i> .....	31
Innovative Approaches for Water and Food Security through Enhancing Irrigation Water Conservation and Productivity in Oman <i>Al-Mulla, Y., Siddiqi, R.</i> .....	32
Three-axis accelerometer for fast evaluation of the gravel road surface quality <i>Marinello F., Grigolato S., Proto A.R., A. Pezzuolo A., Zimbalatti G., Cavalli R.</i> .....	33
Harvesting yield and material other than olives from mechanical harvesting of some Tuscan varieties <i>Masella P., Guerrini L., Angeloni G., Baldi F., Spugnoli P., Parenti A.</i> .....	34
Liner overpressure and teat dimensions: preliminary results of a field study <i>Tangorra F.M., Zucali M., Zanini L., Lazzari M., Costa A.</i> .....	35
A novel instrumented sphere for acceleration measurements during mechanical harvest of grapes <i>Vallone M., Bono F., Febo P., Catania P.</i> .....	36
Development and evaluation of a cereal capacitive mass flow sensor <i>Tabatabaekoloor R.</i> .....	37
Design and development of a low cost device for the automatic estimation of Body Condition Score (BCS) on dairy cattle <i>Calcante A., Bava L., Colombini S., Sandrucci A., Tamburini A., Zucali M., Oberti R.</i> .....	38
Features extraction from vineyard 3D dense point-cloud model for precision viticulture <i>Barge P., Biglia A., Comba L., Gay P., Guidoni S., Tortia C., Ricauda Aimonino D.</i> .....	39
Innovative techniques for the design and the control of operating conditions of rotary harrows: preliminary results on tractor-harrow interactions <i>Barge P., Comba L., Gay P., Manzone M., Mattetti M., Molari G., Ricauda Aimonino D., Tortia C., Varani M. and Balsari P.</i> .....	40
Precise sowing of row crops for bidirectional mechanical weeding <i>Schulze Lammers, P., Schmittmann, O., Klingbeil, L., Kuhlmann, H.</i> .....	41



Interference Analysis of an Heavy Lift Single Rotor UAV Downwash Effects on Sprayed Liquid Droplet Dispersion <i>Sarghini F., De Vivo A.</i> .....	42
Design and preliminary evaluation of a soil resistance sensor for soil compaction sensing in viticulture <i>Sarri D., Lisci R., Rimediotti M., Lombardo S., Vieri M.</i> .....	43
Automatic filling of the register of field activities, from challenge into reality <i>Mazzetto F., Gallo R., Importuni P., Petrera S., Sacco P.</i> .....	44
A further step to the automatic assessment of the yarding operation productivity: an ICT application for the assessment of biomass weight during yarding operations <i>Gallo R., Noggler W., Fabrizio Mazzetto F.</i> .....	46
Business plan tool for small biogas plants <i>Berruto R., Busato P., Sopegno A.</i> ,.....	47
AGROMAP – A precision agriculture tool based on satellite ESA images (Sentinel 1 and 2) <i>Marques da Silva J.R., Luis M., Duarte J., Paixão L.</i> .....	48
Big data in dairy farm: acquisition methods and numerical models for integrated real-time information systems <i>Bonora F., Benni S., Tassinari P., Torreggiani D.</i> .....	49
Assessing spatial and temporal variability of a Mediterranean vineyard using multivariate geostatistics <i>Guido V., Castrignanò A., Gambella F.</i> .....	50
Design and implementation of a Geographical Information System for monitoring transhumant flocks in Lombardy <i>Longoni A., Nava S., Beretta E., Tangorra F.M., Costa A, Lazzari M.</i> .....	51
Automated climate control to reduce leg disorders in broilers farming <i>Tullo E., Fontana I., Peña Fernandez A., Vranken E., Norton T., Berckmans D., Guarino M.</i> .....	52
Toward a dynamically configurable and upgradable greenhouse environment simulation PC platform <i>Bibbiani C., Campiotti C.A., Incrocci L., Pardossi A.</i> .....	53
UAV's multispectral remote sensed imagery for precision agriculture. A case-study in a olive orchard <i>Modica G., Solano F., Merlino A., Fichera C.R.</i> .....	54
Comparison of vegetation indices derived from UAV and satellite images in vineyards <i>Vizzari M., Santaga F., Antognelli S.</i> .....	55
Soil properties mapping by best interpolation gis technique of an area located at northern Iraq <i>Zeki M. Hassan</i> .....	56



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## Sentinel-2 spectral indexes for estimating canopy nitrogen in durum wheat and tomato

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**Keywords: spectral indexes, chlorophyll, nitrogen, Leaf Area Index.**

### Objectives

The availability of Sentinel-2 satellite data at medium spatial resolution (20 m) in the red-edge spectral region opens new perspectives in the assessment of canopy nitrogen status for precision farming fertilisation. The objective of this paper is to present the results of an experimental campaign carried out in the context of the EU Project FATIMA (Farming Tools for external nutrient Inputs and water Management) in the Tarquinia irrigation district (Viterbo). The campaign was aiming at establishing a relationship between spectral indexes derived from Sentinel-2 spectral bands and in-situ direct and indirect measurements of N canopy content.

### Methods

Data were collected in Central Italy during the growing season 2015-16 (November-July). The experiment was carried out at a private farm near the city of Tarquinia (VT), in Lazio region, Italy (42°28'N, 11°68'E). The site is included the area within the Vulnerable Nitrate Area (ZVN), with prescriptions about the maximum N inputs both from livestock and agricultural fertilizer. The experimental plots were set up in a wheat field under continuous rotation with industry tomatoes with different types of N fertilizer (synthetic, slow release and organic N fertilizers). In coincidence of Sentinel-2 overpasses experimental data included: i) green plant sampling at different growth stages; ii) Leaf Area Index (LAI) non-destructive measurements by using a portable LICOR LAI 2000 Plant Canopy Analyser; iii) chlorophyll measurements by means of the MC-100 Apogee Concentration meter; iv) canopy reflectance by means of a hand-held hyperspectral radiometer in the spectral range is 325-1075 nm; v) crop N concentration (total N%) following the LECO N in plant method on a LECO instrument. Different spectral indexes were calculated by using both in-situ spectral data and satellite observations and correlations were investigated with canopy chlorophyll and N contents.

### Results

The results have confirmed the presence of significant correlations ( $p < 0.01$ ) between spectral indexes derived from Sentinel-2 and the chlorophyll canopy content, and consequently N-content (as confirmed by comparison between MC-100 readings and LECO data). These findings will be used for developing a methodology to predict N application at farmers' fields scale in the context of advisory services for intensive agriculture.



## **Prototype of an expert system for the management of irrigation in a greenhouse for ready-to-use vegetables.**

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**Keywords: wireless sensor network, soil water content, irrigation scheduling, greenhouse water management.**

### **Objectives**

This work describes the development and the set-up of a potential Decision Support System for irrigation management in greenhouses focused on the monitoring of agro-climatic parameters by means of a wireless sensors network combined with a simulation model of water flow in the soil-plant-atmosphere system. This activity has produced a prototype expert system called "SEGIS" (*Sistema Esperto per la Gestione dell'Irrigazione in Serra*). The prototype has been installed in 2015 in an greenhouse commercial farm for the production of ready-to-use vegetables located in Battipaglia (SA) with an extension of 6 hectares.

### **Methods**

The development of "SEGIS" includes several steps. Initially, a soil hydraulic characterisation is carried out to evaluate the spatial variability of the soils. Based on this information, the wireless sensor network composed of 20 measuring nodes has been installed in the 7 different production units (PU) of the farm, to monitor soil water content, temperature and conductivity at different depths, plus air temperature, relative humidity and solar radiation in the greenhouse. Each node was equipped with a wireless data logger connected to the server accessible also in remote. In a preliminary set-up of the system the data acquired have been analysed with the support of a soil water flow dynamic model, including root water uptake, to identify the optimal criteria for irrigation scheduling, based on soil water content readings. This information has been used to program an irrigation alert system (accessible via Internet), able to identify the start and stop of hydraulic valves in the irrigation distribution network.

### **Results**

By comparing the irrigation management with and without SEGIS, it has been possible to demonstrate that the information provided by the expert system allows a reduction of water application, which entity is depending on the vegetable type and the season. The reduction of irrigation water also allows to reduce fertilisers and energy consumption, with tangible cost effectiveness and improvement of the environmental impact of this type of cultivation. Systems like SEGIS can improve the quality of the production and marketing of quality guaranteed and environmental friendly products. However, the study has also highlighted the technical constraints in the adoption of this technology in the context of the actual greenhouse system for ready-to-use vegetables in Southern Italy.



## Thermal imaging and EMI data fusion to delineate homogeneous management zones based on the variability of soil hydraulic properties

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**Keywords:** soil sensing, geophysical data, thermal imaging, data fusion, homogeneous management zone, yield maps

### Objectives

Mapping soil electrical conductivity (EC) through geophysical proximal soil sensors is one of the most reliable and commonly used technique to obtain quick and high resolution soil maps. Nevertheless, other type of data from optical sensors in the visible (VIS), near-infrared (NIR) and thermal infrared (TIR) regions can be combined with EC data, to better characterize the soil spatial variability and to improve the delineation of homogeneous site specific management zones (SSMZ) (Lopez-Lozano et al. 2010; Scudiero et al. 2013), required in precision agriculture (PA) for variable-rate irrigation and fertilization management. Recent works by Maltese et al. (2010) and Minacapilli et al. (2012) emphasize the use of optical sensors mounted on unmanned aerial vehicles (UAV) to evaluate the spatial distribution of soil moisture, based on the acquisition of thermal images of bare soils. In particular, the soil apparent thermal inertia (ATI) method is mainly applied for this purpose (Lu et al. 2009; Minacapilli et al. 2009, 2012; Antonucci et al. 2011). Objective of this work is the fusion of EC and ATI data to characterize the spatial variability of soil hydraulic properties, and finally improve the SSMZ delineation.

### Methods

The EC and ATI data were acquired on bare soils during 2016, respectively before the seeding and after the harvesting, in two fields cropped with wheat and barley (almost 14 ha each), situated in Lodi (northern Italy). EC was measured with an electro-magnetic induction (EMI) sensor, while the ATI map was obtained by albedo measurements and maximum and minimum daily temperatures measured with a TIR camera mounted on a UAV. Firstly, the EC map and the ATI map were used to delineate SSMZs maps through the MZA (Management Zone Analyst) software (Fridgen et al., 2004). Afterwards, the two products were assessed and compared. Finally, the principal component analysis (PCA) was carried out to integrate EC and ATI data, with the aim to derive the soil fusion maps related to the main independent factors governing the soil variability. These maps were used to improve the delineation of SSMZs by MZA.

### Results

The main results concerned the production and the comparison of three types of SSMZ maps, one derived from EC data only, one from ATI only, and one from EC and ATI data fusion. These results highlighted how geophysical and thermal data provide complementary information useful to improve the delineation of SSMZs, because of their correlation with the soil water retention properties.



## Soft path water management adaptations to climate change: the SO-WATCH project

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**Keywords: Water management, Climate Change, Drought, Water scarcity, Hydrological model, Optimization**

### Objectives

Climate change and growing population are expected to severely affect freshwater availability across much of Europe by the end of 21th century. In a warmer climate, many river basins, especially in southern Europe, are likely to become more prone to periods of reduced water supply. The last-century dominant approach to cope with water scarcity largely relied on a hard-path, by investing in centralized, large-scale infrastructures such as dams and distribution systems, with the purpose of expanding the existing supply capacity. Nowadays, such a hard-path is becoming economically, environmentally, and socially unsustainable. The SO-WATCH project (supported by Fondazione Cariplo grant n° 2015-0220) aims to develop and test a novel decision-analytic framework to assist decision-makers in designing and assessing alternative soft-path measures, based on the introduction of coordination mechanisms among water sectors, low-cost and reversible infrastructural interventions, and smart economics.

### Methods

The SO-WATCH project is structured into four steps: 1) Development of a spatially distributed, physically-based model to describe the physical system's components. In particular, it is composed by three sub-models: a hydrological model of the Lake Como catchment (TOPKAPI-ETH); an irrigation district model simulating the water balance in the irrigated system downstream of the lake (IDRAGRA); a model of the lake dynamics and the routing of water released from the lake in the Adda River; 2) Development of an agent-based behavioral model to represent human decisions and their effects on the system dynamics (e.g., dam operations, farmers' practices); 3) Construction of hydro-climatic and socio-techno-economic scenarios, assessment of their effects on water-related activities and identification of the sources of vulnerability; 4) Design of soft-path adaption measures to improve the productivity (efficiency) of the multi-sector water use.

### Results

This work presents some of the preliminary results achieved, in particular: (1) Simulation of the main hydrological processes in the Lake Como catchment (e.g., rainfall-runoff, snowpack dynamics) contributing to the lake inflows under current and future climate conditions; (2) Assessment, by means of the simulation system, of solutions for a better coordination between lake outflow management and choice of crop patterns by farmers of the irrigated area downstream; (3) Implementation of a new spatialized index of agricultural drought to provide a reliable measure of the evolution of this phenomena over the territory to irrigation managers and farmers.



## **Innovative Approaches for Water and Food Security through Enhancing Irrigation Water Conservation and Productivity in Oman**

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**Keywords: Hi-Tec sensors, Date palm trees, Lime trees, Open fields, Modern and Alaj irrigation systems, Meteorological data, Evapotranspiration**

### **Objectives**

It is crucial to adopt a mechanism that can preserve the role of irrigation in food security yet with minimal consumption of the already scarce water so that it increases water productivity and leads to water conservation. The main goal of this study was to maximize the irrigation water productivity through introducing innovative approaches on irrigation towards water conservation and increasing irrigation productivity using most contemporary, high-tech sensors and instrumentations for real time measurements of water in the soil-plant-atmosphere continuum.

### **Methods**

Closely located two farms were selected for this study; one farm was irrigated with traditional (Aflaj) irrigation system and the other one was irrigated with modern (bubbler) system. Both farms were planted with date palm and lime trees. Each of the two trees in the two irrigation systems were replicated three times. The experiment was conducted from summer 2014 to summer 2016. Soil volumetric water content, temperature and electrical conductivity sensors were installed at various soil depths under each tree. The logged data were remotely transferred from data logger to control system through ECH2O interface software. The direct tree water requirement through Sap flow rates and velocity were measured using Sap Flow meters. Meteorological parameters required for calculating reference evapotranspiration and crop water requirements, including solar radiation, air temperature, air relative humidity, wind speed, wind direction, and precipitation were obtained by installing a full and automatic weather station in the study area.

### **Results**

Results revealed that type of irrigation and soil depth had significant effect on soil volumetric water content and on soil temperature variations. Whereas, the type of irrigation, soil depth and interaction of type of irrigation or depth had significant effect on soil electrical conductivity. When meteorological data were analyzed against ET, we found that ET was directly related to amount of solar radiation, atmospheric humidity and wind speed. Nevertheless, results showed that the evapotranspiration values were higher than the measured sap flow values. Financial survey results showed that profit for limes per tree and dates per tree grown under modern system was 71% and 57% higher than the aflaj system respectively. In conclusion, results confirm that the integration with high-tech sensors and instrumentations offer valued option for precision irrigation delivery, water productivity and better net farm returns.



## Three-axis accelerometer for fast evaluation of the gravel road surface quality

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**Keywords: three-axis accelerometer; roughness; gravel roads; quality assessment**

### Introduction

With the increment of mechanization in forestry and generally in rural activities in the period 1960-1990, mountainous region in Europe has reported a rapid expansion of the forest and rural road networks. These networks typically include low-volume roads which are generally unpaved road surfaced with gravel. As a consequence, forest and rural areas are connected to primary roads by gravel roads which provide the fundamental access for resources exploitation and management. Besides its traditional use, low-volume roads are essential to the expansion of the outdoor activities much more than in the past. As a consequence, the quality of the gravel road in terms of surface uniformity is fundamental to keep the ride comfort and traffic safety. Unpaved gravel surface quality can be monitored though periodical quantification of its roughness, which is a property of the road surface variable with time. A rapid survey of roughness is central in order to support an effective maintenance planning and to define priorities in maintenance interventions.

### Objectives

The aim of this work is to verify the applicability of low cost three-axis accelerometers for fast evaluation of the quality of gravel road surfaces. Specifically, the response of the sensor quantifies the vibration intensity for different types of vehicles typically used for recreational and outdoor activities in forest and rural areas.

### Methods

Different vehicles (a mountain bike, an off-road motorcycle, an ATV vehicle, a 4WD car and a compact crossover) were included in the experiment in order to verify the vibration intensity when traveling with different road conditions. Road surface roughness were evaluated taking advantage of the implementation of a Kinect depth camera. Three-dimensional data sets of road surface were collected along the track and analysed in terms of average roughness (Sa), root mean square roughness (Sq), Abbott-Firestone curve related indices (Spk, Sk, Svk) and other roughness parameters.

### Results

Coefficients of determination  $R^2$  were estimated after linear regression between average surface roughness Sa and standard deviation of relative accelerations of vehicles vibrations in five different roads. Values ranging between 0.83 and 0.97 were detected, with higher values in the case of lighter vehicles.



## Harvesting yield and material other than olives from mechanical harvesting of some Tuscan varieties

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**Keywords: mechanical harvesting, olive, harvesting yield, crop purity**

### Objectives

In intensive olive groves mechanical harvesting is an essential practice in order to decrease production costs. The most used machines are trunk shakers, which proper working strictly depends on tree and fruit characteristics. Being equal all the other conditions, the genetic factor, i.e. the variety factor, could be crucial to reach the target of a convenient mechanization of the harvesting operation. In the present work some olive Tuscan varieties have been investigated for the efficiency of the mechanical harvesting (HY). Further, the crop purity in terms of amount of material other than olives (MOO) has been assessed and compared.

### Methods

Four Tuscan olive varieties, namely Frantoio, Moraiolo, Leccio del Corno and Pendolino, have been investigated. Three 25-years old trees of each variety were randomly selected from the same olive orchard and treated as plant replicates. Harvesting was performed by means of a hydraulic eccentric-mass trunk. For each plant, the following parameters were recorded: harvested olives; non-harvested olives; amount of material other than olives, i.e. leaf and debris, MOO). Moreover, for each plant 100 olives were manually picked by measuring the detachment force (DF) and the correspondent average mass. Harvest yield (HY) was computed as the ratio between the amount of harvested olives and total olives production. MOO was expressed as mass fraction of the harvested olives.

### Results

Harvest yield (HY) significantly differs (by one-way ANOVA and Tukey's HSD test) between varieties, ranging from about 54% of Moraiolo to about 76% of Frantoio. Varieties also showed significant differences in the DF and consistently with the HY result, Moraiolo showed the highest value (about 6.4 N). The same holds for the average mass of 100-olive, where Moraiolo showed the lowest value (about 140g) against Frantoio with the highest value (about 180g). Only poor and not significant correlations have been found between the considered parameters when computed on the entire dataset, i.e. regardless the varieties factor, so that the HY seems to be not strictly related the overall DF and/or the average mass of 100-olive. Nevertheless, a significant linear relationship was recorded between the HY and the ratio between DF and olive mass, that it might be thought as the average acceleration threshold to provide olives detachment. Finally, significant differences have been found in the amount of MOO, which ranges from about 2% of Pendolino to about 9% of Moraiolo.



## Liner overpressure and teat dimensions: preliminary results of a field study

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**Keywords: liner overpressure, teat dimension, mouthpiece depth**

### Objectives

Overpressure (OP) is defined as the pressure difference across the liner at which milk flow just starts or stops. OP has been proposed as a robust and practical method, which uses live teats in near milking conditions, to estimate the relative value of liner compression across liners. The primary objective of the present study was to measure the OP of a liner and assess the relationship between OP and teat dimensions. A secondary objective was to evaluate the relationship between mouthpiece (MP) depth and congestion of the teat wall in dairy cows.

### Methods

Tests were performed at a commercial dairy farm of Northern Italy (Lombardy) with 94 lactating cows (lactation: 1 to 5; average days in milk: 224) milked in a 8+8 parallel milking parlour with low-level milk line, with system vacuum level of 42 kPa, 60 pulsations/min rate, and 60 % pulsation ratio.

A commercial nitrile rubber round liner with the following main characteristics was tested: MP depth, 43 mm; MP diameter, 20 mm; Mid-barrel diameter, 22.5 mm; Touch point pressure difference, 11 kPa. Fifteen dairy cows (Holstein-Friesian) were randomly selected from the herd. The 15 cows were distributed across early, mid-, and late lactation (11–311 days in milk) with a parity range of 1–5, and an average milk yield of  $15.4 \pm 3.9$  kg/cow per milking. The liner was tested for one milking on each of the cows. The OP was measured 1 min and 3 min after the cluster attachment using an innovative test device, called OP Bucket (OPB), designed and built by Milkline s.r.l. (Podenzano, Italy) in collaboration with the Università degli Studi di Milano. The measurement of teat length and diameter, and the evaluation of teat congestion involved the entire herd. Teat length and diameter were measured before milking. The teat congestion was assessed by observing changes in the color of teat skin (pink, red, and blue) within 1 min of cluster removal. Black teats were excluded from the color-based evaluation.

### Results

The 15 cows had pre-milking teat length between 35 and 60 mm and teat base diameter between 14 and 26 mm. The OP value at 1 min after the cluster attachment was  $9.7 \pm 2.0$  kPa. A significant decrease ( $P < 0.01$ ) of about 2.7 kPa in OP values were recorded at 1 and 3 min from the beginning of the milking. Additionally, a positive significant correlation ( $P < 0.05$ ) was found between teat lengths and OP values and between teat diameter and OP values measured at 1 min after the milking unit attachment, but not at 3 min of milking. The reason for this change in observed OP during the progression of a single milking for an individual cow could be due to subtle changes in the position of the teat within the liner. Of the 376 teats of the herd, 60 were excluded from the color-based evaluation because they were black. The remaining 316 teats had an average pre-milking length and diameter respectively of  $45 \pm 0.7$  mm and  $21 \pm 0.3$  mm. About 80 % of teats were reddened (congested) or tinged with blue (cyanotic). Probably teats were milked with a high MP vacuum, being not long enough to create a seal in the liner barrel.



## **A novel instrumented sphere for acceleration measurements during mechanical harvest of grapes**

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**Keywords: grapevine, quality, shaking frequency**

### **Objectives**

The use of the harvesting machine for grapes harvest has the limit of the production of must coming out from the detachment of the berries that could reflect negatively on the quality of the final product. It depends on many factors including grapes variety, ripeness and frequency of the harvesting machine shakers. The shaking frequency generally adopted is the one that achieves the maximum harvest efficiency, that means high work capacity and low grape juice production. In this paper, the authors present a new system to measure the accelerations received by grapevine during mechanical harvest with the aim of evaluating the influence of the shaking frequency on the quality of the must obtained.

### **Methods**

The device was an instrumented sphere designed and implemented by the Agricultural Mechanics Section of the Department of Agricultural and Forest Sciences, University of Palermo, Italy. It contains a triaxial Micro Electro-Mechanical Systems (MEMS) sensor capable of acquiring acceleration from a few mg to 400 g (where g is the gravitational acceleration). The field tests were carried out in September 2015 on Viognier and Grillo grapes. They allowed to measure the accelerations on the plants during mechanical grape harvest with three different frequencies of shaking, 7.6, 7.9 and 8 Hz, and then to evaluate their influence on the main quality characteristics of the musts obtained.

### **Results**

The results showed that the number of vibrations on the plants increases linearly with the increasing frequency. With reference to the quality of the musts obtained, polyphenols and catechins increased as the shaking frequency increased both for Viognier and Grillo varieties.



## Development and evaluation of a cereal capacitive mass flow sensor

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**Keywords:** Capacitive sensor, Frequency, Mass flow, cereal, Conveyor velocity.

### Objectives

The first stage and most advanced process in precision agriculture is the real time yield monitoring by the use of sensors. The aim of this study was to develop and investigate the effect of input voltage frequency, mass flow rate and velocity of product on the performance of a developed mass flow capacitive sensor.

### Methods

A test rig was developed and equipped with measuring system. In order to measure the mass flow rate of cereal, two aluminum plates with a thickness of 2 mm and dimensions of 800×100 mm were used as sensor. The paddy variety of Ghaem was used as dielectric material between the plates of the capacitor. The treatments were mass flow rates (0.8-2.4 kg/s), frequencies (100-700 kHz) and conveyor velocities (0.5-1 m/s). The experimental data were analyzed with factorial test based on a completely randomized design in three replications.

### Results

Results showed that the effect of mass flow rate, input voltage frequency and their interactions had significant effect on the sensor capacity ( $p \leq 0.01$ ). The product velocity had no significant effect on the sensor performance. The input voltage frequency had an inverse effect on the capacity of sensor. By comparing relationship between capacities of mass flow sensor at different levels of frequency, it was observed a relatively high accuracy relationship between paddy mass flow rate and capacity of sensor. The best frequency range to measure the mass flow of paddy was 300 kHz. Results of this research can be effective on the design of an online system to measure the mass flow rate of paddy in harvesting, storing and processing systems.



## **Design and development of a low cost device for the automatic estimation of Body Condition Score (BCS) on dairy cattle**

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**Keywords: Body Condition Score, Precision Livestock, 3D camera, Microsoft Kinect**

### **Objectives**

Nowadays, the analysis of the Body Condition Score index (BCS) is considered one of the most diffused methodologies to support the farm management in dairy farms. In short, the BCS index analysis is a visual methodology - carried out by specialist personnel - to evaluate the metabolisable energy stored in an animal in the form of adipose and muscle tissue in different periods of the lactation. For every dairy cow, considering nine specific anatomic parts, a score is calculated according to the Edmonson scale (1989). The score ranges from 1 to 5, where low values indicate an underweight dairy cow, a value of about 3-3.5 corresponds to an healthy animal, whilst values above 4 indicate an overweight cow. In this way, the farmer can suitably modify the feeding of the single animal to optimize, ultimately, its milk production according to the Precision Livestock approach.

The objective of the present work is to design and to develop a device for the automatic evaluation of the BCS based on a low cost 3D camera and digital image analysis. The device is implemented in a monitoring system positioned directly in the barn.

### **Methods**

The sensor used is the Microsoft Kinect, or a low cost peripheral device developed for the XBOX 360 home videogame console. This sensor includes a RGB camera (with resolution of 1920x1080 pixels) and an infrared depth camera (resolution of 512x424 pixels). Our idea is to use the Microsoft Kinect as a depth sensor to estimate the BCS index, starting from a 3D image of the dairy cow acquired directly in the barn. The process splits in two steps: i) the image acquisition of the animal through the sensor and the conversion in a depth image, and ii) the identification, on the digital depth image of the animal, of specific points of shape transect (corresponding to the anatomic parts considered by the Edmonson scale) from which to automatically extrapolate the BCS index through tracking algorithms especially designed.

### **Results**

Laboratory tests, necessary to characterize the Kinect sensor, and field tests carried out in the barn on a selected number of dairy cattle demonstrated that the low cost sensor and the developed image analysis are capable to correctly reconstruct the cow' shape with high precision. Furthermore, the identification of the specific anatomic parts of the animal, selected according to Edmonson scale, hallowed us to correlate every digital section with the corresponding BCS value. In this way, it is possible to monitor the herd during time providing useful and traceable information for the farmer about the energetic metabolism of every single dairy cow.



## Features extraction from vineyard 3D dense point-cloud model for precision viticulture

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**Keywords: 3D point cloud, DSM, Precision viticulture**

### Objectives

Precision agriculture, the optimization of crop-managing practices, relies on a reliable knowledge of the vineyards in terms of identification, quantification and response to the crop intrinsic variability. In this context, the identification of new methodologies for the features extraction and crops mapping plays a relevant role. With the recent extension of the Unmanned Aerial Vehicle (UAV) employment also in the agriculture field, a huge amount of high spatial and temporal resolution data provided by fields aerial images, are nowadays available. Objective of the presented work is the further exploitation of UAV imagery information potential, beyond the well-established bi-dimensional mapping, by the vineyard features extraction from 3D dense point-cloud modelling, computed by modern photogrammetry tools.

### Methods

In this work, a 3D point-cloud processing algorithm able to evaluate a set of relevant vineyard features is presented. More in detail, the detection of vine rows location and orientation, of the canopies growing state and the possible presence of missing plants is performed by crop volumetric assessment, performed on the modelled canopy surface. This process is preceded by the crucial detection of cloud points representing vines, discarding alien ones, by means of a local Digital Terrain Model definition, based on both point spatial and spectral information.

### Results

A set of 3D point-cloud models of several vineyard parcels located in Barolo, Piemonte, has been profitably processed by the developed algorithm. The point-cloud has been obtained by processing aerial images acquired at in the red, red-edge and NIR wavelength. The method results to be robust also in the presence of dense inter-row grassing, which make the vine plants detection more difficult, due to the similar response of all the kind vegetation to light radiation. The developed point-cloud processing algorithm do not require any pre-process of the acquired aerial images, being able to autonomously perform the features extraction and requiring a very limited calibration parameters.



## **Innovative techniques for the design and the control of operating conditions of rotary harrows: preliminary results on tractor-harrow interactions**

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**Keywords: rotary harrow, tractor-harrow interactions, soil tillage**

### **Objectives**

Soil tillage is one of the agricultural operation that requires high amount of energy and determines a strong wear of both tractors and implements connected to them.

The rotary harrow is one of the most diffused tools for extensive soil tillage. In modern agriculture, farmers demand to operate at increasingly higher speeds, to possibly coupling other machines to the harrow (e.g. sowing machines), produce an also heavier operating conditions. These aspects make the manufactures to search innovative solutions for the design of structures and mechanical components able to withstand high mechanical stresses. In most cases manufactures simply operate oversizing all mechanical parts with a consequent increase in static and dynamics loads on tractor as well as in fuel consumptions. The research of innovative design solutions requires, as first step, the knowledge of the interactions between tractor and harrow in different operating conditions, in order to identify the most stressed components.

Preliminary results about this topic are presented in this paper, with a particular focus on the measurement of physical parameters that define the tractor-harrow interactions as well as the influence of working conditions. This research is carried out in the contest of PRIN 2015 project, partially financed by the Italian Ministry of University and Research.

### **Methods**

The tests were carried out in the field using a specific device (U-frame hitch coupler ASAE S278.6) interposed between the rotary harrow and coupled tractor. This three-point hitch coupler was able to record the intensity and the direction of negative and positive forces generated by the rotary harrow during the working operation to the three-point of the tractor. In addition, also the torque of the drive shaft of the tractor was determined replacing the PTO shaft with a torque-meter. The measurements were performed: in two different soil conditions (previously worked and no worked), in two different rotary configurations (10 and 20 cm working depth), and with two different forward speeds (3-6 km/h). All tests were carried out on a sandy and dry soil.

### **Results**

Data processing highlighted a high correlation between the working depth, the soil condition, and the forward speed and the resistance forces recorded by the device.

## Precise sowing of row crops for bidirectional mechanical weeding

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**Keywords:** Precision farming, row crops, weed control, field sensors, sensor fusion, cropping systems

### Introduction and objectives

Most commonly applied weed control in row crops currently is herbicide field spraying. Due to restrictions on admission of active herbicidal agents and for reasons of soil protection chemical weeding will be not favourable in the future. An alternative is mechanical weed control by hoeing, which is still not a satisfactory method because of low capacity and the fact that only up to 80% of the soil surface is treated. The space between the plants is not accessible for the weeding tools of conventional hoeing machines. To extend the area of mechanical treatment other cropping systems are required to support the operation of hoeing machines. By controlling a precision seeder via GPS assisted by additional range sensors the seeds were placed in adjacent rows and in successional traces rectangular, thus cross rows were generated.

### Methods

Each sowing unit was equipped with a stepping motor commanded by a control algorithm determining the theoretical position in real-time (Fig.:1). The seeder was used in field experiments to establish plant compounds allowing machine hoeing longitudinal and transverse. Hoeing was applied three times and weeds have been counted before and after operations.

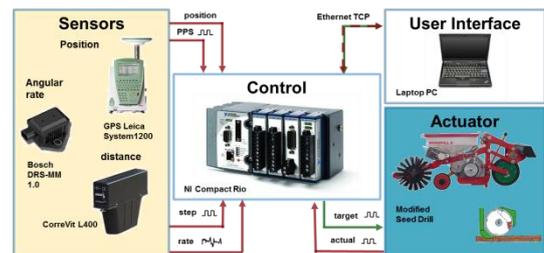


Fig.1: Seeder an control device

### Results

As compared to inter row hoeing by a conventional machine intra row hoeing eliminated 21% more weed plants. The most effective weed control system however was still the herbicide application eliminating weeds to less than two weed plants per square meter. In the mechanically treated plots more than 12 weed plants per square meter were found after the weed control of the plots was terminated.

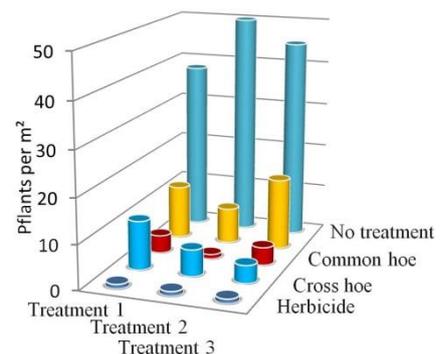


Fig.2: Weed control effect of cross compounds in comparison with other weed control procedures



## Interference Analysis of an Heavy Lift Single Rotor UAV Downwash Effects on Sprayed Liquid Droplet Dispersion

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**Keywords: UAV; precision agriculture; drone design, pesticide distribution,CFD**

### Objectives

Drones in agriculture can be used for a variety of task, aimed to increase farm crop yields and accurately monitor fields, simultaneously decreasing time, labour and possibly resources.

Small and medium size drones can be adopted for some specific tasks like crop analysis and soil recognition, while for other tasks including precision distribution of pesticides or fertilizer an heavy lift drone is more appropriate required.

Prior to the approval of Yamaha R-MAX, an UAV helicopter which is allowed to operate with a maximum payload of 98 kg, the Federal Aviation Administration (FAA) had only issued exemptions for much smaller drones weighing less than 55 pounds (24.98 kg).

The possibility of using larger UAV would introduce the possibility to pursue more selective applications in agriculture, either reducing the environmental impactor the risk for operators, bypassing the limits imposed by actual legislation.

In heavy lift drones the optimal design of transported spraying equipment requires a careful study of fluid dynamics interactions of the downwash wakes generated from the rotors and the spraying nozzle of horizontal or vertical bars.

As a matter of fact experimental investigation of such interactions for the preliminary design of transported spraying systems are complex to setup and use, as results are strongly influenced by the operative and environmental conditions.

A powerful tool to preliminary investigate such interactions is provided by computational fluid dynamics, allowing a predictive analysis of downwash effects with the spraying operative setup and liquid droplet dispersion effects.

In this work a CFD analysis of interactions between spraying systems and aerodynamic flow field in a single rotor UAV (250 kg take-off weight) is presented, together with possible off-target effects, and the effects linked to motor deployed power and flying speed are investigated in full 3D simulations. Droplet dispersion is investigated for different ranges of droplet sizes.



## **Design and preliminary evaluation of a soil resistance sensor for soil compaction sensing in viticulture**

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**Keywords: soil compaction, precision viticulture, technology choice, dynamometric knife**

### **Objectives**

This paper describes a preliminary study in support of ongoing research to model soil compaction in vineyard resulting from tractor traffic. Specifically an overview of the design criteria followed to implement a sensitised dynamometric knife to measure soil resistance was described.

### **Methods**

Until the first years of twenty century the soil in vineyards was not properly managed. In many winemaking production areas for many years were promoted techniques to improve canopy efficiency, the mechanization of everyone seasonal steps mainly devoted to the cost reduction without evaluating the suitability of technology or techniques used. One of the main negative factors that affect plant growth and indirectly crop yield and grape quality is the soil compaction. Currently this issue is managed by winegrowers with permanent grass or alternating cover crop on the row techniques without evaluating information concerning the soil resistance. This study is focused on the design of a sensitised dynamometric knife, which can allow on the go soil resistance measurements and georeferenced data acquisition. The tool was designed to be coupled with standard three hitch point, is adjustable for a range of depth measurement from 0 to 0,4m. A steel pivoted knife linked to a load cell measure the related force. Moreover, a data acquisition software allows the simultaneous force and GPS positioning data acquisition. In order to analyse the tool's weakness some field experiment was carried out.

### **Results**

The preliminary results showed that the designed system works properly and allows an instantaneous overview of soil resistance measurements. Nevertheless further improvements are required to enhance precision and versatility. In the tests carried out, the various soil types and management techniques have documented forces ranging from average values of 250 kg in skeleton soil to peaks of 1500 kg in clay soil. This in progress study is aimed to contribute for the definition of the most suitable technological solution or management techniques in relation to soil features.



## Automatic filling of the register of field activities, from challenge into reality

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**Keywords: Precision Farming, ICT, Automatic operational monitoring**

### Objectives

The focus of this research is to develop a complete system able to collect and to interpret all the operative parameters, for the different agricultural operations, in order to obtain information suitable to carry out management and strategical decisions. In short, the aim of the research is to develop a new concept of intelligent system supporting Precision Farming applications capable to translate ex post, actual operative parameters into information in order to automatically perform an objectivity compilation of the field activity register.

Through this system, the farmer is able to have, on demand, updated information to be used for certification and traceability processes as well as to satisfy any other management task, including the estimation of the actual operative costs at the farm.

### Methods

The solution here proposed is based on the identification of working processes through a tractor-oriented approach, where the power unit is equipped with a GNSS-datalogger and an identification system acting as a detector able to recognize the coupled implements (on their turn equipped with a RF-transmitter sending identifying codes) and the related operation. Both devices are provided with an accelerometer to allow them switching on only when vibrating. The raw data are collected with a frequency of 0.2 Hz fixing and compressed in data packets formed by geographical coordinates, day and the hour of detection, and coupling information.

Data-packets are then sent to a server, thanks to the GPRS-modem integrated into the GNSS-datalogger, where are finally stored into a relational database. Here, an Operational Inference Engine software (OIE) manages all these data through a set of automatic procedures to get final intelligible information on the monitored operations.

The OIE analysis performs (in chronological order): i) the identification of the working sections (WS, i.e. a sequence of activities comprised between two switching on/off subsequent events; ii) the elimination of possible fixings classified as outliers; iii) the classification of the different work phases (effective work, stops, auxiliary operations and manoeuvres, transports and displacements; to this aim an algorithm using speed and direction is applied) together with the related working pattern; iv) the clustering of all contiguous fixings classified as effective work into a common area; v) the splitting of this clustered area among the crop units that intersect with it; vi) the computation of the working coverage rate on each crop unit, as well as a summary of all the consumed inputs and the worktimes occurred during the current WS.

The OIE results can be then uploaded by a Web-GIS client, allowing the farmer an easy and intuitive access to the information directly from his own private web domain.

### Results

A series of field surveys were organized in order to perform the validation of the proposed procedure, through a manual time study and assessment of the followed working sessions. The main operative information obtained automatically by the new system (i.e. speeds, hour of start and finish, WS duration, operation recognition) were compared with those manually registered. Comparisons between automatically estimated and manually registered parameters revealed high level of correlations ( $R^2 > 0.75$ ), especially in terms of time comparison and identification



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of the working session, thus highlighting the capability and reliability of the proposed system to monitor agricultural operations in an automatic way. This solution will facilitate and enable new generations of farm information systems to be specifically developed for applications on agri-environmental enterprises.



## **A further step to the automatic assessment of the yarding operation productivity: an ICT application for the assessment of biomass weight during yarding operations**

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**Keywords: Automatic operational monitoring, Precision Forestry, Load cell sensor, Inclinometer**

### **Objectives**

This paper describes the approach that was followed with the development and application of a new solution for the operational monitoring in forestry activities, aiming to assess the weight of the biomass transported during logging operations. This approach has been applied on yarding logging system. The present approach can be considered as a *Precision Forestry* application, thanks to its capability to monitor the efficiency and the performance of logging operations even according to site-specific approaches. It can be employed either as a stand-alone device or as embedded in other ICT equipment. Indeed, during the tests the module for the assessment of the weight has been connected with a GPS unit which performed time study analysis.

### **Methods**

A simplified experimental setup was created in order to test the device, which consists in an in-scale cable logging system. A specific skyline was designed and installed, with a mainline and a carriage. A load cell and a synchronized inclinometer were used as main sensors of this ICT unit. They have been installed between the carriage and the hook and on the choker, respectively. A control unit performs the reading and the storing of the signal sent by the load cell, while the inclinometer records, in a SD memory, the angles assumed by the choker during the pulling operations due to the soil profile and friction. The synchronization between the two sensors permitted to detect, time by time, which was the component of the timber's weight discharged to the ground and the component kept by the carriage during the travels. Adding these two components of weight it was possible calculate the entire load transported.

### **Results**

The preliminary overview about the application of this approach on harvesting operations has permitted to assess a good feasibility of the use of load cell and inclinometer for the survey of the biomass' weights. The comparison between the results obtained by the approach here proposed with the real weight of the transported timber have presented satisfactory correlation values ( $R^2 \approx 0.7$ ). In conclusion, the use of this ITC device can be considered as a valid tool for the performance monitoring and traceability to perform a CoC (chain of custody) strategy for forest products.



## **Business plan tool for small biogas plants**

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**Keywords: Bioenergy, Biogas, Business plan, Microscale digestion.**

### **Objectives**

Bio-energy production from waste and crops has long been recognised as a significant potential contributor to meeting future energy needs at a global scale. The use of biogas is not a new technology in Europe. Countries like Germany and Italy have thousands or hundreds of plants installed.

Nowadays there is a reduction of economic benefit to adopting biogas plants to produce renewable energy due to the decrease of energy prices from fossil fuels and to the increasing use of the photovoltaic and wind energy sources. Furthermore, co-products utilised in the large scale biogas plants like maize, wheat, grass, etc. which can also be used as feed for animals have risen in price. For these reasons, the economic feasibility of large-scale co-digesting installations decreased dramatically in last years.

The European project Bioenergy Farm II funded by EASME under the Intelligent Energy Europe program aimed to stimulate the realization of micro-scale biogas installations which mainly use own manure and feed left-overs from the farm as feedstock to producing electricity and heat with a CHP installation, gas upgrading for gas grid feed-in, producing heat in a biogas boiler and upgrading the biogas to a transport fuel.

### **Methods**

Within the project was developed a tool that allows, starting from a complex Excel spreadsheet, using templates to achieve a fast and error-free business plans in pdf format customised for the analysed farm.

The tool built for this purpose is a client-server application, highly customizable to follow the target needs. The tool is based on currently accepted biogas plant engineering design practice and incorporates the effects of incentives resulting from energy policies for member nations of the European Union participating in the Bioenergy Farm II project.

### **Results**

The tool provides a comprehensive database that allows consultants and farmers to conduct the analysis at different levels of granularity. Multilingual support is included.

The tool was validated with success by the partners of the project and was used to conduct over 800 Business plan of micro-scale biogas production plants in Europe.

The tool showed a significant potential to develop targeted, standard business plans that could be useful for further development to banks and investors. In addition, the centralised data collection on the cloud allowed retrieving interesting statistics about performance indicators (payback time, the average cost per kWe power, etc.).



## **AGROMAP – A precision agriculture tool based on satellite ESA images (Sentinel 1 and 2)**

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**Keywords: Parcels and crops monitoring, Yield limiting factors detection**

### **Objectives**

Agromap is a commercial WebGis tool that was born within the scope of a University of Évora "Spin Off", the Agroinsider Lda ([www.agroinsider.com](http://www.agroinsider.com)). The objective underlying the construction of Agromap was to create a remote sensing tool for agricultural parcels using ESA satellites (Copernicus program). With this tool farmers can monitor any parcel, anywhere, in order to optimize agronomic processes and agriculture sustainability.

### **Methods**

Agromap is a Software as a Service (SaaS) tool that provides in time and space interesting radiometric indexes for agricultural management. At the moment, the satellites used in Agromap are optical satellites (Sentinel 2) and radar satellites (Sentinel 1), however more ESA satellites will be incorporated in the Agromap as long as they present value to the agricultural activity. The most used indexes are the indexes of chlorophyll, leaf water content, soil moisture, biomass, etc. The spatial and temporal resolution of these images are respectively 10 m and 6 days.

### **Results**

For agriculture a spatial resolution of 10 m and a temporal resolution of 6 days are fantastic because most of the agriculture machinery applications have this spatial resolution and 6 days is a high temporal resolution for crops that stand in a parcel for 100 days. These parcels inspections allows a total revolution in agriculture activities because with these images and the respective indexes we can perceive: i) if the plot/crop is below the optimal curve growth, in time and space; ii) the limiting factors that are reducing the plot/crop potential (irrigation systems, soil, nutrients, diseases, etc.); iii) the best plot/crop; iv) in crops such as vines, where vegetative vigor and water stress are important, Agromap can be used to model this vigor by placing it within the higher or lower vigor potential limits, in order to adjust it to the company strategy (productivity vs quality). A good way to start doing smart agriculture is without any doubt, with Agromap ([www.agromap.agroinsider360.com](http://www.agromap.agroinsider360.com)).



## **Big data in dairy farm: acquisition methods and numerical models for integrated real-time information systems**

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**Keywords: Numerical methods, Precision Livestock Farming (PLF), forecasting models, environmental parameters**

### **Objectives**

The adoption of different types of monitoring systems and control devices within livestock barns in last years has remarkably increased the amount of data available for farmers. Automatic Milking Systems (AMS), collar tags, pedometers and environmental sensors have turned also farms into the big data sources currently available.

This study aims to define tools and methodologies capable to organize such amount of data into meaningful information and user-friendly indications for farmers and technicians of livestock farms. The output of the research is meant to indicate immediate, precise and simple actions to be carried out for herd management.

Different technologies available for data collection in dairy farms have been analyzed in terms of potentials for data acquisition and mutual integration, with particular reference to data acquired by AMS. An experimental monitoring campaign of environmental conditions and herd management data has been carried out on a dairy farm in Bologna (Italy), assumed as a case study. The analyses have been focusing on a livestock barn equipped with one AMS box, hosting about 70 lactating cows.

Data related to milk production, cow behavior and heat stress have been analysed according to a wide-perspective research approach. A cluster-graph analysis has been applied to a dataset containing the time series of the parameters (including activity score, parity, and body weight) recorded for each cow in the barn. This analysis proved capable of identifying groups of animals with features affecting their productivity differently. Moreover, climatic data surveyed inside the barn have been analyzed together with cow productivity and outdoor climatic data. Numerical models correlating the variables under study have thus been developed, also with forecasting potential.

The results proved suitable to enhance the characterization of the herd, lend support to cow monitoring and herd management and provide prediction models for the design of new barns or renovation of existing ones.



## Assessing spatial and temporal variability of a Mediterranean vineyard using multivariate geostatistics

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**Keywords: spatial and temporal variation, multivariate geostatistics, Mediterranean vineyards, precision viticulture**

The appropriate management of spatio-temporal variability is the main purpose of precision viticulture. For this reason, the characterization of vineyard status is essential.

### Objective

The aim of this work was to characterize the spatio-temporal variability of a typical Mediterranean grapevine (cv. Cagnulari), using multivariate geostatistics to determine homogeneous management zones.

### Methods

Leaves and berries were analyzed by a hand-held fluorescence sensor (Multiplex®3). Fluorescence measurements were taken on six dates in 2016, from flowering to harvest, at 110 sampling points located at the nodes of a regular grid overlaid on the vineyard. For each sample the Multiplex®3 provided the emission values at the different wavelengths besides specific indices. Geostatistical analysis was applied to model the spatial variability of the sensor outcomes.

The scale-dependent correlation structure of the fluorescence variables was investigated by means of Factorial Kriging Analysis (FKA) developed by Matheron. That method consists of three basic steps: estimating the linear model of coregionalization (LMC); the analysis of the correlation structure at each spatial scale and the interpolation of the scale-dependent regionalized factors.

### Results

The application of FKA to the data of the first sampling date provided a LMC with a nugget effect and spherical model with range of 23.29 m. The spatially structured component prevailed on error component (66% of total spatial variance explained against 34% of error component). In the FKA, only the first regionalized factor was maintained because with eigenvalue > 1. The variables that weighted more corresponded to the emission signals linked to the vigor and the nitrogen content of the plant.

The data of the remaining five sampling dates are currently underway.



## Design and implementation of a Geographical Information System for monitoring transhumant flocks in Lombardy

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**Keywords: flocks transhumance, GNSS receiver, GIS**

### Objectives

The overall consistency of transhumant flocks in Lombardy (Northern Italy) amounts to 60,000 sheep, mainly of the giant Bergamo breed, belonging to about 150 shepherders of the Milan, Bergamo, Brescia, Cremona, Lodi, and Lecco districts. The transhumance of the flocks remained until today even though, over the centuries, the breeding purposes deeply changed. Nowadays the sheep, so far considered as user of pasture resources, assume a new role of "vegetation controller" and "land resource manager" contributing to improve the biodiversity. Lombardy recently approved (2013) a project to enhance the transhumance and in cooperation with ERSAF developed a plan to maintain and improve this important livestock reality. In this context, our research group designed and developed a system for the territorial monitoring of the flocks by studying their paths and analyzing their land utilization.

### Methods

Collars equipped with GNSS receivers were developed from a commercial satellite alarm system designed for automotive. The main hardware components of the collars included a GSM/GPRS module, a GSM antenna, a GPS receiver and antenna, and a Li-Ion battery. Ten flocks were involved in the study from June 2015 to September 2016. All the flocks were bred in the Lombardy plan area during winter and on the Alps during summer. During spring and autumn they were transferred across the Pre-alps valleys. The dimension of flocks varied from 600 to 1300 sheep. One or two collars for each flock were used depending of the dimension of flocks. The flocks transhumance paths were visualized through a Web-GIS application and the GPS-tracked data were analyzed through a GIS software.

### Results

The land surface pastured by each flocks varied from 500 to 2500 ha/year mainly in the plan and mountain areas. In particular, only two of the 10 flocks monitored entirely travelled by foot for 600-700 km in a year across the Pre-Alps valleys, following during spring and autumn the traditional transhumance paths (batide), and using the pasture of these areas. The transfers took place mainly during the daylight hours, being the night transfers less than 20 % of the total transfers. The remaining eight flocks used motorized vehicles to move from the plan to the mountain areas and vice versa during spring and autumn. The pastures fragmentation in the Pre-alps areas was the main reason of the motorized movements of the flocks. The creation of specific corridors for transhumant flocks could be the solution to overcome the pasture fragmentation and maintain the traditional transhumance in Lombardy in particular in the Pre-Alps valleys contexts.



## Automated climate control to reduce leg disorders in broilers farming

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**Keywords: footpad dermatitis, precision livestock farming, intensive poultry farming, thermal comfort, risk factor, climate control.**

### Objectives

Good environmental conditions allow maintaining good levels of productivity and animal welfare in broiler houses. Indeed, being the broiler house a closed environment, all the variables involved must be carefully controlled and regulated. Broilers are the fastest-growing and cheapest sources of animal protein among farmed species; their performance is heavily conditioned by environmental parameters such as indoor air temperature, relative humidity, and ventilation speed. A good climate manager could be evaluated through the ability of the ventilation system to control air temperature, relative humidity and air speed at animal height to maintain tolerable concentrations of gases, dust and airborne microorganisms.

The wrong management of those parameters may result in poor litter quality with a direct effect on broiler welfare. Genetic selection for fast growth is known to be influential on leg disorders (footpad dermatitis (FPD) and lameness (LMNS)) but several studies linked them to poor environmental conditions. Ulcers that arise from advanced lesions can negatively affect the walking ability of the birds, with significant effects on both animal welfare and economic aspects in intensive broiler farming.

Due to the strong connection between leg disorders, litter quality and thermal comfort, the aim of this study was to find the association between environmental predisposing factors, measured in continuous (such as air temperature and relative humidity) and leg problems, manually scored during the welfare assessment procedure, to develop an automated climate control system to reduce lesions.

### Methods

In this study, the welfare of the chickens was assessed manually three times per production cycle (at week 3, 4 and 5), scoring footpad dermatitis, lameness, and litter quality. In the same broiler farms, variables such as air temperature and relative humidity were automatically measured over the same period. These variables were combined into a thermal comfort index and associated to upper and lower thresholds, which made it possible to quantify the percentage of time the birds spent out of the thermal comfort zone (POOC). The data was analyzed by combining data from the welfare assessments with environmental data collected by the automated monitoring systems.

### Results.

The analysis showed that footpad dermatitis and lameness were more frequent when the flock was exposed to poor environmental conditions for prolonged periods ( $P < 0.001$ ). The potential association between automated control of the environmental conditions and the welfare assessments might be the basis for the development of models and algorithms capable to automatically detect thresholds above which lesions are mostly probable.



## **Toward a dynamically configurable and upgradable greenhouse environment simulation PC platform**

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**Keywords:** greenhouse environment model, Excel-based simulation, interactive courseware

### **Objectives**

The objective of the current paper is to describe the first workbook of the a dynamically configurable and upgradable platform for the simulation of a greenhouse environment. Moreover, it presents the relationship among Xnumbers Excel<sup>®</sup> addin , VBA code and the Excel threads within the application developed in MS Excel Environment to better achieve a PC platform easily and promptly ready for use, essentially for every one owning a laptop or desktop.

### **Methods**

Many greenhouse characteristics such as structural shapes, types of glazing materials, heating/cooling systems, shading devices, lighting, CO<sub>2</sub> enrichment, and different operational strategies, i.e. for energy saving, have been designed aiming to achieve favorable environmental conditions for plant growth. During the past decades, several greenhouse environment simulation and climate control models have been investigated. Regardless the type, the development of a good predictive model is compulsory to achieve adequate control performances. Thus, the understanding of the complexity and dynamic behaviour of greenhouse environments becomes a priority among stakeholders. In order to provide a flexible interactive tool, the Xnumbers Excel<sup>®</sup> addin by Volpi, along with the Visual Basic for Applications (VBA) window, allowed to customize a workbook to fit the simulation of the greenhouse environment. The code follows the energy and mass balance principles, adopting the classical models proposed by Takakura and Fang. A three differential equations system has been integrated numerically with a 2.5 sec step, by the Predictor-Corrector P(EC)<sup>2</sup> schema of 4<sup>th</sup> order of Adams-Bashforth\_Moulton, a function implemented in Xnumbers.

### **Results**

The workbook can be seen as a "quantitative" interactive workbook: any climate control model can be fruitfully explained students, providing continuous binding of theory and exercise, by an illustrative tool to both illustrate the method as well as perform it. The workbook is under a license approval process.

The workbook produce realistic approximations of the dynamic behavior of greenhouse environments with different design configurations and operational strategies for 24-h simulation periods. A user interface enables easier manipulation, and editing the technical data.



## **UAV's multispectral remote sensed imagery for precision agriculture. A case-study in a olive orchard**

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**Keywords: Unmanned Aerial Vehicle (UAV), multispectral imagery, olive orchard, precision agriculture**

### **Objectives**

The objectives of this paper refers to the potential in using UAV platforms, coupled with multispectral imagery at cm-level resolution, in the precision farming domain and in particular in olive orchard management and monitoring. This paper reports some experiences and critical considerations for precision farming applications using new multispectral camera Tetracam MicroMCA6 Snap and photogrammetric methods. In particular, the experiments investigated the performances and potential of the photogrammetric planning and processing of multispectral datasets acquired with multispectral camera mounted on an UAV platform and the generation of high-resolution orthophotos from multispectral images, over two different olive orchard at different growth stage.

### **Methods**

In order to achieve the objectives that the present research aims to, we have prepared a geoprocessing working model that represents the guidance through the processing and extraction of useful information to obtain the expected results. Principal steps of the working process has been the UAV flight mission planning and the *in situ* survey with ground control points (GCPs) positioning over the study area, pre-processing of the acquired images and further ortho-rectification process, DSM extraction and 3-D reconstruction. These steps were performed to understand the easiest and most efficient way to deliver geo-referenced information useful in the precision farming domain at farm scale. Multispectral georeferenced datasets, of both olive orchards, were evaluated in discriminating vegetation reconstruction and properties with different response due to the different growth stage, without any ground radiometric measure. However, careful descriptions of the agricultural characteristics, provided by local farmers who manage the different sites, were used to validate our findings.

### **Results**

For every dataset, using photogrammetric procedures, multiband orthoimages were produced and analyzed in relation to different olive orchard conditions. The use of an UAV platform, coupled with a multispectral camera as Tetracam MicroMCA6 Snap, has proved flexible and reliable in obtaining the photogrammetric reconstruction at the farming scale. Therefore, using high-resolution contents from UAV data, more focused analyses were performed only on the cultivated areas, excluding ground and shadows, in order to obtain a good reconstruction of the olive orchard and the description of the crop conditions.



## Comparison of vegetation indices derived from UAV and satellite images in vineyards

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**Keywords:** Unmanned Aerial Vehicle (UAV), Sentinel 2, Landsat 8, precision viticulture, precision agriculture

### Objectives

Precision viticulture is growing substantially thanks to the availability of improved and cost-effective instruments and methodologies for data acquisition and analysis. In this field, the increasing use of modern Unmanned Aerial Vehicles (UAV) has opened new possibilities for data acquisition due to their low operational costs, high operational flexibility and high spatial resolution of imagery. Therefore, the UAV technology may provide a competitive alternative to traditional platforms namely satellite (SAT) and aircrafts. UAV and SAT platforms differ widely in costs, spatial resolution, time resolution, precision, range, flexibility, endurance and processing time. In this context, this study aims at comparing vegetation indices, derived by both SAT and UAV, to assess the similarities and effectiveness of images characterized by different spatial and radiometric resolutions and to perform an overall evaluation combining operational and economic factors.

### Methods

The study area is an experimental vineyard located in Umbria, central Italy. Multispectral images from UAV (Parrot Sequoia camera) and SAT (Landsat 8, Sentinel 2) were acquired during spring-summer period, year 2016. UAV images were calibrated and mosaicked, while SAT images were radiometrically and atmospherically corrected. Vegetation indices calculated using red, red-edge (UAV and Sentinel 2), and near-infrared bands from UAV and SAT data were compared by means of multi-scale statistical similarity indices.

### Results

Results indicate that SAT and UAV platforms provide comparable results in vineyards characterized by broad vegetation spatial variation. In contrast, in the more heterogeneous vineyards, low-resolution images are not completely effective in representing intra-vineyard variability. SAT spatial resolution, particularly for Landsat 8, resulted adequate for detecting large scale variations, but too low to discriminate inter-row variability. Results provides useful information for the choice of the appropriate detection platform depending on the specific application and scale of the analysis.



## **Soil properties mapping by best interpolation gis technique of an area located at northern Iraq**

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**Keywords: GIS, Iraq, Soil Properties.**

### **Objectives**

This study is highlighted the problem which is how to choose the appropriate spatial interpolation method for mapping processes and representation of a specific soil data? Soil Protection from causes of all types of degradation is a strategic goal in all nations. Properties of the soil are characterized by spatial distributions. A GIS program is able to process and integrate spatial data into a multiple maps, and giving the opportunity to compare them for detecting the internal correlations among the variables under consideration. Founding the relationships between soil properties to location gives us the opportunity for making correct decisions about the land use.

### **Methods**

The study area was located in Northern part of Iraq, and surface soil samples from 21 locations were taken for interpolation of local maps purposes. Texture (sand, silt and clay), pH, EC, organic matter, Calcium Carbonate, Soluble Potassium and Soluble Sodium values were measured for each sample. The chosen interpolation methods were Kriging, Inverse Distance Weighted (IDW), Radial Basis Functions (RBF), Global Polynomial (GP) and Local Polynomial (LP). The performance of the interpolation methods was done using geostatistics analyses by the Mean Absolute Error (MAE), Mean Bias Error (MBE) and Root Mean Square Error (RMSE).

### **Results**

The results showed that the IDW and kriging were the best methods for most of the studied variables, while the RBF, GB and LP were inappropriate. This study is a step forward towards more accurate results.



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## **TOPIC 3**

***ENERGY, WASTE AND BY-PRODUCTS SMART USE***



Effects of polyphenols on biogas production from olive oil mill wastewater <i>Andiloro S., Calabrò P., Folino A., Tamburino V., Zema D.A.</i> .....	60
Gas heat pump for greenhouse heating in a stand-alone hydrogen plant: a mathematical study <i>Anifantis A. S.</i> .....	61
Aquatic plant treatment system (ATPS) based on duckweed for cleaning the liquid fraction of digestate. <i>Marveggio D., Segato S., Mapelli S., Castelli S., Brasca M., Fiala M., Castiglioni B.</i> .....	62
Characterization of biochar obtained from pyro-gasification of <i>Jatropha Curcas</i> residues through an updraft reactor <i>Colantoni A., Gallucci F., Monarca D., Cecchini M., Abenavoli L.M.M., Longo L., Proto A.R.</i> .....	63
Performance Evaluation of Conical Solar Concentrator for Water Heating with Different Flow Rate <i>Gwi Hyun Lee, Mun Soo Na</i> .....	64
Investigation over the parameters affecting the mechanical behaviour of small prismatic straw bales for use in construction <i>Maraldi M., Molari G., Molari L., Regazzi N.</i> .....	65
<i>Oberti R., Finzi A., Perazzolo E., Riva E., Calcante A, Provolo G.</i> .....	66
A model for the assessment of the energy performance of fattening pig houses <i>Costantino A., Fabrizio E., Comba L., Cornale P.</i> .....	67
Mass and heat balance in a production line of fresh mozzarella aimed at assessing energy recovery solutions <i>Bianchi B., Catalano F., Pedone S.</i> .....	68
Technical and energy analysis from the recovery of vineyards pruning residues in an agro-energetic supply chain <i>Gubiani R., Cividino Sirio R.S., Pergher G.</i> .....	69
Full-scale drying of digestate with acid scrubbing of exhaust air <i>Chiumenti A., da Borso F., Pergher G.</i> .....	70
A different approach to limit the pollutants' emissions of agricultural engines <i>Bietresato M., Renzi M., Mazzetto F.</i> .....	71
Sicilian potential biogas production from Citrus industry by-product <i>Comparetti A., Febo P., Greco C., Mammano M.M., Orlando S.</i> .....	72
Energy efficiency in food processing buildings: an integrated approach based on data monitoring, experimental analyses and computer simulations <i>Barbaresi A., Torreggiani D., Tinti F., Tassinari P.</i> .....	73
Ammonia emission from pig slurry before and after anaerobic digestion: a preliminary study <i>Costa A., Nava S., Tangorra F.M., Lazzari M.</i> .....	74



Compostable packaging based on fibrous natural materials and bioplastics. Preliminary results <i>Barbari M. Conti L., Rossi G., Monti M.</i> .....	75
Effect of additives on Phosphorus, Copper and Zinc separation in animal raw and digestate slurries <i>Cattaneo M., Perazzolo F., Riva E., Provolo G.</i> .....	76
Valorization of Tilia L.'s pruning waste as insulation material <i>Grohmann D., Menconi M.E., Petrucci R., Cioli G., Torre L.</i> .....	77
ReNuWal: a software tool to improve manure management and nutrient efficiency <i>Perazzolo F., Galassi G., Cattaneo M., Riva E., Finzi A., Sommariva F., Provolo G.</i> .....	78
Techno-economic performance of small scale biomass CHP: steam vs gas turbines with bottoming ORC <i>Pantaleo A., Vox G., Scarascia Mugnozza G.</i> .....	79
Planning the energy valorization of agricultural co-products, by-products and waste in a landscape context <i>Statuto D., Picuno P.</i> .....	80
Evaluation of citrus pulp and olive pomace potential availability for biogas production by using a GIS-based model <i>Valenti F., Porto S.M.C., Chinnici G., Cascone G., Arcidiacono C.</i> .....	81
Management of livestock soils for the sustained production of pastures. <i>Ruz Reyes R. M., Leyva Rodríguez S. L.</i> .....	82
Process for recovery of proteins and phosphorus from manures <i>Vanotti M., Szogi, A.</i> .....	83
Efficient Solar Energy Systems for Water Treatment <i>Tripanagnostopoulos Y., Kavga A., Karavia E., Toumasis D., Lekkas G.</i> .....	84



## Effects of polyphenols on biogas production from olive oil mill wastewater

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**Keywords: anaerobic digestion, oil residues, inhibiting compounds, methane yield**

### Objectives

Biogas production through anaerobic digestion is a method to valorise the oil extraction residues in a sustainable way. This method allows not only an eco-sustainable disposal of mill effluents, but also provides to farms an additional profit from energy recovery. Despite the significant organic matter content of olive oil mill wastewater (OMW) and pomace, the biochemical processes are hampered by the noticeable concentration of polyphenols (PP), which are toxic for micro-organisms. Scientific literature reports many experimental tests of olive residues digestion (often in co-digestion with other substrates) which quantifies biogas and methane yields. In the case of OMW, showing PP concentrations in the range 0.5 - 24 g L<sup>-1</sup> (Borja et al., 2006; Gonzalez-Lopez et al., 1994), strong methane yield reductions have been noticed even at PP level of about 0.5 - 2 g/L (Borja et al., 1996; Fedorak and Hrudey, 1984). However, the limits of inhibition are not unanimously identified due to the number of factors influencing the biochemical processes, such as temperature, content of organic compounds and nutrients, pH.

### Methods

Experimental batch tests of anaerobic digestion of OMW have been carried out in triplicate. Three blends of OMW and inoculum (this latter taken from a commercial biogas plant) with PP concentration of 0.5, 1.0 and 2.0 g/L, previously characterised (pH, dry matter content, total volatile solids, COD), have been kept for 30 days under mesophilic conditions (37 °C). Throughout the experiment, biogas and methane production have been measured about every two days and compared with a blank (inoculum only).

### Results

The outcomes from the experimental tests confirm the feasibility of biogas production from OMW and suggest reducing its PP concentrations by a proper dilution with other substrates, to avoid reduction of methane yields or even process blockage.

### References

- Borja R., Banks J.C., Alba J., Maestro R. (1996), The effect of the most important phenolic constituents of OMW on batch anaerobic methanogenesis. *Environ. Technol.*, 17, 167–174.
- Fedorak P.M., Hrudey S.E. (1984), The effects of phenols and some alkyl phenolics on batch anaerobic methanogenesis, *Water Res.*, 18, 361-367
- Gonzalez-Lopez J., Bellido E., Benitez C. (1994), Reduction of total polyphenols in olive mill wastewater by physico-chemical purification, *J. Environ. Sci. Health, Part A A29(5)*, 851-865.



## **Gas heat pump for greenhouse heating in a stand-alone hydrogen plant: a mathematical study**

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**Keywords: Gas heat pump, stand-alone hydrogen plant, Greenhouse heating**

### **Objectives**

Although the heat energy consumption represents the main cost item in the greenhouses economy and for several years many studies are addressing on the management of the energy flows, the actual heating systems in this field are still obsolete. Most of them are based on the Diesel, LPG and natural gas boilers. These technologies have a high environmental impact and are subject to an ever increasing cost, for such reasons several current research are addressed to use the renewable energy sources in order to achieve the greenhouse heating equipments and to develop new micro-generation systems, also in according with the new European Directive 2010/31/CE and the Near Zero Energy Building (NZEB) concept. Unfortunately, for greenhouse heating, the energy production and consumption are non-simultaneity and the renewable energy produced during the day must be stored. A good solution is represented by the photovoltaic and hydrogen stand-alone systems, in addition, a ground source gas heat pump (GSGHP) can be used to heat the greenhouse. The GSGHP allow to use the hydrogen in order to feed an internal combustion engine coupled to a compressor of a geothermal heat pump. The aims of this research is to analyzed the performance of this new renewable plant on a winter day.

### **Methods**

In order to analyze the performance of the photovoltaic and hydrogen stand-alone systems integrated with a ground source gas heat pump (GSGHP), a mathematical model was used. The analyzes were carried out with the software "MATHEMATICA". This study is indispensable to determine the total efficiency of whole system and the contribution of each component to the load. In order to enhance the mathematical model, some of the results obtained were matched with the experimental data collect from the hydrogen plant and, instead, the GSGHP performance values were found in the manuals system components and in the bibliography.

### **Results**

The results show that the use of a ground source gas heat pump unit integrated with a photovoltaic stand-alone hydrogen systems allows to have a total energy efficiency, starting from the sun to the heating systems to 12%. It is very interesting to note that the major limitation to the performance of the whole system is represented by the performance of photovoltaic, in fact, starting from the energy available from the PV, the system has a 192% efficiency with a COP of the heat pump to 4. The heating system increasing the greenhouse temperature by about 7°C to 9°C compared with the ambient conditions in a representative winter day of February.



## **Aquatic plant treatment system (ATPS) based on duckweed for cleaning the liquid fraction of digestate.**

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**Keywords: Duckweed, Environmental Assessment, Wastewater treatment**

### **Objectives**

Composting plants combine compost and energy production using the Anaerobic Digestion (AD). However, the AD process generates residue of whose the liquid fraction is polluting and therefore needs to be subjected to expensive waste treatments with the loss of the value of the mineral elements. It is then necessary to develop technologies allowing, from one side, the treatment of liquid fraction and, from the other side, the uptake of those minerals as plant nutrients. The purpose of the project DUCK-TECH was to provide a solution to these aspects through an integrated biological approach, i.e., an aquatic plant treatment system (ATPS). In more details, an ATPS for liquid fraction treatment was realised using duckweed and, in particular, its ability to recover nitrogen and phosphorous and, simultaneously, to reduce COD and pollutants. Duckweed become green biomass useful for realize new bioproducts. In this study, the aim was to compare the environmental performances of a traditional wastewater treatment plants (WWTP) with the aquatic plant treatment system (ATPS) based on duckweed.

### **Methods**

The environmental impact assessment was carried out using a Life Cycle Assessment approach. As functional unit was selected 1 ton of liquid fraction coming from solid-liquid separation of digestate produced by anaerobic digestion plant fed with OFMSW. The analysis considers all the operations carried out between the digestate separation (pumping, dilution, etc.) to the discharge of water after duckweed growth. Primary data were collected over one year-long experimental test in a duckweed growth system on a pilot scale. The classification and characterisation steps were carried out in accordance with the LCD-composed method. The following impact categories were evaluated: climate change, ozone depletion, particulate matter, photochemical ozone formation, terrestrial acidification, freshwater eutrophication, terrestrial eutrophication, marine eutrophication, and mineral, fossil and renewable resource depletion.

### **Results**

The preliminary results highlighted that the environmental impact of liquid fraction treatment with ATPS based on duckweed deeply ranges depending on the duckweed growing. Respect to traditional WWTP the ATPS shows considerably better environmental results for most of the evaluated impact categories. A further reduction of the performances could be achieved by the valorisation of the duckweed produced biomass as starch and oil source for new bio products.

### **Acknowledgements**

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## **Characterization of biochar obtained from pyro-gasification of *Jatropha Curcas* residues through an updraft reactor**

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**Keywords: *Jatropha Curcas*, Biochar, E.B.C., Updraft, Pyro-gasifier**

### **Objectives**

This study concerns the biochar production through pyro-gasification of *Jatropha Curcas* residues coming from the mechanical pressing of *Jatropha* seeds for oil production. *Jatropha C.* is a crop that can grow up in sandy and saline soils, with low levels of rainfall and at the same time it represents a valuable tool in order to reduce the soil erosion and desertification phenomena. The aim of the work is to evaluate the physical and chemical characteristics of the biochar obtained from the thermo-chemical conversion of *Jatropha C.* residues and to compare them with the European Biochar Certificate standards (E.B.C.).

### **Methods**

The residues have been pelletized before using them in the pyro-gasification reactor in order to obtain an efficient and uniform biomass conversion. The system for biochar production is an updraft fixed bed pyro-gasifier. After the filling phase of the reactor, different airflows have been used for the tests. The biochar production occurs in consequence of the advancement of the pyrolysis flame front, from the upper part of the reactor to the bottom part, in counter current respect to the airflow.

### **Results**

The characterization of *Jatropha C.* residues shows a carbon and nitrogen content of about 44-45% and 4-5% respectively, with a higher heating value of about 18,8 MJ/kg. Preliminary results show that biochar is characterized by a carbon content up to 70% with a heating value of about 25 MJ/kg. In addition to these preliminary results, further pyro-gasification tests have been planned to enhance the assessment of the biochar characteristics and to assess different uses such as soil improver and as system for carbon soil sequestration.



## Performance Evaluation of Conical Solar Concentrator for Water Heating with Different Flow Rate

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**Keywords: Conical Solar Concentrator, Performance Evaluation, Solar Energy**

### Objectives

The objectives of this study were to investigate the influence of flow rate affecting on thermal efficiency of a conical solar collector, which has a double tube absorber placed at focal axis for collecting solar radiation.

### Methods

A conical solar concentrator consists of a conical reflector, which reflects direct solar radiation into an absorber. A conical reflector was constructed from an aluminum sheet of 0.5 mm thickness with 92% reflectance. A double tube absorber was placed at the center of focal axis for collecting the solar radiation reflected from a conical reflector. Cone angle of solar concentrator was designed as 90°. The diameter of the aperture for the conical solar concentrator was 1 m with concentration ratio of 17.07. Conical solar concentrator was installed at the dual axis solar tracking system in order to maintain the conical reflector aperture normal to the sun with increasing the collection of incident solar radiation into an absorber. A dual tracking system consists of linear actuator and slew drive with driving cycle of 6 second and tracking angle error of 0.025°. Water was used as circulating fluid, which flows from inlet to outlet of an absorber for collecting solar radiation. Three identical conical solar concentrator systems were installed side by side at the same place for the accurate performance analysis under the same environmental conditions. Performance evaluations were carried out with different volumetric flow rate of 2, 4 and 6 ℓ/min to find the influence of flow rate affecting on thermal efficiency.

### Results

In this study, the thermal performance of conical solar concentrator was evaluated with different flow rates under the same environmental conditions. The results indicated that average thermal efficiency was 73.24%, 81.96%, and 79.78% for each flow rate of 2ℓ/min, 4ℓ/min, and 6ℓ/min. It shows that the flow rate of circulating water has a significant effect on the thermal efficiency of the conical solar concentrator. It is concluded that optimum flow rate of conical solar concentrator is 6ℓ/min.



## Investigation over the parameters affecting the mechanical behaviour of small prismatic straw bales for use in construction

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**Keywords:** Straw bale construction, stress-strain diagrams, Elastic modulus, Poisson's ratio.

### Objectives

Straw bale construction is a building technique offering many advantages: it provides excellent hygro-thermal insulation; being straw bale buildings lightweight, it ensures good performance against earthquakes; and it is sustainable. Indeed, from the point of view of sustainability, the use of straw allows to avoid costs and emissions related to the production of conventional building materials on one hand, and the disposal of excess straw on the other hand. From a mechanical point of view, straw bales can act as a surviving cell for the building in case of calamity. For this reason, measuring the mechanical properties of straw bales is important for the comprehension of the behaviour of straw bale buildings. Despite the fact that the use of straw bales in construction has been constantly increasing since the '80s, the behaviour and the performance of straw bale buildings have not been fully assessed so far.

### Methods

Recently, a test methodology has been developed (Maraldi et al. (2016). *Biosystems Engineering*, 151, 141–151.) which allows to measure the force acting on the bale and the resulting displacement in all the three directions in real time without stopping the test; in this manner it is possible to deal at best with the time-dependent nature of straw bales mechanical behaviour. The methodology has been applied to the analysis of the performance of small prismatic straw bales under monotonic compressive loads; to this end, a test apparatus comprising a hydraulic press for loading plus digital cameras for Digital Image Correlation measurements and a 3D Laser Scanner for measuring bale's lateral displacement has been used. Tests have been performed on bales of different materials (namely: wheat, rice, oat, barley, corn, sorghum and millet) and density, at different loading rates and with different loading orientation (flat and on-edge). Force-displacement curves obtained from the tests have been fitted with a two-parameter rheological model to extract bales performance indicators.

### Results

Results show that bales laid flat are stiffer than bales laid on-edge. However, if the influence of bales initial geometry is discarded by considering stress and strain instead of force and displacement, there is no significant difference in the elastic modulus between flat and on-edge orientation. Furthermore, bales stiffness and elastic modulus are dependent on the initial density of the bale. It has been also found that straw bales exhibit a typical deformation pattern which depends on the baling process and that the Poisson's ratio does not remain constant along the longitudinal direction during loading, whereas it is null along the transverse direction.



## **A fuzzy logic controller of two-stage anaerobic digestion: development and experiments on a lab-scale plant for biohydrogen and biomethane production**

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**Keywords: Fuzzy logic, Automation, Anaerobic digestion, Biohydrogen**

### **Objectives**

Two-stage fermentation is a variant of the traditional anaerobic digestion, based on two sequential reactors each optimized conditions to promote specific bacterial consortia. The first stage produces biohydrogen gas and volatile fatty acids (VFA) effluents, which are fed to the second stage where the traditional digestion is accomplished with production of a biogas rich in methane.

The energy yield and stability of the overall process are the result of the synergic trade-off between the two stages. Indeed, a very-high production of biohydrogen in the first stage is associated with an excess of VFA fed to the second, which in turn will inhibit the production of biomethane. On the contrary, a poor production of biohydrogen associated with poor VFA content, results in a poor feeding of the second stage and low production of biomethane. Due to its complexity, the management of the two-stage digestion can easily be sub-optimal or induce instabilities in the process.

In this study, we developed and implemented a fuzzy-logic automatic control of the feeding rate in a two-stage digester, with the aim of evaluating the capability of this system to reach an overall high production and to keep the process stable.

### **Methods**

A fuzzy-logic controller was developed. It consisted of a state estimator for the hydrogenic and methanogenic stage, based on a set of state variables measured by in-line (pH, volume of gas production) and off-line measurements (gas composition). Then it used state to compute the current feeding in terms of a change (positive or negative) of the previous feeding load value. The fuzzy-logic controller was implemented in Matlab language and experimented on two identical, lab-scale plants (A e B) both consisting of a hydrogenic stage in sequence with a methanogenic stage, operated in a two-stage anaerobic digestion process. Both A and B were fed with a feedstock mixture of livestock effluents and rice bran. Plant A was fed with a constant moderate organic load, while plant B was fed with a changing organic load, controlled by the fuzzy output and obtained by varying the rice bran fraction in the feedstock mix. After an identical start-up phase, plants A and B were continuously operated for a period of 40d during which their biohydrogen and biomethane gas production was monitored.

### **Results**

In overall, the fuzzy-controlled plant B resulted to produce 18% more energy than the constantly-fed plant A. The difference in energy output was only associated to the hydrogenic stage (biohydrogen specific production of 0.27 and 1.05 dm<sup>3</sup>/dm<sup>3</sup><sub>reactor</sub> per day in plant A and B, respectively), while the biomethane production was not different in the two plants (0.51 and 0.52 dm<sup>3</sup>/dm<sup>3</sup><sub>reactor</sub> per day for A and B, respectively).

These results show that the fuzzy-controller was able to increase the sub-optimal feeding of the hydrogenic stage without inhibiting or unbalancing the methanogenic stage.



## **A model for the assessment of the energy performance of fattening pig houses**

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**Keywords: Energy use, Climate control, Livestock housing, Swine**

### **Objectives**

The increment of animal production together with the growing shift of technology to the livestock sector, expected in the further coming future, entail a strategical role for the efficient use of energy in the animal production sector. Currently engineers and farmers do not have reliable tools for the estimation of the energy consumption related to many aspects of the animal production, as the climate control. For this reason, a simulation engine for the calculation of the energy use and financial costs related to the indoor climate control into a fattening pig house is presented this work.

The development of the presented tool belongs to the wider context of a project called EPAnHaus that concerns the energy performance analysis and certification of livestock houses.

### **Methods**

To estimate the energy performance of fattening pig houses, a customized modelling framework was developed, which accounts for the building thermo-physical features, for the pig production boundary conditions (e.g. animal density and animal final live weight) and for the geographical location of the farm.

Using those data, the tool calculates all the needed boundary conditions for the simulation (e.g. pig heat emission), while for simulating the thermal behaviour of the house, the simple hourly method (SHM), defined into the ISO 13790:2008 Standard was adopted in order to estimate the net energy needs for space heating and cooling. For the evaluation of the energy consumptions and the financial costs, the performance of HVAC systems, such as fans, are also implemented in the model.

### **Results**

The customized tool estimates that, for example, an analyzed a fattening pig farm situated in the North of Italy consumes about 20 kWh of electricity per each pig produced (170 kg of final live weight). This kind of information may be employed in the design process or in retrofitting analysis, with the aim of detecting the most effective solution, in term of improved energy performance, among different options regarding both the building envelope and/or the plant systems.

More in general, energy needed by climate control may be used for developing an energy certification scheme that entails an energy saving in the livestock sector.



## Mass and heat balance in a production line of fresh mozzarella aimed at assessing energy recovery solutions

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**Keywords:** Fresh mozzarella line, Mass balance, Heat balance, Energy recovery

### Objectives

Nowadays, the agro food industry has a key role in the Italian and European economy and is characterized by the need to keep down energy costs and CO<sub>2</sub> emissions. Thus it is essential for any company, to give due consideration to the energy efficiency of processes, in order to reduce production costs and maintain adequate levels of market competitiveness.

Moreover, it is well known that most food industries consist of Small Medium Enterprises (SMEs) often characterized by a considerable potential, in terms of energy efficiency improvement.

Therefore, in the present paper a study was carried out on the production and use of thermal energy at each stage of the production process of "pasta filata" cheese.

### Methods

The experimental tests were carried out at the "VIVOLAT SRL" dairy farm located in Gioia del Colle - Italy. The company processes on average 8000-10000 kg of milk per day, coming from external producers.

The study was carried out through three steps:

- 1) description of the "lay-out" of the production process, with the estimated energy flows;
- 2) determining actual mass and energy flows, through direct measurements in the cheese factory;
- 3) outline the opportunities for energy recovery.

It was determined the mass and energy balance of the production plant related to a production batch of 300 kg of "Fior di latte" cheese, corresponding to processing about 2000 kg of milk, with a production yield of 15%.

The energy balance was carried out with respect to both the process steam and the production process, paying particular attention to the operating conditions of the steam generator, the cheese making vat and continuous stretching machine, being all these equipment energy-intensive ones and affected by significant waste heat.

### Results

It was determined both the thermal energy  $Q_p$  demand of the production process and the thermal energy need  $Q_{Gtot}$  for steam production, excluding gains already achieved by the dairy farm: the condensed water at 90 °C outgoing from the cheese making vat is fully recovered in the boiler.

On the contrary, during the stretching stage, it is evident a very low net utilization of the vapour enthalpy with a consequent waste heat, higher than 80% of the total heat flow entering the process, discharged at a temperature of approximately 80 °C.



## Technical and energy analysis from the recovery of vineyards pruning residues in an agro-energetic supply chain

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**Keywords: LCA, winter pruning residuals, energetic sustainability, harvester yards.**

### Objectives

The objectives of this study was to analyse the energy balance of different supply chains based on harvesting of vine, olive and hazelnut pruning residual for combustion in biomass heating plants.

### Methods

During winter 2014 and 2015 several methods of harvesting were tested, including field burning, direct chopper, round baler chopper, pellet by chopper, pellet by round baler. Wood chips were used directly, while the bales were chopped at the moment of feeding them into the combustion plant. One part was used directly in the heater and another part was transformed in pellet. This biomass will be used for burning in a heater in an existing center for drying wood and cereals.

After calculating the cumulative energy demand (CED), this value was compared with another fuel as diesel oil, adopting the LCA (Life Cycle Assessment) methodology.

The energetic sustainability of the three residues supply chain is a priority for evaluating the possibility to use this material as a fuel.

For evaluating the efficiency of the biomass supply chain we used the MJ/kg ss value and g CO<sup>2</sup> eq./kg ss spared for each operation chain. This values is calculated as the ratio of energy in final product after burning to the energy consumption during the whole production process.

### Results

The results showed that the residues supply chain is more convenient if chips are harvested and directly burned; the small-baler and big-baler alternatives were more expensive about energy demand but can spare more CO<sup>2</sup>. Direct use of wood chips resulted in a same MJ/kg ss value than the harvesting with balers with subsequent palletization because wood chips required a lot of energy for dry. Of course the pellet can be commercialized better than the chips.

The evaluation of energetic sustainability of the supply chains for harvesting of winter pruning residuals than both supply chains for production of chips and pellet were sustainable.



## Full-scale drying of digestate with acid scrubbing of exhaust air

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**Keywords:** digestate, drying, dryer, nitrates, ammonia, ammonium sulphate, biogas, scrubbing, cogeneration.

### Objectives

Anaerobic digestion of organic waste and/or livestock manure represents a great opportunity, not only for the revenues related to the production of energy from renewable sources, but also from social and environmental points of view. Nitrogen content of digestate, however, is not affected by the process in terms of quantity: where surplus nitrogen is a problem, dedicated solutions must be implemented.

The present research was conducted on the first full-scale digestate drying plant realized in Italy in order to verify the efficiency of the process and its environmental sustainability.

### Methods

Digestate drying can be considered as one of the "conservative" processes, since nutrients are conserved in the outputs of the system, represented by a dry organic fraction and by a solution of ammonium sulphate.

The system processes part of the output of a 1 MWe biogas plant, fed with bovine manure and other biomasses. The heat needed for the evaporation process was derived from the combined heat and power unit (CHP), in particular, by means of water/air heat exchangers and from the exhaust of the CHP.

The exhaust airflow from the evaporator was treated in a scrubbing unit in order to reduce the emissions of ammonia.

In particular, the inputs and outputs of the process were subject to characterization, mass flows and energy consumption were determined and exhaust emissions were monitored.

### Results

The drying capacity of a full scale plant is determined mainly by the availability of thermal energy, which can be recovered both from exhaust air from and from hot water from CHP units. The throughput of the system, in terms of dry product, resulted variable: the monitored drying equipment was capable of processing an average of 47%, on weight basis, of digestate produced by the biogas plant. The plant diverts from the main stream also 47% of nitrogen, that results contained both in dry digestate and in ammonium sulphate. Further results will be described.



## A different approach to limit the pollutants' emissions of agricultural engines

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**Keywords: agricultural engines; engines' environmental performances; biodiesel, biofuel mixes**

### Objectives and Methods

The many regulatory changes dictated by the roadmap of TIER and EURO norms, begun in 1996, have forced and continues to force the manufacturers of agricultural machines (tractors in particular) to continue working on the engine, developing technical systems to respect the increasingly-stringent limits on carbon monoxide (CO), unburned hydrocarbons (HC), nitrogen oxides (NO<sub>x</sub>) and the particulate matter (PM).

The choice common to all manufacturers was to firstly use solutions already present in the automotive industry (e.g., common rail, EGR), and subsequently to develop other technologies explicitly-thought for the agricultural sector. If the first solutions had all as common denominator to be focussed on the system-engine, subsequently there were efforts to develop systems that did not penalize engine performances. The use of urea-based after-treatment systems downstream of the engine to lower the NO<sub>x</sub> can be framed within this latter type of solutions: a solution of urea (at 32.5%, the AdBlue) is injected, under the control of a dedicated electronic control unit, into the exhaust pipe just before an SCR-catalyst. Another possibility not to decrease the engine performances is represented by intervening, e.g. by using advanced fuels having a greater environmental-friendliness. This is just the solution explored in this work; with the aim of reducing emissions without penalizing the performances, we fuelled a compression-ignition engine with different diesel oil-biodiesel blends.

### Results

In our experiments lower levels of CO (about -20%) and PM (-40%) were recorded in comparison with conventional diesel oil. The engine power was substantially unchanged, being mainly related to the lower heating value (LHV). The NO<sub>x</sub> were generally higher (+20%) due to the higher oxygen content of biodiesel and also to its different compressibility, resulting in an advance of the injection in a fuelling system calibrated on conventional diesel oil. Starting from these first results, the possibility of adding a small percentage of (bio)ethanol to the biodiesel will be examined in future works, with the target of reducing NO<sub>x</sub> formation thanks to the temperature reduction in the combustion chamber. Moreover, this solution is particularly easy to be applied as it does not require any modification of the engine or the fuel system.



## Sicilian potential biogas production from Citrus industry by-product

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**Keywords: Citrus industry, Anaerobic Digestion, biogas, energy**

### Objectives

The increasing needs to protect the environment require a correct management of wastes, including the by-product deriving from Citrus industry.

In Europe, Italy is the second nation after Spain in Citrus production and 50% of national citrus fruit production is located in Sicily, above all in the provinces of Catania, Messina and Palermo.

The by-product obtained from the industrial processing of Citrus fruits into juice and essential oils is called "pastazzo" or Citrus Waste (CW) and is composed of peels, seeds and squeezed pulps.

It is used, both in Italy (especially Sicily) and in other countries as food for livestock, but recently also in Anaerobic Digestion (AD) process for producing biogas and digestate.

This study is aimed at evaluating the Sicilian potential biogas and energy production from the above "pastazzo" and verifying the possibility of using this by-product for AD process within 30 km from a processing plant.

### Methods

The statistical data about the amounts of the by-product of Citrus processing industry were evaluated, in order to compute the Sicilian potential biogas and energy production. The areas cultivated with Citrus species in Sicily and their distribution in the various municipal districts were mapped and analysed by means of a QGIS software, together with the main Citrus processing plants and the three existing AD plants.

### Results

The CW produced in Sicily could be used inside a bio-reactor, together with other raw materials (e.g. pomace and wastewater from olive oil mills, cereal straw, poultry manure and Italian sainfoin or *Hedysarum coronarium*), for AD process.

It can be foreseen that in Sicily it is possible to obtain through the use of "pastazzo", a yearly production of 15,640,000 m<sup>3</sup> ca. of biogas, equal to 29,363,662 kWh of electric energy and 30,831,845 kWh of thermal energy or 7,507,200 m<sup>3</sup> of biomethane.

This high potential biogas and energy production cannot be currently used in a sustainable way from the energetic and economic point of view, because the existing AD plants are farer than 30 km from Citrus processing plants.



## **Energy efficiency in food processing buildings: an integrated approach based on data monitoring, experimental analyses and computer simulations**

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**Keywords: Energy efficiency, Food processing buildings, Integrated design**

### **Objectives**

Since the last decades of the previous century, the rising cost of energy and the increasing sensibility for environmental issues in public opinion have been driving the construction sector to pay increasing attention to energy saving solutions in the design of new buildings and building retrofiting. A similar trend has affected the agricultural industry, and food processing buildings in particular, where the reduction of energy consumption is a challenging goal given the high energy amounts usually requested to guarantee food quality and safety. Therefore, many companies aim to increase their energy efficiency by optimizing the current consumptions and adopting renewable energy sources. However, several factors affect their energy needs – such as production volumes, location, weather, market strategies, logistics, quality standards, etc., basically calling for specific optimization strategies. Moreover, most energy saving solutions are designed for residential and office needs, hence their application in food processing buildings can require specific adaptations. The main aim of this research is to study and test energy efficiency solutions optimized for food processing buildings.

### **Methods**

Since several disciplines are involved in energy efficiency design, we have used an integrated approach aimed to assess the main consequences of the choices related to a specific design sector on other sectors and overall performances. Specific tools and equipment have been realized to improve the precision of the results. The approach takes advantage of three activities: monitoring, experimental tests and computer simulations. Their integration allows to know the trends of the main quantities involved in energy consumption and in the experimental tests, to test and validate different energy saving solutions, to create and calibrate models for computer simulations and data analysis, easing the assessment of the performance of the various solutions.

### **Results**

This procedure has been successfully applied in some case studies, wineries in particular, allowing to test the performances of very shallow geothermal systems, energy saving solutions in building envelopes, energy storage optimization for photovoltaic systems, micro-ventilation in wine-ageing cellars. Finally, continuous monitoring and computer simulations, performed after the installation of the energy saving solutions, proved to be important tools to evaluate different energy saving scenarios and their integration, identifying their strengths and critical issues and providing the actors involved in the project with useful information to improve the decision making processes.



## **Ammonia emission from pig slurry before and after anaerobic digestion: a preliminary study**

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**Keywords: air quality, bees, atomic absorption, lead, nickel, cadmium concentrations**

### **Objectives**

The anaerobic digestion is a biological process of stabilization of an organic substrate decomposable in the absence of oxygen conditions, that allows the stabilization of the wastewater and the energy enhancement.

The purpose of the work is the compare ammonia emissivity from pig slurry added with biomass in a thermophilic system, before and after the anaerobic digestion.

### **Methods**

The farm chosen for sampling is located in Northern Italy, it is a full cycle pig farm with 800 sows. The digester, with the capacity of 1 MW, is fed with liquid pig manure and biomass, usually corn silage. It works in thermophilic conditions, up to 43 °C, with a 56-d retention time. The slurry was sampled before and after the anaerobic digestion. Total Solids, Organic Solids (Volatile), pH, Total N, N Ammonia, Nitric N, P Total (P<sub>2</sub>O<sub>5</sub>), Total K (K<sub>2</sub>O), AGV and FOS/TAC were analyzed on samples.

In order to represent the emissive capacity of the waste (before and after digestion) to be spread on soil, during the trial, 3 samples (200ml) of slurry and 3 samples of digestate (200ml) were collected. On these samples, at the same temperature (18°C) in a climate controlled laboratory, ammonia emitted from the samples was measured through a measuring detector (Gasbadge Pro ammonia) every 2 minutes for 30 minutes,.

Data were submitted to variance analysis (Proc GLM, SAS 9.4) to evaluate the effect of anaerobic digestion on ammonia emission by samples.

### **Results**

All the analytical values (Total Solids, Organic Solids (Volatile), pH, Total N, N Ammonia, Nitric N, P Total (P<sub>2</sub>O<sub>5</sub>), Total K (K<sub>2</sub>O), AGV and FOS/TAC) are similar to those found in the available literature. Results obtained by samples during the trial showed that, during the first 30 minutes, ammonia emission was significantly higher from the digestates, in comparison with pig slurry, with 50.74 mg/m<sup>3</sup> vs 72.01 (P<0.01). For digestates, the higher quantity of ammonia emitted during the 30 minutes of trial was estimated in around + 32.5%, P<0.001. As it was expected, the tests carried out have confirmed that the downstream effluent of the anaerobic digestion of animal sewage presents chemical-physical characteristics and emissive different from the untreated slurry. Despite, it seems that greenhouse gases reduction induced by the anaerobic treatment cannot be guaranteed for ammonia. Therefore, the simultaneous reduction of greenhouse gases and ammonia could be obtained only if good management practices will be applied during manure spreading on field.



## **Compostable packaging based on fibrous natural materials and bioplastics. Preliminary results**

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**Keywords: bio-packaging, straw-waste, bioplastics**

### **Objectives**

The objective of the research is that to propose a different solution for the production of packaging for industrial products in different commercial sectors, in order to reduce the environmental impacts from the production and use of packaging made out of plastics.

The specific objective is the realization of packaging prototypes made of a composite material with straw-waste and bioplastics. The use of straw for the production of compostable packaging is a new process on which the research experience carried out by the Gesaaf staff can enable the effective prototyping.

### **Methods**

The designed solution is a composite material constituted by compostable organic material (straw) in compression state, which is contained within closed and open cells. Cells and organic material are contained all together inside a casing of biopolymers (mater-bi). The compostability of the whole matrix is in according to the standard UNI EN 13432.

The molding process essentially involves a phase of compression pressure in a mold and a heating phase, that can be implemented with traditional technologies and that are already employed for the production of polystyrene packaging. The production process allows to obtain outputs with very different features.

After the production of packaging prototypes, each specimen has been characterized mechanically and physically and all prototypes have shown interesting features that make them usable for packaging but also for the production of structural bearing blocks and non-structural elements (e.g. insulating panels) in the building industry.

### **Results**

The results of preliminary tests have allowed to the Department to present two national and international patent applications both for the material and for the production process of the invention. Both patent applications have had a positive search reports by European Patent Office (EPO).



## Effect of additives on Phosphorus, Copper and Zinc separation in animal raw and digestate slurries

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**Keywords: separation, calcium hydroxide, aluminum sulphate, phosphorus, heavy metals, manure**

### Objectives

Phosphorus (P) is an essential element in agriculture, being one of the nutrient necessary for the proper development of crops. In order to maintain a sustainable local and global environmental balance and for securing a renewable P source, it is necessary to remove and recover P from animal manure. Some concerns are also related to heavy metals contained in manure, especially Copper (Cu) and Zinc (Zn) that, when applied to land, can impair soil and water quality. For these reasons, a suitable technology to remove these elements from slurries can be solid-liquid separation.

However, adequate removal efficiencies can be obtained only with the use of additives.

The objective of this study was to evaluate the effect of two additives on the P, Cu and Zn separation efficiencies using raw slurry and co-digested slurry (before and after a physico-chemical treatment of ammonia stripping).

### Methods

Separation was carried out using two additives,  $\text{Ca}(\text{OH})_2$  and  $\text{Al}_2(\text{SO}_4)_3$  at 6 different doses (from 0 to a maximum value determined with a preliminary test for each slurry). After the addition of the chemicals, slurries were mixed and then separated using a static filter with a mesh of 0.25 mm after 30 minutes of sedimentation.

All tests were conducted in duplicate. Liquid samples were analysed for pH, dry matter content and volatile solids, which were determined using Standard Methods. The contents of P, Cu and Zn were obtained by ICP-MS analysis.

### Results

As expected, the addition of additives can effectively improve separation efficiencies of P, Cu and Zn.

The maximum efficiencies obtained depend on the type of slurry and additive used. For example, the P separation efficiency for raw manure rises from 11% ( $\pm 15\%$ ) without additives to 39% ( $\pm 6\%$ ) with  $\text{Ca}(\text{OH})_2$  and 72% ( $\pm 5\%$ ) with  $\text{Al}_2(\text{SO}_4)_3$ . The results show that the use of  $\text{Al}_2(\text{SO}_4)_3$  increases the P separation efficiency compared to  $\text{Ca}(\text{OH})_2$  for raw slurries and for digestate after stripping, but the removal rate for digestates is similar for the two additives (57-59%).

The high doses of additives requested to raise the separation efficiencies should be carefully evaluated due to the high cost and the potential environmental impact.



## Valorization of Tilia L.'s pruning waste as insulation material

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**Keywords: urban forestry, sustainable construction material, by-product smart use**

### Objectives

This paper is part of a broader research aimed at identifying valorization path for pruning waste of some of the most common tree species in urban greening and forestry.

Urban forestry often suffer for an inadequate maintenance due to economic hardship of Italian public administrations.

The identification of a possible reuse of any by-products resulting from pruning operations, could translate in better care for urban arboreal patrimony, with all the positive fallbacks that this practice would imply in terms of functionality, safety and wellbeing.

### Methods

For this study, we produced different types of tiles based on the residues of pruning of the linden trees obtained in two different periods.

The first sample was generated from the shredding of linden tree's suckers cut at the end of August; the other two samples are obtained through the shredding of the waste of a proper pruning, carried out after the fall of the leaves, to have cleaner samples.

In all cases, the wood fibers were manually mixed with PVA glue and then pressed to obtain a tile. The two samples obtained with the more refined material differ in terms of their density (333 kg/m<sup>3</sup> and 260 kg/m<sup>3</sup>).

Each tile was held four days in the mold, after performing the clamping and the evacuation of all the excess water, and then transferred in the oven with the whole mold, for 48 hours by a temperature of 65 ° C. The measurement of thermal conductivity was performed on all three materials by means of a membrane probe.

Some of the more popular wood fiberboards products on the market were selected as benchmark materials for a first comparison.

### Results

Even though the results are incomplete, since the experimental phase of the research is still in its early stages, the first results look very promising.

The characterization of the first three materials is close enough to the benchmark values to allow foreseeing a possible use in the insulation materials' market for these products.

It could be very useful to test other mixtures of vinyl binder and wood chips and other bio-shredders, with different blades' configurations, in order to optimize the physical attributes of the material that would result in the enhancement of the thermal performances.

Still, the first results suggest that this could be a viable path, one that would open interesting, and crucial, scenarios for urban greening's care and maintenance.



## **ReNuWal: a software tool to improve manure management and nutrient efficiency**

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**Keywords: manure management, decision support system, fertilisation**

### **Objectives**

The use of fertilizers in agriculture, in particular those of livestock origin, is one of the most significant sources of diffuse water pollution. Agricultural sources in the Po basin contribute 53% of the total nitrogen and 23% of the phosphorus on surface waters.

To contribute to the improvement of this situation the project ReNuWal, granted by Fondazione Cariplo aims to i) identify suitable methods to optimize fertilization at farm level and ii) develop innovative techniques for nutrient processing to limit surpluses and the emissions of nutrients, improving the efficiency with which they are used. This paper deals with the software tool developed.

### **Methods**

The approach used for the tool is to compare the characteristics of the manure produced in the farm with the crop requirements, considering also distribution methods used. Thus, it is possible to evaluate if there is the need for additional treatments to reduce the nutrient surplus or to improve the manure efficiency. Furthermore, an assessment of nitrogen losses to air and nitrogen and phosphorus losses to water based on the methods used to manage and spread the manure can be obtained. Thus, the farmer can evaluate possible improvement of nutrient efficiency and reduce fertilisation cost due to mineral fertilisers.

### **Results**

The software tool developed can support the farmer to plan nutrient use on the farm and to assess the effect of different nutrient management strategies on emissions of nutrients to water. The software takes into account crop cultivation techniques adopted and provides guidance on the best strategies for containing nutrient emissions, giving to the farmer an advice on the possible technological alternatives and their relative costs and benefits.

In addition, the software can guide fertilizer management during the year, taking into account the local climate and ongoing nutrient applications. This will allow the farmer to determine the relative risk of releasing nutrients to the environment as a result of particular management activities.



## **Techno-economic performance of small scale biomass CHP: steam vs gas turbines with bottoming ORC**

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**Keywords: CHP, biomass, Cycle Tempo, Steam Turbine, ORC**

### **Objectives**

Small scale Combined Heat and Power (CHP) plants present lower electric efficiency in comparison to large scale ones, and this is particularly valid when biomass fuels are used. In most cases, the use of both heat and electricity to serve on site energy demand is a key to achieve acceptable global energy efficiency and investment profitability. However, the heat demand follows a typical daily and seasonal pattern and it is influenced by climatic conditions. During low heat demand periods, a lot of heat produced by the CHP plant is discharged. In order to increase the electric conversion efficiency of small scale biomass CHP plants, a bottoming ORC system can be coupled to the cycle, however this decreases the temperature and quantity of cogenerated heat available to the load. I

### **Methods**

The paper proposes a thermo-economic analysis of small scale CHP plants based on steam turbine (ST) or externally fired micro gas turbine (EFGT) coupled to different typologies of bottoming Organic Rankine Cycles (ORC). The research assesses the influence of the thermal energy demand and CHP plant operational strategies on the global energy efficiency and profitability of the proposed cogeneration options, taking into account the part load efficiency and the heat to electricity ratio flexibility that could be achieved through a switch on-off of the bottoming ORC. The thermodynamic cycles and their part load efficiency are modeled by Gate-Cycle (Brayton cycles) and Cycle-Tempo (Rankine cycles). The research explores the profitability of bottoming ORC in view of the higher efficiency and electricity generation revenues but higher costs and reduced heat available for cogeneration in the case of bottoming ORC.

### **Results**

The results indicate the optimal CHP technology and configuration for each energy demand segment and the relative key technical and economic factors in the Italian legislative framework.



## Planning the energy valorization of agricultural co-products, by-products and waste in a landscape context

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**Keywords:** renewable energy, rural landscape, agricultural biomass, decomposition process

### Objectives

Big increasing consequences on the global climate connected to the spread of greenhouse gas, led in the last decades the European Union to set very challenging objectives in terms of increase in energy saving and exploitation of renewable energies. Within this central issue, agriculture may play a significant role, mainly if the energy valorization of agricultural by-products, co-products and waste is concerned. Agricultural biomass is a diffuse source of energy, currently considered as having one of the highest potential to cover renewable energy needs for the future, since it could be stored for an optimal use during time. However, it is anyway necessary to previously consider biomass for restoring the level of organic matter in the soil. Litter decomposition governs the soil nutrient levels and the carbon cycle, consequently influencing the physical and chemical properties of the soil, which are the key components to maintain the productivity of agro-ecosystems and the entirety of rural landscapes. The modern concept of landscape is indeed not only limited to the visual perception received by humans, but it considers the results of the interaction among several different ecosystems, *i.e.*, living natural chains connected to the morphological, geological, pedological, hydrological, meteorological, *etc.* characteristics of a certain area.

### Methods

In the present paper, the spatial supply and relationships between renewable energy potentials coming from agricultural co-products, by-products and waste and the rural landscape were analyzed through the implementation of a Geographical Information System over the whole territory of an internal Southern Italian Region, *i.e.*, the Basilicata Region. This Region can be considered as a *benchmarking* case study, since it is characterized by big sources of renewable energy connected to its morphological and environmental structure, as well as to its traditional agricultural and food productions.

### Results

Basing on the quantity of agricultural residues, the energy production in this study area as well as the needs in the nutrient balance of the soil were estimated, allowing to calculate the net availability of energy that could be derived from biomass valorization. The produced maps expressing the values of energy availability show which are the areas most productive in terms of energy obtained through the use of agricultural co-products, by-products and waste, contributing to bridge the gap between energy systems modelling and landscape planning.



## Evaluation of citrus pulp and olive pomace potential availability for biogas production by using a GIS-based model

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**Keywords: Olive pomace; citrus pulp; by-products; anaerobic digestion; biogas-biomethane; GIS; spatial analysis; Sicily.**

### Objectives

Renewable energy sources represent a suitable alternative to conventional fossil fuels, due to the possible advantages in terms of environmental impact reduction. Anaerobic digestion of biomasses is an environmental friendly way to treat and revalorise large amounts of by-products from farming industries because it ensures both pollution control and energy recovery. Therefore, the objective of this study was to evaluate the potential availability of citrus pulp and olive pomace, which are suitable by-products for biogas production, and analyse their spatial distribution in a study area by using a defined and implemented methodology for the computation of spatial indices. The proposed methodology could contribute to build an information base suitable for multi-criteria analysis aimed at finding optimal locations for biogas plants and increasing them in number.

### Methods

In the first phase of the study, the spatial distribution of both olive and citrus-producing areas was analysed in Sicily, a geographical area of the Mediterranean basin highly representative of these types of cultivation. Based on the results obtained for the different provinces of Sicily, Catania province was chosen as the study area of this work since it showed the highest production of both citrus fruits and olives. Then, a GIS-based model, which had been previously defined and utilised to evaluate the amount of citrus pulp and olive pomace production, was applied to this case study to compute the indices suitable to describe the availability of both the considered by-products. In a second phase of this study, the quantification of olive pomace and citrus pulp, which can be available for biogas production, was carried out at the municipal level and a spatial analysis was carried out by using the GIS tool in order to identify the most suitable areas where new biogas plants could be installed.

### Results

The results of this study showed that the total amount of available citrus pulp and olive pomace corresponded theoretically to 11,102,469.68 Nm<sup>3</sup>/year biogas. Since the computation of the indices carried out in this study for the two by-products made it possible to identify the most relevant biomass producing areas in the province of Catania, the results of this research could be used for localising new biogas-biomethane plants which comply with sustainability issues.



## **Management of livestock soils for the sustained production of pastures.**

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**Key words: management system, pastures, organic materials, compost.**

### **Abstract**

Soil quality is an assessment tool that can facilitate the adaptation of management practices that promote sustainable farming systems. In the northern of Las Tunas municipality, a short-term study was established in experimental plots, comparing traditional tillage and non-inverted tillage of the prism, with and without compost application. In both tillage systems, the development of the crop *Pennisetum purpureum* 'CT-115' and soil quality indicators was evaluated. The results showed that the non-inverted tillage system favors a better soil physical quality, maintaining the carbon content and increasing the yield of *P. purpureum*. Traditional tillage, based on plowing and harrowing, reduces the content of organic matter in short term and maintains compact layers in the underlying horizon, also influences unfavorably the flow of air, water and the radical development of the pastures. The tillage system without inversion of the prism led to increases in yields and with the application of compost, better productive results were obtained in both tillage systems. This would justify the implementation of conservation management technologies and the application of organic materials that restore the nutritional elements of the soil for the cultivation of pastures.



## Process for recovery of proteins and phosphorus from manures

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**Key words: Animal Waste, Nutrient recovery, Swine manure, Protein recovery, Phosphate, By-product smart use**

### Objectives

The recovery of phosphorus and proteins from manure could be advantageous to both offset costs and to improve and lessen the environmental impacts of manure storage and treatment. Phosphorous in manure can contaminate rivers, lakes, and bays through runoff, if applied onto a cropland excessively. Thus, recovering phosphorous from manure can not only help reduce such runoffs, but also reduces the use of commercial fertilizer based on phosphate rock. The phosphorus mine has limited reserves and cannot be replaced by other means as fertilizer. Protein is a natural resource used in a wide range of commercial applications from pharmaceuticals to dietary supplements, foods, feeds, and industrial applications.

### Methods

A new method for simultaneous extraction of proteins and phosphorus from biological materials has been developed and is presented. The experiments used swine manure solids fraction after solids-liquid separation. From raw manure, wet solids are dissolved in acidic solution and then treated with a basic solution so phosphorus will precipitate and be reclaimed. The proteins in the washed solids can be extracted and concentrated with ultrafiltration and flocculation.

### Results

On a dry-weight basis, it was found that the separated manure solids contained 15.2-17.4% proteins and 3.0% phosphorus. Quantitative extraction of phosphorus and proteins from manures was possible with this new system. The phosphorus was first separated from the solids in a soluble extract, then the proteins were separated from the solids and solubilized with an alkali solvent. Both phosphorus and protein recovery were enhanced about 19 and 22% with the inclusion of a rinse after the washing. The recovered phosphorus solids had 20.4% phosphates (P<sub>2</sub>O<sub>5</sub>). The protein extract was concentrated using ultrafiltration (UF) and lyophilization to obtain a protein solids concentrate. UF of 5 and 10 kDa captured all the proteins, but 30 kDa resulted in 22% loss. The protein solids were converted into amino-acids using acid hydrolysis. Further, the system was proved effective to extract phosphorus and proteins from other biological materials, such as algae or crops. The recovered proteins could be used for production of amino acids and the recovered phosphorus could be used as a recycled material that replaces commercial phosphate fertilizers. This could be a potential new revenue stream from wastes.



## Efficient Solar Energy Systems for Water Treatment

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**Keywords: solar thermal collectors, photovoltaics, photovoltaic/thermal collectors, water treatment, desalination, disinfection**

### Abstract

Water desalination, water purification, water disinfection and wastewater treatment, demand energy and thus, the water treatment processes are close directly to the availability of energy sources. Solar Energy, as well as the other Renewable Energy Sources, is considered to be the alternative to hydrocarbons in the 21st century and be used for the production of potable water and water treatment processes. Solar Energy Laboratory at the University of Patras has developed a number of solar energy systems, as thermal collectors, photovoltaics and hybrid photovoltaic/thermal (PV/T) systems, which can be used to water treatment processes. In this work, we present the main solar energy systems, which have been studied for practical application to water treatment processes. Regarding water desalination, there have been developed two solar energy devices to be adapted with reverse osmosis system. The one system is consisted of flat plate collectors, combined with booster reflectors, which contribute to the achievement of higher temperature and higher thermal output. The second device is the hybrid PV/T collector, which can provide simultaneously electricity and heat, to adapt effectively the desalination process. For the treatment of industrial and agricultural wastes, we have developed a photocatalytic device based on a concentrating solar collector, which uses effectively the UV solar radiation. Finally, for the drying of sludge we designed a low cost solar thermal collector and also a low cost hybrid PV/T collector, while for the water disinfection, we studied a low concentration solar thermal collector. The above solar energy devices were designed according practical principles and in the paper we present their design and laboratory results.



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## **TOPIC 4**

### ***CHALLENGES IN WATER AND SOIL CONSERVATION AND MANAGEMENT***



Effects of pruning and weed residues maintenance on soil hydrological properties <i>Bombino G., Denisi P., Gomez J.A., Tamburino V., Zema D.A.</i> .....	89
Effect of irrigation and foliar application of calcium nitrate and boric acid on fruit cracking of Thompson navel orange <i>Chalavi V., Javid Jafarian Deev Kolae, Raeini-Sarjaz M., Hossin Sadeghi</i> .....	90
Effects of shading and irrigation cycles on yield, quality and water use efficiency of bell pepper <i>Chalavi V., Asadi Kh., Raeini M.</i> .....	91
Probabilistic forecasting of irrigation requirements by combining Earth Observation data and a limited area ensemble prediction system <i>Chirico G.B., D'Urso G., Pelosi A., De Michele C.</i> .....	92
Earth Observation for non-authorized irrigation detection: the case study of Consorzio Sannio Alifano (Italy) <i>De Michele C., Natalizio M., Falanga Bolognesi S., D'Urso G.</i> .....	93
Hydraulic modeling for the management of irrigation canals: application to the Canale Emiliano Romagnolo (CER) <i>Luppi M., Ciriello V., Battilani A., Villani G., Taglioli G., Di Federico V., Toscano A.</i> .....	94
Constructed wetland for treatment and reuse for irrigation of winery wastewater <i>Milani M., Marzo A., Cirelli G.L., Consoli S., Barbagallo S.</i> .....	95
Improvement of citrus water productivity using partial root zone drying irrigation along with shading nets <i>Raeini-Sarjaz M., Ebadi H., Gholami Sefidkouhi M.A.</i> .....	96
Sugar beet production using partial root zone drying irrigation as a management tool to combat water shortage in a sub-humid region <i>Raeini-Sarjaz M., Mardanian N.</i> .....	97
Towards understanding links between rural landuse changes and local hydrological response <i>Sofia G., CAO W., Tarolli P.</i> .....	98
Analysis of current performance in water delivery systems of Calabria (Southern Italy) <i>Zema D. A., Còrcoles J. I., Nicotra A., Zimbone S. M.</i> .....	99
In situ determination of the lateral soil hydraulic conductivity: Set-up of an infiltration test on a soil monolith <i>Di Prima S., Marrosu R., Pirastru M., Bagarello V., Iovino M., Niedda M.</i> .....	100
Performance of a gravity-fed automated system for bay irrigation <i>Masseroni D., Lasagna A., Carnevale P., Reece T., Gandolfi C.</i> .....	101
Performances of geotextiles in reducing soil erosion: field studies with natural rainfall <i>Petroselli A., Cornelini P., Tauro F., Ciorba P., Cipollari G., Rapiti R., Grimaldi S.</i> .....	102



Agricultural water scarcity assessment in northern Italy by means of the Transpiration Deficit Index (TDI) <i>Borghetti A., Rienzner M., Gandolfi C., Facchi A.</i> .....	103
Role of topographic gradient on water use performance in a paddy area <i>Facchi A., Rienzner M., Cesari de Maria S., Mayer A., Chiaradia E.A., Masseroni D., Buarnè F., Silvestri S., Romani M.</i> .....	104
Wastewater reuse in agriculture: Technical and economic feasibility for Puglia, Southern Italy <i>Giannoccaro G., Arborea S., De Gennaro B. C., Iacobellis V., Balacco G., Piccinni F.A.</i> .....	105
Historical review on Rainwater Harvesting in Jordan <i>Khazal K., Laurita B., Castelli G., Bresci E.</i> .....	106
Integrated use of Landsat images, GIS and AnnAGNPS modeling to estimate the impact of land use changes on runoff and sediment load <i>Romano G., Abdelwahab O.M.M., Gentile F.</i> .....	107
Effect of surface characteristics of soil surface on interrill soil erosion Dynamics <i>Todisco F., Vergni L., Vinci A., Torri D., Mannocchi F.</i> .....	108
Irrigation Water Requirements of "Sinistra Ofanto" district from open satellite data and meteorological data <i>Peschechera G., Caradonna G., Novelli A., Pagano A. Fratino U.</i> .....	109
A model for assessing salinity in root zone by data assimilation in a nectarine orchard irrigated with reclaimed wastewater <i>Berardi M., Vivaldi G. A., Camposeo S., Pedrero Salcedo F., Vurro M.</i> .....	110
Assessing groundwater use in irrigation districts with multiple resources through the MIGRAD model <i>Zingaro D., Portoghese I., Pagano A., Giordano R., Vurro M.</i> .....	111
Water, carbon and heat fluxes from a mountain meadow to the atmosphere. <i>Ferraris S., Canone D., Previati M. Bevilacqua I., Raffelli G., Gisolo D.</i> .....	112
Testing a single USLE-MM model to predict high soil losses in central and south Italy <i>Bagarello V., Ferro V., Giordano G., Mannocchi F., Pampalone V., Porto P., Todisco F., Vergni L.</i> .....	113
Impact of reforestations with exotic and native species on water repellency of forest soils <i>Alagna V., Bagarello V., Giordano G., Iovino M.</i> .....	114
Best management practices as an alternative for flood and urban storm water control in a changing climate: An analysis in a peri urban area in the metropolitan city of Rome (Italy). <i>Recanatesi F., Ripa M.N., Giuliani C., Rossi C. M., Pelorosso R., Gobattoni F., Leone A.</i> .....	115
Satellite remote sensing as a tool for diachronic analysis and mapping of soil sealing: the peri-urban area of Rome and Perugia <i>Giuliani C., Recanatesi F., Vizzari M.</i> .....	116



Sugarcane straw effect evaluation on sustainability soil parameters  
*Veloso M. P. V., Fracaroli J. A.*..... 117



## Effects of pruning and weed residues maintenance on soil hydrological properties

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**Keywords:** Soil conservation, runoff, organic matter, water infiltration, vegetal coverage.

### Objectives

Biomass maintenance over no-tilled soils plays positive effects on hydrological responses and land conservation. Maintaining a proper soil coverage of pruning residues and weeds provides a higher soil infiltration rate so reducing peak runoff and water erosion. Hilly areas of the Mediterranean region, often subject to heavy and intense rainfalls, are particularly prone to high runoff and soil losses by erosion. In this context, the identification of soil management practices minimizing negative hydrological impacts could help to reduce land degradation risk, maintaining an appropriate water balance for the crop.

### Methods

This study analyses the hydrological effects of the following soil management practices in olive groves of Southern Calabria (Italy): i) mechanical tilling operations (2-3 times per year) (thesis A); ii) standard protection by a plastic net (thesis B); iii) coverage by 350 g m<sup>-2</sup> coarse residues from pruning chopping (thesis C); iv) coverage by additional coarse residues from pruning chopping (5-fold dense) (thesis D). For each thesis runoff volumes after natural and simulated rainfall were measured. Soil properties were characterised, measuring the infiltration rate (by double ring infiltrometer) on both undisturbed soil and after heavy rains (50 mm/h); moreover organic matter content (OMC) and vegetation coverage were measured.

### Results

In the upper horizons (up to 10 cm), OMC was noticeably higher in the plots with biomass addition (theses C and D) - also thanks to the greater vegetal coverage - and slightly lower in those with bare soil and standard coverage. The vegetation coverage was highest in the C thesis and low in the thesis with mechanical tilling operations (thesis A), as well as in the thesis D, where the coarse residue in the top soil, reduce the vegetation growth.

Mechanical tilling (thesis A) produced the highest runoff, presumably because the bare soil (characterized by large silt fraction) was sealed by raindrop impacts. In covered plots runoff strongly decreased, also after heavy rainfall, thanks to the protective effect of the net (thesis B) and the residues (thesis C). Undisturbed soil (not subject to rainfall) showed an infiltration rate of 60 mm/h. Simulation of heavy rainfalls produced the highest infiltration rate in the theses B, C and D, whereas infiltration noticeably decreased in the thesis A, presumably due to the soil surface sealing.

These results confirm the improvement of the hydrological response to heavy rainfall, played by the maintenance of coarse weeds and pruning residues on the soil surface. In the other hand, maintaining a vegetal coverage, enhances organic carbon storage (which otherwise would be quickly degraded with tillage operations) with consequent reduction of carbon dioxide emission into atmosphere compared to tillage. This cultivation model with low hydrological impact, thanks to its economical sustainability, (which could be subsidized and implemented on large scale) results in a viable alternative to the soil management based on traditional operations helping to mitigate the risk of land degradation and peak flow reduction, especially in the hilly areas.



## Effect of irrigation and foliar application of calcium nitrate and boric acid on fruit cracking of Thompson navel orange

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**Keywords: Calcium nitrate, Boric acid, Irrigation, Thomson navel orange,**

### Objectives

Water stress and some nutrient deficiencies cause fruit peel cracking of Thompson navel orange (*Citrus chinensis* L.) and reduce its marketability. Fruit cracking is an abiotic disorder which occurs in some fruits and is prevalent in some citrus varieties. Thomson navel orange is one of the most sensitive fruit to cracking. In present study, the effects of irrigation amount and foliar application of calcium nitrate and boric acid were investigated on fruit cracking of Thompson navel orange.

### Methods

The experiment was conducted based on factorial randomized complete block design with three irrigation levels of full irrigation (FI), which trees received 100 percent of depleted soil water, and two deficit irrigation managements of (DI50 and DI75, which orange trees received 50 and 75 percent water relative to FI, in combination with four foliar spraying treatments of calcium nitrate (C), boric acid (B), calcium nitrate + boric acid (CB) and control (water) (W) with 4 replications of 3 trees in each experimental unit. At the end of experiment, traits such as percentage of fruit cracking, leaf and fruit calcium content, titratable acidity (TA), total soluble solids (TSS), and flavor index (the ratio of TSS to TA), fruit volume, fruit firmness, fruit weight with and without peel, and yield fruit were measured. Data were analyzed using SAS software and SNK post-hoc test was employed to compare treatments means.

### Results

According to obtain findings, the effect of irrigation on percentage of fruit cracking was statistically significant ( $p \leq 0.01$ ) and the highest fruit cracking (8.4%) occurred in 50% irrigation treatment (DI50). Irrigation factor was not significant for other traits. Foliar application significantly affected most of the measured traits. Fruit cracking percentage was reduced significantly in calcium nitrate (C) treatment and in calcium nitrate in combination with boric acid (CB) treatment, Leaf and fruit calcium contents significantly increased by 2.5% and 0.61%, respectively, by calcium nitrate treatment (C) and by 2.46% and 0.64% by calcium nitrate + boric acid treatments, respectively. Likewise, yield significantly increased in calcium nitrate treatment. In conclusion, several foliar applications of calcium nitrate in two week intervals after fruit formation in mid June and also having irrigation at 75% to 100% levels was effective in reducing Thomson navel orange fruit cracking.



## Effects of shading and irrigation cycles on yield, quality and water use efficiency of bell pepper

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**Keywords: Shading, Irrigation cycle, Bell pepper, Sub-humid climate**

### Objectives

Bell pepper (*Capsicum annum* L.) is a hot season crop and sensitive to high light intensity and drought. Shading could prevent light stress and increase water use efficiency, which is important for water conservation and management in hot and sub-humid climate, such as Sari region in Iran. Present study was conducted to investigate the effect of shading and irrigation cycle on yield, some quality characteristics and water use efficiency of bell pepper cv. California Wonder fruits.

### Methods

This study was a factorial based on completely randomized design experiment with three levels of 0, 30% and 50% shading, in combination with three irrigation cycles, every 2, 3 or 4 day intervals watering up to field capacity. At the end of experiment, crop characteristics such as yield, plant water use, soluble solid, water use efficiency, leaf area, leaf relative water content (rwc), fresh and dry weight (root, shoot and leaf), vitamin C content, leaf chlorophyll, fruit chlorophyll, antioxidant capacity, anthocyanin, were evaluated. Data were analysed using SAS software and SNK post-hoc test was used to compare treatment means.

### Results

The highest yield (762.9 g plant<sup>-1</sup>) obtained in 30% shading treatment. At this level of shading, 30%, bell pepper plants were protected from negative effects of high light intensity, while enough light was provided for their growth and development. As expected, the highest water use per plant happened in open air treatment which at the same time was favorite for highest soluble solid (4.9%) production. On the other hand, at the lower light intensity or 50% shading treatment, the highest total fruit anthocyanin (0.02 mg per 100 fresh weight) and fruit vitamin C (87.75 mg per 100 g fresh weight) were produced.

Obtained yield for every 2 and 3-day intervals watering cycles were 748.78 and 743.1 g plant<sup>-1</sup>, respectively, which were significantly different with that of 4-day irrigation cycle. Since every 2 and 3-day watering intervals did not differ statistically, the every 3 days irrigation cycle could be beneficial for water conservation. The highest amount of fruit antioxidant capacity (8.4%) was obtained in 4-day watering interval. The highest water use and water use efficiency were observed in every 2 and 3-days irrigation cycles, respectively. Therefore, according to presented results, providing 30% shading reduced the negative effects of heat stress and increased yield of bell pepper fruit crop and the every 3 days irrigation cycle improved water use efficiency in hot and sub-humid condition of Sari region in Iran.



## Probabilistic forecasting of irrigation requirements by combining Earth Observation data and a limited area ensemble prediction system

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**Keywords: evapotranspiration, numerical weather prediction, irrigation management, Earth Observation.**

### Objectives

Forecast performance of numerical weather prediction (NWP) models has considerably improved in the 21st century, making their output a valuable source for estimating evapotranspiration maps, alternative to the spatial interpolation of spatially coarse ground based weather datasets, often inaccurate, or in areas where ground-based stations are not available. In the last two decades, Ensemble Prediction Systems (EPS) have become increasingly popular in operational decision-making processes. In EPS the NWP model is run several times from very slightly different initial conditions and perturbed model parameters, to produce an ensemble of forecasts that are used to account for uncertainty in initial atmospheric conditions and NWP model errors. This study aims at evaluating the performance of probabilistic forecasts of the crop irrigation water requirements (CIWR), based on the combination of: i) a limited area ensemble prediction systems (LEPS) for forecasting the relevant climatic variables; ii) Earth Observation data to determine surface albedo and Leaf Area Index.

### Methods

The NWP outputs are those given by COSMO-LEPS (ARPA-SIMC, Bologna, Italy). COSMO-LEPS is based on 16 integrations of the non-hydrostatic mesoscale model COSMO, and it runs twice a day, at 00:00 UTC and 12:00 UTC. The model has a forecast range of 132 hours, with data available at 3-hours intervals, and a spatial resolution of 7.5 km. Maps of canopy development (leaf area index, albedo and soil cover) are derived from VIS-NIR high-resolution (30 m) multispectral Landsat satellite images, delivered in near real time (24 hours). Indirect LAI estimates are derived from the analysis of the surface reflectance.

### Results

The procedure has been evaluated by computing CIWR either from daily data from 18 ground stations either from corresponding values of COSMO-LEPS grid for the Campania Region. Forecasts performances were assessed with both deterministic indices and probabilistic metrics, such as the Brier skill score, reliability diagrams and relative operating characteristic. CIWR forecasts were robust and reliable, with slight sensitivity to the forecast lead time.



## **Earth Observation for non-authorised irrigation detection: the case study of Consorzio Sannio Alifano (Italy)**

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**Keywords: non-authorised irrigation, irrigation management, Earth Observation.**

### **Objectives**

Unauthorized irrigation and over-consumption can have social consequences in terms of conflicting water use as well as reducing water availability in the Planet. The EU Water Framework Directive has outlined the future EU agenda on water policy and determined that this practice should be strongly opposed to ensure a sustainable use of water resources. In order to address this problem efficiently, water managers need to map irrigated area, plan a rational use of water resources under limited availability, and prevent the unauthorized irrigations. It has been demonstrated repeatedly that the Earth Observation techniques are an effective tool for mapping irrigated areas worldwide and at different spatial scales (global, regional, local). Our current work has shown an innovative system based on Earth Observation data for mapping irrigated areas in semi-arid environment.

### **Methods**

The methodology has been preliminary tested in 2013 by using multispectral data from the orbiting platforms DEIMOS-1 and RapidEye, with spatial resolution of 22 and 6.5 meters respectively. The procedure has been repeated during the irrigation season 2016 by using data from the platform Sentinel-2 of the European Space Agency. The procedure is based on a two-step classification, firstly unsupervised and successively supervised, where each spectral class is identified on the basis of the mean and standard deviation values of vegetation indexes NDVI and NDWI (the second one only for Sentinel-2 data). Classes corresponding to irrigated areas are labelled by analysing the temporal pattern in relation to the different canopy development between irrigated and not irrigated crops.

The methodology described above was applied to map the irrigated area of a part of the overall district served by Consorzio Sannio Alifano, located in Southern Italy, encompassing a surface of about 5,000 hectares and named Valle Telesina. The study area is characterized by agriculture irrigation in the period from May to September, with main crops grown corn, alfalfa, fruit trees and vegetables. The average size of each plot is about 2 hectares.

### **Results**

The overall accuracy of the procedure resulted equal to 82%; this evaluation has been conducted on the basis of the results of the analysis carried out in 2013 with an independent field survey.



## Hydraulic modeling for the management of irrigation canals: application to the Canale Emiliano Romagnolo (CER)

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**Keywords: Irrigation canal, hydraulic modeling, water management**

### Objectives

The study is finalised to the implementation of a model simulating the water flow into the greater irrigation canal of the Emilia-Romagna Region: the Canale Emiliano Romagnolo (CER). The final goal is to implement a modeling tool for the optimisation of water resources management, as increasingly needed to comply with the European and National directives. In particular, the simulation of hydraulic flow of CER, never implemented till now, requires specific studies and a wide data collection to adapt a well-known and quite simple simulation model (i.e., HEC-RAS) to the very complex operational and geometric configuration of the case-study, without direct flow rate measurements.

### Methods

The CER is a major hydraulic infrastructure that ensures water supply for the irrigation of about 3,000 km<sup>2</sup> of cultivated land. The canal is in concrete, with a total length of 133 km and a flow rate ranging from 6 to 60 m<sup>3</sup>/s. The CER can be represented as a one-dimensional system made of a sequence of pseudo-independent segments, without water entries from surface runoff or water discharges, and with several water withdrawals to supply about 5 irrigation Consortia. The present application concerns the calibration and validation of the hydraulic model on a pilot segment 7 km long, characterised by 3 culverts and 6 water withdrawals for the irrigation of about 3,000 hectares. The hydraulic simulations have been developed with the code HEC-RAS under steady state conditions. The following data have been collected: meteo-climatic information, types of crops, soil textures, irrigated surfaces, geometric and hydraulic features of the canal (i.e., size, dimensions, roughness, water levels, water withdrawn volumes). The actual agricultural water needs of each irrigation district have been also calculated by a water balance method using the Irriframe tool ([www.irriframe.it](http://www.irriframe.it)). All the collected and calculated information have been reported on 10-day data series, over a 4-years period, to run the model.

### Results

Results demonstrate that the integration of information at different levels may be incorporated into a model that is suitable for improving the irrigation management, with a focus on the relationship between the flow along the canal and the water withdrawals. The first simulations show satisfactory results since the observed vs. simulated water levels into the canal achieved RMSE values ranging from 0.01 m to 0.23 m, highlighting a good adaptability of the model to the case-study.



## Constructed wetland for treatment and reuse for irrigation of winery wastewater

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**Keywords:** multistage constructed wetland, winery wastewater, wastewater reuse

### Objectives

The aim of this paper was to identify the reliability of constructed wetland (CW) systems to treat winery wastewater for irrigation reuse purposes. In particular, the performance of a multistage CW systems, located in South Est Sicily (Italy) was presented and discussed.

### Methods

The research activity was carried out in a multistage pilot-scale CW, treating part of winery wastewater produced by the Marabino farm (i.e. production capacity of about 1,500 hL wine year<sup>-1</sup>) in South East Sicily. At the farm, winery wastewater is treated by a Imhoff tank and effluents are generally disposed on the soil by a sub-irrigation system. From October 2013, the treatment system was integrated with a preliminary treatment, which consists in a coarse screening, and about 3 m<sup>3</sup> day<sup>-1</sup> of Imhoff effluent were then diverted into a equalization tank (5 m<sup>3</sup>) and treated with a multistage CW. The CW has a total surface area of about 230 m<sup>2</sup> and is made of a vertical subsurface flow (VF) bed, followed by a horizontal subsurface flow (HF) bed and then by a free water (FW) system. The end of the FW section operates as a subsurface flow and it was vegetated with *Iris pseudacorus*. The CW system was planted with *Phragmites australis* (HF), *Cyperus Papyrus var. Siculus* and *Canna indica* (VF), *Nymphaea alba* and *Scirpus lacustris* (FW). The CW effluent is reused for irrigation of a green area close to the experimental plant. From March 2014, wastewater quality samples were collected, with a monthly frequency, at the inlet and outlet of each stage of the treatment system and chemical-physical and microbiological characteristics of wastewater were analysed. CW efficiency was evaluated both in terms of water quality improvement (removal percentage) and achievement of the Italian wastewater discharge and irrigation reuse limits.

### Results

The multistage pilot-scale CW exhibited a strong buffer capacity, that was able to mitigate the wide fluctuations of influent quality characteristics. For TSS, COD and BOD<sub>5</sub> concentrations, the CW system had a mean removal efficiencies of about 70%, 74% and 79%, respectively. The experimental plant, during the monitoring period, has shown an effluent average quality compatible with the limits required by the Italian law for wastewater discharge in water bodies and for wastewater reuse. The irrigation reuse of winery wastewater, treated with natural systems, may represent a valid option for wastewater disposal by farmers.



## Improvement of citrus water productivity using partial root zone drying irrigation along with shading nets

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**Keywords:** Citrus, shading nets, PRD, Iran

### Objectives

Climate change and ever-increasing water use, along with water scarcity, reduces crop production. Thus, efficient water management, such as deficit irrigation and shading could resolve some of these shortcomings. In deficit irrigation with partial root zone drying (PRD), half of the root zone is irrigated and the other half is left unirrigated. Therefore, it could benefit crop water use efficiency. Meanwhile in orchards during dry and warm weather conditions high irradiance might be load an extra stress on trees and increase transpiration. Shading screens could help to reduce irradiance loads. Therefore, the aims of this research are to evaluate the effects of PRD along with shading screens on yield, water use efficiency and stomatal conductance of citrus trees in a humid area with hot and relatively dry air during summer time.

### Methods

The experiment was conducted in the Citrus and Subtropical Fruits Research Center of Ramsar, close to Caspian Sea, IRAN. The following treatments were employed on citrus trees (*Citrus chinensis* L), cultivar Valencia, (1) full irrigation, which trees received 100 percent of soil field capacity (FC), 2) two PRD treatments, which trees receiving 50 (PRD50) and 75% (PRD75) of FI, and 3) two PRD treatments, such as above which trees were treated with shading nets as well (SHPRD50 and SHPRD75). Tukey post-hoc test was used to compare treatment's means of stomatal conductance ( $g_s$ ), leaf relative water content (rwc), stem water potential ( $\Psi_{st}$ ), and leaf temperature ( $T_l$ ). Moreover, Regression analysis was done between the above factors and leaf to air vapor pressure difference.

### Results

The results show that  $g_s$  and rwc were higher in FI, PRD75 and SHPRD75 relative to stressed treatments of PRD50 and SHPRD50. The same trend was registered for  $\Psi_{st}$ , and the lowest values were achieved by treatments receiving 50% water of FI. Leaf temperatures in some measurement intervals were significantly higher in stressed treatments of PRD50 and SHPRD50. Water deficiency significantly reduced yield in stressed treatments of PRD50, while reversely affected fruit soluble solids in PRD50 and PRD75. Shading on PRD treatments increased fruit size and yield, although this improvement was significant only for fruit diameter of SHPRD75 in comparison with PRD50. In conclusion, mild PRD along with shading screen could improve citrus yield and water consumption during hot summers of Northern Iran.



## **Sugar beet production using partial root zone drying irrigation as a management tool to combat water shortage in a sub-humid region**

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**Keywords: water scarcity, PRD, WUE, Iran**

### **Objectives**

Water scarcity nowadays is becoming one of the common features of arid and semi-arid regions of the world, due to population growth, water allocations, low water productivity, climate change, and water mismanagements. Therefore, the aim of this paper is to employ a recently developed water management procedure, partial root zone drying irrigation system (PRD), to increase crop water-use efficiency (WUE).

### **Methods**

Sugar beet (*Beta vulgaris* L.), Toucan cultivar, was grown in 2014 summer growing season in a loam soil at the Agricultural Research Station of Shahr-e-Kord, a temperate semi-humid region with cold winters and dry summers, with 319 mm annual precipitation. The experiment was conducted in a complete block design using five water treatments of (1) full irrigation (FI), as control, where plants received 100 percent of soil water field capacity (FC), (2) two conventional deficit irrigations with 60 (DI60) and 80 (DI80) percent water relative to FI, where water was applied to whole root system, and (3) two PRD treatments of fixed PRD (FPRD), where plants received their corresponding water in one side, and an alternate PRD (APRD), where one side of root system was irrigated and irrigation was switched to the dry part at the next irrigation schedule. Plants were irrigated using a drip irrigation system and water volumes were established using a time domain reflectometer (TDR). Data were analyzed using SAS software and SNK post-hoc test was employed to compare treatment means.

### **Results**

The percentage of saved water during whole sugar beet growth and development period relative to FI were 18, 44, 33 and 45 percent for DI80, DI60, APRD and FPRD, respectively. Soil water content significantly ( $p \leq 0.05$ ) affected root yield, sugar content, sugar yield, and root and sugar yield water use efficiencies ( $WUE_{ry}$  and  $WUE_{sy}$ ). Soil water content also significantly ( $p \leq 0.05$ ) affected proline contents, and vegetative factors, such as root length and diameter, and leaf relative water content (rwc). In conclusion, although full irrigation provided 15 and 20 percent more root and sugar yields, respectively, relative to alternate PRD, the latter consumed 33 percent less water and had higher water-use efficiency. Therefore, in regions with water scarcity PRD could be recommended as an appropriate water management tool to combat water shortage and increase water productivity.



## **Towards understanding links between rural landuse changes and local hydrological response**

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**Keywords: Hydrological response, Agriculture, Land use changes, Drainage network, Rainfall, Infiltration**

### **Objectives**

Agriculture controls through irrigation and reclamation networks more water than any other activity on this planet. Over the past century, significant changes in agricultural practices have occurred, driven by local or European policies, and changes in the local economy. As a result, many drainage networks have changed, and there is substantial evidence that these changes can create impacts on the environment, producing a greater exposure to flooding. Such impact has a broad range of implications for society, also because of climate inputs coupling with these human drivers. Despite this, there are very few studies in which evidence has been sought to understand how does the influence on the watershed response to agricultural changes depends on the rainfall event characteristics and soil conditions, and what is their related significance. This work presents an analysis of farmland changes observed in the most recent years (~30 years) in a study area in Veneto (Northeastern Italy).

### **Methods**

The investigation considers water infiltration based on soil properties, and it analyses the changes in the distributed water storage offered by the agricultural drainage system. More in detail, the research considers the variability of network response caused by variations in the storm duration and rainfall distribution over time, for a given network system, and for a given soil condition (i.e., dry to completely saturated).

### **Results**

Evidences show that economic drivers control the development of agro-industrial landscapes, with effects on the hydrological response. When comparing the past to the present, key elements that can enhance or reduce differences in the network response are the antecedent soil conditions and the climate characteristics. Based on the case presented in this article, intense and irregular rainfall events present the higher criticality, especially for frequent storms. These results highlight the importance of agricultural practices as drivers of or mitigations for flooding, through the adoption of improved land management practices. The presented analysis can be a valuable tool to evaluate the costs and benefits of surface-water management, also to inform better the local population and decision-makers.



## **Analysis of current performance in water delivery systems of Calabria (Southern Italy)**

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**Keywords: water delivery system; performance indicators; collective irrigation.**

### **Objectives**

Water delivery systems of collective irrigation services in Southern Italy suffer from poor performance and low user satisfaction, rarely evaluated by a quantitative approach. To fill this gap, this study has evaluated water delivery performances in three irrigation systems ("Angitola 3DMF", "Angitola 6DMF" and "Savuto", Water Users Association "Tirreno Catanzarese") of Calabria (Southern Italy). Moreover, two new indicators ("User Satisfaction Index" and "Water Exploitation Index") have been proposed to analyze the user satisfaction and the efficiency water use.

### **Methods**

Irrigation water delivered to users were measured and recorded by the automated system "Acquacard®" throughout four irrigation seasons. Net irrigation requirement of each crop (olives, citrus and other fruits, vegetables, gardens, forage, and maize, irrigated by sprinkler farm systems) was computed using the software CROPWAT 8.0. For the investigated farms, the adequacy, efficiency, dependability and equity of water delivery was evaluated through the indicators proposed by Molden and Gates (1990) for each crop and at the monthly scale.

### **Results**

Referring to service adequacy and efficiency, the results of this investigation indicated that the delivered water was much lower than the monthly irrigation requirement for almost all the irrigated crops. Conversely, irrigation water was used efficiently without significant waste. The analysis of the spatial (equity) and temporal (dependability) uniformity of the water delivery service indicated that the water was never delivered when required (that is, when indicated by the water balance of crops), while the systems assured a delivery of fair volumes among users (with few exceptions). The user satisfaction towards the collective irrigation service was low and the water exploitation level in using the available water resource was acceptable, as shown by the new synthetic indicators (User Satisfaction and Water Exploitation Indices) developed and applied in this study. This study contributes to the diffusion of diagnostic tools of the collective irrigation service in the agricultural sector of Southern Italy and, more generally, in the Mediterranean basin, in order to promote a more productive and efficient use of water resources and a sustainable irrigated agriculture.

### **Reference**

Molden, D.J., Gates, T.K., 1990. Performance measures for evaluation of irrigation water delivery systems. *J. Irrig. Drain. Eng. ASCE* 116(6), 804-823.



## **In situ determination of the lateral soil hydraulic conductivity: Set-up of an infiltration test on a soil monolith**

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**Keywords: Subsurface flow, Macropore flow, Soil block, Lateral saturated soil hydraulic conductivity**

Lateral saturated soil hydraulic conductivity,  $K_{s,l}$ , is a key parameter for understanding the hydrological processes and simulating soil water movement both at the hillslope and catchment scales. Although several laboratory and field methods have been developed over time to measure hydraulic conductivity of saturated soil,  $K_{s,l}$  determinations representative at a large scale are difficult to obtain because of anisotropy and high spatial and temporal variability that this soil property exhibits.

In this research, the set-up of an in situ infiltration test on a soil monolith 50 cm wide by 68 cm long by 34.5 cm deep (the depth to the substratum) is presented. By this method, a soil monolith is carved out by removing the soil along its sides. Once the monolith has the prescribed size, the exposed faces are hydraulically isolated by an appropriate encasing material. Using expandable polyurethane foam to backfill the trench was found to be appropriate to prevent edge flow. This material is advantageous compared to the originally used materials, namely bentonite and still plates, which are difficult to transport especially in sloping and impervious areas such as those commonly considered in this type of investigations. Furthermore, their right placement is often cumbersome.

The method allows to measure  $K_{s,l}$  on a large soil volume in order to mediate the soil heterogeneity effects. In addition, it causes little disturbance of the soil structure, which principally controls the saturated subsurface flow. Therefore, the proposed setup is suitable to routinely characterize subsurface flow and to obtain representative  $K_{s,l}$  values at the scale of hydrological interest.



## Performance of a gravity-fed automated system for bay irrigation

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**Keywords: Gravity-fed surface irrigation systems; rice field irrigation management; automatic and remote controlled gate.**

### Objectives

In Italy about 70% of water resources for irrigation are used in Lombardy and Piedmont regions. In these agricultural contexts surface irrigations methods (mainly border and basin irrigation) account for about 85% of irrigated areas. Generally, the regulation of flows in the open-canals network, from the water sources down to the individual fields is managed by manually opening and closing gates and sluices in order to guarantee deliveries according to the actual water requirements. This operational practice is generally characterised by low water use efficiencies and a high levels of labour requirements for maintaining the correct distribution of water. Therefore, it is evident that there is a need for automated and remote controlled irrigation management systems aimed to improve the flexibility and efficiency of the irrigation procedures, reducing the management costs. The aim of this study is to evaluate the performances of an automated system for the control of the irrigation supply to rice fields under flood irrigation.

### Methods

In this study, a commercial system for the automation of the control of the water supply to rice fields under flood irrigation is described and tested during the irrigation season 2016. The system combines an automatic gate (BayDrive<sup>R</sup> by Rubicon Water AU) with a real-time optimization routine aimed to maintain a constant level of water in the field according to the best agronomic practices for rice cultivation. A FloodTech<sup>R</sup> (Rubicon Water, AU) ultrasonic water level sensor to measure the water level in the field was located in a chamber installed below the ground surface level. Data from the water level sensor are used to trigger the gate to open or close, according to the requirements. Irrigation scheduling was established *via* web-interface (FarmConnect<sup>R</sup> Gateway by Rubicon Water, AU) and left to run with no need for on-site user interaction. System performances were evaluated calculating the main irrigation efficiency indexes (such as application and distribution uniformity efficiency) as well as analysing the ability of the system to maintain the correct level of water in the field according the farmer planning.

### Results

The results from the evaluations demonstrate that application and distribution uniformity efficiencies can be improved of about 20% in respect to those obtained by a manual management, achieving, moreover, a correct and precise management of water level in the field during the whole irrigation season. We can conclude that the future of the gravity-fed surface irrigation systems will increasingly depend from how these systems will be managed and from how they will increase the flexibility of water distribution.



## Performances of geotextiles in reducing soil erosion: field studies with natural rainfall

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**Keywords: bioengineering materials; erosion control; soil loss.**

A dense and well-established vegetation cover can sensibly reduce the soil loss from hillslopes, minimizing the effect of water erosion. Indeed, canopy protects the soil surface from the impact of the raindrops, reduces the runoff surface velocity and the related transport capacity, and promotes infiltration and increments the soil cohesion, reducing its erodibility. This effect is relevant in case of artificial hillslopes and after construction works, when there is a high risk of soil erosion due to rainfall, in particular before the establishment of vegetation.

In such circumstances, the soil loss resulting from water erosion can be reduced employing bioengineering materials like biodegradable geotextiles. The longevity of these materials ranges usually between two and five years, and after this period the vegetation is fully established and geotextiles become redundant in terms of soil loss reduction.

Aim of the present contribution is to assess the performances of three commercial biodegradable geotextiles, in terms of soil loss reduction compared to bare ground area and vegetated area. The first geotextile is composed of jute and it is characterized by a net shape, the second is composed of jute fibres, and the last is composed of wool fibres. All the three geotextiles are biodegradable, permeable to the rainfall, and commonly used in hillslopes protection against the erosion.

A small artificial hill was built in the experimental laboratory (MecHydroLab) of Tuscia University, in Central Italy, and divided in five facets. The three investigated geotextiles have been mechanically fixed on three facets. The other two facets are covered with spontaneous vegetation and without any vegetation simulating a bare ground area. Five natural rainfall events, with precipitation amounts ranging from 7 to 43 mm and with average intensities up to 35 mm/h were observed and analyzed in terms of eroded material from each facet. Results showed that the three geotextiles strongly decreased the sediment concentration, and that the geotextiles efficiency is decreasing with the increasing of the rainfall intensity.



## **Agricultural water scarcity assessment in northern Italy by means of the Transpiration Deficit Index (TDI)**

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**Keywords: Agricultural drought, Indicator, Hydrological model, Transpiration Deficit Index, Water scarcity**

### **Objectives**

The Mediterranean is considered the most vulnerable European region to short-term (water shortage) or long-term (water scarcity) water imbalance (i.e. abstractions exceeding resource availability). Since irrigated agriculture accounts for a considerable share of water abstractions, areas where irrigation is used to compensate for drought impacts are prone to water shortage and/or scarcity. In this framework, the development and adoption of spatially distributed indicators able to recognize and predict water shortage and water scarcity situations are crucial to manage their effects, also in the view of an adaptation to the climate change. This work, supported by Fondazione Cariplo grant n° 2015-0220, aims to present the Transpiration Deficit Index (TDI) and to show its ability to monitor water shortages in a pilot study area of the Padana Plain (northern Italy) characterized by a limited surface water availability.

### **Methods**

TDI is based on transforming the distribution of the crop transpiration deficit (potential – actual transpiration) calculated for a fixed time lapse (e.g. 1<sup>st</sup>-10<sup>th</sup> July, but the example could refer to any other time lapse of the year) over a long time period (e.g. 50 years), into a standard normal distribution. TDI is therefore expressed in standard deviations from the long-term mean of the considered time lapse. TDI is calculated by means of a spatially distributed hydrological model taking into account irrigation water availability and consumption in agricultural areas. For the application to the pilot study area, 22 years (1993-2014) of input data were used, and TDI maps with a time step of 10 days and a spatial resolution of 250 m were produced. Two years, respectively characterized by abundant rainfall (2014) and drought conditions (2009), were selected to illustrate the TDI behaviour. To verify TDI predictions, TDI maps were compared to an earth observation (EO) product, the yearly Absorbed Photosynthetically Active Radiation (APAR) obtained by a Landsat dataset, through an ensemble correlation analysis.

### **Results**

The results show that dry spells effects are mitigated by irrigation, although in some areas the water availability is still not sufficient. Slightly different TDI values are found for soils with different hydrological characteristics. The ensemble correlation analysis between TDI and productivity data shows that a positive correlation exists between the two variables, therefore productivity maps obtained from EO data can be usefully adopted in the validation of the index, as the shortage of water in irrigated areas leads to a reduction in crop production. More in general, the results highlight that TDI may be used as an effective tool for the monitoring of water shortage/scarcity phenomena evolution in agricultural areas.



## Role of topographic gradient on water use performance in a paddy area

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**Keywords: Topography, Water use efficiency, Water balance, Paddy field, Water reuse, Seepage, Percolation, Slope**

### Objectives

Italy is the largest rice producer in Europe, with the main production concentrated in Lombardy and Piedmont regions. Due to the high water requirements of paddy rice cultivation, irrigation efficiencies in rice areas range between 20% and 60%. However, water performance indicators may increase with increasing spatial scale because of water reuse. In paddy areas, topography is one of the factors that may activate water exchanges and reuse between paddies. In particular, lower paddies may receive seepage and runoff from paddies located upslope. This phenomenon is described in many studies but, to the authors' knowledge, no experiments in the literature led to its quantification. This study investigated the water balance terms and the water use performance of a group of adjacent rice paddies on a slope, with a focus on both the single fields and the group of rice paddies.

### Methods

A two-year monitoring activity (2015-2016) was conducted in a rice farm located in Semiana (PV, Northern Italy), in the context of the WATPAD project funded by Fondazione Cariplo (grant n° 2014-1260). Four rice fields (A, B, C, D, for a total of 30 ha) were instrumented with devices measuring water inflows, water outflows, water levels, soil moisture and groundwater depths. Soil samples were collected in each field to measure the retention curves of different horizons of soil profiles and the saturated hydraulic conductivity (Ks) of the hardpan. Only fields A, C and D were adjacent, while B was separated by a deep drainage channel. Elevations were in the order  $A \approx B > C > D$ . Groundwater depths at the site were within 1 m from the soil surface during the flooding period. Water balances were computed at a daily time step from seeding till harvest. The sum of lateral and percolation fluxes was obtained as the residual term of the water balance. An approach based on the Darcy's law considering experimental Ks and hydraulic heads was used to separate the two terms during the flooding period.

### Results

Irrigation amounts around 2,000 mm were required by A and B, whereas inputs to C and D were less than 1,000 mm. The lower values of C and D were not only due to less permeable soils (e.g.,  $Ks-C = 0.12$  cm/d against  $Ks-A = 1.02$  cm/d), but also to the contribution given by lateral fluxes, which provided extra water inputs to C and D not measured by inflow meters. Water use efficiencies [WUE, computed as  $\text{evapotranspiration}/(\text{rainfall} + \text{net irrigation})$ ] of A and B were around 0.2, D showed a  $WUE > 1$ , while an intermediate value was found for C. Considering fields A, C and D as a group, the overall efficiency increases with respect to the value found for A and B, due to subsurface lateral exchanges between fields promoted by the topographic gradient.



## **Wastewater reuse in agriculture: Technical and economic feasibility for Puglia, Southern Italy**

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**Keywords: Wastewater reuse, cost-benefit analysis, scale effect, irrigation**

### **Objectives**

Although technological progress ensures that recycling is safe, the total volume of treated wastewater reuse in Europe is a tiny percentage of the treated effluent. Water reuse projects may fail for various reasons. One is the lack of popular support, because the perceived risk of poor water quality leads to problems with acceptance. However, the main driver of the implementation of wastewater reuse is the economic feasibility of treatments. To ensure long-term economic, environmental, and social sustainability, a comprehensive economic analysis of the associated costs and benefits derived from wastewater treatment is a pre-condition. This research aims to improve the economic evaluation of directly treated wastewater reuse.

### **Methods**

We draw up a methodological framework for the application of cost-benefit analysis (CBA) to wastewater project plants. We focus on the irrigation usage of reclaimed wastewater as a complementary source to current irrigation groundwater resource. We assess the real economic benefits of reclaimed wastewater as a productive factor for irrigation. These estimated benefits are aggregated over the population of the relevant farms and weighed against the costs of providing the reclaimed water at the plant gate. The treatment costs are analyzed in relation to the incoming effluent quality standard, with or without oxidation and sediment filtration in addition to the treatment of coagulation and disinfection. The scale effect of plant size on treatment costs is analyzed, which represents an innovative approach. A case study is carried out in the Puglia region Southern Italy, where two thirds of irrigation water comes from groundwater.

### **Results**

The technical and economic feasibility of wastewater reuse in Puglia is assessed. We show that the population equivalent (PE) capacity can be used to determine the size at which, according to the treatment features, it is economically convenient to reuse wastewater for agriculture.

The economic feasibility of reusing wastewater is primarily affected by the quality of the incoming effluent, with higher costs for lower quality effluent. The sedimentation temperature has less of an effect on the treatment cost.



## Historical review on Rainwater Harvesting in Jordan

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**Keywords: Water harvesting, Jordan, Water scarcity**

### Objectives

Jordan is one of the most water scarce countries in the world; where around the 90% of its area receives less than 100 mm of rainfall per year. Water security in the country is not only affected by climatic factors, but also severely threatened by the increasing demand given by the growing of population and by the fluxes of incoming refugees from the conflict of the surrounding areas of Jordan is considered the cradle of many of the Middle Eastern civilizations and a witness to the evolution of a lot of water harvesting systems. Many of them are still functioning after being restored. The paper reviews recent literature on rain water harvesting systems and their potentiality in Jordan, providing a first assessment of the current status of water harvesting interventions in the country,. The most common techniques used since centuries are analyzed over time to underline the criteria used for designing and siting. The results are collected in a database that can be queried for getting information on new water harvesting systems planning

### Methods

A literature review on water harvesting interventions realized in the past in Jordan has been carried out. A database is constructed to collect the main characteristics of realized water harvesting structures such as type, location, coordinates, water use, construction material, height, year of construction. The data collected were then represented in Geographical Information System (GIS) maps.

### Results

The historical analysis carried out on the water harvesting techniques commonly used in Jordan provided valuable information for understanding most suitable water harvesting techniques for the diverse areas of the country.

The review will be useful for the implementation of new projects, providing information on the main techniques realized in the country, sites and related parameters.

The application of GIS highlighted the influence of main technical and biophysical parameters on the different water harvesting interventions, adding valuable information to water harvesting future planning.

The obtained database can be used as a reference for setting new water harvesting interventions in Jordan.



## **Integrated use of Landsat images, GIS and AnnAGNPS modeling to estimate the impact of land use changes on runoff and sediment load**

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**Keywords: Remote sensing, GIS, Land use change prediction, AnnAGNPS**

### **Objectives**

Objectives of the study are: elaboration of past and actual land use maps, starting by the preprocessing of a set of remote sensing images through their classification and expert post classification; delineation of a trend of land cover changes, its validation and prediction of a future land use scenario; individuation of two additional future land use scenarios, according to European planning policies; simulation of the impact of future land use scenarios on runoff and sediment load at a watershed scale.

### **Methods**

Land use changes were investigated, for the Carapelle watershed (Northern Apulia), by the combined use of remote sensing images, geographic information systems (GIS) and transition potentials modeling. Data used include also a set of high-resolution aerial ortho-photos and Corine Land Cover maps. The Landsat 5 Thematic Mapper (TM) were used together with the TerrSet software, whose Land Change Modeler module was used to perform the land cover change analysis and for the prediction of the future land uses of the watershed. The transitions between the land use classes were modeled using a multi-layer perceptron (MLP) neural network. The transition potential maps, obtained from MLP, provide the controls for the subsequent dynamic land cover change predictions performed with the use of the Markov chain analysis. The impact of predicted land use changes on runoff and sediment load was estimated at watershed and sub-watershed scales using the AnnAGNPS model.

### **Results**

Land cover classification maps for the Carapelle watershed were produced for the years 1987, 2002 and 2011. A long term land cover change analysis was performed to detect the landscape dynamics in the Carapelle watershed over the observation period. Then, a predicted land cover map for 2011 was produced. The model validation was based on a cross-tabulation between the projected and the real land use cover maps of 2011. So, three scenarios were projected for 2035 and 2050, a base map with the normal parametrization of the model and two additional ones according with current developing programs based on EU policies. Lastly, the AnnAGNPS model was used to simulate the impact on runoff and sediment load, at watershed and sub-watershed scales, under the predicted land use changes.



## Effect of surface characteristics of soil surface on interrill soil erosion Dynamics

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**Keywords: interrill erosion, rainfall simulation, random roughness, soil loss**

### Objectives

The objectives of the investigation was to evaluate the effect of pre-event soil surface characteristics on the dynamic of interrill erosion process at plot scale.

### Methods

The experiments were performed in a replicated 1m x 1m square plot, located in a 16% slope and equipped with a nozzle-type rainfall simulator on a loam loam loamy. Each experiment started from a just ploughed surface and included a sequence of 3 trials carried out in the range of few days. Each trials included two phases: a wetting phase that allows to have constant initial soil water conditions (average 31% by weight) and bulk density (mean 1.3 g/cm<sup>3</sup> and CV = 3%). The rainfall intensity was almost constant (I mean = 67 mm/h, CV = 2.7 %). The independent variables in each experiment is the initial soil surface conditions that are progressively modified by the rainfall runoff process and therefore are different for the three subsequent simulations. The soil surface initial and final shear strength, the soil surface initial and final micro-topography were monitored. All the runoff was collected and measured changing the tank every 5 min. The soil that was eroded from each plot at each time interval was measured by drying the runoff samples and weighting the dry material.

### Results

The surface roughness decreases with cumulative rainfall and this relationship changes in time probably due to the changing in soil aggregate stability. The runoff increases both during the simulation, stabilizing only for lower initial roughness, and at a given time of subsequent trials. The dynamic during rainfall of sediment concentration, C, appeared to be due surface roughness. For the higher roughness the main trend of C was practically similar for the two experiments, the C stabilizing quite rapidly after runoff begun. On the contrary, the C dynamics for the lower roughness were strongly affected by the initial surface conditions. It increased mildly to a maximum value after 60mm of rainfall, and then decreased slightly. These and other results open interesting scenarios in the study of the dynamics of the erosion process with particular reference to the relationship between the characteristics of the soil surface and the climatic and hydrological forcing both at event and intra-event time scale. In addition, some results offer discussion points relative to the dynamics of the soil erodibility, showing that the concentration behavior cannot be fully explained by the runoff dynamics.



## Irrigation Water Requirements of "Sinistra Ofanto" district from open satellite data and meteorological data

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**Keywords: Irrigation Water Requirements, Leaf Area Index, evapotranspiration, Landsat-8, MODIS**

**Abstract:** Sustainable water resources management plays a critical role in agriculture, one of the key economic activities of the Apulia Region (Southern Italy). Moreover, water use assessment is crucial particularly in semi-arid environments to ensure its availability for multiple uses. In this contest, an accurate water balance is an essential system to support decisions. The water balance for agricultural activities, depending on the purpose of the study, can be defined at different temporal (hourly, daily, seasonal) and spatial (crop, farm, regional) resolutions. At regional scale, the water balance compares the water resources available with the requirements of users, and is useful to assess the present and future needs of the distribution system. This allows also to define the infrastructural improvements and management strategies for an optimized use of water resources. However, developing a water balance over large areas (like river basins or irrigation districts) requires many input data from field measurements. For this reasons, it is extremely expensive and time-consuming. Earth observations thus represent a valid alternative to provide useful information for the estimation of the Irrigation Water Requirements (IWR). In this study, the seasonal water balance was estimated for the irrigation district "Sinistra Ofanto" located in the Apulia Region and managed by the "Capitanata" irrigation Consortium. The input data were retrieved by combining meteorological measurements performed by the Consortium, and crop parameters estimated from remotely sensed observations. The satellite-derived Leaf Area Index (LAI) was estimated by using the semi-empirical CLAIR model, a simplified reflectance model that links LAI to optical data. The parameters of the CLAIR model were taken from a previous study in which were estimated by using an image-based procedure, because of lacking both LAI and surface reflectance field measurements. Moreover, the method exploited only free of charge data as the novel high level Landsat 8 Operational Land Imager Surface Reflectance (OLISR) product and the MODIS LAI (MCD15A3H level 4 product). For the estimation of the evapotranspiration, was adopted the standard approach proposed by the Food and Agriculture Organization (FAO). Lastly, the IWR retrieved from the water balance was compared, for each irrigation district, with the amount of water provided during all the crop year in order to assess the quality of the estimated IWR.



## **A model for assessing salinity in root zone by data assimilation in a nectarine orchard irrigated with reclaimed wastewater**

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**Keywords: trees root zone, data assimilation, Brownian bridges, Richards' equation, salinity of soils**

### **Objectives**

The main objective of this work is to assess the salinity in the root zone by combining data of water saturation with a mathematical model. This assessment is of crucial importance for evaluating desertification risk, saline intrusion in aquifers and peach nutritional imbalances or toxicity when irrigation has been carried out with reclaimed wastewater.

### **Methods**

Data of soil water saturation collected at different depths in (0-20, 20-40 and 40-60 cm) for 3 years, at the end of each irrigation season, are used for dynamically "tuning" the numerical solution of Richards' equation. This equation models the phenomenon of water infiltration into the unsaturated zone. This "tuning" is accomplished by a data assimilation scheme, based on the ensemble Kalman filter coupled with a Brownian bridges approach. The data assimilation procedure is used just to correct the system states between one observation and the following one, this means we include the uncertainty on the parameters in the general expression of model error. Fictitious data of water saturation are obtained by interpolating the real ones, and afterwards their confidence is estimated by a stochastic Brownian bridges technique. This data can dynamically correct the deterministic flow model based on Richards' equation, that is an unstable parabolic partial differential equation whose numerical solution is highly dependent on the parameter choice. The assessment of salinity concentration is computed starting from the water content, by an algebraic equation and evaluating electrical conductivity in soil saturated paste and by using leaf indicators.

### **Results**

Because of the uncertainties upon the hydrologic model parameters, typically very difficult to estimate in laboratory, the proposed data assimilation technique seems to be particularly suitable, because of the greater confidence posed in the observations rather than in the model. This method allows us to better understand the relation between soil salinity and peach leaf toxicity increasing our knowledge about the salts uptake and their effect on crops. This method helps us to monitor the excess of salinity in the soil in order to reduce the risk of both soil desertification and plant toxicity.



## Assessing groundwater use in irrigation districts with multiple resources through the MIGRAD model

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**Keywords: water allocation criteria, integrated water management for irrigation, groundwater use, multi-resources water supply system**

### Objectives

The objective is to evaluate the impact of farm-scale water costs on water resources management and groundwater exploitation, for the case of Capitanata plain (Southern Italy), which is supplied by district networks and groundwater with variable costs and management regimes. Starting from the observed water allocation regime, a farm-scale water allocation model was defined to evaluate the effectiveness of water policies based on water-pricing schemes.

### Methods

The selection of water sources for irrigation is analysed as a function of costs payed by farmers for both volume-based unit price and pumping energy considered respectively for collective networks and private wells. The proposed water allocation model is based on semi-structured interviews carried out to define (i) the relationship between irrigation source selection and water tariff in the irrigation district, and (ii) the cost convenience thresholds regulating the conjunctive use of groundwater and surface water.

An average hectare approach was adopted to describe the overall variability of cropping patterns in the period of interest, while CROPWAT was used to estimate the monthly irrigation demand. To jointly analyse the dynamics of the available groundwater stock and irrigation-water volumes, a simplified groundwater balance model was implemented highlighting the sensitivity of groundwater to climate and tariff variations.

### Results

The behaviour of farmers with respect to water use for irrigation depends on energy and water pricing. The selection of water source aims at reducing farming costs, therefore, depending on the irrigation demand and tariff thresholds, groundwater source is preferred when the water cost from collective networks increases. The validation of results was performed comparing the simulated and measured irrigation volumes derived from reservoir ( $R^2=0,91$ ). Considering water tariff adjustments related to annual available stocks, restrictive tariff plans usually applied under drought conditions produced marked increase in the groundwater use, rather than reducing the overall water consumption. Under such conditions, groundwater depletion resulted more evident than during regular irrigation seasons, remarking the overall reduction of irrigation demand as the only option to achieve effective decrease of groundwater uptakes.



## **Water, carbon and heat fluxes from a mountain meadow to the atmosphere.**

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**Keywords: Alps, micrometeorology, water resources**

### **Objectives**

The influence of soil moisture in climate and meteorological models needs to be studied, due to the fact that the Alps are an hotspot of climate change. The objectives of this paper are to quantify the water, carbon and heat fluxes along an abandoned meadow on a mountain slope, in order to evaluate the effects of albedo and surface temperature along a sequence of relatively cold and hot years.

### **Methods**

Both modeling and measurements have been performed in order to quantify the effect of meteorological variables on mountain fluxes. Water infiltration and snowmelt have been also modeled. The influence of the meteorological forcing has been assessed through a sonic anemometer, a four component radiometer, a rain gage, and a snow depth gage. The role of soil moisture, together with soil temperature are also assessed.

### **Results**

The results show that the system present a marked time variability during the almost 7 years of measurements. The snowmelt is usually completed in a few days, giving an intermittence of albedo values during the coldest months of the year. The relationships with the spatial resolution of atmospheric models has also been investigated.



## Testing a single USLE-MM model to predict high soil losses in central and south Italy

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**Keywords: Plot soil loss, Event temporal scale, USLE-MM**

### Objectives

With reference to three experimental sites located in Calabria (Bagnara), Sicily (Sparacia), and Umbria (Masse), the objective of this investigation was to establish if using a site-independent exponent of the erosivity term is possible from a practical point of view, especially to predict high soil loss values.

### Methods

Initially, the USLE-MM was calibrated at each site using a large dataset of normalized soil loss values,  $A_{e,N}$  (sample size,  $N = 90, 532$  and  $570$  for Bagnara, Masse and Sparacia, respectively), collected on bare plots. Then, a single dataset was developed by pooling the ( $Q_{REI_{30}}, A_{e,N}$ ) data pairs collected at these three stations together and a common estimate of the  $b_1$  coefficient,  $b_{1c}$ , was obtained by using regression analysis. Subsequently, the soil erodibility factor of the USLE-MM,  $K_{UMM}$ , was calculated for the three stations by the same procedure that was used to determine the soil erodibility factor of the USLE. Finally, a comparison between the measured and the predicted  $A_{e,N}$  values was carried out with reference to the two considered scenarios, i.e. locally calibrated models and single model. The commonly used coefficient of determination,  $R^2$ , the root mean square error, RMSE, and NSEI were used to establish the performances of the calibrated models. Taking into account that the events of most practical interest are those determining high soil loss, the above procedure was also carried out by only considering high soil loss values, i.e.  $A_{e,N} > 1 \text{ Mg ha}^{-1}$  ( $N = 496$   $Q_{REI_{30}}, A_{e,N}$  data pairs) and  $A_{e,N} > 10 \text{ Mg ha}^{-1}$  ( $N = 139$ ).

### Results

The locally calibrated model performed satisfactorily well at all sites, supporting the validity of the considered scheme to predict soil loss at the event temporal scale. The worsening of the performances of the single model was an expected result but it was not substantial, suggesting that using a site-independent exponent of the erosivity term was a practically reasonable choice. In conclusion, developing a model of the USLE-MM type having an applicability that is not limited to a few experimental sites appears to be a practical possibility. Additional tests of the USLE-MM scheme are necessary in other places. Procedures to simply estimate both the plot runoff coefficient and the soil erodibility factor should then be developed.



## Impact of reforestations with exotic and native species on water repellency of forest soils

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**Keywords:** Forest soils, Soil water repellency, Water Drop Penetration Time test, Ethanol Percentage test

### Objectives

Forest soils include a surface duff layer that is usually water repellent due to the hydrophobic organic compounds resulting from leaf exudates and degradation of tree tissues. Hydrophobicity hinders water infiltration thus reducing plant available water and increasing runoff and soil erosion. Transition from hydrophobic to wettable conditions, or vice versa, is largely controlled by water content and, thus, by overall climatic conditions. The main objective of this investigation was to compare the degree of soil water repellency induced by reforestations with both exotic and native trees.

### Methods

Influence of initial soil moisture as well as of rainfall leaching on the occurrence of water repellency was investigated by the water drop penetration time (WDPT) and the ethanol percentage (EP) tests on four Sicilian forest soils. Sampling was conducted in the duff layers of exotic species used in the past for reforestation (*Pinus pinaster*, P, and *Eucalyptus camaldulensis*, E), and native forests species (*Quercus ilex*, L, and *Quercus pubescens*, R). Potential water repellency, accounting for hyper-dry soil conditions, and actual water repellency, accounting for the effect of actual initial moisture contents, were assessed.

### Results

The E duff was characterized by the highest potential water repellency (WDPT = 4610 s, EP = 23.8%) whereas the P duff was the least repellent one (WDPT = 2099 s, EP = 22.0%). The largest difference between potential and actual water repellency was observed for the R duff. The water repellency vs. initial moisture relationship was different for WDPT and EP. In the former case, a decreasing relationship was observed with a transition between hydrophobic and wettable conditions in the range  $0.14 < \theta < 0.19 \text{ cm}^3\text{cm}^{-3}$ . The WDPT vs.  $\theta$  relationship was successfully modeled by a non-linear S-shaped curve. The EP vs.  $\theta$  relationships showed a maximum in the range  $0.10 < \theta < 0.15 \text{ cm}^3\text{cm}^{-3}$ . Leaching of organic compounds by simulated rainfall was always effective in reducing water repellency even if the WDPT reductions were one or two orders of magnitude larger than the EP ones. Wettable conditions were generally more easily restored in the duff of exotic species (P and E) than in native ones (L and R), probably as consequence of the relatively higher content of soluble hydrophobic compounds that are easily leached from the particles surface.



## **Best management practices as an alternative for flood and urban storm water control in a changing climate: An analysis in a peri urban area in the metropolitan city of Rome (Italy).**

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**Keywords: Soil sealing, Best management practices (BMPs), Stormwater management**

### **Objectives**

Soil degradation by sealing is increasing at an alarming rate in developed countries. In this context, coastal wetlands are areas that suffer from great pressure. Much of it is due to the rapid development of the surrounding artificial landscapes, where socio-economic factors lead to alterations in the nearby environment, affecting the quality of environmental systems. In Italy, the great urban and industrial development of the towns surrounding Rome has caused an irreversible and rapid soil loss in last decades. Best management practices (BMPs) and low impact development (LID) practices are increasingly being used as stormwater management techniques to reduce the impacts of urban development on hydrology and water quality. In the present paper, a procedure for BMPs planning and analysis using a comprehensive decision support tool was proposed to mitigate urban runoff. A case study was conducted to the planning of an BMPs implementation effort at a peri urban area in the metropolitan city of Rome (Italy).

### **Methods**

The study area is about 2.744 ha and consists of contiguous and discontinuous urban fabric and a Protected Area (Natural Reserve of Castelporziano). Within the considered study area, eight watersheds have been selected, based on the possibility to create BMP in the proximity of the watershed outlet. For each case study, in the proximity of the watershed outlet, a BMP that will be used for storing a part of the surface runoff volume flowing toward the outlet of the case study was designed. BMP types, sizes, and spatial layouts should be determined in accord with local conditions (elevation, slope, soil type, urban land use, roads, water table depth, stream location, and drainage area). For these reasons a data set with high resolution was collected in GIS environment to stimulate the introduction of BMPs in the considered study area. The hydrologic modelling has been performed applying the recently developed EBA4SUB (Event Based Approach for Small and Ungauged Basins) framework and software. Instead, the flood routing is developed employing here the bidimensional commercial hydraulic model FLO-2D. The FLO-2D scheme is based on the dynamic wave momentum equation solved on a numerical grid of square cells through which the hydrograph is routed propagating the surface flow along the eight cardinal directions.

### **Results**

The present study examined the use of BMPs in mitigating urban runoff impacts. The study area can be considered a paradigmatic study case in analyzing the benefits of BMP's implementation on reducing runoff volume and peak rates. The coupled EBA4SUB–FLO-2D model and a high resolution data-set was used for the analysis. The results showed that compared to the existing condition, the recommended BMP plan would cause a 38% and 29% reduction for total runoff volume and the peak flow rate, respectively.



## Satellite remote sensing as a tool for diachronic analysis and mapping of soil sealing: the peri-urban area of Rome and Perugia

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**Keywords: Peri-urban environment – Land cover change – Soil sealing – Remote sensing – Diachronic analysis**

### Objectives

Satellite remote sensing is a very effective tool for monitoring earth's surface dynamics. Multispectral images acquired by modern satellite sensors are able to provide useful information for a broad range of applications. Soil sealing due to urbanization processes represents an important challenge for a proper land management, because is directly connected with important issues such as "runoff" phenomena, ecosystem fragmentation, subtraction of important agricultural areas. In this framework, the research is aimed to a land use land cover (LULC) change analysis, using remote sensed data, in two peri-urban areas located in the Italian regions of Lazio and Umbria. In particular, the analysis quantifies and locates the land consumption in terms of irreversible sealing of agro-natural spaces.

### Methods

To perform the LULC diachronic analysis, multispectral satellite images were retrieved for the 1985-1990 period (Landsat 5) and 2015-2016 (Landsat 8). The images were pre-processed through a radiometric and atmospheric correction. The final classification was performed by means of a supervised approach based on a maximum likelihood algorithm. An accuracy assessment procedure using aerial high-resolution ortho images allowed to quantify the omission and commission classification errors. All the procedure was developed in an open-source environment (QGIS and its semi-automatic classification plug-in). The LULC change dynamics of the two peri-urban areas were finally quantified and analyzed filling two transition matrices.

### Results

The methodology developed in the research allowed the analysis of soil sealing phenomena in the peri-urban contexts under investigation. The quantification of land use dynamics, the identification of the urban assets and natural resource management methods support the investigation of critical issues due to this phenomenon and the definition of specific interventions that can mitigate it.



## **Sugarcane straw effect evaluation on sustainability soil parameters**

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**Keywords: Soil water Retention, Sugarcane industry, Pedotransfer functions.**

### **Objectives**

Taking into account the importance of sugarcane straw to the sugarcane industry sector and the soil quality under sugarcane cultivation, the objective of this study was to address the straw characterization and its effects on soil properties, used as subsidies for sugarcane producers to improve the system sustainability and in order that sugarcane plants can increase their power generation in a sustainable way. An important issue regarding this scope is to know the amount of straw that can be removed from the field and be used in industry to generate electricity in a way that ensures the sustainability of the system and maintain soil quality.

### **Methods**

For that, the water soil retention was obtained. It is an important parameter because from that it is possible to scale drainage systems, irrigation, soil indicative in capacity regarding terms of crop to be grown and the knowledge of physicochemical characteristics of the soil. In addition to this parameter, the soil temperature is of utmost importance for proper seed germination, management of pH and availability of soil nutrients. Em50G Datalogger sensors were installed to obtain the soil matrix potential (kPA) and soil temperature (°C) in the research areas at the Ester (SP) and Quatá (SP) plants. For the determination of water retention in the soil by the use of the mathematical model developed by Van Genuchten (1980), the data of matrix potential obtained from the experimentation sensors were used.

### **Results**

Straw has an important role in soil water retention and soil temperature and the absence of straw on the soil surface significantly increases soil temperatures and thermal amplitudes compared to the presence of straw in various quantities. In parallel, the absence of straw also contributes to the increase of the rate of variation of the amount of water in the soil, that is, the incidence of solar rays directly in the soil and the high temperatures have increased evapotranspiration of the soil-plant-atmosphere system.

The correlation of these parameters with the amount of straw left on the soil surface and thus proves to be an important study and interest of various stakeholders, including the sugarcane industry sector, producers, research centers and universities.



## **TOPIC 5**

### ***HYDROLOGY, DEBRIS FLOW, SEDIMENT-LARGE WOOD CONNECTIVITY IN CHANGING ENVIRONMENT: PROCESS, CONTROL AND CONSEQUENCES***



Temporal dynamics of runoff and suspended sediment transport in the Rio cordon instrumented basin <i>Rainato R., Picco L., Oss Cazzador D., García-Rama A., Mao L. and Lenzi M.A.</i> .....	120
Quantification and spatial variability of rooted-soil reinforcement in abandoned chestnut coppice forests: effects on slope stability <i>Cislaghi, A., Vergani, C., Denicola, R., Chiaradia, E.A., Bischetti G.B.</i> .....	121
Designing the retention check dams: a feedback from the real protection needs <i>D'Agostino V.</i> .....	122
Linking erosional processes and riparian vegetation <i>Oss Cazzador D., Picco L., Rainato R., and Lenzi M.A.</i> .....	123
Isotope hydrology and ecohydrology in Italian catchments: recent experiences and way forward <i>Penna D.</i> .....	124
Effects of under-vacuum and vessel soil sample saturation on soil hydraulic conductivity estimated by the core method in the case of paddy soils <i>Rienzner M., Facchi A.</i> .....	125
Comparison of subsurface hydrologic connectivity in mountain headwater catchments <i>Zuecco G., Rinderer M., van Meerveld H.J., Penna D., Borga M.</i> .....	126
Assessment of different survey techniques to quantify sediment redistribution after restoration works in Mareiter river. <i>Andreoli A., Senoner G., Dell'Agnese A., Theule J., Comiti F.</i> .....	127
Geomorphological characterization of rivers to detect sediment (dis)connectivity: the rio cordon study case. <i>Oss Cazzador D., Rainato R., Picco L., Neverman A.J. and Lenzi M.A.</i> .....	128
Role of terrain indexes in explaining spatial variability of soil moisture in three experimental sites in Italy <i>Nasta P., Zuecco G., Brocca L., Penna D., Borga M., Romano N.</i> .....	129
Methodology and instruments for the surveys and costs analysis of proposed solution for the Cancia debris flow case in the municipality of Borca di Cadore (BL) <i>Benucci G., Errico A., Preti F.</i> .....	130
Modeling the vegetation resistance in drainage channels. Comparison with experimental and simulated roughness coefficients at the real scale. <i>Errico A., Pasquino V., Chirico G.B., Preti F.</i> .....	131



## Temporal dynamics of runoff and suspended sediment transport in the Rio Cordon instrumented basin

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**Keywords: alpine basin, suspended load, temporal trend, sediment transport.**

### Objectives

The aim of this study is to explore the trends, breaking points and regimes of runoff and suspended sediment transport during the last 30 years in the Rio Cordon basin (Eastern Italian Alps).

### Methods

Using the dataset produced by the continuous measurement operating in the Rio Cordon instrumented basin, the water and sediment yields were analyzed.

### Results

The annual suspended sediment load showed a decreasing trend through the years, while the suspended fraction is relatively increased in the latest 15 years. From 1986 to 1993, there was a slight diminishing trend of the suspended sediment supply, but in September 1994 an extraordinary rainfall event destroyed the bed armor layer and altered the channel bed morphology. After this event, higher values of annual suspended budget were recorded. Also, in 2001, a mud flow led to unlimited availability conditions that affected the dynamics of the following years. Notwithstanding the stable trend of annual runoff volumes, after 2002 the catchment showed a marked decrease in terms of annual budget. The depletion of the active sediment sources and the lack of flood events capable to activate new source areas can explain the recent trend. The analysis of the seasonal suspended budget showed a significant temporal variability. Before 1994, summer contribution prevailed, yet with high interannual fluctuations, while for about a decade after the September 1994 flood, the sediment fluxes were clearly dominated by the autumnal delivery. During the last decade, the snowmelt has been the main suspended load contributor, with a mean annual fraction of 58%. However, the recent snowmelt contributions were clearly lower than those previously recorded. The runoff volumes have not decreased enough to explain this, but the analysis of the rainfall regime suggests that the temporal distribution of the precipitation changed in the last 15 years, showing longer durations and lower rainfall intensities. In fact, the 2002-2015 period has been characterized by the absence of high magnitude floods. Consequently, the activation of the sediment sources during rainfall events has been weak or localized in a very constrained area. Hence, no sediment availability was provided for the next floods, not affecting the subsequent summer- and autumn-seasonal load.

This research was funded by the University of Padova Research Projects “BIRD167919-Sediment transfer processes in an Alpine basin: sediment cascades from hillslopes to the channel network” and “PRAT-CPDA149091-WoodAlp: linking large wood and morphological dynamics of gravel bed rivers of Eastern Italian Alps”



## Quantification and spatial variability of rooted-soil reinforcement in abandoned chestnut coppice forests: effects on slope stability

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**Keywords: Root reinforcement, Slope stability, Sweet chestnut**

### Objectives

Sweet chestnut dominates the Italian mountainous landscape, and in particular the low- and mid- altitude areas, where it played a fundamental role in mountain economy and for people subsistence. In such areas, sweet chestnut stands have always been a source of woody material, and have been traditionally managed by coppicing in short rotation. Due to socio-economical changes of Italian mountain areas during the last decades, the sweet chestnut stands have been largely abandoned, starting from the steepest hillslopes and where forest roads were almost absent. Therefore, most of these stands are now over-aged and stools uprooting events are very common giving rise to concern among the forest managers, especially in areas prone to shallow landslides and debris flows. To provide new information on the effects of chestnut abandonment on slope stability, this study focuses on the variability of root reinforcement in two different conditions: abandoned and managed sweet chestnut stands. In particular, the main objectives are: (i) to define the probabilistic distribution functions for the root reinforcement, accordingly to the characteristics of the stand; (ii) to apply a slope stability model combining a multidimensional approach and a Monte Carlo simulation technique; and (iii) to quantify the differences between abandoned and managed stands in terms of landslide risks.

### Methods

The study sites are located in Prealpine areas, in Northern Italy, where managed and abandoned stands co-exist. In each site, we excavated trenches at different distances from the plants to analyze the spatial root distribution both in vertical and horizontal direction. Undamaged roots were collected at each site and, tensile tests were carried out in laboratory to evaluate the root mechanical properties. Root distribution and mechanical properties were used to calculate the root reinforcement in terms of additional cohesion to the soil strength. Finally, we applied a multidimensional and probabilistic model using the obtained data to evaluate the probability of failure in the study sites and then the differences between abandoned and managed stands.

### Results

The results of this study allow the generation of more reliable landslides hazard maps and provide useful information for understanding the consequences of chestnut abandonment. In addition, identifying the most hazardous areas allow to design more efficient, and forest strategies and/or to suggest more appropriate bioengineering techniques.



## Designing the retention check dams: a feedback from the real protection needs

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**Keywords: Torrent control works, Hazard mitigation, Open check dams, Fan protection**

### Objectives

The goal of the paper is evidencing the high range of solutions and related hypotheses of hydraulic mode of operation, which are in play in the design of retention open check dams. Since the 1960-1970 period, the evolution and specialization of these types of protection works from closed barriers to filtering structures has brought to almost abandon the full-retention check dams in favour of open-filtering check dams. Nevertheless, knowing the real needs of protection in mountain and hilly areas, the design approach should be better defined and updated through merging traditional functional concepts of sediment-transport interception with the expected, but not necessarily warranted, higher efficiency of the open check dams.

### Methods

After an introductory research position on the evolution of the retention check dams, the design context of some retention check dams is presented accounting both for the different goals of protections (e.g., torrential processes to control, existing local constraints, elements under risk) and observed performances of the work typology after the occurrence of significant flood events.

### Results

The results highlight that the a priori adoption of an open retention check dam could provide a false expectation of hazard mitigation against the different forms of sediment and/or large wood transport occurring in hilly and mountain creeks (bedload, debris flood, debris flow, mud flow associated or not to Large Wood recruitment). Technical suggestions are then presented on the panel of design solutions emphasizing how any sediment retention rate (partial or total) can be obtained without disregarding river hydro-ecology and sediment dynamics. Under this framework, the research experience via the back-analysis on successful/failure cases of check-dam operation still continues to be fundamental.



## Linking erosional processes and riparian vegetation

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**Keywords:** riparian vegetation, morphological changes, gravel bed river, LiDAR, Piave River.

### Abstract

Fluvial ecosystems continually change their hydrologic and morphologic settings, as well as the equilibrium between their components constantly evolve. Water discharge, sediment transport and vegetation regulate physical and morphological processes in riverine environments. Riparian vegetation, among other functions, can protect banks from erosion through banks stabilization, controlling and mitigating the flood effects through energy dissipation, intercepting sediments and improving the conditions for the stabilization of vegetation. This research is carried out along a reach of the transitional gravel bed Piave River, characterized by the presence of many different vegetated patches as vegetated bars and islands. The aim is to analyse the different localized geomorphic changes considering the characteristics of the surrounding vegetated units. Analysis of LiDAR data, gathered in 2003 and 2010, were performed using the free ArcGIS plug-in GCD (Geomorphic Change Detection), computing the DEMs of Difference (DoDs). In this way, it was possible to characterize the riparian and fluvial islands distribution, linking these to the geomorphic effects observed during the study period. Between 2003 and 2010, a clear distinction exists between the response to flood events of the area characterized by the presence of mature forest and those where the vegetation is young. The floodplain, characterized by the more mature and stable forest, was eroded contemporary to bank erosion processes during the floods. The lower and denser vegetation produced localized erosion into the active channel due, probably, to the dissipation of energy by vortices and turbulences consequently to the alteration of the flow velocity and direction. These results permit to better understand how to handle the in-channel and riparian vegetation. In fact, different approaches in the management of these vegetated units may help to decrease the lateral migration of the active channel protecting the floodplains from erosional processes. On the other way, to restore a wider active channel there is the need to remove the smaller vegetation from the banks, decreasing the bank protection and its stability. This research was supported by the projects: 'WoodAlp: linking large wood and morphological dynamics of gravel bed rivers of Eastern Italian Alps-PRAT-CPDA149091' and 'Relationship between sediment transport, riparian vegetation and Large Wood along a gravel bed river: the Piave River study case (North-East Italy)-DOR1695175'.



## **Isotope hydrology and ecohydrology in Italian catchments: recent experiences and way forward**

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**Keywords: stable isotopes of water; catchment; hydrological and ecohydrological processes; Italy.**

### **Objectives**

The use of stable isotopes of water as environmental tracers in catchment studies has started more than 40 years ago. The first benchmark papers appeared in the literature offered new insight into runoff generation processes and separation of runoff components. Since then, the use of isotopic tracers has grown noticeably and many advancements have been achieved in our comprehension of the internal functioning of catchments. In the 1990s, researchers began to frequently use stable isotopes of water also to investigate the sources of water uptake by plants (mainly trees) and the functional interactions between vegetation and the other components of the water cycle, thus going beyond pure ecological or hydrological applications and fostering research in the field of ecohydrology. In the last decade, cheaper and simpler instruments for the isotope determination in liquid samples, compared to the traditional mass spectrometry, have been introduced, and many research groups all over the world, including Italy, started experimental isotope-based studies to follow water from its input to its return back to the atmosphere.

The objective of this work is to review and summarise the main research lines and the most important findings obtained in hydrological and ecohydrological studies based on stable isotopes of water, and carried out in Italian catchments.

### **Methods**

I review all published literature on studies carried out in Italian catchments. I group the results of experimental observations in natural and agricultural catchments characterised by different water inputs and environmental settings: i) rainfall-dominated; ii) cryosphere water-dominated; iii) snowmelt-dominated; and iv) irrigation-dominated catchments.

### **Results**

Results show that the main findings of the published studies focus on the following specific aspects: i) identification and quantification of the temporal and spatial sources to streamflow; ii) analysis of water flow pathways and runoff generation mechanisms; iii) assessment of water mixing processes, solute transport and computation of transit time; iv) determination of sources for tree water uptake. To conclude and give a perspective on future work, I identify the most novel and intriguing scientific topics and the most urgent research lines (including methodological issues) necessary to significantly improve our knowledge of hydrological and ecohydrological processes at the catchment scale and to increase the international visibility of isotope-based studies in Italy.



## Effects of under-vacuum and vessel soil sample saturation on soil hydraulic conductivity estimated by the core method in the case of paddy soils

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**Keywords:** soil saturated hydraulic conductivity, best practice, core method, soil saturation, under-vacuum saturation, vessel saturation

### Objectives

Saturated soil hydraulic conductivity ( $K_s$ ) is a key parameter in predicting soil water fluxes, especially in paddy areas. The core method, reproducing the Darcy's experiment over large undisturbed soil samples, is considered the reference for  $K_s$  estimation. To saturate soil samples before the analysis, two different procedures are available: vessel saturation (*AtmSat*, where the water level in the vessel is raised slowly), and under-vacuum saturation (*VacSat*). A comparison between  $K_s$  estimations obtained by adopting the two procedures is still missing in the literature. Objective of this work is to perform a comparison of  $K_s$  values estimated with the core method for ten soil samples collected in paddy fields after their saturation with *AtmSat* and *VacSat* procedures.

### Methods

Ten paddy hardpan samples (H 15 cm,  $\phi$  14.6 cm) were collected in a rice farm located in Semiana (PV) in the context of the WATPAD project founded by Fondazione Cariplo (grant n° 2014-1260). Samples were saturated by using *AtmSat* and *VacSat* procedures. To evaluate the resulting  $K_s$  values, percolation fluxes calculated by the Darcy's law (based on lab-estimated  $K_s$ ) were assessed versus those obtained as residual terms in the water balance of paddy fields (the other fluxes were derived by field measurements).

### Results

The main results, partially diverging from what reported in literature, are as follows. (1) During the experiments, the transient-time behaviour of the flux was observed to start up to 26 h after the start. (2) Steady-state flux was often reached after a long time (up to 25 days) and the resulting  $K_s$ , used in the Darcy's equation, allowed precise estimates of the "field determined" percolation, while the initial  $K_s$  values were misleading. (3) *AtmSat* showed to provide reasonable results only for sandy soils while, in the case of low  $K_s$ , the underestimation was up to 10 fold, probably because of permanent air entrapment. (4) When vacuum was applied slowly, *VacSat* provided very precise estimations of  $K_s$  (fast application of the vacuum can produce a relevant hydraulic gradient within the core and damage the sample). (5) Applying *VacSat* the initial estimation of  $K_s$  was usually 10 times higher than the convergence value; this might be explained by changes in the electrical diffuse layer (EDL) due to interactions between pore water and within-aggregate water, and/or to an abnormal release of biological gasses due to the vacuum conditions.

These results may partially depend on the peculiarity of the soils explored (paddy hardpan), and need to be verified with other soil types.



## Comparison of subsurface hydrologic connectivity in mountain headwater catchments

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**Keywords: subsurface connectivity, groundwater, graph theory, headwater catchments**

Knowledge of hydrologic connectivity (i.e. the linkage of different areas in a catchment to the stream via water flow) is essential for understanding and predicting runoff responses and stream water quality. However, it is difficult to quantify hydrological connectivity. In this study, we used spatially-distributed shallow groundwater measurements in four small (<14 ha) headwater catchments to i) analyze the relation between streamflow and subsurface connectivity; ii) investigate the effects of rainfall characteristics and catchment topography on subsurface connectivity; and iii) assess the sensitivity of the connectivity results to the structure of the piezometric network.

Shallow groundwater levels were measured in a 14 and 3.3 ha catchment in the Italian Dolomites (two years of data from spring to fall, 16 and 12 locations, respectively) and in two <1 ha Swiss pre-alpine catchments (four years of data, 8 locations each). We estimated subsurface connectivity by a graph-theory approach, considering linear connections (edges) between the piezometers (nodes). A node was considered to be connected to the stream when shallow groundwater was observed in the piezometer and it was connected via the edges to the stream.

In all four catchments, subsurface connectivity increased during rainfall events but generally lagged the rise in streamflow, suggesting that other processes other than shallow subsurface flow, such as direct channel precipitation and runoff from near-stream saturated areas, contributed to streamflow at the beginning of the rainfall event. This resulted in anti-clockwise hysteretic relations between streamflow and the catchment area that was connected to the stream. Threshold relations between maximum connectivity and total stormflow and between maximum connectivity and the sum of total rainfall plus antecedent rainfall were evident for the Dolomitic catchments, but were less clear for the Swiss catchments. Rainfall amount predicted maximum subsurface connectivity better than indices related to antecedent wetness conditions. For the Swiss catchments, the duration that piezometers were connected to the stream was significantly correlated to the local and upslope site characteristics, such as the topographic wetness index and accumulated area. For the Dolomitic catchments, the fraction of time that piezometers were connected to the stream was correlated with the overland flow distance to the nearest stream in the 14-ha catchment, and with the topographic characteristics of the upslope contributing areas in the 3.3-ha catchment. The structure of the network had only a small influence on the results and we, therefore, conclude that graph-theory approaches can be used to describe subsurface hydrologic connectivity.



## **Assessment of different survey techniques to quantify sediment redistribution after restoration works in Mareiter river.**

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**Keywords: Structure from Motion Photogrammetry, Total Station, River restoration, morphological changes.**

### **Objectives**

The objective of this work is to assess different techniques for evaluating riverbed morphological changes and sediment redistribution in a restored river reach.

### **Methods**

The study was carried out in a restored reach of the Mareiter river, in South Tyrol, Italy. Methods used are (1) repeated cross-section surveys by total station (TS) and (2) Structure from Motion Photogrammetry (SfM) with validation points by RTK dGPS. A DEM of riverbed surface was produced and sediment redistribution was estimated by Difference of DEM (DoD).

### **Results**

Results show different values of mobilized sediments between the two methodologies. Points restitutions with TS is more accurate than SfM, but spatial resolution is lower, affecting the volumes of mobilized sediments estimation. Errors of TS rise with increasing distances between cross-sections. On the other hand, SfM is not that accurate at point scale, and errors can arise from vegetation cover, shadows or image reflection. However, their errors do not depend on reach longitude, so the 3D reconstruction model and consequent estimation of sediment redistribution is more accurate than with TS.

Advantages of TS is the reliability on riverbed points under water up to depths of wadable conditions, while SfM needs to use a refraction coefficient to correct the bathymetric points for an accurate DEM. Refraction is greater where water is less clear, so typically on riffle, water jetting into pools and high sediment transport rivers (i.e. feed by glacier melt). However, depending on water clarity, SfM bathymetric points can go deeper than wadable depths.

SfM involves a relatively fast photo survey in the field, depending on the acquisition method: pole method, RPAS (Remotely Piloted Aircraft System), light weight aircraft, or by helicopter. The first method is even cheaper than the use of TS, while aerial methods are progressively more expensive. SfM can optionally rely on control points to increase accuracy, but they do not need to be permanent like with the TS.

Concluding, as new applications (like river restoration monitoring and evaluation) demands higher resolution data, the use of SfM is preferable for estimating morphological changes and sediment redistribution in medium to long reaches, but requires survey integration with other techniques to obtain validation points. Thus, an accurate pre-survey planning is necessary and guidelines for application needed.



## Geomorphological characterization of rivers to detect sediment (dis)connectivity: the rio cordon study case.

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**Keywords: sediment connectivity, alpine stream, roughness, fluvial forms.**

### Abstract

Debris flows, debris floods, and floods influence sediment transport in mountain catchments. Sediment connectivity is defined as the connected transfer of sediment from the source areas to the channel network. Through the analysis of riverine morphological parameters, the aim of this study is to evaluate the (dis)connectivity of two sub-reaches of the Rio Cordon creek, focusing on the interactions between bed roughness, fluvial forms and sediment transport processes. The main channel, with a mean slope of 17%, drains an area of 5 km<sup>2</sup> in the Veneto Region. Here, two sub-reaches located at 2,200 (S1) and 1,930 (S2) m a.s.l. were surveyed using a Terrestrial Laser Scanner (TLS), while the superficial grain size distribution (GSD) was measured using the grid by number approach. Sub-reach S1 is characterized by a mean slope of 11%, the active channel width ranges from 6.9 m to 9.6 m, while the mean wetted channel width is ~ 2.2 m, with a predominantly step-pool morphology. In terms of GSD, S1 is characterized by  $D_{16} = 16$  mm,  $D_{50} = 47$  mm,  $D_{84} = 173$  mm,  $D_{90} = 237$  mm. S2 is located immediately downstream of a waterfall, exhibiting a mean slope of about 8.5% and an active channel width between 2.6 - 4.2 m. Here, the mean flowing channel width is 1.9 m, with a predominantly riffle- step pool morphology and a GSD equal to  $D_{16} = 48$  mm,  $D_{50} = 121$  mm,  $D_{84} = 335$  mm and  $D_{90} = 411$  mm. A detailed Digital Terrain Model (DTM) (cell size 0.03x0.03m) permitted assessment of the roughness, which showed values lower than the grain size distribution. In this sense, the roughness, divided into  $D_{16}$ ,  $D_{50}$ ,  $D_{84}$ ,  $D_{90}$ , ranges 2-5 times lower than GSD in S1, and 7-11 times lower in S2. Analysis on the longitudinal profile has permitted the detection of bed forms: S1 and S2 present step bedforms spaced every 8 and 13 m, respectively. These results can be explained considering the morphology of the catchment. In fact, S1 flows along scree deposits, favoring subsurface runoff and limiting sediment transport. Moreover, the presence of a flat area between the sub-reaches, just upstream of the waterfall, disrupts the longitudinal connectivity. Thus, S2 is under a supply-limited condition, favoring the armoring of the channel. A better understanding of the connectivity dynamics in alpine catchments can enhance the knowledge of sediment processes and management of mountain areas. This research was funded by the University of Padova Research Projects 'Sediment transfer processes in an Alpine basin: sediment cascades from hillslopes to the channel network-BIRD167919'.



## Role of terrain indexes in explaining spatial variability of soil moisture in three experimental sites in Italy

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**Keywords: Soil moisture, spatial variability, terrain indexes**

### Summary

Knowledge of soil moisture dynamics is crucial for improving water management strategies and setting optimal use of available water resources. The main hydrological processes such as evapotranspiration and surface runoff are controlled by surface soil moisture. Organizing an optimal program for monitoring surface soil moisture ideally needs a large number of accurate in-situ measurements. However, such experimental system requires excessive cost, time and effort for installation and maintenance. The key is to identify an explained spatial-temporal structure of variability in order to optimize available information, to identify a limited number of representative monitoring locations and to improve spatial interpolation at ungauged locations. Therefore it is necessary to establish guidance on efficient ground-point installation of soil moisture sensors that combines decreasing costs with increasing optimal information. Spatial structure of soil moisture can be partly assessed by exploiting readily available ancillary information such as terrain attributes. In this context, this study investigates the role of flow-related (curvature, slope, contributing area and wetness index) and radiation-related (elevation, aspect) terrain indexes in determining the explained variance of spatially distributed soil moisture at the field scale in three experimental catchments located in Northern, Central and Southern Italy, characterized by different climate and land-use. Soil moisture was determined in different sampling campaigns by using portable Time Domain Reflectometer (TDR) devices. We used the partial least-squares regression (PLSR) which exploits cross-correlated soil-terrain predictors by constructing new predictor variables, known as components, as linear combinations of the original predictors. The role of each individual terrain index is isolated by running an iterative bootstrapping (by removing one terrain index in each run) and related to climate indicators retrieved from monthly rainfall and reference evapotranspiration. In conclusion, this work allowed for a better comprehension of the topographic and climatic controls on soil moisture variability at the field scale.



## **Methodology and instruments for the surveys and costs analysis of purposed solution for the Cancia debris flow case in the municipality of Borca di Cadore (BL)**

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**Keywords: Debris flow, mitigation measures, risk management**

### **Objectives**

The study presents the design proposal of a flood risk mitigation measure in the downstream section of the Boite stream, crossing an urbanized area. To date, the most critical issues are represented by a number of culverts, through which the Boite stream is underpassing public roads. These structures resulted to be not sufficient in case of flood.

In the past years other projects have been proposed to lower the risk of damages caused by a possible debris flow for the Cancia case, but they have not been implemented yet because of the high costs and possible urban planning issues. In fact, buildings expropriation and demolition were involved, with a considerable problem of public opinion and urban management.

### **Methods**

The present work describes the materials and the methodology used for the Cancia debris flow study, located in the Municipality of Borca di Cadore (BL). To better understand the dynamics occurring in the study area, GIS analysis were carried out based on CTR, Italian IGM maps and DTMs. Moreover, indirect surveys on a high resolution point cloud were conducted to define the channel morphology. The historical evolution of the debris fan (caused by the building of the Corte touristic village) was reconstructed by the analysis of IGM historical aerial imagery. The modification of the culverts and the channel morphology was the object of the proposed design.

### **Results**

An alternative and cheaper approach, able to reduce the risk of damages by means of a low-cost solution is proposed, acting on the downstream section of the Boite stream. The cost comparison with the other solutions, and the fact that the proposed project does not need additional land, demonstrates the relevance of the presented approach.



## **Modeling the vegetation resistance in drainage channels. Comparison with experimental and simulated roughness coefficients at the real scale.**

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**Keywords: Streamside vegetation, water management, flood risk**

### **Objectives**

The present study aimed to compare modelled and observed roughness coefficients for a vegetated drainage channel, which was object of experimental hydraulic measures in different vegetated scenarios. The aim of these tests was to assess the ability of different existing models in predicting the observed dynamics, which could support their application also outside the testing site.

### **Methods**

An experimental field campaign was conducted in Versilia, Northern Tuscany, in order to estimate the real roughness coefficients of a typical reclamation channel in different management scenarios. The work was supported by the Northern Tuscany Land Reclamation Authority, which was interested in better understanding the effect of the vegetation on flood risk. The vegetation observed within the channel was mainly composed by emergent common reed (*Phragmites australis*), which appeared to significantly rise the flood risk in condition of non-management, respect to the reference condition represented by the totally cleared channel. An intermediate sustainable solution was found to be the release of a vegetated strip on one of the banks, which resulted to be not affecting significantly hydraulic aspects in the channel while maintaining a refuge site for the fauna.

The harvested experimental data allowed a series of tests aiming at validating different resistance models available in literature. The input data was represented by the vegetation parameters collected before the hydraulic measurements. Different resistance models were run using the surveyed vegetation parameters, dividing the section in subareas with different geometric characteristics and vegetation patterns. Tests regarded different resistance models but also different roughness composition equations.

### **Results**

Average roughness coefficients resulted to be less than 10% different from the experimental ones, confirming the capability of channel modellization based just on morphological and vegetational surveys. The results of this work will be useful for water service managers to take decisions about the management of vegetation along the drainage systems of the area, and will be the base for upcoming research planned for the next months.



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*"Biosystems Engineering addressing the human challenges of the 21<sup>st</sup> century"*

## **TOPIC 6**

### ***POST HARVEST, LOGISTICS AND FOOD CHAIN EQUIPMENTS AND STRUCTURES***



Exploitation of technological innovations along the olive oil milling process for an optimization of the plant performance <i>Beghi R., Giovenzana V., Guidetti R., D'Antoni A., Menditto N., Cini E.</i> .....	136
Monitoring of the vegetables quality in large-scale mass distribution channel: the potential role of vis/NIR spectroscopy <i>Beghi R., Giovenzana V., Guidetti R.</i> .....	137
Comparison between two different pomegranate juice extraction systems <i>Catania P., De Pasquale C., Vallone M.</i> .....	138
3D finite element model of packaged frozen vegetable thawing <i>Cevoli C., Fabbri A.</i> .....	139
Evaluation of a mobile NIR spectrometer and cloud data analysis system for food quality rapid assessment <i>Cevoli C., Fabbri A.</i> .....	140
Performance testing of a full-scale ultrasound equipment for the extra-virgin olive oil industrial sector <i>Clodoveo M.L., Colonna M.A., Corbo F., Paduano A., Distaso E., Tamburrano P., Amirante R.</i> .....	141
Application of NIRs spectroscopy for rapid evaluation of grape health status directly at the grape consignment: comparison of measurement methods <i>Giovenzana V., Beghi R., Brancadoro L., Guidetti R.</i> .....	142
Influence of pressing temperature on hemp seed oil flavour <i>Sacchi R., Faugno S., Paduano A., Ardito L., Crimaldi M., Scala G., Sannino M.</i> .....	143
Investigating and modeling the effect of temperature and shelf life in osmotic solutions on qualitative properties of Button Mushroom ( <i>Agaricus Bisporus</i> ) <i>Hashemi S.J., Ebrahimi S., and Tabatabaee Reza</i> .....	144
Effects of modified atmosphere packaging on postharvest qualities of strawberry <i>Tabatabaeeekoloor R., Hashemi J.</i> .....	145
Machine vision algorithms for online raw material selection: classification of defective rocket leaves <i>Amodio M.L., Li Vigni M., Colelli G.</i> .....	146
Potential of hyperspectral imaging to predict quality and shelf-life of fresh rocket leaves to be used for fresh-cut processing <i>Chaudhry M., Amodio M. L., Colelli G.</i> .....	147
Olive oil extraction by microwave and megasonic combined technology <i>Leone A., Tamborrino A., Romaniello R., Xu Xin-Qing, and Juliano P.</i> .....	148
An innovative horizontal centrifuge for solid-liquid separation in a olive oil production plant <i>Romaniello R., Tamborrino A., Leone A.</i> .....	149



Engineering design and prototype development of a pilot scale pulsed electric field system for wine industry. <i>Amirante R., Mescia L., Cannone F., Bia P., Bonaventura C., Chiapperino M.A., Corbo F., Paduano A., Distaso E., Tamburrano P., Pantaleo A.M., Clodoveo M.L.</i> .....	150
Design and testing of a full-scale scraped surface heat-exchanger for the thermal conditioning of olive paste coupled with a passive malaxer <i>Clodoveo M.L., Colonna M.A., Giannico F., Corbo F., Paduano A., Pantaleo A.M., Distaso E., Tamburrano P., Amirante R.</i> .....	151
Drying behavior of organic apples and carrots by using k-means unsupervised learning <i>Moscetti R., Ferri S., Colantoni A., Massantini R.</i> .....	152
Experimental study of high-capacity two-phase decanter with different feed pipe position of olive paste <i>Bianchi B., Squeo G., Silletti R., Brunetti L., Natrella G., Nasti R., Caponio F., Catalano P.</i> .....	153
Real-time monitoring of apples ( <i>Malus domestica</i> var. Gala) during hot-air drying using NIR spectroscopy <i>Moscetti R., Ferri S., Monarca D., Cecchini M.</i> .....	154
Rotased - A Patented Innovative system for the clarification of Olive Oil <i>Altieri G., Matera A., Tauriello A., Genovese F., Di Renzo G.C.</i> .....	155
Modeling of a full-scale microwave system for tomato sauce processing <i>Bia P., Bonaventura C., Clodoveo M.L., Corbo F., Mescia L., Amirante R.</i> .....	156
Testing of ozone generating equipment to reduce ethylene during postharvest storage of fresh produce <i>de Chiara M.L.V., Amodio M.L., Simonelli R., Colelli G.</i> .....	157
Effects of the operating conditions of a microwave equipment on quality and safety of fresh-cut produce <i>de Chiara M.L.V., Antonetti E., Amodio M.L., Colelli G.</i> .....	158
Preliminary trials of one-pass windrowing of corn-stover with innovative corn header <i>Berruto R., Busato P., Sopegno A.</i> .....	159
CFD modelling and simulation for assessing temperature distribution inside flour mills during heat treatments for insect pest control <i>Porto S.M.C., Valenti F., Tomasello N., Cascone G., Arcidiacono C.</i> .....	160
Analysis of sanitary and physical qualities of maize grains stored in silo bags and in metallic silos <i>Prado da Fonseca G., Aguiar R. H., Fracarolli J. A.</i> .....	161
Use of the dynamic speckle for the analysis of maize seeds submitted to thermotherapy <i>Peixoto L. S., Silva G. M., Aguiar R. H., Fracarolli J. A.</i> .....	162
Maize Seeds Treated with Bioprotector and Evaluated through Biospeckle <i>Silva G.S., Peixoto L.S., Aguiar R.H., Fracarolli J.A.</i> .....	163



**Influence of the roughness of floor tiles on the cleanability from wheat flour residues in agri-food facilities.**

*Barreca F., Cardinali G., Borgese E., Fichera C.R. .... 164*



## Exploitation of technological innovations along the olive oil milling process for an optimization of the plant performance

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**Keywords:** Olive, paste, husk, malaxer machine, leaf conditioner, UV, vis/NIR spectroscopy

### Objectives

In literature, most of the scientific studies highlight the optimization of the oil production process considering only the quality aspect of the final product. This work aims to evaluate the production process also in terms of production yield and reducing waste of by-products with a view to enhancing the economic savings without leaving out the production quality aspect. In this work, in order to optimize the oil extraction process, some solutions in different critical points of the process were evaluated.

### Methods

The study focused on: (i) the use of a conditioning of olive tree leaves to reduce the leaves volumes deriving from the cleaning machine of the mill and to facilitate the humification process in order to obtain a by-product rich in nitrogen, a crucial lacking element in composting processes; (ii) the conditioning of paste temperature using a continuous malaxer machine to increase, in a short time, the temperature of paste during processing, and to limit the oxygen exposure thanks to the controlled conditions and no water addition; (iii) the feasibility of the application of UV treatment on olive washing water in order to reduce the microbial load for recycling water in the process and to minimize the water consumption, (iv) the application of vis/NIR spectroscopy in order to correlate spectral data, acquired on intact olives and on pastes, to the crucial parameters for an optimization of the process.

### Results

The use of olive tree leaves conditioner reduce the leaf volume deriving from the washing section by 40-50%, reducing the humification time and allowing an easier spreading in the field and significant amount of nitrogen in the soil. The use of the continuous malaxer machine, thanks to the useful operating conditions, is enabled to obtain the best performance on the extracted oil in terms of acidity, peroxides, polyphenols and tocopherols content. Moreover, the obtained husk results in a fewer moisture content (about 10%) respect to the husk deriving from the traditional process, allowing an easier disposal. Moreover, considering that the microbial load unchanged between unwashed olives and olives washed using traditional method, the use of UV treatment on washing water results promising and easily applicable to the plant. Regarding vis/NIR spectroscopy, the obtained results were encouraging for the prediction of chemical analysis (moisture, oil and sugars content), physical measurements (i.e. yield point force and total deformation energy) and Maturity Index parameters, demonstrating the feasibility of real-time prediction of crucial indices for the milling plant settings.



## **Monitoring of the vegetables quality in large-scale mass distribution channel: the potential role of vis/NIR spectroscopy**

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**Keywords: MDC, market, store, carrot, tomato, optical technique**

### **Objectives**

Today the vegetable market is controlled mainly by the "mass distribution channel" (MDC). The role of the MDC in the vegetable market is growing rapidly, but this phenomenon can represent a problem for the farmers because the market power results completely unbalanced in favour of MDC. Moreover, MDC's buyers nowadays have not useful and rapid instruments to evaluate the quality of the products. As a result, decisions taken by the buyers are driven mainly by price policy and not correlated with the product quality. For these reasons, simple, rapid, and easy-to-use methods for objectively evaluating the quality parameters of the vegetable products are needed. The aim of this work is to apply the visible and near infrared (vis/NIR) spectroscopy in order to estimate the qualitative parameters of two case studies of low-price products (carrots and tomatoes) coming from different Brands and evaluate the applicability of this technique directly at the stores.

### **Methods**

A non-destructive optical system (vis/NIR spectrophotometer with a reflection probe, spectral range 430-1650 nm) was tested. The samples were purchased at 13 different MDC stores of the Milan hinterland. It was studied the difference among the products sold in different stores and among the dates of purchase to analyse the quality of carrots and tomatoes. The reference quality parameters (firmness, water content, soluble solids content, pH and color) were correlated to the spectra. Qualitative (Principal Component Analysis, PCA) and quantitative (Partial Least Squares, PLS) analyses were applied on carrots and tomatoes spectra in order to calibrate regression models and to test the prediction performance of the vis/NIR device.

### **Results**

Results showed a substantially standardized quality along time with no differences among dates, while a significant difference regarding quality parameters can be noticed among the different Brands. The PLS models deriving from the optical data gave positive results, in particular for the prediction of the soluble solids content and the color (better results for tomato). In conclusion, the application of optical techniques could be of help for the vegetable sector for an easier monitoring of the products quality and it could therefore lead to an effective optimization of the entire supply chain. Moreover, the MDC could provide a better service for consumers with the final aim to be more competitive on quality also towards foreign competitors.



## Comparison between two different pomegranate juice extraction systems

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**Keywords: antioxidant power, nutraceutical properties, pneumatic press**

### Objectives

Pomegranate juice (PJ) has got many health properties due to the anticarcinogenic, antimicrobial and antiviral compounds of pomegranate fruits. Its consumption have greatly increased throughout the world in recent years due to the potential of its different components, polyphenols and anthocyanins among all. Many studies have been performed on the pomegranate juice yield demonstrating its influence on the organoleptic and physicochemical properties of the juice. Commercial pomegranate juice production involves pressing the fruits. As a consequence, there is a need to investigate the pressing machine types and adjustment in order to maximize juice yield and enhance its health properties. The aim of this study was to assess the influence of the pressing system on the pomegranate juice yield and properties.

### Methods

Pomegranate fruits of the Wonderful One variety were manually harvested in November 2015 and mechanically processed to extract juice within 24 hours of harvesting. Two different pressing systems were used. The first one was a hydraulic pressing machine where the fruits were put after being sliced in half; the second extraction method consisted in using a destemming machine for the entire fruit followed by a pneumatic press, very similar to those typically applied in grape processing. The pneumatic press was set up to make 6 pressing cycles with pressures from 0.3 to 1.6 bar. The duration of the whole pressing phase was 70 min. Each extraction cycle was maintained for 3 minutes. Before applying the first pressure level, two juice samples were taken respectively after drainage and after settling of the previous one. A whole sample was taken at the end of the process, coming from the whole juice extracted by the entire process. The tests were performed in triplicates. Pomegranate Juice (PJ) yield (%) was calculated and pH, Total Soluble Solid (TSS), Titratable Acidity (TA), Total phenolic content, radical-scavenging ability (RSA), and Total anthocyanins were determined. Chemical analyses were performed on three samples for each case of studies within one week from extraction. The data were subjected to ANOVA and Tukey's test to evaluate the statistical significance of the tests at the 95 % confidence level.

### Results

The juices obtained with the two systems were analyzed and compared in order to identify the best extraction technique.

The plant with the pneumatic press gave a PJ yield about 15 % higher than the system which involved the use of the hydraulic press; pH, ° Brix and titratable acidity showed the same values for both types of machines. Antioxidant power inhibition of PJ coming from the pneumatic press was 28 % higher than the product coming from the hydraulic press.



## 3D finite element model of packaged frozen vegetable thawing

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**Keywords:** numerical model, heat transfer, frozen vegetable

### Objectives

Among all food preservation methods, freezing is the most important operation for long-term preservation of food qualities. The time-temperature tolerance of frozen products is the most important factor responsible for the final quality of products. Temperature variation vs. time within a food product can be determined experimentally. However, experimental tests can be often time consuming and difficult to set up. Numerical heat transfer models are considered to be an alternative valuable tool to estimate food temperature change even under wide thermal environment fluctuations. The aim of research was to develop a 3D parametric finite element model to evaluate how the temperature field inside a frozen products (e.g. peas, grilled eggplants and spinach cubes) is affected by environment temperature.

### Methods

The heat transfer by conduction and convection, inside and on the surface of the packages, was considered in a finite element model. An *apparent specific heat* was used to describe both the specific heat of the product and the released latent heat, during the phase transition.

### Results

Numerical results and the experimental test were in good agreement. The percentage differences between calculated and measured temperature values (at product core, as maximum value during the thawing process) were 1.4, 4.5 and 3.7 %, for peas, spinach cubes and grilled eggplant, respectively. The model made possible to evaluate the temperature distribution inside the whole package and not only in specific points. It was also possible to identify the thermally most critical area (bottom zone). The relation between calculated temperatures ( $z$ ), ambient temperature ( $x$ ) and time ( $y$ ) was investigated. A good fit ( $R^2 > 0.97$ ) was obtained by using the following equation:  $z = a + (x^b + cy)/(e + xd + y)$ , useful for industrial purposes. Furthermore, specific exponential relations were determined to identify the time required to reach the initial thawing temperature at the critical area, over the ambient temperature.

\* The author propose this work as short oral presentation (e-poster). Conference topic 06: Post harvest, logistics and food chain equipment and structures.



## Evaluation of a mobile NIR spectrometer and cloud data analysis system for food quality rapid assessment

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**Keywords: NIR spectroscopy, portable devices, food quality, multivariate statistical analysis**

### Objectives

In recent years a significant increasing of the interest for food quality was observed both in industrial and consumer environment. Near Infrared spectroscopy (NIR) is one of main techniques used in industry to determine food quality parameters in a rapid and nondestructive way. However the common NIR tools are expensive and hard to use. Recently, some simple and cheaper NIR spectrometers are becoming more common. Particularly the SCiO solution (ConsumerPhysics, Inc) combines two powerful technological components, the SCiO NIR sensor, and the SCiO cloud. The SCiO sensor is a low cost (about 250\$) handheld NIR spectrometer (700-1100 nm) that fits in the palm of the hand and transmits the spectra, via bluetooth, directly to a smartphone app. The SCiO cloud can stores a huge database of spectral data and provides the statistical models for their interpretation. After collecting the required spectra, a specific web tool (SCiO Lab) can be used to analyze the data, and generate the model. The aim of this research was to evaluate the performance of the SCiO System for the determination of quality parameters of some common foodstuff.

### Methods

Vegetable (apples, peaches and pistachio), bakery (bread), diary (milk and cheese) and confectionary (chocolate) products were analyzed by using SCiO sensor and a common NIR tool (MATRIX TM-F, Bruker Optics). To estimate specific qualitative parameters (e.g. fat, carbohydrate and protein content), classification and predictive statistical models (PCA and PLS) were developed by using SCiO Lab tool and a commercial multivariate statistical software (Unscrambler 9.7).

### Results

Similar results were achieved by using SCiO and classical NIR. In general, good models were obtained for all food products. As concerning the dairy products, fat content was predicted by a  $R^2$  of 0.947 and 0.952 for milk (fat range: 0-3.5%, RMSE=0.28%) and cheese (fat range: 5-35%, RMSE=1.8%), respectively. Samples belonging at five type of bread (white, cereal, integral and durum wheat) were corrected classified (97%) and the carbohydrate content (37-48%) was estimated by a  $R^2=0.937$  (RMSE=1%). Optimal results was achieved for the cacao percentage (46-99%) in chocolate bars ( $R^2=0.979$ , RMSE=2.3%). Results obtained for the fruits are slightly lower, probably due to the high heterogeneity of the product and to the unsuitable sampling (restricted reference value range). For the peaches, soluble solid content was determined with a  $R^2=0.765$  (RMSE=0.459°Brix), while five type of apples were classified with a performance index of 89%. Considering the final consumer demands, the SCiO solution appears a suitable instrument for a rapid evaluation of some food quality indexes.



## Performance testing of a full-scale ultrasound equipment for the extra-virgin olive oil industrial sector

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**Keywords: Extra Virgin Olive oil, Ultrasound, Full-scale plant, Process Efficiency, Oil yield.**

### Objectives

The basic principles applied also in the newest olive oil industrial plants still follow the technical knowledge which have been empirically learned by humans thousands of years ago. In fact, it is well known that three factors, mixing, water adding and warming, are the three macroscopic driving forces able to favour the separation of the oily phase from the mass of crushed olives. The perseverance into the optimization of existing machines composing the virgin olive oil extraction line offers reduced margins for the performance increment of the process. The aim of the experimentation supported by EU through the Apulia Region by means the project "Perform Tech (Puglia Emerging Food Technology) was to develop an innovative full scale device, based on the application of high power ultrasound into the olive paste, useful to reduce the malaxing time or replace the malaxing phase. In fact, the malaxation is considered the weakest link of the chain in the extra virgin olive oil extraction process. The malaxer is a batch machine, which works between two continuous devices, the fruit crusher and the decanter. It is also a bad heat exchanger due to a not favorable ratio between the volume of olive paste and surface for the heat exchange. The aim of this paper is demonstrate that the new ultrasonic reactor, named sono-heat-exchanger, placed between the crusher and the malaxer is able to obtain a simultaneous increment of both oil yield and quality.

### Methods

The performance of the sono-heat-exchanger thermal was measured in terms of heat exchanger efficiency, and mechanical effect obtained by means the measurement of the pigments concentration in the product. The effects of the innovative device were also evaluated in terms of extra virgin olive oil yields and quality, evaluating the main legal parameters, the polyphenol and tocopherol content, and the volatile compounds concentration.

### Results

The application of ultrasounds showed both mechanical and thermal effects. The ultrasound technology is able to induce the rupture of cell walls, recovering the oil and minor compounds, increasing the work capacity of the extraction plant and reducing the process time. Is the first time in the history of the development of the olive oil industrial machines that this goal has been reached. Usually these two parameters are inversely correlated.



## **Application of NIRs spectroscopy for rapid evaluation of grape health status directly at the grape consignment: comparison of measurement methods**

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**Keywords: Quality, Optical analysis, winery, chemometrics**

### **Objectives**

The grape selection at the check point station entering the winery is a particularly delicate phase to obtain a qualitatively good product, especially for big companies such as cooperatives with a high number of partners. The aim of this work was to investigate the applicability of NIRs spectroscopy for rapid grape infection assessment in a view of a grape classification directly at the check point station entering the winery.

### **Methods**

The experimentation was conducted on white and red wine varieties, using grape bunches naturally infected with *Botrytis cinerea*, powdery mildew (*Erysiphe necator*) and sour rot, the major grape diseases. The research tested two devices: (i) a compact vis/NIR device for analysis of flows and/or non-homogeneous product. The system is capable to perform measurements in reflection at a variable distance between sensor and sample of 80-600 mm, in the spectral range vis/NIR (400-1650 nm). Spectral measurements were carried out on healthy (48 %) and diseased bunches (52 %), for a total of 2559 spectral acquisitions and (ii) a vis/NIR and NIR device (spectral range 430-1650 nm) suitable also for liquid matrices. The acquisitions, using a reflection probe, were carried out on must samples consisting of healthy (51 %) and diseased (49 %) grapes, for a total of 159 spectral acquisitions. Qualitative (Principal Component Analysis, PCA) and quantitative (Partial Least Squares – Discriminant Analysis, PLS-DA) analyses were applied on grape and must spectra in order to test the performance of NIRs devices to classify healthy and infected samples.

### **Results**

The results obtained from PLS-DA models, in validation, gave a positive predictive value (PPV) of classification between 89.8% and 94.0% for grape and between 70.5 and 87.5% for must.

Overall, chemometric models deriving from the elaboration using grape spectra are better than models calculated using must spectra. In a view of a possible future application in operative conditions of the two tested devices, some issues have to be kept into account: (i) regarding the grape monitoring, the analysis concern only the surface of the wagon and it may results in a not representative investigation; while for the must analysis the monitoring is representative of the whole grape mass due to the sampling method (using a coring and cutting device usually implemented in big wineries), (ii) the sample number used for calculating the PLS-DA models from grape spectra is more than 10 times higher than that from must acquisitions. Enhancing the number of must samples, the classification models could improve their performance.



## Influence of pressing temperature on hemp seed oil flavour

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**Keywords:** hemp oil, mechanical oil extraction, oil acidity, peroxide value, sensory analysis

### Objectives

For pressed seed oils, as well as in virgin olive oils, the sensory properties have a great importance to define oil perceived quality. The pressed oils are subjected only to filtration, without the application of refining processes normally used for all solvent-extracted edible oils. This way, flavor and sensory notes of pressed oil reflects the kind of used seed, the quality-freshness of seeds and the post-harvesting history, the pressing technology and conditions used during oil extraction. This work was designed to evaluate the effect of pressing temperature on extraction yield, sensory properties and flavor composition of pressed hemp (*Cannabis sativa* L.) oils. Volatile compounds, studied by SPME-GC/MS, showed clear differences in oils obtained at 50°C and 70°C as well as the seed pre-heating step have an effect of volatile and sensory profile.

### Methods

In this study, dried hemp seeds ('USO 31' variety) have been used. The hemp oil was obtained with a mechanical screw press. Different sensors were installed for measuring temperature, rotation speed of the screw and oil yield. The sensors were connected to a data-logger and data transferred to a laboratory computer. The oil was centrifuged in a laboratory centrifuge at 3500 rpm for 20 minutes in order to remove components that settled during storage. Hemp oil acidity (% oleic acid/100g oil) and peroxide value (m<sub>eq</sub>O<sub>2</sub>/kg oil) were carried out according to the EC Reg.2568/1991 and later amendments. Sensory analysis was carried out by eight assessors who were fully trained in the evaluation of VOO according to the IOOC method (1996) for virgin olive oils. Analysis of fatty acid methyl esters (FAMES) were carried out by cold trans-methylation in KOH/methanol. A headspace solid-phase micro-extraction (HS-SPME) method coupled to gas chromatography-mass spectrometry (GC/MS) has been applied for profiling volatile compounds.

### Results

The free acidity showed a significantly higher value in the samples obtained at a higher temperature while the peroxide values were not influenced by the extraction temperatures. The different extractive conditions do not affect the relationship between the fatty acids. A first assessment of the sensory attributes of hemp oils by tasters showed the presence of notes of "green-grass", "hay-straw", "woody", "toasted-cooked-roasted", "hazelnut", "pumpkin-like", "cucumber-like". Oils obtained at lower temperature showed a lower concentration of volatiles except to furan-2-methyl. Hemp oils extracted at a temperature of 70°C, on the contrary, appear characterized by a high level of volatile compounds.



## **Investigating and modeling the effect of temperature and shelf life in osmotic solutions on qualitative properties of Button Mushroom (*Agaricus Bisporus*)**

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**Keywords: modeling, mushroom, osmotic solution, temperature**

### **Abstract**

The Button Mushroom (*Agaricus Bisporus*) includes the highest production of edible mushrooms in the world and its production rate is about 40% of the global production of edible mushrooms. Due to high moisture, the increase of its storage and shelf life should be critically attended. The purpose of modeling is to choose the most appropriate method for drying and the best operating conditions for producing the mushroom. First, mushroom is cut into uniform vertical slices of 5-mm-thickness and soaked in 1% citric acid solutions. During osmotic drying process, samples were removed from the solution under the effect of concentration at 3 levels (25%, 35% and 45% w/w) and temperature at 3 levels (40°C, 50°C and 60 °C), and in 14 consecutive times from 10 to 300 min. Reducing the variations of osmotic pressure and concentration between mushroom and osmotic solution, the driving force mass transfer, the intensity of moisture, and the brix increase will gradually reduce. At higher concentrations of sucrose in constant temperature and weight ratio, the absorption of solid substances rises by concentration increase. The absorption amount of solid substances has an increasing trend by temperature rises on the passage of time. According to kinetic of brix and result of water removal and absorption of solid substances during time, the high values of R<sup>2</sup> indicates that a model that proposed by Aurora et al. is suitable for predicting the percent of solid substances absorption and water removal.



## Effects of modified atmosphere packaging on postharvest qualities of strawberry

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**Keywords: Modified atmosphere packaging, Quality, Strawberry,**

### Objectives

Preserving the postharvest quality of fruit and vegetables in the short and long term is one of the most important challenges of postharvest process. In this research, the effects of packaging type, modified atmosphere and temperature on the postharvest quality and storage time of strawberry were investigated during storage.

### Methods

The fresh strawberry fruits were picked up in May 2016 from the Sari Agricultural University green house in Caspian Sea region in Iran. After cleaning and sorting, the samples were transferred to the post-harvest laboratory and stored at 4°C for further analysis. Polyethylene packaging bags with two thicknesses of 30 and 50 µm with oxygen permeability of 35 and 45 cm<sup>3</sup>/ m<sup>2</sup> were used respectively and six strawberries, approximately 100 g, were placed in polyethylene packages. Three different gas compositions (MAP1; 10% O<sub>2</sub>+15% CO<sub>2</sub>+75% N<sub>2</sub> and MAP2; 15% O<sub>2</sub>+10% CO<sub>2</sub>+75% N<sub>2</sub> and control), were applied with the modified atmosphere packaging machine (Model; DZQ-400RE) combined with a triple gas mixer. Then the samples were stored at two temperatures of (4±1)°C and (8±1)°C for 20 days. Several quality parameters of strawberry such as weight loss, firmness, soluble solids, titratable acidity and pH were measured.

### Results

The results indicated that the effect of most treatments on the measured factors were significant. The weight loss and firmness in MAP1 and thickness of 50 µm was lower than other treatments. The temperature and gas compositions also had significant effect on the firmness. Preservation of soluble solids and titratable acidity in MAP2 and 4 °C was better than MAP1 and control. The PH was preserved better at 4°C and MAP1. The samples stored in MAP1 maintained their texture and appearance better than those packaged under MAP2 and control. The strawberry stored in a polyethylene package with a thickness of 50 µm maintained the quality much better than 30 µm due to small micro pores and less transpiration and evaporation. Also, storage temperature of 4 °C maintained the quality of strawberry much better than 8 °C due to slow down metabolic activities. In general, strawberry stored at packages with 50 µm thickness, MAP1 and temperature of 4 °C resulted in better quality preservation and longer storage time.



## **Machine vision algorithms for online raw material selection: classification of defective rocket leaves**

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**Keywords: PCA, wavelet, PLS-DA, discrimination**

### **Abstract**

In fresh-cut processing companies the quality evaluation of incoming raw material is subjectively evaluated by the operators applying rating scales (from 3 to 5 points) for the main quality attributes (colour, defects, decay, and wilting) and/or calculating the incidence of particular defect on a representative samples. Consequently the product is rejected or accepted, and eventually in presence of major problems, the priority of processing is assigned. Therefore many companies are looking for possible alternative systems for the evaluation of the quality in a faster, automated, non-destructive, and more objective way. Objective of this work was the discrimination of fresh leaves with no defects (regular) from leaves presenting different kinds of imperfections. To this aim images of different classes of defects were acquired with a digital camera. Defective classes included yellow, rotten, top-burned, broken leaves, and other kind of shape related defects, including flowered, long-stem leaves, and shootings. Two different algorithms were developed, one aimed to describe morphological defects (shape/dimension) and a second one focused on pixel features related to color and texture. Shape, area and axes dimensions of normal leaves were used to build a 'regular condition' PCA model which could be used to reject defective leaves based on Q residuals and hotelling  $T^2$ . This model showed satisfactory ability to recognized defective leaves. As for the other defects a wavelet based feature extraction method was applied to selected regions of interest representative of each defect in order to consider both color and texture proprieties. A PLS-DA approach was then used to discriminate pixels of test images according to 4 classes (background, rotten leaves, other defects, and normal leaves). Results showed that color based defects were easier to detect if compared to other textural ones as rotten leaves showed a representative presence of green pixels. Further research investigation may be aimed to improve the classification ability of the developed algorithms and to optimise the methods for the online implementation.

Preferred type of presentation: oral



## Potential of hyperspectral imaging to predict quality and shelf-life of fresh rocket leaves to be used for fresh-cut processing

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**Keywords: shelf life, sensorial, PLS, PLDA, marketability**

### Abstract

Wild rocket (*Diplotaxis tenuifolia*) is one of the most popular leafy vegetable in Europe, often eaten raw, alone or in mixed salads. One of the major postharvest attribute that directly affects the marketability of the rocket leaves is the color which is prone to rapid senescence or yellowing. A preliminary study was conducted to investigate the potentiality of hyperspectral images (HSIs) in the Vis-NIR range combined with chemometric tools for the estimation of the potential shelf life of rocket leaves. Three experiments were conducted in order to collect different raw material. For each experiment, rocket leaves were packaged in polypropylene (PP) bags with passive modified atmosphere (MA), simulating commercial conditions, and stored at 5°C. Each trail comprised 70 bags of 50g each, with 10 bags per evaluation time, which were opened over storage for sensory evaluation by a trained panel of 5 members. A 5 point scale was used both for appearance (5=fresh; 3=limit of marketability; 1=not edible) and off-odor (1=no off odor; 3=limit of marketability; 5=strong off-odor). HSIs of 10 rocket leaves per bag were acquired using a Multi-Purpose FT-NIR analyzer (Bruker Optics, Ettlingen, Germany). PLSDA was used to classify the samples based on the visual scores using 179 spectra (69, 70 and 40 for each HT respectively) with a non-error rate of 71.3% in the calibration (61% in CV), correctly classifying 152 out of 179 samples for various classes. In order to estimate the potential shelf-life (number of days to reach score 3 for visual appearance and off odors), a PLS calibration model was developed based on 30 initial spectra. For appearance models  $R_{cal}^2$  of 0.89 and  $R_{cv}^2$  of 0.86 with the RMSEC and RMSECV of 1.58 and 1.73 respectively were achieved. The calibration model developed for shelf-life based on off-odor scores yielded higher values of RMSEP=3.54 and RMSECV=3.63 and lower values of  $R^2$  i.e. 0.78 and 0.76 for calibration and CV, respectively. The study provided good potential results for the further studies of the potential of hyperspectral imaging for shelf life prediction and marketability categorization of rocket leaves.

Preferred type of presentation: poster.



## Olive oil extraction by microwave and megasonic combined technology

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**Keywords: microwave; olive oil; malaxation; rheology; megasonic.**

### Summary

Malaxation step is a lengthy batch operation in the traditional olive oil extraction, consisting of kneading and shearing the olive paste for up to 30-45 min.

The aim of the experimentation was to evaluate the possibility to shorten the olive paste conditioning, to permit the process continuity by using the microwave heating and megasonics technology.

An industrial microwave prototype was installed in a commercial olive oil plant for continuous conditioning of the paste, bypassing malaxation, followed by a flow-through megasonic vessel prototype connected to the decanter. Four processing scenarios were evaluated: (a) traditional malaxation for 30 min (control), (b) microwaves (MW), (c) traditional malaxation followed by a megasonic treatment (MS), and (d) microwave conditioning followed by a megasonic treatment (MW + MS). The average olive oil yield obtained from non-malaxed olive paste treated by microwaves, showed no significant difference with respect to the yield obtained by traditional processing, including malaxation. Yields showed increased extractability ( $P < 0.05$ ) after exposing the microwave-treated and malaxed paste to a megasonic field by 1.98% and 2.25%, respectively. The oil content in the pomace verified the yield trends observed. Both microwave and megasonic treatments reduced the consistency of the paste.

Quality parameters specific for definition of virgin olive oil quality (free acidity, peroxide value, K232, K270) were within the international specifications. Considering the total phenols there are no significant differences between MW and control despite the short time of treatment with microwave compared to traditional malaxation and between MS and control. Finally, there is a significant increase in total phenols when the MW + MS combination is used compared the other thesis.

This study for the confirms demonstrates the ability of microwave processing to substitute the malaxation process industrially and for the first time demonstrates the ability of a subsequent megasonic intervention to further aid the process towards increased yields.



## **An innovative horizontal centrifuge for solid-liquid separation in a olive oil production plant**

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**Keywords: mathematical modeling; olive oil; decanter**

### **Summary**

A new model of horizontal centrifugal decanter was tested to retrieve its performances' parameters. The machine belongs to the decanter's pâté generation. The experimental tests were performed in a mill working at plant's nominal mass flow rate. It was tested the functionality of the decanter using two different configurations: WA (using the water addition) and WW (do not using the water addition). The machine has the possibility to work in 2-phase and 3-phase configuration with and without water added. Because these machine's characteristics, the aim of this experimentation was to test the ability of this machine to work correctly in all configurations. Several tests were conducted and a lot of oil, husk and pulp were collected to perform quantitative analyses. To describe the behaviour of the machine, a mathematical model was built to predict the extraction efficiency and the oil content in the husk, wastewater and pâté, respectively, as a function of the olive paste's mass flow rate. The mathematical model was calibrated and tested using some statistical parameters (mean, percentage error, mean bias error, root mean square error, modelling efficiency and chi-square test).

The extraction efficiency reached values higher than 90%, working in WA condition. Moreover, in both conditions considered (WA and WW) it was been obtained dry solids and olive oil clarified by light solids. The decanter also demonstrated to be able to switch from one configuration to the other without stopping operation. This result shows the possibility to adjust the decanter settings in on going operation, without time losses. Finally, the mathematical model shows high generalisation capability, than it can predict the residual oil in husk, wastewater and pulp in several decanter conditions.

This type of decanter represents an important innovation that could convert wastewater with no current economic value to a by-product with economic value when coupled with improving technologies for the use of pâté for the production of biogas or for human or animal feeding. This machine could avoid or significantly reduce the influence of wastewater management on the production costs of oil and on the environment.



## Engineering design and prototype development of a pilot scale pulsed electric field system for wine industry.

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**Keywords: Electroporation, Phenolic compounds, Grape, Pulse generator.**

### Objectives

Pulsed electric fields (PEFs) technology is a novel non-thermal food processing technique ensuring good product quality and energy use efficiency. The capability of PEFs to accelerate by electroporation the release of intracellular compounds into cell surroundings offers potential applications in the production of grape wines. In order to meet these requirements, a pilot scale PEFs treatment system has been designed, constructed, manufactured and tested. The developed system is flexible since it allows the full control over the main electric pulse parameters such as intensity, shape, duration, number of pulses and duty cycle. In the actual configuration it can handle low volume and laboratory scale flow rates. However, it could be easily scaled up to the higher food processing flows.

### Methods

The PEFs treatment system is based on high voltage (HV) solid-state pulse generator and a parallel plate static treatment chamber. The HV MOSFET-based wave generator is a fast switching element allowing operation with voltages ranging from 0.7 V to 1 kV. Moreover, it could operate i) using a 15 VDC, ii) with variable pulse durations from tens of nanoseconds to hundreds of microseconds, iii) with variable pulse repetition rate of 1 kHz to 50 kHz. The HV module is compact, portable and provides the reliability and the process consistency compatible with commercial PEF systems. In particular, the designed HV pulse generator can be structured in three building blocks: 1) low power pulse generator block, 2) high voltage source block, 3) switching block. Such design approach make possible an easy integration with industrial automation systems, the scale up to higher voltage and power delivering by only change the high voltage source block and a reduced maintenance costs.

### Results

Several electric tests have been carried out to check and stress the device performance. The obtained results highlight a reduced power consumption as well as the overall costs. Moreover, some preliminary experiments confirmed the feasibility of such device for wine industry.



## Design and testing of a full-scale scraped surface heat-exchanger for the thermal conditioning of olive paste coupled with a passive malaxer

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**Keywords: heat exchange, energy efficiency, malaxer, olive oil extraction process**

### Objectives

The aim of the project was to design and test a low-cost and high-efficiency system composed by a scraped heat-exchanger coupled with passive malaxers. The developed system is useful to warm up and knead the olive paste simultaneously. Respect to the heat-exchangers already commercialized, this prototype is equipped with a scraping blades that increase the convective movements, reducing the process time, optimizing the sustainability of the continuous olive oil extraction system. The innovative device, placed downstream the crusher, was dimensioned to allow a fast worming up the olive paste reducing the malaxing time. The passive hermetic malaxer is a cylindrical tank equipped with rotating blades. Respect to the traditional malaxer, the passive one is built excluding the water jacket simplifying the constructive aspects. Both the heat exchange and the passive malaxers are thermally insulated to avoid any possible thermal losses towards the external environment, including all the pipes through which the olive paste passes when already heated. The thermal conditioning allows both cooling and warming.

### Methods

The thermal power transferred to the olive paste can be calculated knowing its mass flow rate, the specific heat capacity and the difference of temperature between outlet and inlet. Assuming that the thermal losses towards the external environment are negligible thanks to the efficient thermal insulation, the amount of heat power transferred to the oil paste can be considered equal to the amount of heat power taken from the water stream. The thermal power to be exchanged between the oil paste and the water flux needs to be achieved by using an appropriate heat transfer surface area. In fact, the value of the thermal power is equal to the global heat exchange coefficient multiplied by the overall heat transfer surface area and the logarithmic mean temperature difference. With regard to the global heat exchange coefficient, it depends on the convective coefficients of water and olive paste. The convective coefficients of olive paste depends on scraper velocity. This consideration depends on the possibility to retrieve the Nusselt number from the Reynolds number. The thermal power loss from the passive malaxer can be evaluated by means of the Fourier's Law.

### Results

The innovative low cost device (TRL9) allows a fast worming up the olive paste reducing the malaxing time and with a minor energy employment, assuring satisfactory oil yields.



## Drying behavior of organic apples and carrots by using k-means unsupervised learning

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**Keywords: hot-water blanching, microwave blanching, carrots, apples**

### Objectives

Drying prevents food spoilage and decay through moisture removal due to simultaneous heat and mass transfer from food, which may be stored for long period with minimal deterioration occurring. However, drying technology is not always paired with good/excellent organoleptic, nutritional and/or functional properties of food. In fact, during drying the heat-sensitive substances are often destroyed and degradation processes may be exacerbated due to various and concurrent reaction mechanisms. Based on authors' best knowledge, drying degradation kinetics of biological materials are usually pseudo first-order or first order reactions (i.e. carotenoids degradation in carrots) and may be affected by the initial quality of the product itself. Therefore, the main objective of the proposed study was to investigate the feasibility of *k*-means unsupervised learning to proactively monitor quality change in organic apples and carrots during hot-air drying. Based on authors' best knowledge, fruit and vegetables drying has been widely addressed in literature; nevertheless, little insight is available on smart drying, while knowledge of its potential use in the organic sector is totally lacking.

### Methods

Organic apples (*Malus domestica* B. var. Gala) and carrots (*Daucus carota* var. Romance) were both purchased from a local organic trader and stored at 4±1°C until processing. Apple and carrot samples were both prepared by washing, peeling and cutting them into discs of 5-mm thick. Samples free from decay and/or blemish were used in the experimentation to perform (1) hot-water and microwave blanching pre-treatments and (2) 8-h hot-air drying tests. Apples and carrots were dried at 60 and 40°C, respectively. Batch sampling was performed at 0, 1, 2, 3, 4, 5, 6, 7 and 8 h drying. Each batch was subjected to the analysis of CIELab color, moisture content, water activity, soluble solids content, titratable acidity and pH. Subsequently, *k*-means cluster analysis was performed to determine the number of drying phases on the basis of the observed drying state variables. The best cluster level was chosen as solution at which the actual sum of squared error (SSE) differed the most from the random SSEs. Random SSEs were computed from 300 randomized versions of the original dataset.

### Results

Results were useful to identify drying phases as clusters, performing a *k*-means unsupervised analysis of the drying state variables. The proposed methodology showed very-good (> 90%) selectivity and sensitivity for each drying phase, regardless the pretreatment used. Thus, the method lays the foundations for further researches aimed to the development of accurate and automated drying control systems.



## Experimental study of high-capacity two-phase decanter with different feed pipe position of olive paste

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**Keywords:** Two-phase olive oil extraction, Decanter, Feed pipe position

### Objectives

Different positions of the decanter feed pipe were tested during continuous two-phase olive-oil production. The objective was to evaluate the most proper position of the olive paste feed zone during two-phase process, in relation to the oil yield and the separation efficiency.

### Sampling

The experimental tests were carried out in a cooperative oil mill in the province of Bari, Apulia, equipped with a plant for continuous extraction in two-phase with a maximum operational capacity of 9000 kg/h. During the harvest season 2016-2017, three independent and consecutive trials were made on homogeneous olives batch. After crushing and malaxing at 26-28 °C for 90 min, the olive paste was sent to the decanter, working at a constant flow rate of 6000 kg/h and a differential speed ( $\Delta n$ ) of 25. Three different positions of the feed pipe were tested, measured in regard to the flange section exits of the liquids: 82.5 cm (position 1); 61 cm (position 2); 52 cm (position 3).

Olive pastes, pomaces and the oily phases were sampled from the malaxer and the decanter, respectively.

### Results

The malaxed olive pastes from the different trials showed similar values of viscosity, as expected.

Regarding the oil yield, lower percentages of oil in the olive pomace were detected relatively to the position 3. More precisely, the mean percentages of residual oil in the olive pomace were: 3.60% position 1; 3.24% position 2; and 2.96% position 3. However, when the decanter feed was set in position 3, the resulting oily phase, collected at the decanter exit, showed higher water and sediments content.

The interpretation of the above stated results leads to affirm that the tendency of the manufacturers of these machines to maintain a position of the feed zone of the olive paste in a section next to the conical section, can be considered as valid only in the three phases processing; in fact, moving away from the diffuser, the solid content in the liquid decreases, up to the point at which the liquids leave completely clarified by mat unloading and the olive pomace exits from the opposite side of the bowl sufficiently dehydrated. On the contrary, in two-phase process, the light phase constituted by the oil must be removed immediately from the machine as soon as it is separated from the wet pomace; in feed zones more distant from the liquids discharge ports, is more frequent that there might have oil leaks in the olive pomace, since there is not the water-oil interface.



## Real-time monitoring of apples (*Malus domestica* var. Gala) during hot-air drying using NIR spectroscopy

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**Keywords: smart drying, convective air drying, partial least squares regression, discriminant analysis, feature selection**

### Objectives

Among commercial fruits, apple shows a growing trend to its worldwide consumption, where dried apple plays a major part in food industry as raw material. Despite apple tissue exhibits extensive and non-homogeneous discoloration during drying, it is nowadays often dried by conventional methods which, however, are usually uncontrolled and then prone to product quality deterioration. However, because not all conventional drying treatments are allowed by the European Organic Regulation (i.e. EC No. 834/2007 and EC No. 889/2008), drying of organic apples should be carefully optimized to obtain comparable results to conventional methods. Therefore, the main objective of the proposed study was to investigate the feasibility of near-infrared (NIR) spectroscopy as smart drying technology to proactively and non-destructively detect and monitor quality change in organic apple wedges during hot-air drying.

### Methods

Organic apples (*Malus domestica* B. var. Gala) were purchased from a local organic trader and stored at 4±1°C until processing. Apple wedges, without core and peel, were prepared by washing and cutting fruit into discs (5-mm thick) and subsequently cutting each disc into quarters. Samples were subjected to 8-h hot-air drying and batch sampling was performed from 0 to 8 h drying with steps of 1 h. Each batch was subjected to both NIR spectral data acquisition (range 1100-2300 nm, 2-nm resolution) and determination of CIELab color, moisture content, water activity, soluble solids content, titratable acidity and pH. PLS (partial least squares) regression models were computed to changes in state variables, while PLS-DA (partial least squares discriminant analysis) was used to assign each apple wedge to a specific dehydration phase based on its spectral profile. Interval PLS (iPLS) and PLS-DA (iPLS-DA) algorithms were also used to perform feature selection with the aim of reducing the number of wavelengths of each prediction model.

### Results

The feasibility of using NIR spectroscopy as an automated, non-destructive and rapid method to measure state variables of apple wedges during drying was demonstrated. PLS models showed excellent performance metrics for moisture ( $r^2=0.98$ ), water activity ( $r^2=0.97$ ), chroma ( $r^2=0.85$ ) and soluble solids content ( $r^2=0.96$ ) prediction. PLS-DA models allowed recognition of drying phases with a total accuracy of 96.03%. Both regression and classification models based on few wavelengths (i.e. iPLS and iPLS-DA, respectively) showed metrics comparable to models obtained from the full spectrum.



## **Rotased - A Patented Innovative system for the clarification of Olive Oil**

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**Keywords: Olive oil quality, Polyphenols,**

### **Objectives**

In this paper, authors show the design criteria and operation of an innovative clarification system named Rotased. Olive oil quality is strictly related to the extraction process, which consists of the breakage of olive fruits to obtain a paste that is firstly malaxated and then centrifugated to obtain an oily must, which still contains small amounts of residual vegetative water and impurities, so a further stage is required to improve the clarification, generally performed by a disc stack separator. Recently some authors showed that using the disc stack centrifuge, negative effects are produced on olive oil quality, due to the loss of stability and oxidative reactions.

### **Methods**

The effects of Rotased on olive oil quality was assessed in terms of chemical/physical properties, through comparative tests carried out in an olive oil mill. At regular time intervals during the olive oil extraction process, the following samples were collected: Control (oily must samples collected from the decanter), Sedoil (samples collected from Rotased) and Cenoil (samples collected from the traditional vertical disc stack separator).

Within 48 hours after the treatment, and after 5 months, the following parameters were evaluated: free acidity (FA), peroxides (PV), chlorophylls (Chlo), carotenoids (CAR), specific extinction coefficients K232 and K270, total polyphenols (POL) and turbidity (TUR).

### **Results**

Results showed that Rotased had a positive effect on olive oil quality, both after 48 hours and 5 months. In particular, Sedoil was characterized by significant differences (p-values<0.05) in POL, PV, CHLO, CAR, K232 and K270. Not significant differences were found in FA e TUR. Collected data will be used to optimize the operating parameters of Rotased in order to develop the industrial plant.



## Modeling of a full-scale microwave system for tomato sauce processing

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**Keywords: Microwave heating, Mathematical modelling, Food processing**

### Objectives

The use of microwaves in food heating has received significant attention over the last few decades. Modern consumers demand products of high quality which are convenient, nutritious and minimally processed with fresh like characteristics. As result, the food producers are showing a greater interest in the use of novel food processing technologies minimizing thermal damage. Microwave heating is one of these technologies and it allows a faster processing as well as it can enhance the shelf life, quality and nutrient content. However, some problems related to temperature distribution inside the product can occur. An important one is the appearance of hot spot in several zones, depending on product geometry and dielectric properties, geometry of both the microwave applicator and reverberation chamber. This phenomenon has become one of the major drawbacks for application at domestic or industrial level. An accurate modeling of a full-scale microwave system has been carried out with the aim to evaluate both electromagnetic and temperature profiles in the whole system.

### Methods

The modelling of the full-scale microwave system is based on a three-dimensional computer code, employing finite integration technique, to predict the time-dependent temperatures distributions of food sample. In particular, the temperature distribution was calculated by coupling electromagnetic and heat transfer analysis, while heat generation was evaluated by using the measured dielectric and thermal properties of some tomato sauce samples. The microwave heating section consists of an irregular reverberating chamber loaded with a dielectric cylindrical tube ensuring the continuous flow of tomato sauce. The chamber is connected to a two microwave generators.

### Results

Several simulations have been carried out to investigate how the variation of the physical, geometrical and operative parameters affects both the electromagnetic field distribution inside the microwave system and the time-dependent temperature profile in microwave heated tomato sauce. The shape and geometrical parameters pertaining the reverberation chamber as well as the size and placement of the dielectric tube have been optimized in order to i) minimize the reflected power coming back to microwave generator, ii) enhance the average absorbed electromagnetic power by the tomato sauce, iii) improve the overall heating rate within the foods, iv) suppress resonating peaks giving optimal heating with minimal thermal runaway, v) obtain almost uniform spatial temperature profile inside the tomato sauce.



## Testing of ozone generating equipment to reduce ethylene during postharvest storage of fresh produce

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**Keywords: Ozone, Ethylene, Postharvest, Fruit and Vegetables, Storage**

### Objectives

Development of innovative and efficient methods to prolong shelf-life during storage of horticultural products is of great interest to the industry. Ethylene (C<sub>2</sub>H<sub>4</sub>) is a major source of deterioration for fresh produce and the search for new technologies aimed to reduce its concentration in cold storage rooms is one of the industry priorities. Among different approaches to reduce ethylene, ozone (O<sub>3</sub>) application is a promising one given its known beneficial effects in reducing microbial contamination in the storage environment. Tomatoes and kiwifruit are very sensitive at very low ethylene concentrations, and its presence in the storage rooms should be completely avoided. Objective of the present work was, therefore, to test ozone generator equipments to reduce ethylene within storage room during postharvest life of these horticultural produce.

### Methods

Ozone generator equipments were developed and provided by Ozono Sanificazione<sup>®</sup>. Preliminary trials were performed in order to optimize operational conditions of the equipments. Subsequently, tomatoes at three different ripening stages were stored up to 8 days in a closed system at 15±1 °C. Three condition were tested: i) *Ctrl*: storage in air; ii) *Eth-Oz*: storage in the presence of 2 ppm of exogenous ethylene and 1 ppm of residual ozone; iii) *Eth*: storage in the presence of 2 ppm of exogenous ethylene. Kiwifruit were stored up to approximately 4 months at 1±0.5 °C. Four condition were applied: i) *CTRL*: storage in air; ii) *Oz*: storage in the presence of 0.5 ppm of residual ozone; iii) *Eth-Oz*: storage in the presence of 1 ppm of exogenous ethylene and 0.5 ppm of residual ozone; iiiii) *Eth*: storage in the presence of 1 ppm of exogenous ethylene. Firmness and other physicochemical parameters were evaluated on representative samples of the product during storage.

### Results

The presence of residual ozone resulted to be able to control and reduce the concentration of ethylene up to 90%, thus making this technique an effective alternative to the use of traditional approaches for C<sub>2</sub>H<sub>4</sub> reduction. The developed equipment showed good potential for indoor use within storage rooms for fruit and vegetables, without causing damage of any kind to the product. At the end of storage, tomatoes held with exogenous ethylene combined with ozone treatment, showed higher texture values and a slightly lower colour evolution. As for kiwifruit, *Eth-Oz* samples showed significantly higher firmness if compared to *Eth* treatment, demonstrating the efficacy of ozone in reducing ethylene to an extent that is perceptible by plant tissue. Further optimization studies are needed in order to make the equipment perfectly efficient in the postharvest field.



## Effects of the operating conditions of a microwave equipment on quality and safety of fresh-cut produce

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**Keywords: Microwave, Fresh fruit and vegetables, Quality, Postharvest treatment**

### Objectives

A sustainable and efficient alternative for shelf-life extension of fresh and fresh cut products is the microwave-assisted mild-heat treatment that shows the advantages of short exposure times, avoiding the leaching of vitamins, flavors, pigments, carbohydrates and other water soluble components, and the enzymes inactivation. Little information is available about the use of microwave energy as a post-harvest treatment to reduce bacterial populations on fruits or vegetables. For this reason the main objective of this study was to study and optimize the operating conditions of microwave application on fresh-cut produce, aiming to identify the most effective combinations in terms of reduction of the microbial load and/or preservation of organoleptic and nutritional qualities of the product. The effect of microwave treatment on quality and safety of fresh cut apples, carrots and potatoes were evaluated.

### Methods

A preliminary phase involved the application of a Central Composite Design (CCD) to evaluate the effects of the treatment on quality and safety parameters, determining the most suitable operating conditions. Factors considered were treatment time (s) and microwave power level (expressed as output Watt). Eleven combinations of the factors were selected by applying a CCD 2<sup>2</sup> + star with three central points using the software Statgraphics Centurion XVI.I. The products (apples, carrots and potatoes) were washed, peeled, cut into equal pieces and treated as previously described using a microwave equipment (Kennex AG925CTW, 2450 MHz, maximum power 1000 W). Products were then stored in air within macro-perforated trays at 5±1 °C up to 4 days. Immediately after treatment and at the end of storage time the main physical, chemical and microbiological parameters were monitored. The obtained results were subjected to statistical analysis.

### Results

On potato sticks the longer the exposure time to microwave treatment and the lower the psychrophilic bacteria load of the product. However, the application of high energy level treatments caused the onset of severe browning, which strongly affected its quality below the limit of marketability. As for carrot slices, significant effects were observed at the end of the storage period on lightness (L\*), yellowness (b\*) and on global color change (ΔE). Lower variation of ΔE value were obtained when treated for 60s at a power level corresponding to an output of 500 W. Power level of the treatment significantly influenced ascorbic acid and vitamin C content of the carrots, while the duration of the process had effects on dehydroascorbic acid. For apple slices a reduction of microbial load increasing microwaving power level was observed, however, also for this product, a stronger treatment affected visual quality of the product, resulting in serious browning, showing that border line between positive and negative effects of this technology is very thin.



## **Preliminary trials of one-pass windrowing of corn-stover with innovative corn header**

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**Keywords: Bioenergy, Corn stover, Harvest.**

### **Objectives**

The work focuses on agricultural residues originated at field level for their use for the production of bioenergy or bioethanol.

The theoretical potential of primary agricultural residues (eg corn stalks) that is available for energy or other applications from renewable sources from a specific crop is determined by: (i) the cultivated surface of a crop (ha), (ii) the availability of crop residues according to the harvesting system used. (iii) Last but not least is the availability of adequate technology and logistics to collect a high-quality residue. The use of residues is well acknowledged by the European Union as there is no competition with the food chain for the production of biomass as residues are produced on the same ground where food production takes place. Using residues also helps achieve the goals of using renewable energies (20-20-20 vision) for 2020 without competing on soil use with food productions.

The crop residues of corn stalks vary according to the cultivated variety. However, they are present in fairly large quantities (9.6-11.6 t SS ha<sup>-1</sup> year<sup>-1</sup>), and this allows for economic exploitation for Biofuel, biogas and bioenergy supply chains .

However, their traditional harvesting involves a high residual soil that prevents the use, often limited to livestock as litter.

The main aim of the work is the development of an innovative corn grain harvester header to reduce costs of corn stover harvest.

### **Methods**

For this research, a prototype of corn grain harvester header has been developed by OLIMAC srl, Margarita, Cuneo. This innovative header allows to carry out three operations in a single step (collection): grain harvesting, cutting and windrowing crop residues. At present, without this prototype, the last two operations are conducted separately.

To evaluate the functioning of the innovative device preliminary field tests have been carried out in Margarita comparing it with the traditional corn grain collection. These tests allow us to understand the potential of the prototype and further adjustments to be made to reach the expected improvement in corn stover harvest.

### **Results**

The device has been shown to be effective to collect 48% of the product in one pass, absolutely free of soil residues, compared to 65% gathered with the traditional three passes.

This innovative device allows energy savings and emissions of about 30% compared to traditional harvesting that requires two further steps.

Considering that 176000 hectares of grain maize are grown in the Piedmont Region, the proposed innovation will allow collecting about 550000 t y<sup>-1</sup> of clean corn stover, usable in the biogas or combustion / bioethanol , which at the commercial value of € 60 t<sup>-1</sup> would lead to an induced market of 33 M €.



## **CFD modelling and simulation for assessing temperature distribution inside flour mills during heat treatments for insect pest control**

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**Keywords: Computational fluid dynamics, Thermal behaviour, Milling industry, Heat flux.**

### **Objectives**

The heat treatment of the indoor environment of flour mills is an alternative to chemical fumigation for controlling insect pests. This method requires the increase of air temperatures between 45°C and 55°C, which should be maintained for a time interval of 36-48 hours to eliminate all the insect vital stages. However, some building components of the mill, such as floors, walls, and ceilings, can provide a refuge for insects from the heat, because their surface temperatures usually don't reach levels that are lethal to insects. Therefore, the objective of this research was to assess temperature distribution inside a flour mill during a heat treatment for insect pest control by computational fluid dynamics (CFD) modelling and simulation. The model was validated by means of experimental data acquired during a heat treatment carried out in a flour mill located in Sicily (Italy), representative of building materials and techniques used in the milling industry of South Italy.

### **Methods**

Firstly, the architectural survey of the flour mill was carried out in order to obtain the 3D model of the building. Because of the presence of equipment that is extremely sensible to high temperatures, i.e., the plansifters, only the second floor was monitored before and during the heat treatment by Grillobee dataloggers manufactured by Tecnoel. Furthermore, the locations of the fan heaters used to raise air temperature in the second floor of the mill were acquired for the CFD modelling and simulation.

After these preliminary operations, the heat treatment of the mill, which was carried out by a specialised firm, involved the use of three fan heaters set at a ventilation rate of 2500 m<sup>3</sup>/h and a temperature of 70°C.

The final step of the study was the design of an accurate CFD model including building components and materials of the flour mill as well as the electric fan heaters used for the treatment.

### **Results**

Simulations were carried out and data simulated were validated by means of dataloggers measurements. Since the modelled temperature distribution fitted the real one in the mill with a good accuracy, the CFD model could be considered reliable to simulate other operating conditions aimed at improving the effectiveness of heat treatments.



## **Analysis of sanitary and physical qualities of maize grains stored in silo bags and in metallic silos**

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**Keywords: Silo bag, Physical quality, Classification, Sanitary quality**

### **Objectives**

The quality of maize grains may change during the harvesting and post-harvesting stages. During those processes, the grains can be damaged, resulting in defective grains such as burnt, insect-attacked, moldy, fermented, sprouted, and broken grains. In addition, grains can be contaminated by fungi which produce mycotoxins, causing problems for human and animal health. Furthermore, there may be considerable losses in the commercial aspect. The purpose of the present study was to analyze and compare the physical and sanitary quality of maize grains stored for approximately 30 and 180 days in different types of storage silos (silo bags and metallic silos).

### **Methods**

Samples were collected in both types of silos (silo bags and metallic silo) for each storage period (30 and 180 days). The physical characteristics analyzed were: moisture, hectoliter weight, and physical classification. The sanitary quality of the grains was also analyzed, considering the incidence of fungi in the samples.

### **Results**

Grains stored in metallic silo showed 11.8% of moisture for the storage period of 30 days and 11.9% for the period of 180 days. The hectoliter weight for both storage periods was 77.3kg/hL. The results obtained for the winter maize grains stored in the silo bag were 12.3% of moisture and 74.4kg/hL weight. For the summer maize grains stored in the silo bag, moisture and weight were 12.2% and 76.4kg/hL, respectively. All the samples presented more than 5.0% of broken grains. The highest incidence of fungi in the analyzed grains was of the genus *Penicillium*, followed by *Fusarium*, and *Aspergillus*. Grains harvested in the winter crop presented higher incidences of fungal contamination regardless of the storage system. However, the highest incidence of fungi was found in the sample stored in the silo bag (81.7%). This percentage of contamination indicates an inadequate management of the grains during the harvesting and post-harvesting processes.



## **Use of the dynamic speckle for the analysis of maize seeds submitted to thermotherapy**

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**Keywords: Treatment, Wet heat, Dry heat, Fusarium, Germination.**

### **Objectives**

Maize is largely used in the food and pharmaceutical industries, and it is extremely representative of our food, which raises the value of research that may improve processes involving its production. The quality of the seeds used for sowing is fundamental for a high productivity and quality of the crop. Therefore, eradicating pathogens is essential for the plant to develop in the best possible way. The eradication of those pathogens can be accomplished by means of treatments that consist of the application of substances to the seeds or by performing physical procedures. Thermotherapy is a physical treatment in which the seed is exposed to a given thermal energy, such as heated air or steam, and can be highly efficient for controlling those pathogens, in addition to reducing environmental damage and costs. The present work aims to evaluate the efficiency of thermotherapy in two ways: wet heat (water) and dry heat (water vapor), both at 60°C, alternating the exposure time to the thermal sources.

### **Methods**

The quality of the treatments was evaluated through standard methodologies, complying with the rules for seed analysis, such as germination and sanitation tests; Biospeckle laser was used for the identification of microbial activity in those seeds.

### **Results**

Wet heat thermotherapy caused greater damages to the seeds, reducing germination and vigor, with emphasis on the treatment with longer exposure time, but it was the treatment that presented lower occurrence of *Fusarium* ssp. In this way, research involving thermotherapy may be done by varying the temperature and exposure time, to obtain values that will considerably reduce pathogens and preserve quality, in order to maintain germination and vigor values acceptable for commercialization.



## **Maize Seeds Treated with Bioprotector and Evaluated through Biospeckle**

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**Keywords: Treatment, Trichoderma harzianum, Germination, Sanitation, Storage**

### **Objectives**

The present work aimed to study the treatment with the bioprotector *Trichoderma harzianum* on maize seeds immediately after treatment and during storage. Seed treatment is safer and provides better results without disease control on plants. Under Brazilian conditions, the main fungi that affect maize seeds under storage conditions are *Aspergillus* spp, *Fusarium* spp., and *Penicillium* spp. Bioprotectors have antagonistic fungi that produce and release substances (metabolites and enzymes) that will degrade the hyphae of phytopathogenic fungi, preventing their proliferation. Among the bioprotectors, *Trichoderma* spp., used for phytosanitary control of seeds, stands out. The tests were carried out with treatment in order to evaluate the physiological potential caused by the treatment with the bioprotector. The Biospeckle experimental runs were performed in parallel with the sanitation test.

### **Methods**

They were analyzed through germination test, vigor tests (cold test, accelerated aging, and aerial length), and the viability of the treated seeds was verified through the Biospeckle optical technique.

### **Results**

The germination percentages of 93.0%, 87.5%, and 87.5%, respectively, showed that they were all above the minimum requirement for commercialization. Analyzing the vigor and sanitation tests, it was verified that the best treatment was on day zero. Among the seeds analyzed through Biospeckle, using the LASCA technique, (Laser Speckle Contrast Analysis), it was possible to identify fungi activity.



## **Influence of the roughness of floor tiles on the cleanability from wheat flour residues in agri-food facilities.**

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**Keywords: Cleanability, Floor, Food processing buildings, Wheat flour**

### **Objectives**

Floors in agri-food buildings are the surfaces most at risk of microbial contamination because, during processing phases, small amounts of food may be accidentally spilled and become the principal source of nourishment for the metabolic activities of microorganisms. The objective of this paper is to establish the correlations between the geometry of the klinker floor tiles and their dry-cleanability from wheat flour residues.

### **Methods**

The proposed method is based on the measurement of protein residues by means of a solution of copper sulphate pentahydrate and bicinchoninic acid, which changes colour as the quantity of proteins in the solution varies. Flour residues were sampled after dry-cleaning, which was simulated through a specially designed automated system. By correlating the surface roughness parameters with the quantity of residue measured, it was possible to establish which surface characteristics allow easier dry-cleaning.

### **Results**

In order to validate the proposed method, the optimal ratio between copper sulphate pentahydrate and bicinchoninic acid, which is useful to find even small traces of proteins on the surfaces, was first found. Measure with spectrophotometric in laboratory showed an important correlation between the maximum light absorbance value at 562 nm, the quantity of proteins and the average floor roughness  $R_a$ . Such a correlation was also highlighted in the construction of the relative regression function. In order to show the results of the spectrophotometric analysis in a more immediate manner, a qualitative evaluation scale was defined. It was characterized by 7 degrees of judgement, according to the maximum absorbance value at 562 nm, which corresponded to the intervals of evaluation and to different degrees of cleanliness from wheat flour residues.

Such a scale can be easily and quickly applied and used in design solutions for sustainable buildings in the agri-food sector, which is particularly concerned with issues related to health and hygiene.



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## **TOPIC 7**

### ***ORGANIC FARMING, SUSTAINABLE PLANT AND LIVESTOCK PRODUCTION PROCESSES AND TECHNOLOGIES***



Assessment of an innovative aerobic treatment system based on hydrodynamic cavitation for N removal from the liquid fraction of pig slurry <i>Dinuccio E., Gioelli F., Rolle L., Balsari P.</i> .....	168
Onion seeds: mechanical versus manual threshing, survey on quality parameters. <i>Foppa Pedretti E., Duca D., Ilari A., Toscano G., Tesei D.</i> .....	169
How to maximise the manure value in a high livestock concentration area: the Life Optimal project <i>Gioelli F., Dinuccio E., Rolle L., Balsari P.</i> .....	170
Evaluation anti-radical activity of essential oil and extract of thymus vulgares, compared with synthetic antioxidant BHT <i>Abdi N., Hashemi J.</i> .....	171
Automatic Milking System effects on Mediterranean buffalo milk production and quality <i>Sannino M., Faugno S., Crimaldi M., Di Francia A., Ardito L., Masucci F.</i> .....	172
Ammonia emissions assessment after buffalo slurry application to bare soil in Mediterranean climate <i>Scotto di Perta E., Fiorentino N., Gioia L., Faugno S., E. Cervelli, Pindozi S.</i> .....	173
Developing technique and equipment for the management of organic and conservative horticultural systems <i>Frasconi C., Martelloni L., Raffaelli M., Fontanelli M., Antichi D., Abou Cheade L., Pirchio M. Peruzzi A.</i> .....	174
Performance of a hot-foam machine for the herbicide-free weeding of the vineyard <i>Pessina D., Facchinetti D., Bacenetti J., Spezia G.</i> .....	175
Effects of long-term of different management scenario on energy consumption for durum wheat cultivation in Sicily <i>Failla S., Schillaci G.</i> .....	176
Effect of sulfate water and fertilizer on yield and quality of sugar beet ( <i>beta vulgaris l.</i> ) in Iraq <i>Alrashidi S.M.</i> .....	177
Numerical simulation of natural airflows in greenhouse: definition of optimized CFD models in a case study <i>Santolini E., Beni S., Pulvirenti B., Torreggiani D., Tassinari P.</i> .....	178
Microclimate measurements and evapotranspiration modeling in high-tunnel greenhouses and screenhouses in semi-arid regions <i>Hadad D., Lukyanov V., Cohen S., Tanny J.</i> .....	179
Design and management of dairy cow barns in Lombardy <i>Riva E., Sandrucci A., Cattaneo M., Perazzolo F., Provolo G.</i> .....	180



Indoor environmental conditions and energy consumption of a plastic multi-span greenhouse: numerical simulations vs. monitoring <i>Serale G., Lando I., Fabrizio E.</i> .....	181
Viewpoints and visibility analysis: a case study on the UNESCO site of Langhe-Roero and Monferrato (Piemonte Region) <i>Garnero G., Fabrizio E.</i> .....	182
Heat stress of dairy cows subjected to different cooling systems <i>Porto S.M.C., D'Emilio A., Cascone G., Bella M., Gulino M.</i> .....	183
Numerical 3D finite element modelling and experimental validation of dowel and tenon-mortise wooden joints for structural applications <i>Pantaleo A., Vox G., Scarascia Mugnozza G.</i> .....	184
Micro-climatic effect of plastic nets for crop protection in greenhouse <i>Picuno P., Statuto D.</i> .....	185
Testing of net based protection systems of olive trees against the vector of <i>Xylella fastidiosa</i> <i>Castellano S., Di Palma A. M., Germinara S. G., Lippolis M., Scarascia Mugnozza G., Starace G.</i> .....	186
Evaluation of rain permeability of agricultural nets- first experimental results <i>Castellano S., Lippolis M., De Musso M., Starace G.</i> .....	187
Photovoltaic greenhouse: a simple technique for passive shading variation <i>Marucci A.</i> .....	188
Experimental cultivation of peppers in low energy demand greenhouses. An interdisciplinary study. <i>Evangelopoulou F., Bantileska M., Tsihlias C., Krinas K., Koulopoulos A., Kavga A., Tripanagnostopoulos Y.</i> .....	189



## Assessment of an innovative aerobic treatment system based on hydrodynamic cavitation for N removal from the liquid fraction of pig slurry

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**Keywords:** hydrodynamic cavitation, manure, ammonia, greenhouse gases

### Objectives

A comparative study carried out with the objective to assess the effectiveness and environmental performance, in terms of ammonia (NH<sub>3</sub>) and nitrous oxide (N<sub>2</sub>O) emissions, of an innovative treatment method for nitrogen (N) removal from the liquid fraction of pig slurry (LFPS). The treatment method consists of the intermittent aeration of manure in a single tank by hydrodynamic cavitation (HC).

### Methods

Two pilot scale batch experiments were carried out, in summer (average environmental temperature: 25.3°C; Exp. 1) and winter (average environmental temperature: 8.4°C; Exp. 2) conditions. For each experiment three plastic storage tanks (total volume: 1.0 m<sup>3</sup>), specifically equipped for this study, filled with 0.8 m<sup>3</sup> of the same LFPS, were used. Each experiment lasted for 60 days. In Exp. 1 the effect of two management settings of HC (B1: 8 repeated treatment cycles per day, each consisting of 2h cavitation followed by 1h non-aerated stages; B2: one treatment cycle per day consisting of 8h cavitation followed by 16h non-aerated stages) were assessed and the results compared to those obtained with a control (B0: LFPS storage without cavitation). In Exp. 2 the effect of two air flow rates (0.12 m<sup>3</sup> m<sup>-3</sup> slurry h<sup>-1</sup>, 0.25 m<sup>3</sup> m<sup>-3</sup> slurry h<sup>-1</sup>) and two cavitation air bubble diameters (~80 µm; ~2.0 µm) were assessed. Ammonia and N<sub>2</sub>O emissions were monitored at least twice a week using a dynamic chamber technique.

### Results

Under the specific conditions adopted in this study, the aerobic treatment of LFPS by HC showed a N removal efficiency ranging from 23.3% and 76.4%. The average N removal efficiency increased with increasing temperature (27.8% in winter vs 69.7% in summer conditions), and decreased with increasing the air bubbles diameter (23.3% with bubbles of air ~80 µm in diameter vs 38.9% with bubbles of air ~2.0 µm in diameter, Exp. 2). However, high NH<sub>3</sub> and N<sub>2</sub>O emissions to the atmosphere were detected during both the HC and non-aerated stages. Specifically, the average daily N<sub>2</sub>O emissions recorded during Exp. 1 from B1 and B2 resulted, respectively, 121% and 65% higher than those obtained from the control (B0). The air flow rate and air bubbles diameter did not affect N<sub>2</sub>O emissions (Exp. 2). In contrast, it was found that NH<sub>3</sub> emissions increased by 41.1% and 29.7%, respectively, when the air flow rate was reduced from 0.25 to 0.12 m<sup>3</sup> m<sup>-3</sup> slurry h<sup>-1</sup> and the average air bubbles diameter was reduced from ~80 µm to ~2.0 µm. Further trials are in progress to identify the optimal operating conditions (e.g., air flow rate, air bubbles cavitation diameter) for the successful implementation of this manure treatment technology in the livestock sector.



## **Onion seeds: mechanical versus manual threshing, survey on quality parameters.**

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**Keywords: Seeds germination, Allium cepa, complete survey.**

### **Objectives**

Among all crops, seed crops hold a strategic position due to their high gross economic value. The standard price for some species could reach 5,000- 7,000 €/ha (Allegato A – Tabella rese e prezzi standard per le attività aziendali). From a statistics conducted by Assosementi in 2014, the production of seed crops in Italy was concentrated in three regions Emilia Romagna (40%), Marche (28%) and Puglia (14%). The increment in term of cultivated surface was constant from 2006. The most represented species is onion (1747 ha) if we exclude coriander (Assosementi 2014). One of the shortcomings in seeds production is the high labour requirements for planting, harvesting and threshing. In order to reduce the economic costs of post-harvest and logistic operations some companies are making use of specific equipment for mechanical threshing. Unlike other crops, where high productivity is the primary object in seed crops, the first target is the respect of high and narrow qualitative parameters. The beating elements movement could be cause of breakage and squashing. The main object of this study is the evaluation of two threshing methods (mechanical or manual) for biennial onion seed collection through the assessment of standard germination parameters.

### **Methods**

The survey was conducted considering different management aspects for 12 companies in Ancona district. For the local/geographical context have been considered soil texture, coordinates, exposition and altitude. For management context, 7 cultivars, ratio pollen-bearing/seed-bearing lines, drying and threshing system have been considered. Quality parameters tested are: germination, germination energy, abnormal seeds, rotten germs, rotten seeds, full seeds, empty seeds, double germ seeds, triple germ seeds. A statistical analysis has been conducted comparing different treatments and conditions and the effects on quality parameters.

### **Results**

From the analysis carried out for the two system, comparing the average value for germination and germination energy, it is noted that between the two groups of treatment, mechanical or manually threshed, there are clear differences of about 10% in favour of manual threshing for both parameters considered. Another interesting aspect is given by the abnormal seeds parameter: for the mechanically threshed seeds it is clearly higher respect to the manually threshed with differences even higher than 75%.



## How to maximise the manure value in a high livestock concentration area: the Life Optimal project

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**Keywords: Biogas, Technological innovations, Sustainability**

### Objectives

Livestock farms in the 5 municipalities of Alta Valle Isarco (north-eastern Italy) generate approximately 250000 tons of manure per year, which due to the provisions transposing the Nitrates Directive (91/676/EEC) cannot be entirely spread over the farm's land. Orchards, where manure is generally not applied, represent an opportunity to improve nitrogen utilization in soils that often suffer from a progressive reduction of soil organic matter content. Life Optimal is a project financed by the European LIFE+ program. Two universities (Torino and Bolzano) and three industrial partners (Biogas Wipptal, Rota Guido, Zunhammer) are cooperating in order to develop an environmentally friendly system for the optimisation of manure management in Alta Valle Isarco. The project started in 2012 and will be finalised in 2018. The general aim of the project is to maximise the value chain of manure – to range from the production of renewable energy through anaerobic digestion, to the agronomic utilisation of digestate.

### Methods

To reach the project targets a new digestate treatment system (DTS) has been developed and installed at a 1 MWeL. centralised anaerobic digestion plant (ADP) having 65 farmers as members, operating in Vipiteno (BZ). The DTS is made up of a screw press separator, a centrifugal separator, an ultrafiltration unit, a reverse osmosis unit, an ammonia (NH<sub>3</sub>) stripping unit, and a section for drying and pelletizing the solid fraction. Through this system, 2 types of high quality fertilizers will be produced: a solid one, that can be enriched with the concentrates from the ultrafiltration and reverse osmosis process in order to produce a fertilizer that respects the balance between the nutrients needed in vineyards and orchards; a liquid one, consisting in an ammonium sulphate solution, which can be used in agriculture in an environmentally friendly manner. The project's idea expected that only a part of the digestate produced by ADP will be driven to the DTS. Approximately 50% of digestate will be directly spread on the fields (sloped grassland) of the 65 local farms who supply animal manure to the ADP. A self-propelled manure spreader prototype with a high precision and a low emission application system has been designed and constructed. Field demonstrations of all technologies and methods developed are the core element of the project.

### Results

Thanks to the implementation of this project the following concrete results are expected to be achieved: i) reduction of the nutrient load by 50% in the area in which the system is implemented; ii) reduction of NH<sub>3</sub> emissions by transforming the ammonia contained in the digestate into sulphate fertilizers; iii) production of high quality fertilizers for their use in vineyards and orchards; iiiii) conservation of income for the farmers in mountainous regions.



## Evaluation anti-radical activity of essential oil and extract of thymus vulgares, compared with synthetic antioxidant BHT

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**Keywords:** Anti-radical activity, DPPH Method, extract, Thymus vulgares

### Abstract

Recently, the attention to natural antioxidant compounds with intention to using in the pharmaceutical and food industries has been increased. It is mainly due to increasing unintentional side-effects of synthetic antioxidants. Polyphenols compounds are the major compounds of plants which has been antioxidant activity. In this research, Anti-radical activity of essential oil and extract of thyme (*Thymus vulgares*) were determined and compared with synthetic antioxidant BHT (Butyl Hydroxy Toluene). In this study, thyme essential oil were analyzed by GC/MC and its main chemical components were identified. The amount of phenolic compounds in extract of thyme has been evaluated. Anti-radical activity of essential oil and extract of thyme was investigate and also compared with BHT method 2, 2-diphenyl-1-Pycryl Hydrazyl (DPPH). The results showed that the main components of savory essential oil were thymol (60.54%), gamma-terpinene (9.47%), para-cymene (8.54%) and carvacrol (3.33%); and the total phenolic content of the extract was  $21.5 \pm 0.62$  mg Gallic acid per g. In the evaluation of free radical scavenging activity, the highest antioxidant activity was observed at the concentration of 2% BHT (84% inhibition), 2% essence of thyme essential oil (79% inhibition) and 1.5% of thyme extract (87% inhibition). According to the results, the highest activity was observed of the thyme extract, BHT and thyme essential oil, respectively. Finally, by considering of antioxidant activity of extract, it can be used as natural antioxidants in relevant industries.



## Automatic Milking System effects on Mediterranean buffalo milk production and quality

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**Keywords:** automatic milking, buffaloes, milking frequency, milk yield, effective length and persistence of the lactation

### Objectives

The first Automatic Milking System (AMS) for buffaloes was introduced in a commercial dairy farm in south Italy in 2008. AMS are deeply studied in dairy cows applications, but not yet deeply studied on buffaloes, though a few applications to the species can be found in literature. The objective of this study is to compare some important functional and productive aspects of AMS with the conventional milking systems. Aspects such as milking frequency, daily milk yield were evaluated. to evaluate the possible effects of AMS introduction in buffalo farm on the effective length and persistence of the lactation curve. Interest was also shown to the quality of milk, intended as analysis of compositional parameters and health and safety standards.

### Methods

The study was carried out in the organic buffalo farm located in southern Italy. The farm is equipped with 2 types of milking parlours: a traditional tandem, and an AMS system. 90 lactating primiparous buffaloes were randomly allotted into 2 groups, one milked with the traditional system and one with AMS. The groups were homogenous for number, age and lactation stage. Groups were housed in free stall pens and were handled in similar way in terms of feeding and management. The buffaloes were milked in the same period, in the same concern and in the same environmental conditions to avoid the influence of season and photoperiod on milk quality. During the observation period, number of milking per day, milk yield per milking and daily milk yield of each cow were collected. Moreover, the lactation persistence was calculated. Milk sampling for each buffalo was carried out twice a month. Samples were analyzed for fat, protein lactose and casein at the regional Milk Analysis Laboratory of Campania Animal Breeders' Association.

### Results

Milking frequency and daily milk yield with the AMS was significantly higher than traditional methods. There was no significant difference between the lactation length, but there was a greater persistence of lactation curve of the AMS (88.8%) than lactation curve of tandem system (79.2%). AMS system use does not cause a decay of buffalo milk quality, even better there is a slightly improvement of protein content due to a cleaner and healthier breast.



## **Ammonia emissions assessment after buffalo slurry application to bare soil in Mediterranean climate**

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**Keywords: Ammonia emissions, buffalo manure, Mediterranean climate**

### **Objectives**

Ammonia emissions represent a growing issue for European countries due to the rapid increase in livestock production and next National Emission Ceilings EU Directive adoption, which will limit emissions of NH<sub>3</sub> as well as SO<sub>2</sub>, NO<sub>x</sub> and NMVOC applicable from 2020 and 2030.

Recent researches are devoted to the individuation of standard methods for reliable assessment, consequently many European countries are now building national emissions inventory. The main issue is a lack of data about ammonia losses from buffalo manure, under Mediterranean climate. Buffalo is reared mostly in South Italy, and even if well studied, there are not researches about ammonia emissions. Besides measurement method itself, meteorological conditions influence emissions too. In this paper, ammonia emissions assessment from buffalo manure application to the field under Mediterranean climate is proposed, with aim of giving first data for this animal species.

### **Methods**

During summer period of 2016 an experimental trial combining the use of three wind tunnel (WT) and Micrometeorological method specifically Integrate Horizontal flux (IHF) in circular plot was carried out. Buffalo slurry was applied with splash plate spreader for IHF and manually under WT. Acid traps were used to assess ammonia fluxes from WT. Acid solutions were replaced every 2 hours for the first two days and every three to four hours for the remaining two days. Glass tubes were employed for IHF method, sampled with same time step of WT. Meteorological data were acquired during the trial and soil samples were taken at the end of each day for pH and NH<sub>4</sub>-N and NO<sub>3</sub>-N.

### **Results**

Results confirm the reliability of WT assessments in ammonia emissions compared to IHF method. The total ammonia fluxes is in the order of about 40% and 50% (of applied TAN) for WT and IHF, respectively. Moreover it appears that ammonia loss had a positive relationship with air Temperature and wind speed.



## Developing technique and equipment for the management of organic and conservative horticultural systems

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**Keywords: Organic agriculture, conservation agriculture, cover crop management, physical weed control, no-tillage.**

### Objectives

Combining organic farming techniques and conservation agriculture techniques is considered not feasible due mainly to the strong dependence of conservation cropping systems by chemical control of weeds and the use of mineral fertilizers. The use of subsidiary crop could be a winning strategy in order to successfully combine conservation and organic cropping systems in horticulture.

The object of this work is to develop and test specific versatile and efficient machines for non-chemical cover-crop management (dead mulch or living mulch), physical weed control and no-till transplanting.

### Methods

In order to achieve the integration of organic and conservative horticultural systems, during the research activities, several operative machines were modified, adjusted and tested. Following is reported a list and a brief description of these equipment.

The mounted machines for non chemical cover crop termination consists in a main frame that supports two rolls provided with blades. The aim of this equipment is to mechanically devitalize the cover crops crimping the stem of the plants, obtaining, in this way, a thick layer of dead mulch, that should provide an acceptable level of weed control for the following vegetable crop that will be transplanted in no-tilled soil.

The mounted equipment for thermal weed control was used for cover crop devitalisation (in combination with the rolling) and, after a modification addressed to partialize the working width, also for the management of living mulch or weeds in the inter-row space of the vegetable crop.

A no till-vegetable transplanter were developed in order to properly work in soil covered by dead or living mulch. The main changes respect to a "conventional" transplanter consisted in adding frontal disc coulter in order to cut the mulch and adding a shank before the furrower

### Results

The results of this research could be assessed as promising. The equipment modified, adjusted and tested worked properly in the agro-environmental condition of the horticultural farming systems of the central Tuscan coastal area. But there is a clear need to continue the research, in order to optimize the machines according to the agronomic strategies addressed to minimize the ecological impact and to maximize the sustainability of the agriculture.



## Performance of a hot-foam machine for the herbicide-free weeding of the vineyard

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**Keywords: hot-foam, bio-weeding, vineyard**

### Objectives

The complete elimination of the herbicides use is a key factor in the biological management of the vineyard. In this view, for the area under the row, the machines performing the mechanical weeding are characterized by a low travelling speed; on the other hand, those with flails can damage significantly the vine stock, increasing the possibility of pathogens attack. The flame weeding is an alternative solution, but this is quite costly and a possible high fire risk has to be taken into account if the grass growth is important. An other possibility provides the use of steam, in order to destroy the internal structure of the weeds.

A new solution is represented by the use of hot-foam, in order to transmit the heat to the weeds, maintaining it for the longest time possible, consuming a reduced amount of energy in comparison with the flame-weeding and the steam techniques.

### Methods

The machine is fitted in front of the tractor, and produces a foam (possibly coming from both a 100% biodegradable and a traditional surfactants) that is deposited on the upper part of the weeds at a temperature of about 70 °C. The hot air contained inside of the bubbles then collapse the internal structure of the vegetation.

In detail, the machine includes a fan-burner group for the production of hot air, blowed into a device producing the foam, to be deposited in strip under the row. The machine tools are not working between the plants and therefore the working speed can be comparable to that typically adopted for the chemical weeding. Moreover, in case of use of a 100% biological surfactant, also an ecological and effective elimination of many parasites living in the weeds growing under the rows could be assured, so leading to a better health level of the vineyard.

The target data of the hot-foam machine are: travelling speed: approx 4 km/h; water-foaming consumption: 200-400 l/ha; airflow of the fan: 400 m<sup>3</sup>/h; foam temperature: 70-75 °C; foam persistence time: 5-6 min; 100% biodegradable surfactant: medium-high expansion ratio.

### Results

The preliminary tests of the prototype show encouraging results: foam strips of a width of approx 40 cm and a height of 20-25 cm were produced, having a temperature of more than 75 °C (recorded at the machine outlet). The effect of the weeding appears significant after 3 days, although complete killing of the upper part of the weeds occurs after 7-14 days, mainly depending on the species and amount treated.



## Effects of long-term of different management scenario on energy consumption for durum wheat cultivation in Sicily

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**Keywords: Sustainable agriculture, Energy consumption, Durum Wheat**

### Objectives

Minimum tillage and no-tillage cultivation systems in the Mediterranean area of winter cereals tend to get more interesting, because these cultivation practices, appropriately carried out, allows to achieve production yields comparable to those obtained with conventional farming techniques, while reducing costs and environmental impact.

Aim of this paper is to evaluate the effects of the long-term (5 years) use of three tillage techniques (conventional tillage, CT; minimum tillage, MT; and no-till, NT) on energy consumption and on wheat (*Triticum turgidum* L. var. durum) yield for the different combinations of machines and techniques distinguishing the experimental years. The hypothesis differ in terms of tillage intensity, depth and time required.

### Methods

The trials were carried out in a representative flat land area extended about 1 ha, which is mainly used for extensive cereal farming (Mineo - CT - Sicily). The machines and techniques applied during the tests were alternated in accordance with those commonly adopted for the durum wheat cultivation in the territory where the tests were carried out.

Due to the interaction between tillage systems and experiment year a total of 15 scenarios were compared in terms of energy consumption for wheat production. The amount of input and output energy required for the cultivation of durum wheat was calculated based on energy equivalent values given in the literature. On the basis of energy input and output calculations, the net energy gain, energy efficiency, energy productivity, energy profitability and energy intensity were either calculated for each scenario.

### Results

The average values of the 5-years trials demonstrate that NT requires less or equal Inputs (13.97 GJ ha<sup>-1</sup>) than CT (14.41 GJ ha<sup>-1</sup>) and MT (13.95 GJ ha<sup>-1</sup>) farming systems. This is due both for direct energy costs of fuel (from 30% to 50% less) and especially indirect, linked to use of the machines (from 37% to 45% less). The use of herbicides is greater in NT thesis than CT and MT, thus reducing the benefit of this technique in terms of energy savings.

In general, NT thesis showed a better efficiency and timeliness because mean work capacities were always higher than other theses, due to the minor use of the machines. On the average, the yields of the CT and MT thesis are greater (about 2198 kg ha<sup>-1</sup> and 2166 kg ha<sup>-1</sup>) than NT thesis (1784 kg ha<sup>-1</sup>) and thus Output average values in the NT are lesser (52.16 GJ ha<sup>-1</sup>) than the other two for whom values are higher especially for CT thesis (64.27 GJ ha<sup>-1</sup>).

Energy ratio (O/I) is more efficient for CT thesis (4.46) and MT thesis (4.54) than NT (3.73). But also the other indicators are less favourable for NT thesis.



## **Effect of sulfate water and fertilizer on yield and quality of sugar beet (beta vulgaris l. )in Iraq**

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**Keywords: sulfate water, sugar beet**

### **Objectives**

The purpose of this study to know the negative effect of using Sulfate Water (Sw) with Phosphate fertilizer (Pf) levels on yield and quality of sugar beet .Field experiments carried out in Alshora 40 km southern Mosul City in Iraq, in a silt clay soil. Non saline, moderately alkaline, low organic matter, high in lime, Sugar beet crop were planting in 4 hectares area. Three fertilizer levels included; 400, 600 and 800 kg /ha of super phosphate 45% P<sub>2</sub>O<sub>5</sub>, which divided into two parts with planting and after thinning the plants, were used. Sw coming from well without pumping using to irrigate sugar beet about 36% and 40% with (Sw ) reduced with compared with (Fw) in yield and percent Sugar in root respectively otherwise (Pf ) increasing the yield and sugar percentage especially in high levels 600 and 800 kg /ha with (Fw) and educed the effect of (Sw), in yield and quality, we can't got a high yield and good quality without fertilizer in both (Fw) or (Sw) of Sugar beet in this region of Iraq.



## **Numerical simulation of natural airflows in greenhouse: definition of optimized CFD models in a case study**

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**Keywords: modelling, CFD, greenhouse, microclimate**

### **Objectives**

Control and management of the climatic conditions in greenhouses are the subject of numerous studies and researches, with the aim of continuous improvement of production performance, in correlation to a growing attention to the issue of environmental and economic sustainability. Several studies focus on the control of parameters, such as temperature, humidity, concentration of oxygen and carbon dioxide, in which ventilation can play a key role. Natural ventilation is highly dependent on external conditions, determined by numerous factors and their mutual influences. An indirect method of study involves the use of computational fluid dynamics (CFD), which is a tool increasingly used in the management and optimization of greenhouse indoor environment, allowing to simulate airflows and other microclimatic parameters, in relation to different configurations of the building, as well as to different external conditions.

### **Methods**

This work aims to the definition of models that allow the simulation and analysis of the main parameters affecting the internal microclimate, according to different configurations of the greenhouse and different external conditions. A teaching and experimental three-spans greenhouse of the University of Bologna, located in Imola, has been chosen as case study. In particular, the research has focused on one of the three spans. The principal purpose has been to study the ventilation and the fluid dynamics in the structure. Primarily, a 2D analysis of the central section of the cultivation area, with constant wind speed as input, has been conducted. This analysis has been performed by means of two different software, Fluent and Autodesk CFD, in order to evaluate the differences and similarities in the assessment of speed profiles. From the 2D model, a more complex 3D model has been created, validated with an experimental measurements campaign, with which simulations in Fluent have been performed, according to different configurations and different input speed profiles.

### **Results**

The simulations have proved to be a valuable tool for the analysis and evaluation of the internal fluid dynamics, and have provided quantitative elements allowing to assess the opportunity of constructive or managerial adaptations of the greenhouse, in relation to the needs of the various agronomic activities, as well as to identify other specific needs of experimental insights.



## Microclimate measurements and evapotranspiration modeling in high-tunnel greenhouses and screenhouses in semi-arid regions

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**Keywords: Temperature, Radiation, Relative humidity, Air velocity, Penman-Monteith**

### Objectives

The area of crops grown in protected environments is constantly increasing worldwide. Greenhouse tunnels are covered by an impermeable plastic roof whereas screenhouses are covered by a porous screen. In both structures sidewall openings are covered with dense insect-proof screens. In agricultural practice, most growers do not consider the difference in cover type in their irrigation management.

The objective was to study the effect of roof cover type, either plastic or porous screen, on microclimate and Penman-Monteith evapotranspiration (ET), to improve irrigation management.

### Methods

A field study was carried out in spring 2015 in two otherwise identical structures in which a pepper crop was grown. One roof was a plastic sheet (hereafter denoted as the greenhouse) and the other a 17-mesh screen (screenhouse). In both houses, air velocity, air temperature and humidity, and solar and net radiation were measured simultaneously above the canopy. Evapotranspiration was estimated using 8 different Penman-Monteith models, differing either in the resistance terms, or in the type of microclimatic data used, i.e. internal or external.

### Results

Results showed that in the greenhouse, radiation was slightly lower than in the screenhouse. Wind speed in the screenhouse was larger than in the greenhouse, as expected. Maximum air temperature, during daytime, was higher in the greenhouse, while minimum relative humidity during daytime was only slightly higher in the greenhouse than in the screenhouse. Linear regressions were derived between internal and external climatic conditions, with  $R^2$  values between 0.51 and 0.97. Higher  $R^2$  values were obtained for the screenhouse because internal microclimate interacted with the outside more than in the greenhouse. Mean daily evapotranspiration for the eight Penman-Monteith models tested was 2.12 – 2.74 and 1.66 – 2.41 mm day<sup>-1</sup> for the greenhouse and screenhouse respectively.



## **Design and management of dairy cow barns in Lombardy**

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**Keywords: barn design, welfare, management**

### **Objectives**

As well known, design and management of barns can significantly affect productivity and welfare of dairy cows. Although guidelines have been defined and are available to technicians and farmers, the effective application of these indications is not straightforward.

The aim of the work is to better understand the characteristics of the barns and their management in practical farms in Lombardy and to highlight the need of better information and the gaps to fill to improve the performances of the herd. Therefore an assessment of the compliance of practical farms with design criteria and management guideless has been performed.

### **Methods**

The assessment has been carried out on 38 freestall barns in Lombardy (provinces of Milano, Lodi and Cremona). The main parameters of the structure (materials, size, height, roof slope, openings, type of floor), layout (arrangement of cubicles, width of alleys, crossovers, drinking troughs), and management (feeding strategy, milking times) have been investigated in relation to animal welfare and herd performances. Each farm has been visited twice in spring and in summer 2016. During the visits, also data on cow activity (number of cows standing, resting, feeding two hours after the milking) and microclimatic condition (THI and air velocity) have been collected.

The characteristics of each farm have been compared to the guidelines by using a classification scheme for the different parameters.

Thus, for each barn a score as been obtained to indicate the expected degree of welfare in relation to the considered factors.

### **Results**

The results obtained show how most of the barns examined follow the guidelines, but a relevant number of farms has suboptimal conditions. For example, 20% of the barns are inadequate number of stalls both for feeding and resting. The availability of drinking troughs is adequate only in 22% of the barns. Also the results on structural aspects highlight some critical points. For example, only 25% of the farms have a roof slope that can be considered optimal for a good natural ventilation.

The survey highlighted how the criteria for the correct design of stalls for dairy cattle in order to ensure animal welfare and sustain the productivity of the barn are not always followed.

In some cases, the deficiencies are linked to structural problems, certainly not easy to solve, but for other situations easily achievable interventions with limited costs could be envisaged.



## Indoor environmental conditions and energy consumption of a plastic multi-span greenhouse: numerical simulations vs. monitoring

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**Keywords:** energy modelling, dynamic simulation, multi-span greenhouse

### Objectives

The present work deals with the simulation and calibration of an energy model of a 3 hectares plastic multi-span greenhouse in Piemonte. The dynamic energy simulations were performed by means the EnergyPlus software tool; the energy model of the greenhouse was calibrated against monitoring data of the 2014 year that were retrieved from the control system and automation of the greenhouse. The present paper aims at carrying out reliable simulation results considering all the complex physical processes influencing the thermo-energetic behaviour of a greenhouse.

### Methods

The greenhouse is designated for the hydroponic cultivation of tomatoes throughout the year. It is equipped with an automatic control system that monitors the entire production process and regulates the greenhouse internal air temperature, carbon dioxide concentration and RH. First, a simplified geometrical model of the greenhouse and its external shadings was developed. Then, thermal zones and material thermal properties (e.g. thermal conductivity and capacity, solar and visible transmission) were assigned and additional information about the heat exchange with the ground and the HVAC system were introduced, as well as the actual schedules of the control system. Weather disturbances affecting the structure were defined from the data monitored by the greenhouse external weather station. An internal source of vapour was used to represent plants evapotranspiration, and its hourly schedule was retrieved from a plant physiological model, calibrated with data of real water consumption. Simulations were performed aiming at obtaining a trial and error calibration procedure that allows the gap between real data and simulated result to be reduced, by adjusting simulation coefficients and parameters. The calibration process was focused on the parameters concerning air change rate that are the more stochastic values affecting the process – (e.g. leakage through the greenhouse envelope and natural ventilation through windows opening). 15 different combinations of such parameters were considered and evaluated.

### Results

The most performing combination estimated a yearly energy consumption of 194 kWh/m<sup>2</sup>year. This result is comparable both with benchmark values reported in the literature and with the actual energy use of the greenhouse retrieved from the natural gas energy consumption (difference of 7.6%). Furthermore, the largest amount of this difference is attributable to the consumptions of the December month where some missing monitoring data affect the reliability. The simulated internal air temperature shows a trend that matches with the real data with a RMSE of 10.6 % and a NMBE of 0.57 % amply below the maximum threshold values indicated by ASHRAE (respectively 30 % and 10 %).



## **Viewpoints and visibility analysis: a case study on the UNESCO site of Langhe-Roero and Monferrato (Piemonte Region)**

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**Keywords: Visibility analysis, Landscape analysis, UNESCO sites**

### **Objectives**

It is well established the fact that new developments impact on the viewing conditions of a landscape. Visibility analyses for the landscape settings have widely been used, especially in rural and forest areas, in order to determine through viewsheds to which extent a portion of a landscape is/can be seen from another point.

At the same time, the application of such analyses within the regulatory frameworks of new developments is not an easy task since it is difficult to determine which are the "viewing points" from which visibility analyses should be performed.

The scope of this work is not to obtain a static map, but to set out an interactive tool that, based on visibility analyses, can be used to measure the landscape sensitivity of sites. The area named "Vineyard Landscape of Piedmont: Langhe-Roero and Monferrato", listed as the 50<sup>th</sup> Italian site in the World Heritage UNESCO list, was identified as a case study, since it is a cultural landscape of exceptional and universal value.

### **Methods**

The present work is based on the coupling between the visibility analysis based on viewsheds/cumulative viewsheds (binary maps) and the study conducted at a regional level that identifies points that can be considered and that should be preserved.

In this work we combined the binary information that is the result of a viewshed analysis with some points in order to verify if the proposed points are effectively significant, if other points can be added to this list and if some points may be neglected and not considered among those to be preserved.

Such methodology can now exploit the resources that public administrations shares within the open data normative requirements. This implies a further valorisation of the investments done through the creation and update of geographical data.

### **Results**

The information provided by this application may be used into the regulatory framework for all the authorization process of new developments in preserved areas.

The objective is to provide technicians and local administrators tools based on objective data for the conservation, preservation and valorization of the landscape on one side, and for the development of economic activities that can promote a sustainable development of such peculiar locations.



## Heat stress of dairy cows subjected to different cooling systems

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**Keywords: Livestock buildings, Cooling systems, Heat stress**

### Objectives

Among the causes that influence cow welfare, heat stress induced by microclimatic conditions is one of the most relevant.

This paper presents the results of a trial carried out with the aim to investigate the effects of two different cooling systems on the heat stress of the cows.

### Methods

The experiment was carried out inside a free-stall dairy house located in the province of Ragusa (Sicily, Italy). The barn was closed on the side along the feeding alley and opened on the other three sides. The experiment was carried out in two adjacent pens separated by transverse passages: one with a resting area consisting of 26 cubicles housing 19 Friesian cows (box 1) and the other one with a resting area consisting of 16 cubicles housing 15 Friesian cows (box 2).

The free-stall barn was equipped with two different cooling systems. A fogging system associated with forced ventilation was installed in the resting area and a sprinkler system associated with forced ventilation was installed in the feeding alley.

The trial started on 27<sup>th</sup> June 2016 and ended on 3<sup>rd</sup> September 2016. The experimental protocol was structured as follows: in the box 1 the two cooling systems were always activated following an established timetable, whereas in the box 2 the sprinkler system associated with forced ventilation was deactivated in the following periods: 27<sup>th</sup> June – 7<sup>th</sup> July (P1), 25<sup>th</sup> July – 4<sup>th</sup> August (P2), 24<sup>th</sup> August – 3<sup>rd</sup> September (P3).

Climatic parameters were measured inside each box of the barn and outside. Then, THI index was calculated.

Rectal temperature and respiratory rate of 6 cows in box 1 and 5 cows in box 2 were monitored at about 14:00 of each day during the three periods considered (P1, P2 and P3).

### Results

During the experiment, the cows of both group were subjected to moderate heat stress. Indeed, the mean values of THI index in each period ranged from 72.8 (P3) to 73.9 (P2) in the box 1 and from 73.3 (P3) to 74.7 (P2) in the box 2. The maximum value of THI was 82.0 (P2) in the box 1 and 83.4 (P2) in the box 2.

The results show that although the sprinklers in the feeding alley do not influence the microclimatic conditions, their use could contribute to relieve heat stress. Specifically, physiological measurements indicates that the mean value of the respiratory rate of the cows in the box 2 was much higher than the one of the cows in the box 1. A more limited effect was noticed in the value of rectal temperature that was higher in the cows in the box 2, but kept itself almost always within normal limits.



## **Numerical 3D finite element modelling and experimental validation of dowel and tenon-mortise wooden joints for structural applications**

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**Keywords: FEM, greenhouses, wooden joint, mechanical tests**

### **Objectives**

Wood is enjoying increasing popularity in the building sector, and its use, also in greenhouses, presents specific advantages in terms of energy performance, fast construction time, light structures with excellent seismic behaviour, fire protection, easiness to obtain different building sizes and geometries. In order to fully exploit the potential of this material, particularly in three-dimensional structures, improved knowledge of the mechanical behaviour of the material and more complex constitutive models are required. The mechanical performances of timber joints are particularly important for the design of wood structures, since joints are one of the weakest points in timber structures.

### **Methods**

In this paper, a finite element model for a dowel-type vs mortise-tenon glulam joint is proposed to investigate the mechanical performances of various typologies of joints for wooden frames to be employed in greenhouses. The numerical prediction of the proposed finite element method is compared to experimental results of mechanical testing. Moreover, failure mechanisms are assessed, in order to predict the strength of such joints. The rationale of the research relies on the potential damages (i.e. breaking of the frame) that can be caused by poor quality of 90° joints, due to a number of factors such as joint geometry, gluing processes, typology of adhesives.

### **Results**

The test results show that the 90° tenon-mortise corner joints have higher strength than dowel type, and the accuracy of the FE model is acceptable in the proposed range of admissible deformations. The proposed approach can be applied when evaluating the suitability of a given typology of corner joint for specific window frame geometries, windowpane weight and external loads.



## Micro-climatic effect of plastic nets for crop protection in greenhouse

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**Keywords:** greenhouse, crop shading, plastic nets, radiometric characteristics, photo-selective properties, micro-climatic effect

### Objectives

Excessive levels of solar radiation may negatively influence crop growth, with sunburns or other possible crop damages, while increasing the internal greenhouse temperature above levels that are tolerable for plants and workers. In order to control hot air temperature inside a greenhouse, one of the most common solutions traditionally employed by growers in Southern Europe is whitening the external side of its cladding material, by painting it with liquid calcium carbonate. More recently, the use of plastic shading nets is progressively affirming, thanks to their cheaper price and some improved technical characteristics that enable them to act as a "passive" tool for controlling internal microclimate and produce suitable environmental conditions. A plastic net - characterized by a shading factor determined in a laboratory, usually ranging from 10% to 90%, which expresses its capacity to reduce the incoming solar radiation - could be produced indeed thanks to a specific formulation of its chemical and physical properties, (size and shape of the threads, mesh texture, colour, *etc.*). Also suitable specific photo-selective properties could be given to the plastic net, so as to proactively contribute to a combination of the shade effect with some specific features useful for creating more favourable microclimatic conditions for the crop growth inside a confined airspace. A comparative analysis between a plastic net and a traditional whitening technique, aimed to critically assess the efficacy of the two different shading methods to modify and control the internal microclimate inside a plastic-covered greenhouse, is presented in this paper.

### Methods

A trial was carried out in Pontecagnano (Southern Italy), where one small-scale tunnel was shaded with a plastic net characterized by 60% of shade effect, while another identical small-scale tunnel was whitened with liquid calcium carbonate on the external side of the cladding plastic film. The radiometrical characteristics both of the plastic net and the whitened film were determined in the laboratory of the SAFE School of the University of Basilicata (Italy). Inside air and soil temperatures were measured during some spring/summer months of Year 2016.

### Results

The results obtained through these experimental trails enabled a comparative analysis of the performances of the two tested shading methods, confirming the relationship among the shading conditions and the transmittance in the solar range, and highlighting the role that a correct installation may play on the final results in terms of crop protection from high temperatures and sunburns. It would be concluded that an accurate choice of a "customized" plastic net could give useful results in terms of technical performance, as well as of real efficacy in protecting the crops from excessive sun radiation and possible consequent damages.



## Testing of net based protection systems of olive trees against the vector of *Xylella fastidiosa*

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**Keywords: insect net, integrated pest management, nursery**

### Objectives

A net protection system- specific for in field cultivations and nurseries of olive trees- against the vector of *Xylella fastidiosa* was studied. Mesh size, colour, kind of fabric, threads typologies were taken into account for the design optimization of the net.

### Methods

Based on literature research, the maximum size of the mesh of a net built up to avoid the vector insects passing through the net was defined. In-field test allowed to define which colours attract vectors and which are considered neutral. Based on first results, two kind of nets were designed with different kind of fabrics: flat woven and knitted (a Raschel textile scheme). Tests were performed in Sachim and University of Bari labs. Permeability indexes, stress/strain-elongation curves and radiometric properties were measured. Finally, four “netting boxes” containing young olive trees protected by selected nets were built to verify the effective performance to limit the vectors of *Xylella fastidiosa* passing through the net.

### Results

Results allowed to reach the definition of the textile scheme with the best performance and the characteristics of the other system requirements, such as dimensions of structural elements, easy-to-use connections of the net to the supporting system and to the ground.



## Evaluation of rain permeability of agricultural nets- first experimental results

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**Keywords: porosity, HDPE nets, rain test bench**

### Objectives

A system made of technical textiles able to protect cultivations from the damages of rain fall and to let air to pass through, could tremendously increase the reliability of predictions for the harvesting of many fruits such as cherries. To this purpose a test device was designed and set up at Sachim srl to simulate and measure the rain permeability of agricultural nets at different inclinations, in terms of water amount reduction passing through the net when exposed to rain.

### Methods

A specific device was built up in the Sachim R&D lab. The rain simulator test bench was made of several nozzles spraying water, a steel frame supporting the net samples wet by the simulated rain at different angles ( $0 \div 45^\circ$ ), a container where the water passing through the net was gathered, and a purposely designed measuring system. The rain permeability index of the net was defined as the ratio between the water sprayed by the nozzles and the water gathered into the container under the net sample. Nets with different geometrical characteristics such as porosity, texture, kind of threads were tested; the effect of the net inclination was investigated, as well as the real contribution to the rain permeability decrease of a double layers textile scheme.

### Results

First results allowed to understand the influence of the main parameters to the rain permeability of the nets. The porosity, defined as the ratio between the surface of empties and the area of the net, seemed not to play a significant role as was observed when air permeability tests were performed. The mesh size, the inclination of the net and the use of the double layers scheme of the protection system were found to give the most significant change to the rain permeability behaviour of the nets.



## **Photovoltaic greenhouse: a simple technique for passive shading variation**

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**Keywords: PV greenhouse; Renewable energy; Energy production; Solar radiation.**

### **Objectives**

In the high-insolation areas, during the summer season the solar radiation exceeds the requirements of crops and therefore it is necessary to use the shading and/or air cooling. The idea of transforming into electrical energy the solar radiation exceeding the requirement of crops is of great interest because it solves the problem of excess solar radiation and allows to produce electrical energy which may also be used to power the technological systems of the greenhouse. In the photovoltaic greenhouses until today realized the PV panels are arranged on the coverage according to fixed values of shading. But a fixed value of shading from PV panels may be fine in some months of the year but not in others, may be fine in clear sky conditions but not in totally or partially cloudy sky conditions, may be fine for some crops but not for the others plants. Besides realizing dynamic photovoltaic greenhouses with variable shading within a wide ranges it is possible to use the variation of the height angle of the solar rays for obtaining a passive variation of shading (lower in winter and higher in summer).

### **Methods**

For this research a prototype of experimental photovoltaic greenhouse has been realized. The south-oriented roof was covered with 24 polycrystalline silicon photovoltaic panels fixed in a horizontal position. For to reduce the possible losses due to the reflection of solar radiation caused by non optimal inclinations of the photovoltaic panels these were fitted with 24 highly reflective aluminum mirrors always oriented according to the solar rays. With reference to solar radiation measured in clear sky conditions in 2016 has been analyzed the shading variation in according the height angle of sun rays.

### **Results**

The strong variation of the height of the solar rays during the year, at least in the middle latitudes, can be used to vary the shading on the part of the photovoltaic panels.

This simple technique allows to vary the shading significantly: by about 30% in winter at about 75% in summer. This shading variation is obtained in passive way only for the effect of the variation of the height angle of the solar rays. Only the mirrors must be rotated to be aligned with the solar rays.



## **Experimental cultivation of peppers in low energy demand greenhouses. An interdisciplinary study.**

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**Keywords: solar radiation, greenhouse, infrared radiation, photovoltaics, crop quality.**

### **Objectives**

Energy demand of greenhouses is an important factor for their economics and photovoltaics (PV) can be considered an alternative solution to cover their electrical and heating needs. On the other hand, Infrared radiation (IR) heating systems possess the advantage of high directional control and focused compensation of energy losses, appropriate for creating local temperature conditions in open or thermally unprotected spaces resulting in an overall reduction of heat losses and consequently heating energy needs. The objective of this research is to develop a low energy demand greenhouse by using IR heating and the cover of remaining energy needs by the installation of fixed PV panels on the greenhouse's roof. Also, to investigate the effect of PV panels induced partial shading on growth parameters and physiological characteristics of plants.

### **Methods**

Experimental results are presented from a full cultivation period inside two greenhouses under the weather conditions in South-West of Peloponnese, Greece. Two identical, small scale experimental greenhouses of same dimensions, placed side by side were implemented with and without fixed PV panels correspondingly. Pepper (*California Wonder* L.) is used as the test crop for a three (3) months period.

### **Results**

The results are presented in this paper, include electrical energy output, greenhouse inside space lighting and temperature and plant growing. Results were compared to classical cultivation. The design and energy performance of the above PV installation modes is analyzed and results are presented. An analysis of plants' nutrients absorption is provided, which reveals the effect of shading in the PV greenhouse plants.

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<sup>+</sup> In memory of Professor Yiannis Tripanagnostopoulos



## **TOPIC 8**

***SAFETY, HEALTH, ERGONOMICS, MANAGEMENT AND  
STANDARDIZATION FOR AGRICULTURE AND  
FORESTRY MACHINES, EQUIPMENT AND STRUCTURES***



The Italian sprayers inspection situation after the expiry of the deadline set by the National Action Plan and the Directive 2009/128/EC <i>Allochis D., Balsari P., Marucco P.</i> .....	194
A review of the methods used for the assessment of seed dressed dust drift <i>Biocca M., Fanigliulo R., Gallo P., Grilli R., Pochi D.</i> .....	195
Safety of manure spreaders: proposal of a solution against risks due to contact, entanglement, dragging, cutting and crushing <i>Cecchini M., Monarca D., Colantoni A., Mazzocchi F., Cossio F., Laurendi V., Puri D.</i> .....	196
Different dust (PM <sub>10</sub> and PM <sub>0.25</sub> ) resuspension time in piggeries following animal activity <i>Costa A., Tangorra F.M., Lazzari M.</i> .....	197
Virtual test as a complement tool of the actual ROPS testing on agricultural tractors <i>Franceschetti B., Capacci E., Rondelli V., Martin C., Bolla G.</i> .....	198
Performance evaluation of a cyclone to clean the air exiting from pneumatic seed drills during maize sowing <i>Manzone M., Marucco P., Tamagnone M., Balsari P.</i> .....	199
The need for International Standards on dusters: first proposal of test protocols for their functional evaluation and periodical inspections <i>Marucco P., Balsari P., Matta F.</i> .....	200
The introduction of cable assisted forest machines in the Italian alps: a preliminary eco-efficiency and optimal operating condition analysis <i>Mologni O., Grigolato S., Zanetti M., Cavalli R.</i> .....	201
Ranking of the Italian Regions over similar groups on the strength of the agricultural mechanization levels <i>Mongelli L., Pascuzzi S.</i> .....	202
Reference prices of agricultural machines <i>Marinello F., Armentano G., Sartori L.</i> .....	203
Operating cost of milking in automatic and conventional milking systems <i>Tangorra F.M., Costa A., Nava S., Beretta E., Lazzari M.</i> .....	204
Using Statistical Process Control to monitor milking process <i>Tangorra F.M., Melzi C.</i> .....	205
Tractive and soil compaction performances of an agricultural tractor fitted with rubber tracks <i>Varani M., Mattetti M., Molari G.</i> .....	206
Worker's energy consumption during weed management <i>Bernardi B., Benalia S., Abenavoli L., Franco G., Fazari A., Zimbalatti G.</i> .....	207



Issues in ensuring the minimum safety requirement for in-use manure spreader: overview and preliminary results from the PROMOSIC project <i>Bagagiolo G., Cavallo E.</i> .....	208
A laboratory test bench for nozzle spray droplet analysis <i>Cerruto E., Longo D., Manetto G., Failla S., Schillaci G.</i> .....	209
Design and assessment of an hydraulic oils test bench <i>Pochi D., Fornaciari L., Grilli R., Benigni S., Fanigliulo R.</i> .....	210
Technical solutions for reducing the risk of roll-over while working under trees with an agricultural tractor <i>Laurendi V., Vita L., Gattamelata D., Puri D., Salierno F.</i> .....	211
Contribution of the Self Protective Structures (SPS) to the driver's safety in case of combine-harvester rolling- or tipping-over <i>Pessina D., Facchinetti D.</i> .....	213
Energy efficiency of narrow tractors used in wine and fruit cultivations <i>Pessina D., Facchinetti D.</i> .....	214
Sicurtrac 2.0: An Integrated System for Assisted Driving of Orchard Tractors <i>Sarghini F., De Vivo A.</i> .....	215
Updated LCIA computation of an agricultural tractor based on open-access datasets <i>Masella P., Guerrini L., Angeloni G., Parenti A.</i> .....	216
Durability design criteria for agricultural powershift transmissions <i>Mattetti M., Molari G., Sereni E.</i> .....	217
A survey on work safety in agricultural farms and a risk model <i>Gubiani R., Cividino Sirio R. S., Pergher G.</i> .....	218
Screw log splitter design and risk management <i>Gubiani R., Cividino Sirio R. S., Pergher G., Zucchiatti N.</i> .....	219
Concept of a safety system to be used when performing dynamic tests of stability on agricultural machines <i>Bietresato M., Mazzetto F.</i> .....	220
Functional analysis as a conceptual instrument for studying and developing new farm-implements. An application to the design of a hand-tool for collecting kaki fruits. <i>Bonvicini I., Bietresato M., Mazzetto F., Hackl K.</i> .....	221
Normative and operative issue on the use of ULV <i>Balsari P., Oggero G., Marucco P., Tamagnone M., Matta F.</i> .....	222
About risk of fall from the top <i>Porceddu P.R., Spitella S.</i> .....	223
Proposal of an advanced facility for testing the static stability of agricultural machinery	



<i>Bietresato M., Mazzetto F.</i> .....	224
<b>Proposal of a system to perform dynamic tests of stability on agricultural machines</b>	
<i>Bietresato M., Mazzetto F.</i> .....	225
<b>EU Directive 16952: preliminary evaluation</b>	
<i>Pascuzzi S., Santoro F.</i> .....	226
<b>Carbon monoxide content of exhaust emissions from agricultural tractor engines: case study of Ogbomoso, Oyo State, Nigeria</b>	
<i>Taiwo A., Onifade T.B.</i> .....	227
<b>CARTS - Canopy Adjusted Real Time Spraying</b>	
<i>Marques da Silva J.R., Correia M., Dias A., Serrano J., Nunes P., Rodrigues R., Alves, C., Lima L., Tavares, F., Carola J., Damas F., Martins J., Oliveira B., Almeida C., Clayton J., Sander T., Botfield M., Denton D., Mills M.</i> .....	228



## **The Italian sprayers inspection situation after the expiry of the deadline set by the National Action Plan and the Directive 2009/128/EC**

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**Keywords: sprayers inspection, Directive 2009/128/EC, National Action Plan, workshop, licensed inspectors**

### **Objectives**

At present in Italy the sprayers inspection activity is running in all Regions and is performed by more than 200 workshops and by more than 600 licensed inspectors, that work throughout the National territory. In the last few years the number of workshops and inspectors grew up significantly, especially after the introduction of the compulsory inspection for all sprayers in use by the National Action Plan (NAP).

Nevertheless, in these years the inspection activity did not increase in a homogeneous way in all the Regions. This unsatisfactory situation is highlighted by the number of sprayers inspected until now compared with the total number of the equipment to check by the official deadline set by the 2009/128/EU Directive and by the Italian NAP (26<sup>th</sup> November 2016). The aim of this work was to realize a report on the Italian current situation of sprayers inspection activity after the expiry of the NAP official deadline.

### **Methods**

The report was realized on the basis of data provided by the responsible persons for sprayers inspections in all the Italian Regions and Autonomous Provinces, members of the ENAMA Working Group.

These information include: a) the number of sprayers inspections carried out annually on each Region from 2012 (year of NAP's publication) to 2016 (expiry of the official deadline for the inspections); b) the percentage of inspections carried out in Italy after the 26<sup>th</sup> November 2016 compared to the total sprayers that should have been checked; c) the increase of the workshops and the licensed inspectors number from 2012 to 2016.

Regarding these last data, they were obtained by the Italian National Database (source: [www.centriprovairroratrici.unito.it](http://www.centriprovairroratrici.unito.it)), that is regularly updated with the information from the Regional responsible persons.

### **Results**

Thanks to the data and the information collected it was possible to realize a general framework of the national sprayers inspection activity after the official Directive deadline. This framework revealed that the inspected sprayers represent just a small percentage (17%) of the total number of spraying equipment which constitute the Italian fleet (estimated to approximately 600000 units).

On the basis of these results the main possible reasons which negatively affect the sprayer inspection service were analyzed. The situation of the not inspected sprayers (the majority) was considered, with particular attention on the disciplinary aspects provided to the owners of the equipment.



## **A review of the methods used for the assessment of seed dressed dust drift**

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**Keywords: pesticides, particulate matter, maize, honeybees, neonicotinoids**

### **Objectives**

Since the year 2010, CREA-ING has been involved in researches about the role of pneumatic precision drills in the phenomenon of dust drift coming from the abrasion of dressed seed. To assess the quantity of dust containing insecticides that can be released into the environment during the sowing operations, we have employed several methods and we have developed facilities and systems to assess dust drift. These methods were used to evaluate different seed drills and prototypes capable of effectively reduce dust drift. The objective of the paper is to review methods we have employed to carry out these studies.

### **Methods**

The methods employed in our studies can be divided in field and static (with the machine in stationary position) trials. The determination of dust expelled and drifted by the drill has been carried out by means of air sampling (with both active and passive samplers) and by passive samplers to assess ground deposition. Air sampling entails the use of: (1) air pumps operating at medium and low volume, equipped with various membrane filters (Teflon, cellulose-nitrate); (2) multistage impactor; (3) passive MWAC samplers. The determination of residues at ground level has been carried out by means of Petri dishes filled with an aqueous solution of acetonitrile. Depending on the employed sampler, the collected content was analysed in different ways. Membrane filters can be both weighted and analysed to determine the content of chemical species. Moreover, filters can be observed at light microscope to obtain information on size and morphology of particulate matter.

Regarding the test at fixed point, part of the experiments has been carried out in a sort of wind tunnel that we arranged in our institute. The results of the experiments in the wind tunnel were also validated with respect to field findings. Regarding the field studies, we have carried out trials in small and large plots, and we developed an original placement of samplers to determine the drift in uncontrolled environment conditions.

### **Results**

The methods employed in our studies were useful to determine the quantity of dust released by drills sowing dressed seeds. The results were employed: (1) to determine threshold levels of hazard for honeybees; (2) to test new and modified model of drills capable of reduce the dust drift; (3) to determine size, morphology and other characteristics of the abraded particles; (4) to assess the operator exposure to dust during sowing operations. A comparison among different methods is discussed.



## **Safety of manure spreaders: proposal of a solution against risks due to contact, entanglement, dragging, cutting and crushing**

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**Keywords: Manure spreader, Safety, Agricultural machine, Declutching**

### **Objectives**

A manure spreader is an agricultural machine used to distribute manure over a field as a fertilizer. It consists of a towed or carried trailer with a rotating mechanism driven by the tractor's power take off (PTO). Self-propelled trailers are also on the market.

The use of manure spreader involves several risks for workers: contact, entanglement, dragging, cutting, crushing and so on.

This study concerns the prevention and protection from safety risks during work inside the loading hopper of the manure spreader when the working bodies of the same are in motion. This situation often occurs during cleaning operations of the machine and exposes workers to serious or fatal injuries.

Technical standards for this type of machine not always proved effective in the protection of workers. Therefore the present study intends to evaluate regulatory deficiencies trying to propose adequate solutions to resolve them.

### **Methods**

Against the above described risk, various solutions have been suggested. The present work describes a motion decoupling device controlled by motion sensors applied on the axles of the wheels of the manure spreader.

This solution has been tested at the INAIL research center of Monte Porzio Catone (Italy) on a prototype developed by Ren Mark (Ren Mark Snc di Fontana e Genitoni - San Polo D'Enza, Italy).

### **Results**

The research results show the technological feasibility of the device with a certain impact, however, on the overall cost of the machine. Incidence that can be significant for smaller trailers and almost negligible for the larger ones. The results also may be useful for the definition of new technical standards or to update existing ones.

### **Acknowledgement**

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## Different dust (PM<sub>10</sub> and PM<sub>0.25</sub>) resuspension time in piggeries following animal activity

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**Keywords: dust, PM<sub>10</sub> and PM<sub>0.25</sub>, animal activity, pig facilities.**

### Objectives

The aim of this study was to evaluate the contribution of animal activity to dust concentration in finishing pig facilities. The study was addressed to estimate the lag time occurring from maximum level of activity and peaks of particulate matter (PM<sub>10</sub> and PM<sub>0.25</sub> concentrations) in the barn, and to evaluate dust deposition times for the different PM size categories.

### Methods

For this purpose, two finishing rooms, with around 360 animals distributed in 16 pens, mean age of 140d and mean weight of 73 kg, were used. The floor was concrete slatted, eight valves released liquid feeding to the 16 pens three times a day. The facilities were mechanically ventilated, with a climate controller set up on pigs temperature requirements system and based on a free running impeller (type Fancom FMS).

A Grimm Portable Laser Aerosol Spectrometer Model Mini-LAS 11-R was used to evaluate dust particles ranging from 0.25 µm to 30 µm, in mass and count, in the facilities.

The instrument was placed in the middle of the pen in a protective shell, at a height of 50 cm, at the respiratory apparatus level of pigs. Measurements were performed continuously for 3 d every two weeks during the three months of the finishing phase.

### Results

As demonstrated in previous works, data showed that, there is a lag time between the beginning of increased animal activity (at visual observation) and PM<sub>10</sub> peaks: the peaks were registered eighteen minutes after the beginning of feed release.

During feed assumption, PM<sub>10</sub> reached the peak of concentration, up to 1400 µg/m<sup>3</sup> during the driest day. Usually, the PM<sub>10</sub> concentration lowered to 80 µg/m<sup>3</sup>, in around 15 minutes. PM<sub>0.25</sub> showed a peak directly in correspondence with the beginning of animal activity (around 7 µg/m<sup>3</sup>, 437000 particles, in count). The concentration remained high during the positioning of pigs on the floor to rest, lowering to reach a linear "rest trend" only 90 minutes after the feeding time.

These results take importance for the risk induced by environmental pollution in animal facilities for workers and veterinarians, since, for example, during vaccination time and inspection, animals reach a great level of activity.

At this point, a further study addressed to analyze the type of dust raised in particular moment, would be helpful to avoid undesired risks for the health status of animals and workers, through additional good management procedures application.



## **Virtual test as a complement tool of the actual ROPS testing on agricultural tractors**

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**Keywords: Tractor, Rollover, ROPS, Virtual test, Normalized test**

### **Objectives**

The Roll Over Protective Structure (ROPS) is a key safety feature in agricultural and forestry tractors in order to minimize risks to the driver in case of rollover during normal use. The Organization for Economic Co-operation and Development (OECD) in an effort to improve operator's safety has set up harmonized testing procedures for ROPS systems. The current OECD Codes for tractors relate to several features of performance. OECD Code 7 is related to the strength of ROPS fitted on narrow-track tractors. On the one hand, Code 7 foresees a sequence of loadings that the protective system has to withstand until the prescribed energy or force is satisfied. In addition to successfully resist the loading sequence, the ROPS has to guarantee a clearance zone during the complete loading sequence. Nowadays tractor manufacturers often adopt numerical simulations for optimizing ROPS design and foresee in advance the strength behavior of the protective structure with respect to the standardized ROPS test requirements. Evaluating the numerical simulations as complement of the ROPS official actual tests is the current goal.

### **Methods**

A new ROPS system designed by the BCS manufacturer for a narrow track tractor was officially tested according to the OECD Code 7 test requirements. The actual tests were performed at the OECD Test Station of Bologna. Because of the ROPS did not successfully resist during the loading sequence, a numerical simulation with LS-DYNA® was carried out to virtually assess the performance. EnginSoft performed the virtual tests.

### **Results**

A comparison between the results of virtual and actual tests was performed to check the critical points in ROPS design and in simulation assumptions for improving the ROPS model simulation with respect to the official test requirements. A new ROPS based on the feedback of the virtual test was manufactured. The ROPS structure satisfied the OECD test requirement ensuring a clearance zone during the actual strength tests. The use of numerical simulation accompanied by a robust methodology could ensure a high reliability of the virtual prediction with respect to the normalized tests.



## **Performance evaluation of a cyclone to clean the air exiting from pneumatic seed drills during maize sowing**

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**Keywords: Neonicotinoids, treated seeds, pneumatic seeders, pesticides dispersion, SweepAir® kit**

### **Objectives**

Seed dressing for pests control has been used on a large variety of crops. Although this pest control has high efficiency and low costs, in recent years, it has been banned in several UE countries for some pesticide products (e.g. neonicotinoids) because the dust pesticide coating released into the atmosphere by pneumatic sowing machines and can be responsible for bee killing. Bayer Crop Science® has developed an innovative device to clean the air at the exit of the pneumatic seeder's fan (patented as SweepAir®).

This system is able to separate the dust from the fan exhaust airflow and convey it into the soil while the cleaned air is returned to the atmosphere. This paper reports experimental tests on the performance of this innovative system.

### **Methods**

Two series of tests were performed to assess the system's performance. First, the system efficiency was determined through: 1) cyclone dust separation efficiency, 2) vacuum rotary valve life and 3) furrow system efficiency. Second, the influence of the system on the seeder performance was evaluated: 4) fan airflow rate and vacuum level inside the seeding elements. Tests 3 and 4 were performed with and without the kit on the sowing machine. Tests were performed without dressed maize seeds but using a definite tracers amount to simulate the seed dressing dust. This choice allow to eliminate the variability in the amount of dust abraded from the coated seeds during each test and to have reproducible test conditions for all the trials.

### **Results**

The tested system, in the experiment conditions, has been resulted able to remove almost 100% of the dust dispersed from the fan of maize pneumatic seeder during sowing activities. Furthermore, the kit can be used with all types of maize pneumatic seed drills because it is only necessary to direct the air stream from the seeder fan into the kit primary pipe.

In addition, tested kit could improve operator and environmental safety because the external surface of the seeder is not contaminated by pesticides.

These results apply only to Tartrazine E 102 powder used in the tests and shall be confirmed in further field tests that are ongoing using dressed (coated with pesticide) seeds.



## **The need for International Standards on dusters: first proposal of test protocols for their functional evaluation and periodical inspections**

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**Keywords: duster, International Standard, test protocol, inspection.**

### **Objectives**

It is estimated that more than 200000 dusters, mainly used to apply sulphur dry powder in vineyards to prevent powdery mildew, are actually in use in Southern Europe. At present there are no any reference International Standard for the technical features and the performance assessment of brand new dusters. This lack is a problem also in the perspective to define criteria for the inspection of dusters in use, which according to the European Directive on Sustainable Use of Pesticides (EC 128/2009) is mandatory and with reference to the Italian National Action Plan (DLgs n. 150, 2012) shall be carried out as soon as a standardized inspection methodology is developed.

First draft of test protocols both for assessing the performance of brand new dusters and for making the periodical functional inspection of dusters already in use are presented.

### **Methods**

The draft of test protocols to be discussed with manufacturers and International experts for setting up an International Standard on environmental requirements and testing for dusters was prepared considering: a) first experimental results obtained using this type of machinery at DiSAFA – University of Torino, concerning the measurement of air symmetry distribution and the dust flow rate, using different test materials (kaolin or sulphur dust); b) some requirements present in ISO 16119-3 concerning air-assisted sprayers for bush and tree crops. The applicability of these draft test protocols was checked on three different models of dusters that were tested at DiSAFA – University of Torino.

### **Results**

Concerning air velocity measurements, a test protocol based on the measurement of the air velocity at the spout and at a defined distance from the center of the machine on the two sides resulted able to provide information about symmetry of air distribution.

About dust flow rate measurements, problems were encountered in carrying out the trials due to the difficulties in managing the dust emitted by the machines. Tests made using kaolin clay dust as test material and filling the tank with a limited amount of powder provided results very different with respect to the nominal values indicated by the manufacturers while tests carried out with sulphur dust indicated that the dose rate depends very much on the tank filling level and is also affected by the specific type of sulphur dust. Further tests are necessary in order to: a) define the minimum performance requirements for brand new dusters; b) improve the present dosage test methodology.



## **The introduction of cable assisted forest machines in the Italian alps: a preliminary eco-efficiency and optimal operating condition analysis**

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**Keywords: steep terrain, forest transportation, eco-efficiency, safety**

### **Introduction**

The steep slope forest operations in the Central European mountains are traditionally based on the use of the cable-based harvesting system. The cable-based system is generally considered an environmentally friendly harvesting system mainly because of its low physical soil interaction. However, the set-up time, the operating costs, the high level of manual and motor-manual tasks, and the related safety risk are limiting its application, favouring alternative harvesting systems. As a consequence, the recently extension of the operative range of the ground-based harvesting system seems to be one of the main alternative possibilities for steep slope forest operations. This solution, based on a cable-winch synchronized with the vehicle traction, allows the use of the ground-based machines in steep terrain also for the wood extraction phase, increasing the competition and the overlap area with the cable-based harvesting system.

### **Objectives**

To explore the overall effects in steep terrain of the conversion from the cable-based system to the ground-based system by comparing their eco-efficiencies in the specific condition of the Italian alps.

### **Methods**

An eco-efficient evaluation is here proposed including productivity and costs analyses and environmental impacts assessment. Environmental impact assessment will consider: *i)* direct impacts to the soil and the residual stand; *ii)* natural resource consumption and pollutant emission levels related to the production and use of the machines; *iii)* operator safety.

The eco-efficiency of the two systems will be evaluated through a review of the available literature and by direct preliminary analyse in the field. The field test will be conducted in spring 2017 in the North-eastern part of Italy.

### **Expected results**

Preliminary indicators are expected to support decision on the choice of the most efficient harvesting system in relation to the terrain and stand characteristics as well as in relation to the safety of the operators and the direct and indirect environmental impacts.



## Ranking of the Italian Regions over similar groups on the strength of the agricultural mechanization levels

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**Keywords: Agricultural Mechanization, clustering, Agglomerative hierarchy**

### Objectives

The aim of this paper is to spread the Italian Regions over similar groups on the strength of the agricultural mechanization. The analysis was carried out taking into account of the following 15 related variables: average agricultural farm's land (ha); rates of farms whose agricultural land was less than 2 ha; rates of farms whose agricultural land was equal or larger than 50 ha; tractors-number/ha-agricultural land; cultivators-hoeing machines-rotary hoes-motor mowers-number/ha-agricultural land; harvester-number/ha-agricultural land; other machines for mechanized harvester number/ha-agricultural land; other machines number/ha-agricultural land; machines power (kW); yearly work days/ha-agricultural land; farm yearly work days; farmer yearly work days; active contractors yearly days/ha-agricultural land; passive contractors yearly days/ha-agricultural land and farm contractors yearly days. Therefore, there are 3 variables linked to the farm sizes, 6 variables connected to their mechanization degree and 6 variables assessing the labour employment.

### Methods

The "bottom up" agglomerative hierarchical cluster analysis has been used, prearranging 6 groups, employing the coefficient of Pearson as similarity criterion and the average binding as agglomerative technique.

### Results

The obtained bundling consists of the following grouping of Italian Regions. 1<sup>st</sup> group: Piedmont, Valle d'Aosta, Lombardy, Friuli Venezia Giulia, Emilia-Romagna, Marche, Basilicata and Sardinia; 2<sup>nd</sup> group: Liguria, Lazio, Campania, Puglia and Calabria; 3<sup>th</sup> group: Trentino-Alto Adige, Veneto and Abruzzo; 4<sup>th</sup> group: Tuscany and Umbria; 5<sup>th</sup> group: only Molise; 6<sup>th</sup> group: only Sicily. The analysis of the each other distances of the aforesaid groups centroids and the distance among these ones and the national centroid point out sizeable aspects. In particular, the 5<sup>th</sup> group, characterized for all mechanization levels higher than the average, is by far the most remote from the other ones and the national centroid. Furthermore, the results highlight also a dramatic distance between the 1<sup>st</sup> group, characterized by farms with large agricultural land and the 2<sup>nd</sup> one contrariwise characterized by small farms. The ranking of the groups set up on the strength of the increasing distance from the national average is the following: 4<sup>th</sup> group, 3<sup>rd</sup> group (big machines), 6<sup>th</sup> group, 1<sup>st</sup> group (large farms), 2<sup>nd</sup> group (small farms), 5<sup>th</sup> group (Molise).



## Reference prices of agricultural machines

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**Keywords: Influencing factors, Modelling, Tractors, Implements**

### Objectives

The possibility of foreseeing the prices of agricultural machines is increasingly important both for policy makers (involved in definition and evaluation of subsidiary actions for rural development) and for farmers (needing tools for definition of new machinery investments). Furthermore the availability of models for a priori estimation of prices is interesting for the possibility of defining and optimizing the costs associated to different management conditions in agricultural productions. The objective of the present paper is to show how consistent correlations can be determined between the costs of tractors and implements and some specific technical parameters.

### Methods

The present work takes advantage of a data set, indexing more than 6000 agricultural models, including tractors, machines for soil cultivation (harrows, cultivators, ploughs,...), fertilizing and pest control (fertilizer spreader, sprayers,...), hay making (mowers, balers,...), harvesting (combines, grape harvesters,...), seeders, mixing wagons, trailers, etc.

All different machines have been analysed in order to define the technical parameters which most influence final price.

In most of cases, linear regressions are sufficient to define the models which quantify the prices as a function of defined technical parameters. Coefficient of determinations and standard errors have been calculated to quantify the forecasting capacity and applicability of the same models.

### Results

Agricultural machinery costs are correlated to a few parameters.

In the case of tractors and self propelled equipment, most relevant parameters are ascribable to engine maximum or nominal power, dimensions, mass and cabin set up.

In the case of implements, price is primarily influenced by mass, dimensions, work capacity, presence of hydraulic, mechanic electric or electronic controls.

Coefficients of determination in general higher than 0.60 have been detected, with higher correlations ( $R^2 > 0.9$ ) in the case of tractors, harvesters and tillers.



## Operating cost of milking in automatic and conventional milking systems

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**Keywords:** automatic milking, milking parlour, milking cost

### Objectives

Automatic milking represents a revolutionary innovation in dairy farming. The adoption of an Automatic Milking System (AMS) is to be considered not only as a replacement for a milking parlour but also mainly as a new concept of managing a dairy farm. The most relevant benefits of automatic milking are the increase in milk yield and the labor saving. The aim of this study was to estimate the operating cost of milking (€/t of milk) in an Italian dairy farm when cows were milked in an AMS as compared to a conventional milking system (CMS).

### Methods

In a Lombardy dairy farm the simultaneous presence of an AMS and a CSM allowed the herd to be splitted into two homogeneous groups. The Holstein Frisian herd of 99 lactating cows was randomly divided into two groups ( $G_1=49$  and  $G_2=50$ ), according to their lactation number and lactation stage. For the one-year testing period cows belonging to group  $G_1$  were milked by an AMS one box system with free cow traffic. Cows of group  $G_2$  were milked conventionally twice a day (12 h interval between two milking cycles) by a 5+5 herringbone milking parlour, equipped with automatic cow identification (RF-ID), milk metering technology and automatic cluster removers. The average milk yield/cow recorded in  $G_1$  and  $G_2$  was used as benchmark to calculate the AMS and CSM operating cost of milking (€/t of milk).

The average annual fixed costs (AFCs) included the capital amortization (AMS or CMS) and the costs for its insurance, management and maintenance. The average annual variable costs (AVCs) were estimated by adding up the average unit cost of the main factors (electricity, water, detergents, disinfectants, and labour) used at milking. The operating cost of milking (OCM, €/t) in the AMS and the CMS was calculated from the average annual total costs (ATCs = AFCs + AVCs) and the average annual milk yield/cow, corrected for fat content (4%). The extra feeding cost required to cover the additional milk yield produced by the cows milked in the AMS and the relative benefits originating from the selling of the extra milk were also taken into account.

### Results

The AFCs per cow in the AMS were 79 % higher than in the CMS (470 €/y vs. 262 €/y), mainly due to the higher capital investment and the higher maintenance and updating costs related to the adoption of AM-systems, compared to CM-systems. On the contrary, the AVCs per cow in the AMS were 48 % lower than in the CMS (217 €/y vs. 414 €/y), mainly due to the lower labour costs. Overall, the ATCs per cow were equal to 687 €/y and 677 €/y respectively in the AMS and CMS, which correspond OCM respectively of 68 and 64 €/t. Nevertheless, taking into account the benefits originating from the extra milk yield, in the AMS the OCM reduces at 48 €/t (-29 % if compared with the CMS).



## Using Statistical Process Control to monitor milking process

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**Keywords: Statistical Process Control, Control Chart, milking parlour performance**

### Objectives

Every process, regardless of how it is well designed, is always subject to a certain variability. This variability, also called "noise", depends on many random factors. A process, whose variability is caused just by "noise", is referred to as under control process. On the contrary, an out of control process exhibits variation due to the presence of special causes.

The objective of the work was to monitor milking process using the Statistical Process Control (SPC). SPC is a statistical method of interpreting time-series data, whose general principle is having a wide database collected on a regular basis that generates a historical perspective and a normal pattern to the data. Irregular patterns can be interpreted as management issues that need to be addressed.

### Methods

Parlour performance data from 20 milking parlours (17 herringbone, 2 parallel, 1 rotary) of Northern Italy were collected for SPC analysis. Overall, 7122 dairy cows (Holstein Frisian), milked two times per day during one year, were involved in the study. The following data were extracted from the herd management software of each milking parlour: average milk flow rate [kg/min]; milk flow rates at 0-15 s, 15-30 s, 30-60 s, 60-120 s after the milking unit attachment; percentage of milk during the first two minutes of milking [%]; average milking time [min]; average milk yield/cow per milking [kg]; time of low flow - below 1 kg/min [min]; cows milked/stall per hour [n]; milk yield/stall per hour [kg]; milking efficiency [%]. Through the Principal Components Analysis (PCA), two new variables were identified (principal components) that can be interpreted as a synthetic index of flows or animal performance (first component) and as a synthetic index of the milking parlour performance (second component). The milking process was then analyzed using Control Charts based on the principal components previously identified.

### Results

By graphing the 20 milking parlours with respect to the principal component axes, four groups were highlighted:

- High animal performance and high milking parlour performance (first quarter);
- Low animal performance and high milking parlour performance (second quarter);
- Low animal performance and low milking parlour performance (third quarter);
- High animal performance and low milking parlour performance (fourth quarter).

The use of Control Charts highlighted a marked variability of the milking process within the milking parlours, regardless of the belonging quarter. These results suggest the need to further study the milking process looking for management solutions that can make it constant in time.



## **Tractive and soil compaction performances of an agricultural tractor fitted with rubber tracks**

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**Keywords: agricultural tractor, rubber tracks, traction efficiency, soil compaction**

### **Objectives**

From the birth of agricultural mechanization, agricultural tractor main specifications have evolved over the years to keep pace with the development of the agricultural processes. Regarding traction systems, tractors could be divided into two main categories, wheeled and steel-tracked tractors. The latter provides higher tractive performance and lower soil compaction, but nowadays this traction system is rarely used due to its complexity and the difficulties of driving steel-tracked tractors on paved roads. In the last decades, rubber belt tracks for agricultural machines became a popular solution, in fact they combine excellent tractive performance and low soil compaction without motion problems. A further evolution of this technology was the development of triangular rubber track systems that can be installed on conventional wheeled tractors. The objective of this study was to compare the tractive and the soil compaction performances of a conventional wheeled tractor with the fully tracked version of the same model.

### **Methods**

The tested tractors were connected each other through a steel chain equipped with a load cell. The performances of the towing tractor were evaluated using the towed tractor as a brake, then the tractors were inverted in order to test both. Field tests were performed on both dry and wet soil, in order to evaluate the performance of the two traction systems not only in normal condition but also in low adherence condition. The traction efficiency and the maximum draft force of the tractor were measured through the load cell and the tractor parameters acquired with a CAN logger. The soil compaction was evaluated through the analysis of soil bulk density and cone index data.

### **Results**

The results show a reduced soil compaction for the tracked tractor with respect to the wheeled version despite of the increase of the tractor mass due to the four rubber tracks weight. Furthermore, the tractor equipped with rubber tracks showed an improvement of the traction efficiency, especially on low grip surfaces.



## Worker's energy consumption during weed management

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**Keywords:** Oxygen consumption, Heart rate, Metabolic rate, Occupational illness

### Objectives

Weed management, as well as any other agricultural practice, represents one of the working sectors where professional accidents and diseases occurrence is significant. The existing regulatory obligations take into account the workers' welfare in a wide sense. Indeed, beside the traditional risk agents, a new attention is paid toward the ergonomic aspects. Among the factors affecting the psychophysical workers' safety, the aerobic metabolism engendered while carrying out specific duties in agriculture and the stress that goes with it, constitute important aspects. Through the evaluation of some functional parameters of the human body, it is possible to determine how the individual reacts to physical stress to which he is subject. The present work focuses on this issue, and aims to evaluate the worker's energy consumption during weeding.

### Methods

The experimental trials assessed two workers aged 28 years old in average while weeding in a flat terrain using a brush cutter. Sampling considered the determination of the metabolic rate through the measurement of oxygen consumption rate at level 4 (expertise) according to UNI EN ISO 8996:2005 standard. Functional parameters such as oxygen uptake ( $\dot{V}O_2$ ), respiratory exchange ratio (RQ) and heart ratio (HR) were recorded in real time with a portable metabolimeter K4b<sup>2</sup> (COSMED).

Both of the steady state (or preliminary period), reachable after 3 to 5 minutes, and the main period (of full activity), which lasts 10 minutes according to the previously cited standard, were monitored.

### Results

Meteorological conditions recorded an average temperature of 27°C, a relative humidity HR of 54% and a barometric pressure of 744 mmHg (an almost comfortable condition). Data analysis highlighted that the amount of consumed oxygen ( $VO_2$ ) during the whole period of trials, was equal to  $48,04 \pm 25,23 \text{ lO}_2 \times \text{h}^{-1}$  in average. Considering the two monitored periods separately, this value corresponded to  $43,38 \pm 20,82 \text{ lO}_2 \times \text{h}^{-1}$  in average for the steady state, and reached  $54,18 \pm 26,82 \text{ lO}_2 \times \text{h}^{-1}$  during the main period.

Respiratory exchange ratio (RQ) mean value in the achieved trials was equal to 0,8 indicating that the work was realized in aerobic conditions without lactic acid production.

The heart ratio (HR) mean corresponded to  $98 \pm 17$  bpm, while the highest value corresponded to  $156 \pm 25$  bpm. The determined metabolic rate mean value was equal to  $143 \text{ W} \times \text{m}^{-2}$  (or  $229 \text{ kcal} \times \text{h}^{-1}$ ).

According to the evaluation of the metabolic rate at level 1 (screening), such a value corresponds to gardener's duties, which lie in "agriculture" occupation category (method 1A). In addition, it refers to a "moderate" metabolic rate (Class 2) when considering the kind of activity (method 1B).



## **Issues in ensuring the minimum safety requirement for in-use manure spreader: overview and preliminary results from the PROMOSIC project**

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**Keywords: safety, manure spreaders, harmonized standards**

### **Objectives**

Manure spreader are agricultural machineries, mostly trailed, used for transportation and application on fields of manure. The agricultural machines can be responsible of accidents caused by entanglement because of unintentional contact of operators upper and lower limbs with moving parts such as the spreading devices (rollers), the conveyor belt and the power transmission system. The risk of accident increases with the age of machines because, usually, older units are not equipped with the most up-to-date features according to safety standards. On the other hand, the commitment for users to ensure minimum safety requirements on existing machinery often represent a serious issue: most of the farm operators, being small and medium sized, are not able to bear additional costs due to the mechanical interventions on the machinery. The objectives of the study were: i) to analyze solutions to adopt on in-use trailed manure spreader to ensure safety requirements in accordance to the most recent safety standards and ii) to evaluate the technical and economic feasibility of the identified solutions.

### **Methods**

The EN 690:2014, the European harmonized standard for manure spreaders has been examined to identify the novelties introduced with the last edition. Then, through a qualitative analysis on a sample of manure spreaders in use on farms, most significant technical intervention to achieve required safety requirements were identified. Moreover different individuals (manufacturers, suppliers, users, mechanical shops operators), were interviewed to point out the technical and economic obstacle in adopting such solutions.

### **Results**

The investigation confirms that majority of the in-use manure spreaders would not comply with the most recent harmonized standard especially for what concerns protection against the risk of entanglement. The study points out solutions to achieve required level of safety for operators verifying for some of them the effective technical feasibility and the economic impact. Some solutions proposed in harmonized standard resulted possible only on machines equipped with hydraulic drive system. In general, technical implementation resulted very difficult to be applied on oldest units, while the adaptation to the current safety standard resulted economically not-convenient for smaller machines.



## A laboratory test bench for nozzle spray droplet analysis

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**Keywords:** Pesticide application, Image analysis, Drop pulverisation

### Objectives

One of the most important factors influencing spray deposit and superficial coverage during a phytosanitary treatment is the spray spectrum. In fact, the ideal spectrum maximises the spray efficiency as ensures the transfer of the required dose to the target and minimises the off-target losses due to drift and run-off. There are many drop size analysers available on the market nowadays, most of which use optical imaging, laser diffraction and phase Doppler to characterise sprays. Objective of this paper is the presentation of a laboratory test bench, under construction at the Section of Mechanics and Mechanisation of the Di3A, capable of analysing the nozzle spray droplets.

### Methods

The test bench was designed to characterise nozzle sprays according to the procedure described in ISO 5682-1 (Equipment for crop protection - Spraying equipment - Part 1: Test methods for sprayer nozzles). The nozzle under test sprays a mixture containing water-soluble dye (Ponceau Red) above *Petri* dishes filled with silicon oil. The image analysis of the drops trapped into the oil, carried out by using the *ImageJ* software, allows measuring the spray drop diameters and then all the spray features. Moreover, placing water sensitive papers (WSP) and natural targets (fruits or leaves) beside the *Petri* dishes, the data deriving from the analysis of the drops inside the *Petri* dishes could be correlated with those deriving from the analysis of WSP and with the deposit on natural targets: if the correlations will be statistically significant, the WSP image analysis alone will allow both to measure the unitary deposit and to characterise the sprays.

### Results

The test bench consists of a transportable trolley carrying a 70 L tank, a diaphragm pump driven by an electric motor, and a spray boom carrying one multiple nozzle holder. The spray boom is applied to a mobile support that moves, driven by a dedicated motor, along two slides placed above and parallel to the plane of the trolley, at a distance of about 0.5 m. Travel speed, acceleration and deceleration ramps of the mobile support are imposed by a speed controller. Pressure and nozzle flow rate are measured on-line by means of suitable transducers. Drop images acquisition system was realised by means of a high resolution (24 Mpixel) DSLR camera equipped with a macro lens.

The whole system is not easily movable between farms, because of its weight and size: it could stay in workshop centres and used during sprayer calibration. Moreover, its use requires a stable position: in fact, to eliminate the effects of vibration, *Petri* dishes are placed on a supplementary table, distinct and isolated from the trolley. With respect to commercial drop analysers, its strength lies in its low cost (moreover, the camera can be used independently). Its accuracy depends on the measuring method: it might be lower than that obtained with laser diffraction or phase Doppler analyzers, but conform to ISO 5682-1 standard.



## Design and assessment of an hydraulic oils test bench

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**Keywords:** radial piston pump, operating pressure and temperature, oil viscosity, particulate contamination, dynamical performance

### Objectives

In order to assess the technical performance of hydraulic fluids, we designed and realized a test bench (OTB) which consists of hydraulic components capable to perform hydraulic work cycles. In order to accelerate the aging of the tested fluid with respect to what normally occurs in an agricultural tractor, the bench was designed for employing small volume of oil. The working assumption foresees the adoption of working cycles of 150 hours with oil volume of 20 l (instead of an average oil lifetime of 800-1000 h of 80-100 L oil volume in tractors), with the aim of stressing the oil under test in terms of both operating temperature and pressure. Such conditions can be applied by means of controlled and repeatable workloads provided by an oleodynamic circuit, in order to evaluate the fluid by observing its hydraulic performance and the variation of its chemical and physical characteristics.

### Methods

The OTB is based on a hydraulic circuit consisting of a tank, a low-pressure circulation pump, a 30  $\mu\text{m}$  primary filter, a radial pistons high-pressure pump, a series of solenoid valves that drive the oil towards overpressure relief valves (up to 400 bar) and a water / oil heat exchanger. The OTB hydraulic workload is generated by the high pressure pump that force the oil through the high pressure valves at high temperatures (70° up to 90° C), which determines the output oil lamination. A series of sensors allows the continuous monitoring of the operative parameter (flow rate, pressure, oil temperature in different section of the circuit) and the calculation of hydraulic power and work.

The OTB was tested by subjecting a mineral hydraulic fluid to a working cycle of 245 hours at an operating pressure of 400 bar. During this cycle, 150 hours were conducted while maintaining the oil temperature at the outlet of the 400 bar valve at 70°C, 70 hours with a temperature of 80°C and the last 25 hours at about 90°C.

The main dynamics parameters have been detected (operating pressure and temperature, oil flow rate, hydraulic power continuously delivered by the high-pressure pump). Moreover, oil samples were taken at time intervals of 30 h, and sent to a laboratory for the measurement of significant chemical-physical parameters: kinematic viscosity at 40°C, TAN (Total Acid Number), particulate contamination.

### Results

The data recorded during the test and the results of the chemical-physical analyses show that during the working cycle all functional parameter kept constant, indicating that the oil performance was stable and showing, at the same time, the capability of the OTB to reliably apply repeatable working cycles in which the operative conditions can be adjusted depending on the specific requirements of the tests.



## Technical solutions for reducing the risk of roll-over while working under trees with an agricultural tractor

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**Keywords: Roll-Over Protective Structures (ROPS), Self-deployable ROPS.**

### Objectives

Nowadays many narrow-track wheeled agricultural tractors are equipped with two posts front mounted Roll-Over Protective Structures (ROPS). These kind of ROPS are of two different types: fixed or completely foldable. In Italy is largely widespread the foldable type of ROPS because in its folded configuration it allows to work under trees or in greenhouses. On the other hand when the ROPS is in folded position it does not give any protection to the driver. Many fatal accidents occur in Italy per year involving tractors, articulated or not, equipped with two posts front mounted foldable ROPS not in safety position. For these reasons the Italian National Institute for Insurance against Accidents at Work (Inail) developed a specific research activity. As a first result the following technical solutions have been considered as achievable and able to reduce the risk of roll-over while working in specific narrow environment conditions (e.g. under trees, in greenhouses, etc.):

1. systems for reducing the activation force for bringing the foldable ROPS in safety configuration;
2. compact roll-over protective structures (CROPS);
3. self-deployable ROPS (autoROPS);
4. innovative low profile agricultural tractor.

### Methods

The methodology applied for each of the previous points consists in the following three steps:

1. design by means of a parametric CAD model of the structure fitted on a virtual model of a narrow-track tractor. By means of reverse engineering approach the main frame of the tractor is reproduced in an virtual environment. There it is possible to fit on it a first virtual prototype of ROPS in order to verify possible interferences with structural elements of tractor;
2. structural verification by means of finite element analyses (FEA) according to the applicable OECD codes. The finite elements simulations are necessary in order to verify that the geometric solutions adopted are able to withstand the required forces and to absorb the proper energy;
3. kinematic and dynamic analyses. Where there are mobile portion of the structure (e.g. foldable or movable ROPS) it is necessary to analyse their motion not only in terms of displacement, velocity and acceleration (kinematic) but also investigating the activation forces (dynamic). In particular, the resultant activation forces shall be compliant with ergonomic principles defined in relevant international standards, as for example the OECD code 6 which defines a specific test procedure to ascertain the activation force of the moving 2-post front mounted roll-bars;
4. experimental tests. Finally, the functionality of the structure it-self and of the tractor fitted with it are investigated by means of experimental tests in the field and on specific test rigs by means of physical prototypes.

### Results



The results achieved by means of the research activity herein described could be summarized as follow:

- defining the technical features of systems for reducing the activation force for moving foldable ROPS. In particular, the information acquired will be useful in order to give to final users the opportunity to apply these systems to foldable ROPS realized in compliance to the information of Inail national guide line;
- implement into Inail national guide line the technical information and drawings for realizing compact ROPS to be fitted on old tractors;
- verifying the benefits of a self-deployable protective structure with an innovative kinematic design;
- starting the analysis of an innovative compact narrow-track wheeled agricultural tractor.



## Contribution of the Self Protective Structures (SPS) to the driver's safety in case of combine-harvester rolling- or tipping-over

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**Keywords: combine-harvester, overturning, self-protective structure**

### Objectives

The overturning of tractors has always been recognized as the main risk of serious and fatal accidents in agriculture. Even for the Self-Propelled Machines (SPM) such risk cannot be excluded. The slope and the irregular size of the agricultural Italian land are, among others, aggravating factors. For this reasons, for some categories of SPM (such as the combine- and the grape-harvesters), for many years are available on the market self-levelling models. Nevertheless, several fatal rollovers involving SPM still occur in Italy.

However, in some cases the features of some important components of the machine, defined Self Protective Structures (SPS), helped to reduce significantly the driver's injury in case of rolling- or tipping-over.

The ISO 16231 standard (Self-propelled agricultural machinery - Assessment of stability) is finalized to define the minimum requirements for the stability of these categories of machines, and considers the SPS as "structural components of the machine with sufficient strength to provide a deflection limiting volume if the machine overturns".

### Methods

With reference to the combine-harvester, the various components of the machine were considered, in order to ascertain their possible contribution as suitable SPS. Preliminarily, it seemed appropriate to introduce the concept of "minimum requirements" in order a given component can be considered a suitable SPS.

*The grain tank of a traditional medium-sized combine harvester was then considered as a case study.*

Due to its large dimensions and fitting position on the frame of the combine, this component plays in fact an important role on the strength of the machine frame in case of lateral rolling- or tipping-over. Then, on the selected combine-harvester, the so-called "Boundary Simulated Groud Planes" were defined, to highlight adequate structural strength in the event of rollover.

### Results

The minimum structural requirements of the grain tank were then defined (e.g. sheet thickness), as well as some shape ratios and distance between this component and the driver's place. After having ascertained the component as a suitable SPS, its contribution could be taken into account for the drafting of new Standards for the testing of ROPS to be fitted on SPM.



## Energy efficiency of narrow tractors used in wine and fruit cultivations

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**Keywords:** narrow tractor, fuel consumption, efficiency index

### Objectives

Due to the increasing cost of energy and the need to reduce the environmental impact, over the last years studies and researches on energy saving have increased remarkably at a worldwide level, also in the agricultural sector. In this view, many national and international organizations have defined methods to calculate some Energy Efficiency Indexes (EEI). The DLG (Germany) decided to investigate the real EEI of agricultural tractor used in open field with its "Powermix": in practice, the most commons field conditions are simulated on track and on road through 12 standardized operating cycles. Similarly, starting from the fuel consumption values obtained by applying the Code 2 (performance test), the OECD (Organization for Economic Co-operation and Development) is working for the definition of one or more EEI(s).

### Methods

In any case, all these EEIs do not concern narrow tractors used in wine and fruit production processes. This is a quite important item for Italian conditions, because vineyard and orchard are very diffused, and narrow track tractors are very popular. Moreover, some Italian manufacturer are market leader of this type of tractor.

The main goal of this research is the definition of EEIs concerning the narrow tractors for wine and fruit italian cultivations, starting from a detailed analysis of the working conditions and the frequency and duration of the tasks .

Various parameters have been considered, such as travelling and engine speed, hydraulic and PTO power usage, task time duration, etc. The data were obtained measuring torque, engine speed, etc. by means of several transducers (torque meter, load cells, encoders, angular velocity sensors, ...). The experimental data have been considered for creating 10 different operating cycles, taking into account the real vineyard and orchard working conditions of the main agricultural operations carried out.

### Results

The attempt was finalized to produce not only one but some EEIs, showing the suitability of the narrow tractors for different tasks and usage intensity, both in terms of engine load and working time. Moreover, a dedicated software was created, able to predict the energy cost of a task, referring to its execution using a given tractor and under defined operating conditions.



## **Sicurtrac 2.0: An Integrated System for Assisted Driving of Orchard Tractors**

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**Keywords: Rollover Avoidance, Tractor Safety, Sensors**

### **Objectives**

Although today's tractors are safer than before, they are still involved in many on field accidents.

Statistics show that most machinery -related accidents occur due to human negligence, due to errors involving improper or lack of machinery maintenance, taking shortcuts to save time, failure to follow safety rules, failure to read the operator's manual or ignoring machine's warnings.

While a lot of effort in researches has been devoted to the optimization of protective devices (ROPS-Roll Over Protection Structures), little attention has been devoted to real-time sensor analysis to assist the driver during field operations.

Small orchard tractors are particularly risk-affected, given the narrow-track characteristic of the vehicles.

Environmental conditions (terrain status) as well as the global configuration of the vehicle (trained or ported tools) affect the stability, and in this work a multi-sensor platform was developed, in which real time assisted driving algorithm based on instantaneous accelerations are developed and integrated with an early warning post-accident assistance alarm system.

The system is based on an integrated IMU platform with 9 DOF (Bosch BN055).

The BNO055 is a System in Package (SiP), integrating a triaxial 14-bit accelerometer, a triaxial 16-bit gyroscope with a range of  $\pm 2000$  degrees per second, a triaxial geomagnetic sensor and a 32-bit microcontroller (a low-power 32-bit ARM Cortex M0+) running the Fusion algorithm.

The system integrates also a wireless communication device to identify the attached load and compute the stability envelope of the multi body system.

Interaction with the driver is provided by a Bluetooth Low Energy device, allowing communications with a portable device like a tablet.

The data storing implemented in the device allows also a dynamic mapping of the operational field to develop a map of risk to be used for real time warning during the field operations.



## Updated LCIA computation of an agricultural tractor based on open-access datasets

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**Keywords: agricultural machinery, life cycle inventory, carbon footprint, fossil energy**

### Objectives

Life cycle assessment and the related computational frameworks, specifically the life cycle inventory (LCI) and the life cycle impact assessment (LCIA), are even more important tools in agricultural engineering to assess, to evaluate, to revise and to improve agricultural processes on the base of their environmental load. The free availability of proper, detailed and reliable life cycle datasets to perform these investigations is a crucial aspect to reach in an affordable way shared results that should be as more as possible accurate, reliable, repeatable and rules-compliant, at the same time. The agricultural tractor is a nodal means of production of several agricultural processes. In the present work an updated LCIA computation of an agricultural tractor has been performed. Computation was entirely based on fully free available databases and analysis software.

### Methods

LCI data of an agricultural tractor during its lifetime (10000 hours), comprehensive of production, maintenance and repair stages, have been taken from the free available life cycle inventory database Agribalise® (version 1.2, year 2013). This database provides 136 LCI datasets for arable, horticultural and livestock products. The database does not provide data for the background processes, thus the free available European ELCD life cycle database (version 3.2, year 2015) was fitted to the foreground system. Processes that are not present in the ELCD have been taken and adapted from the US-NREL life cycle database. The LCIA computation was performed according to the free available database of ILCD 2011 impact assessment methods package, as developed by Joint Research Centre (JRC) of the European Commission. All the used databases were imported into openLCA, a free and open source software for modelling the life cycle of things. The functional unit (FU) used in the study was "one kilogram of tractor during its entire lifetime".

### Results

Focusing on the two main impact indicators, global warming potential (GWP, kgCO<sub>2</sub>eq/FU) and fossil energy demand (FED, MJ/FU), the tractor impacts were 7.29kgCO<sub>2</sub>eq and 134MJ. For GWP, the production stage accounts for about 44%, the maintenance about 44%, the repair stage about 12%. For FED, the production stage accounts for about 36%, the maintenance about 53%, the repair stage about 10%. The overall process main direct contribution to GWP was electricity use (1.68kgCO<sub>2</sub>eq), and synthetic rubber for tires (production and maintenance) in the case of FED (about 42MJ).



## **Durability design criteria for agricultural powershift transmissions**

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**Keywords: agricultural tractors, transmission, durability, duty cycle.**

### **Objectives**

Over the last decade, tractor manufactures are trying to reduce as much as possible the specific tractor weight in order to reduce material cost, increase payload, and tractor efficiency for less demanding operations (such as implement transportation, haying, etc). Thus, designing lightweight components is getting more and more important even in the agricultural machinery industry where durability, reliability and product diversification are strategies for increasing the market share. Designing lightweight components requires a detailed knowledge of service loads in terms of expected maximum load amplitudes and their occurrences throughout machine life. Service load monitoring is not a trivial task because loads are especially affected by: tractor configuration, working operation, machine set up and driver usage. Recently, autonomous data-loggers were used to monitor vehicle operating parameters during real customer usage in order to acquire the most common operating conditions where the machine should be optimized. Thus, data from a large fleet of tractors can be easily recorded but its analysing is not a trivial task due to the large data variability. The aim of this study was the definition of a method to analyse data from a fleet of machines in order to set durability targets for powershift transmissions.

### **Methods**

An onboard data-logger able to acquire and store the tractor working parameters was installed on a fleet of 181 tractors of different rated engine power. Tractors were located in different countries and each one was used for around 850 hours in different tasks by different customers. Engine and transmission operating parameters were acquired and from them, the damage per hour of each gearwheel was calculated through the inverse-power law. Damage data was then statistically analysed in order to extrapolate the most severe usage pattern, through the calculation of the probability distribution and a specific percentile.

### **Results**

The data analysis reveals high variability in customer usage especially in terms of relative frequency of used gear ratios. Moreover, on heavy tillage work, engine torque is highly variable due to soil variability, but the average engine torque is limited to the 75% of the maximum. Through this methodology, tractor manufactures can design lighter transmission components and match customer expectations.



## **A survey on work safety in agricultural farms and a risk model**

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**Keywords: farm risk, risk matrix, safety survey, safety guidelines.**

### **Objectives**

The objective of this study was to investigate current levels of work safety in agriculture, based on interviews conducted in a composite sample of one hundred farms located in the region Friuli Venezia Giulia (North-East of Italy)..

### **Methods**

The survey has outlined a number of patterns that were consistently found across all types of farms and only slightly varied depending on farm size, type of production and location. The results were used to define guidelines for safety experts on the field with new, updated approaches for risk assessment and accident prevention in the farms. Further and more in-depth analyses were performed on 11 sample farms in order to build a risk model and a positioning matrix able to guide farmers along suitable strategies for decreasing operational risks.

### **Results**

Comparing The main findings from the survey suggested that many agricultural farms were sufficiently aware of the risks associated with their specific production systems, or with the machinery used, but had a tendency to neglect them to some extent, particularly in order to avoid the related economic costs. More important, information about legal obligations was generally insufficient, as was the understanding of the possible cost, in terms of fines, damage compensations and similar, that failure to comply with the rules might cause.



## Screw log splitter design and risk management

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**Keywords: agricultural machine, log splitter, occupational safety.**

### Objectives

The proper design of agricultural machines for both professional and non-professional use has assumed a relevant role in workers protection and accident avoidance. The activities related to cutting and sawing of firewood is the main cause of injuries or death of the operator. This is often due to the use of inadequately built or modified machines, improper use of equipment and use of tools intended for other purposes. This study aimed to design a conical screw log splitter that meets the criteria of the European Directive 2006/42/EC and the technical standards of EN 609-2:1999+A1:2009(E) guideline.

### Methods

For a proper design of a conical screw has been determined the forces that influence the machine during its use, and the sized the machine accordingly. The log splitter was scanned and digitalized in three dimensions. From the digital model obtained a real model in 5:1 scaling. After the implementation of the project, the booklet for its use and maintenance was prepared. In addition, we performed a comparison of the hypothesized log splitter and the commonly used

### Results

This work developed an innovative contribution in the agricultural mechanics, developing new equipment that is in accordance with the highest levels of security and performance. The main parts of screw log splitter are three: the frame, on which is mounted the screw with the conical coupling shaft and the housing for the release of the transmission; the three-point hitch of the tractor; the guides for the power supply; the anti-rotation bar; side guards and the supply cart in which is placed the log; external, lateral and top protections.

The designed log splitter meets the essential safety requirements of EN 6092:1999+A1:2009 and of the European Directive 2006/42/EC designed with a conical screw diameter of 100 mm that can develop the necessary force to break logs as calculated. In the case that the designed machine is driven by a tractor with a power of 52 kW the range of useful forces to split the logs goes from 10.02  $t_{\text{force}}$  (200 revolutions/min) to 2.80  $t_{\text{force}}$  (700 revolution/min). These considerations make this designed log splitter comparable to a vertical or horizontal hydraulic log splitter that develops a power of 10 t.



## Concept of a safety system to be used when performing dynamic tests of stability on agricultural machines

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**Keywords: dynamic stability tests, tiltable and anglable platform, incipient rollover of a machine, anti-reversal safety system, vehicle's trajectories in a controlled environment**

### Objectives

With the aim of overcoming the limits of the tests that are currently carried out to characterize the agricultural machines' stability (mainly to static rollover), a large tiltable platform (about 15×15 m), on which vehicles in test can travel on complete circular paths, has been conceived. The same platform offers also the possibility to angle itself at half of its extension, creating an edge useful for simulating the abrupt slope-changes that a machine can meet going out of rows in the field. This platform will be installed within the "Agroforestry Innovation Laboratory" of the Free University of Bozen-Bolzano, located at the upcoming "NOI - Technology Park".

The execution of real-scale dynamic tests with machines having considerable masses (according to the platform project: up to 4500 kg) raises very important issues regarding the general safety. The tests to be conducted on this equipment aim at verifying the machines' stability in several conditions, so they can lead the vehicle to the overturning. However, an unstopped overturning must be avoided at all to prevent serious damages to people and things near the facility due to the dangerous condition of having a relevant mass in a not-controlled motion within an enclosed area. Therefore, this work presents the study that was made to concept a retaining system for the machine in test.

### Methods and Results

The spatial trajectory that a vehicle can travel during a test on this innovative platform is perfectly circular only when the support-plan is not angled. Starting from this consideration and studying the possible motions and trajectories of a tested vehicles, we therefore propose a system that can provide up to 6 degrees-of-freedom and block selectively some of them in case of danger. Looking at its technical characteristics, it can be named to as: *system with rotating-translating pincer-cage and carousel-like arm.*



## **Functional analysis as a conceptual instrument for studying and developing new farm-implements. An application to the design of a hand-tool for collecting kaki fruits.**

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**Keywords: design process, creative design, agricultural-implement design, functional analysis, kaki-collection implement.**

### **Objectives**

The development of a new agricultural implement is a complex and creative process that requires a multidisciplinary approach. Many skills of the designer are involved in this process, including his ability of re-elaborating already-existing solutions, together with his personal creativity, with the purpose of finding the best configuration to fulfil a requirement expressed in technical terms. Due to the crucial role of creativity, there is the need of making effective the ideational process, avoiding any issue that could bring to partially-suitable solutions or to reinvent existing tools already on the market.

The study reported here has the aim to illustrate a proposal of systematization of the design approach for agricultural tools, codifying it in sequential steps centred on the so-called *functional analysis* (FA). The effectiveness of the approach is then proved by showing its application to a case-study: the design of a hand-implement for collecting kaki fruits.

### **Methods**

The design approach is illustrated describing the different steps and its main conceptual tool: the FA. In the present case (implement for fruit-harvesting), FA was used to prepare a multidimensional matrix of the technical requirements; the same matrix is then used to classify the current design-requirements, verifying also any pre-existing solutions already classified in it. The method is therefore applied to a first prototype of a hand-implement for collecting kaki fruits, usable also with very ripe fruits (i.e., ready to be eaten). It has been decided to undertake the design of a tool to harvest kakis due to the remarkable difficulties the picker has to face with the manipulation of these particularly delicate fruits (abscission, interception/grasping of fruits and adduction to the operator).

### **Results**

The creative process has been systematized in a four-stepped effective procedure: the first two steps are mainly analytic, the others, instead, creative and synthetic. In particular, thanks to the FA, core of this approach, it is possible to study many existing solutions and understand how a new project will relate with these, in terms of required innovation-degree and of focus-points for the creative action.

The presented case-study has demonstrated the applicative easiness and effectiveness of the procedure; hence, a kaki-collecting hand-implement with many innovative features has been developed: it is easily scalable, uses components readily-available on the market and ensures the product integrity during the harvest.



## Normative and operative issue on the use of ULV

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**Keywords: fogger, knapsack mistblower, droplets size, functional inspection**

### Objectives

Ultra Low Volume (ULV) Pesticide Application Equipment (PAE - hot fogger, cold fogger, knapsack mistblower fitted with ULV kit) are sprayers which produce very small droplets (1-50  $\mu\text{m}$ ) and allow to apply pesticides with very low volume application rate. At present, for these type of PAE no EN/ISO Standard methods and requirements for both brand new and in use machines are available.

In Italy the national law which implements the EU Directive 128/2009 on sustainable use of pesticides (D.lgs 150/2012 and the relative National Action Plan) requires the mandatory inspection also for the ULV sprayers in use. At the same time in some Italian Regions restrictions about the minimum size of droplets emitted by the sprayers have been introduced aimed at containing spray drift and its environmental and bystanders risk. If this latter aspect should not be a problem for the foggers, as they are usually operated indoor (e.g. in glasshouses and storerooms), it could pose limitations for use of mistblowers in open fields. As there is not a bibliography on the subject, this work was aimed at assessing the droplets size generated by three models of commercial mistblowers and two models of commercial foggers. Moreover, a specific test protocol for the inspection of foggers in use was prepared.

### Methods

Droplet size sprayed by different models of foggers and knapsack mistblowers, adjusted to apply different volume rates, was measured using a laser diffraction instrument (Malvern Spraytec). Thanks to a dedicated software, for each equipment and setting tested, the instrument provided the droplets parameters used to characterize the sprayed droplets size (VMD or D50, D10 and D90).

The draft of test protocol for the inspection of foggers in use was prepared on the basis of elements available in EN ISO 16122 parts 1 and 4 and in analogue documents already prepared and used in some EU countries, like Belgium and the Netherlands.

### Results

Concerning foggers tested (one cold fogger and one hot fogger) results pointed out that ultra fine droplets were sprayed, featured by VMD values ranging between 37 and 78  $\mu\text{m}$  according to the liquid flow rate. Droplets sprayed by mistblowers resulted slightly coarser, with VMD ranging from 70 to 90  $\mu\text{m}$  when the liquid flow rate was set below 1 l/min and ranging between 100 and 120  $\mu\text{m}$  at higher liquid flow rates. The draft test protocol seems to be applied without problems for the inspection of this type of PAE in use.



## About risk of fall from the top

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**Keywords: PPE, safety, fall from the top**

### Objectives

According to Italian Law on workers' safety (Legislative Decree n. 81/2008), the work made at two or more meters of height causes risk of fall from the top. This type of risk is very widespread not only in building sector, but it is also present in agriculture, especially in the maintenance of rural buildings. This activity is very often carried out by the farmers themselves during periods of absence of agriculture activity. Due to the lack of training and information of employees, who are not workers in the construction industry, the risk increases. The fall can result in impact with the ground or obstacles such as support structures. It is very important to consider the pendulum effect, due to the oscillations of the body, if the worker was bound to a fixed point.

Objective of the study is to evaluate the personal and collective protection equipment, which can be used for work, as well as the possibility of access to these places.

### Methods

First of all the work analyzes all the Italian Regulations on the risk of fall from the top and all the relations between the workers and the rural buildings.

All personal and collective protective equipment are considered, in order to indicate the necessary devices of the building for work at more than two meter of height and interactions with workers.

### Results

The carried out analysis allowed the identification of the personal protective equipment necessary for work, as well as the devices of the building that will bind the worker and reduce the risk of fall from the top.

It was possible to investigate how to calculate the personal protective equipment to adapt their use to the different buildings.



## Proposal of an advanced facility for testing the static stability of agricultural machinery

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**Keywords: stability of agricultural machines, spatial position of a vehicle's center of gravity, static tests of stability, innovative testing equipment, tilting turntable**

### Objectives and Methods

The tests that are normally proposed to characterize the stability of an agricultural machine are substantially of two types: (1) static tests of lateral overturning of a vehicle in a straight-ahead configuration, (2) static tests of lateral overturning of a vehicle in a specific steering configuration. These tests have as output the maximum angle of lateral overturning of a vehicle, measured when all the vehicle's tanks are completely filled with their operating liquids and some weights are placed on the seat, to simulate the presence of the driver. There is also a third category of tests, less used, carried out via a system oscillating like a pendulum; the output of this test is the distance of the tractor's centre of gravity from the oscillation point, and, thus, the vertical position of the centre of gravity.

The above-presented tests do not allow providing the complete spatial position (Cartesian coordinates) of the centre of gravity in relation to the vehicle's supporting base and, therefore, they prevent the prediction of the stability conditions of that vehicle when it travels on variously-inclined slopes and at angles with the maximum-slope direction different from the test conditions. Our objective was therefore to conceive a device that can overcome the above-highlighted shortcomings.

### Results

The new-concept device, the *tilting turntable*, has the following characteristics: (1) the turntable has a circular shape and it is divided into quadrants capable of measuring the weight sustained by each of them due to the motionless vehicle positioned on them; (2) the turntable is installed on a tilting structure, and therefore it is able to simulate different gradients of the ground on which the vehicle is placed; (3) the turntable can rotate around an axis perpendicular to the surface supporting the vehicle, thus allowing to vary the angular position of the vehicle's longitudinal axis with respect to the maximum-slope direction of the tiltable structure.

This equipment will allow precisely locating the centre of gravity of a vehicle and making many experimental (static) tests simulating a lot of working conditions of agricultural machines on slopes.

It will be installed within the "Agroforestry Innovation Laboratory" of the Free University of Bozen-Bolzano, located at the upcoming "NOI - Technology Park".



## **Proposal of a system to perform dynamic tests of stability on agricultural machines**

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**Keywords: agricultural machinery stability, dynamic stability tests, innovative test equipment, tiltable platform**

### **Objectives and Methods**

The tests that are normally proposed to characterize the stability of an agricultural machine suffer from evident limitations, first of all being limited to static conditions only. Although these tests are able to identify the lateral overturning angle of a machine, they do not take in any way into account the load-transfer phenomena related to the velocity factor, concerning not only the appearance of a centrifugal force applied on the centre of gravity, but also a readjustment of the machine's trim due to all the components having a certain elasticity (tires, suspensions where present, supports of the cabin) or having a degree of freedom in the plane transversal to the machine's longitudinal axis (suspended loads, liquids, inconsistent solids such as grain products, stacked solids such as pseudo-spherical fruits). The behaviour of a system of this type, having a dynamically-variable trim, could be difficult to predict a priori by only knowing the position of the centre of gravity inquired under static conditions.

For the above-explained reasons, with the aim of overcoming the limitations of actual testing facilities, we have studied a system that allows to investigate experimentally also the described dynamic aspects, allowing reproducing any real-scale manoeuvres in a controlled and safe environment.

### **Results**

The proposed system is a tiltable plane with dimensions (15 x 15 m) letting an agricultural vehicle travel on it along complete circular paths, eventually with an artificial edge in the middle of the trajectory, simulating the sharp slope-changes that a machine can meet in the field, for example going out of rows in the field.

It will be installed within the "Agroforestry Innovation Laboratory" of the Free University of Bozen-Bolzano, located at the upcoming "NOI - Technology Park".

A special attention has also been paid to the study of a safety system, to prevent ruinous turnovers of the vehicle in test.



## **EU Directive 16952: preliminary evaluation**

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**Keywords: Farm workers' safety; mobile aerial platforms; orchard's operations; fruit harvesting, work platforms for orchard's operations-WPO**

### **Objectives**

In the present paper the main safety requirements and measures provided by the forthcoming standard EN 16952 are analysed and highlighted.

### **Methods**

Self-propelled machines equipped with mobile elevated platforms able to raise workers and materials are frequently employed for orchard's operations, such harvesting fruit, pruning operations, opening and closing anti-hail nets and so on. These machines, which are designed to work on unimproved natural and/or disturbed terrain, are mainly composed by a frame which supports the wheels and drive components, the lifting mechanism, the working platform and, optionally, the platform lateral extensions. The movement of workers and fruit beans on the platform placed at different heights above the soil, also during the machine movement, makes the safety characteristics of these kind of aerial platforms deserving of great attention, even if the projection of the centre of gravity of the entire machine always lies inside the tipping lines. This typology of agricultural machinery is the object of a forthcoming EC Directive, actually in draft phase, which has the final aim to specify the relevant safety requirements and measures. The manufacturers of these kind of machines refers, in order to comply with the EN "Machinery Directive", to the harmonized technical standard EN 280 which is actually in force. This European Standard does not fully meet the specific requirements of agricultural context so the European standardization Committee (CEN) approved a new specific standard processing, the upcoming EN 16952, which will come into force in late 2017.

### **Results**

The main innovation of the forthcoming standard EN 16952 is that it defines the conditions pertinent to different aspects of the mobile aerial platforms and of the automatic control systems, in order to have different devices grant workers' safety. For example the pressure relief device or the slope controller device that will automatic stop the machine in case of exceeding the maximum tilt specified by the manufacturer. In relation to the stability, dynamic tests will be required, such as the overcoming of obstacles that simulate holes in the soil, or static tests, such as the evaluation the slope at which the overturning begins (physical limit of the machine) performed on a tilting plane. Finally, the expected performance level of the automatic control systems aimed at the safety functions will be also established.



## **Carbon monoxide content of exhaust emissions from agricultural tractor engines: case study of Ogbomoso, Oyo State, Nigeria**

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**Keywords: Carbon monoxide, Exhaust emissions, diesel engines, air pollution, agricultural tractors**

The objectives of this paper were to: (1) determine whether or not the carbon monoxide content of the exhaust emissions of the sampled tractors were higher than the maximum level recommended by the Environmental Protection Agency (EPA), (2) determine which make and model of the sampled agricultural tractors had the highest and minimum carbon monoxide content in their exhaust emissions (3) determine whether or not the engine capacities and model selection significantly affected the carbon monoxide content of exhaust emissions of sampled agricultural tractor engines.

Twenty (20) standard-sized agricultural tractors consisting of two(2) makes of three(3) models each, operating within Ogbomoso and environs, were selected as samples and tested with the use of a Digital Exhaust carbon monoxide analyzer in a Completely Randomized Experimental Design.

The average carbon monoxide content of the exhaust emissions of the agricultural tractors is 2.445 % vol of CO (v/v) with FIAT 70-666 contributing the largest content of 2.9 % vol of CO (v/v) while MASSEY FERGUSON MF 375 contributed the least amount of 1.7 % vol of CO(v/v).

The average carbon monoxide content of the exhaust emissions of the agricultural tractors was 49 times higher than the maximum level recommended by the World Health Organization (WHO) and US Environmental Protection Agency (EPA).



## CARTS - Canopy Adjusted Real Time Spraying

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**Keywords: VRT, Spraying, Vineyards**

### Objectives

The structural characteristics of the canopy are a key consideration for improving the efficiency of the spray application process for tree crops. However, obtaining accurate data in an easy, practical, and efficient way, and in-real-time, is an important problem to be solved. The main objective of the project CARTS is to develop a sprayer prototype and the respective algorithms in order to manage variable rate spraying in vineyards and other orchards.

### Methods

This prototype modifies the sprayed volume application rate according to the target geometry by using an algorithm based on the canopy volume inspired by the tree row volume (TRV) model. Variations in canopy width along the row crop are electronically measured using several ultrasonic sensors placed on the sprayer and used to modify the emitted flow rate from the nozzles in real time; the objective during this process is to maintain the sprayed volume per unit canopy volume.

### Results

Field trials already carried out at different crop stages in a vineyard indicated a good relationship between the applied volume and canopy characteristics. The potential pesticide savings were estimated to be at between 20% and 55% relative to the costs of a conventional application.



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## **TOPIC 9**

### ***NATURAL RESOURCES AND ENVIRONMENTAL SYSTEMS MONITORING AND ASSESSMENT***



Dielectric characterization of olive mill wastewater (OMW) contaminated soils by means of time domain reflectometry (TDR) technique <i>Comegna A., Coppola A., Dragonetti G., Severino G. Sommella A.</i> .....	232
Establish database and analysis technique for the estimation of the increase of livestock breeding impact on water quality <i>Sang Min Kim, So Rae Kim</i> .....	233
Time and frequency domain analysis of Solute breakthrough curves (BTCs) for transport parameter estimation in soils <i>Severino G., Comegna A., Dragonetti G.,Sommella A. Coppola A.</i> .....	234
Novel observations in hydrology: image analysis for streamflow measurements <i>Tauro F., Petroselli A., Grimaldi S.</i> .....	235
Removal performance and clogging investigation of an hybrid treatment wetland in Sicily <i>Marzo A., Cirelli G.L., Consoli S., Milani M., Rapisarda R., Toscano A., Vanella D., Ventura D., Barbagallo S.</i> .....	236
Identifying suitable sites for underground dams using GIS: a case study in North-East Brazil <i>Laurita B., Castelli G., Khazal K., Bresci E.</i> .....	237
Rainwater harvesting monitoring through Remote Sensing in Jordan <i>Khazal K., Laurita B., Castelli G., Bresci E.</i> .....	238
Fate of cadmium accumulation in a high-contaminated area using microtopography map in 3-D numerical modeling <i>Nasta P., Capolupo A., Palladino M., Boccia L., Pindoizzi S. Romano N.</i> .....	239
Drainage channels under pressure from invasive animal species: investigation on the regional and local impact of Coypu ( <i>Myocastor coypus</i> ) damages <i>Tarolli P., Breda F., Sofia G., Masin R.</i> .....	240
Above- and below-ground biomass of <i>Moringa oleifera</i> Lam. and <i>Ricinus communis</i> L. grown in clayey soils <i>Valdés-Rodríguez A.O., Giadrossich F., Pérez-Vázquez A., Moreno-Secena J.C., Ruiz-Bello R.</i> .....	241
Case study: recovery of mariana-mg brazil's degraded area <i>Hirano S. C., Nagy L. K., Fracarolli J. A.</i> .....	242
Leaf Area Index from Landsat-8: review and comparison of existing algorithms applied to mixed agricultural and forest areas. <i>Regina P., Bevilacqua F., Matarrese R., Portoghese I., Guerriero A.</i> .....	243
The production of traditional pasta: a case study in Tuscany <i>Recchia L., Cini E., Garbati Pegna F., Boncinelli P.</i> .....	244
Life cycle assessment and environmental evaluation of agricultural mechanisation: potentiality, unsolved issues and possible interactions. <i>Bacenetti J., Lovarelli D., Pessina D.</i> .....	245



Developing a new tool for assessing environmental emissions of tillage operation <i>Notarnicola B., Tassielli G., Renzulli P.A., Mousavi Avval, S. H.</i> .....	246
Carbon storage assessment in Valle Camonica forest ecosystems: the first step to promote a local voluntary carbon market for climate change mitigation <i>Nonini L., Fiala M.</i> .....	247
Monitoring mangrove forest in the South coast of Sancti Spíritus province (Cuba) through Landsat 8-OLI images. <i>Ceballo Melandres O., Galli A., Marcheggiani E., Somers B.</i> .....	248
The use of Unmanned Aerial Systems (UAS) for wildlife monitoring <i>Racanelli V., Sorbetti Guerri E., Bartolozzi S., Sorbetti Guerri F.</i> .....	249
Evaluating the Impact of Measured versus Predicted Solar Radiation on Reference Evapotranspiration <i>Georgiou P.E., Karpouzios D.K.</i> .....	250
Land use change multi-approach assessment in a interregional context in South Italy <i>Cervelli E., Pindozi S., Capolupo A., Rigillo M., Cialdea D., Sigura M., Ripa M. N., Boccia L.</i> .....	251
Study of greenhouse gas emissions in Cuban agroproductive systems <i>Vargas Blandino D., Miranda S., Valdés N., Hernández A., Valentín P.</i> .....	252
Environmental analysis of the construction of a “tendone system” for table grapes <i>Russo G., Casieri A.</i> .....	253



## Dielectric characterization of olive mill wastewater (OMW) contaminated soils by means of time domain reflectometry (TDR) technique

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**Keywords: soil contamination, soil-OMW mixtures, dielectric models, time domain reflectometry**

### Objectives

Olive mill wastewater (OMW) is an aqueous product of the industrial olive oil extraction process. The uncontrolled disposal on the soil of OMWs is a major environmental problem that affects soil and groundwater. To develop effective soil management techniques, characterization and identification of OMW-contaminated soils are needed. In recent years, several studies have been conducted both in saturated and unsaturated soils to detect organic contamination by means of time domain reflectometry (TDR) technique. This technique is widely used for measuring the apparent dielectric permittivity ( $\epsilon_a$ ) and the apparent electrical conductivity ( $EC_a$ ) of multiphase systems. In this study, TDR technique has been proposed as potentially exhibiting sufficient sensitivity for estimation the volumetric ( $\theta_{OMW}$ ) content. Specifically, we demonstrated an intrinsic dependence of such volumes on the soil apparent electrical conductivity ( $EC_a$ ), which was exploited to develop a dielectric model which allowed to quantify the soil  $\theta_{OMW}$  content.

### Methods

The soil investigated in this study was a loam *Eutric Cambisol*, located in southern Italy. The experimental equipment is composed of a TDR unit (Tektronix 1502C cable tester) and a three-wire TDR probe, with wave guides 14.5 cm long, and an RG58 coaxial cable 2 m long. The collected TDR signals were post-processed for  $\epsilon_a$  and  $EC_a$  calculation. A group of experiments were performed in the laboratory in order to characterize the dielectric behavior of the OMW-contaminated soil samples.

### Results

The collected data showed that the presence of olive mill wastes in the soil influenced the dielectric behavior of the medium in terms of apparent electrical conductivity ( $EC_a$ ). On the basis of the results obtained, a dielectric model which allows to quantify the volumetric OMW content was developed and properly validated. The performance of the model developed was evaluated by calculating different statistical indices. These indices globally showed that the suggested methodology can be used to obtain accurate predictions of soil volumetric OMW content ( $\theta_{OMW}$ ).



## **Establish database and analysis technique for the estimation of the increase of livestock breeding impact on water quality**

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**Keywords: Livestock, Water quality, Database, Source characterization**

### **Objectives**

The objective of this study was to analyze the source characterization after establishing database for water environment and livestock to estimate the increase of livestock breeding impact on water quality. As the national income level increases, the consumption of meat is increasing. As a result, the number of livestock breeding is rapidly increasing. Water quality is expected to deteriorate due to manure excreted from livestock, but research on how it affects is in short supply. In this study, we build a database and analyze the source characterization to analyze the effect of water quality on the increase of the number of livestock using water quality modeling technique.

### **Methods**

Spatial data such as DEM, stream network, land use, administrative boundary, water monitoring stations, weather stations, and location of manure and sewage treatment plants were collected. Water environment related data such as weather, water flow, water quality, and livestock were collected. The spatial and temporal characteristics of the water quality were analyzed from the collected data on the environment. The changes in meat consumption and the number of livestock were analyzed from the collected statistical data of consumption of livestock products and number of livestock and poultry. Also, the spatial characteristics of livestock were analyzed and the treatment status of livestock manure was analyzed. A database system for water quality modeling was constructed using collected spatial information and information related to water environment.

### **Results**

According to statistics from the Ministry of Agriculture, Forestry and Fisheries, meat consumption per capita is 45.1 kg as of 2014, a 42% increase from 31.9 kg in 2000, and a 127% increase from 19.9 kg in 1990. Livestock breeding has been on the rise due to the increase in meat consumption. As of 2014, the number of breeding cattle, pig, and chicken has increased by 74%, 23%, and 53%, respectively, compared to 2010. According to the non-point pollution control measures by the government, the livestock accounts for 28.4% of the daily BOD generation loadings by pollution sources, which is second largest portion after the loadings from land use.



## **Time and frequency domain analysis of Solute breakthrough curves (BTCs) for transport parameter estimation in soils**

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**Keywords: solute transport, frequency domain, moments, estimate of parameters**

In this paper we consider two distinct approaches to estimating solute transport parameters in soils. The first is based on the moments method, which is by far the most commonly used. The second requires that the solute transport parameters be determined by optimizing the quadratic differences between the theoretical frequency response, namely the Fourier transform of the breakthrough curves (BTCs), and that estimated from the experimental data. Both the methods were used to analyze a plot-scale solute transport experiment. With respect to the calibration of the advective transport component  $u$  of the convection-dispersion equation (CDE), both methods lead to the same estimate. This is because  $u$  is much less sensitive to experimental noise as it is related to the centre of gravity (and hence to the first-order moment) of the BTCs. Instead, the dispersivity  $\lambda$  (which regulates the dispersion phenomenon) obtained through the frequency domain response was better than that obtained by the moments method. This difference is attributed to the build-up of the distortion effect due to the experimental errors in the estimation of higher moments.



## **Novel observations in hydrology: image analysis for streamflow measurements**

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**Keywords: streamflow measurements, image analysis, Unmanned Aerial Systems.**

In latest years, a considerable part of the hydrological community has demonstrated interest toward the design and development of innovative, and often unintended, approaches for the acquisition of hydrological data. In the realm of streamflow measurements, such novel methodologies aim at enabling rapid, affordable, and accurate observations of natural streams. Although flow monitoring is an integral part of hydrological sciences and is essential for disaster risk reduction and the comprehension of natural phenomena, water processes are indeed characterized by multiscale and highly heterogeneous phenomena that have traditionally demanded sophisticated and costly measurement techniques. Challenges in the implementation of standard techniques have also resulted in lack of hydrological data during extreme events, in difficult-to-access environments, and at high temporal resolution.

This presentation illustrates recent advancements toward the establishment of a novel noninvasive and potentially continuous methodology based on the acquisition and analysis of images for spatially distributed observations of the kinematics of surface waters. By combining low-cost yet high-resolution images and several velocimetry algorithms, noninvasive flow monitoring has been successfully conducted at highly heterogeneous scales, spanning from rills to highly turbulent streams, and medium-scale rivers, with minimal supervision by external users. Noninvasive image data acquisition has also afforded observations in high flow conditions. Latest progresses toward continuous streamflow monitoring at the catchment scale have entailed the development of a remote gauge-cam station on the Tiber River and integration of flow monitoring through image analysis with unmanned aerial systems (UASs) technology. The gauge-cam station and the UAS platform both afford noninvasive image acquisition and calibration through an innovative laser-based setup. Compared to traditional point-based instrumentation, images allow for generating surface flow velocity maps which fully describe the kinematics of the velocity field in natural streams. Also, continuous observations provide a close picture of the evolving dynamics of natural water bodies.



## Removal performance and clogging investigation of an hybrid treatment wetland in Sicily

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**Keywords: hybrid constructed wetland, clogging, geophysical methods, tracer test, hydraulic conductivity**

### Objectives

The objective of this study was to: 1) analyze the treatment efficiency of hybrid constructed wetland (CW) combined with a Sequential Batch Reactor (SBR) for treating the wastewater produced by a retail store (IKEA Store) in Southern Italy (Sicily) and 2) investigate the clogging phenomena in horizontal subsurface flow bed

### Methods

The hybrid Constructed Wetland (CW) consists of a horizontal subsurface flow bed (HF) and two vertical subsurface flow beds (VF1 and VF2) working in series. HF was placed first to remove organic matter and suspended solids. It has a surface area of about 400 m<sup>2</sup> and is planted for 2/3 with *Phragmites australis*, and for 1/3 with *Iris pseudacorus*, near the outlet. VF1 was designed for further removal of organics and to nitrify ammonia to nitrate. It has a surface area of about 580 m<sup>2</sup> and is planted with *Cyperus Papyrus var. Siculus* and *Canna indica*. It was filled at the bottom with coarse gravel (25–40 mm) for 0.30 m and at the top with volcanic sand (5–15 mm) for 0.45 m. VF2 has the same design characteristics as VF1 but was planted with *Typha latifolia* and *Iris pseudacorus*. It was designed for the further removal of total nitrogen and microbiological parameters. Physical-chemical and microbiological analyses were carried out on wastewater samples collected at the inlet of CW plant and at the outlet of each treatment stage. Clogging phenomena in HF was investigate through in situ measurements of horizontal hydraulic conductivity measurements on samples collected by mobile baskets, flow paths visualization by means of tracer tests and geophysical electrical resistivity tomography (ERT).

### Results

The HF-VF1-VF2 system, realised for the treatment of wastewater produced by IKEA in Catania, efficiently removed all the monitored parameters and has been able to manage the pollutant load and hydraulic peaks. The mean removal performances of hybrid CW system were: 81% for COD, 79% for BOD5, 80% for total suspended solids, 93% for NH<sub>4</sub>, 68% for total nitrogen, and EColi 3.6 Ulog. Hydraulic conductivity measurements and flow paths visualization were able to provide useful information on hydraulic aspects of HF system. The ERT preliminary results give useful information on the characteristics of HF in terms of electrical resistivity anomalies. Potential clogged areas, close to the inlet, have been detected by the technique. As ancillary benefits, the CW has improved the surrounding landscape due to the high aesthetic value of vegetation.



## Identifying suitable sites for underground dams using GIS: a case study in North-East Brazil

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**Keywords: Water harvesting, Siting, Underground dams, MCDA, AHP**

### Objectives

In arid and semi-arid areas, where rainfall tends to be erratic and unpredictable, concentrated in a few intense storms, water scarcity is a looming threat to water security. Water security is turning into a priority and it can be achieved only through the collection, conservation and wise use of the available water resources. Water harvesting, defined as the concentration and collection of floodwater or rainwater runoff for multi-purpose use, can ensure water availability for domestic and agricultural use. In water scarce areas, the selection of the best sites for the construction of water harvesting structures is often based on farmers' traditional knowledge. Starting from the necessity of strengthening and complementing traditional knowledge in the definition of the best sites, a methodology for the assessment of suitable sites for underground dams site selection is presented.

### Methods

A GIS based Multi Criteria Decision Analysis (MCDA) approach, able to integrate and transform spatial data (input) into the decision (output), where qualitative information of individual themes and features are converted into quantitative values, by constructing pairwise comparison matrix, is proposed. The weights of the themes and their features were assigned and normalized using the Analytic Hierarchy Process (AHP). The procedure is applied to a portion of the Alagoas region, in the North-East of Brazil, where the construction of underground dams has been going on since ten years. A suitability map with values ranging from 0 (not suitable area) to 10 (very suitable area) is obtained. In addition, the comparison analysis of NDVI (Normalized Difference Vegetation Index) values before and after the construction of two dams has been carried out for assessing the fluctuations in vegetation occurring with changes in soil moisture, due to underground dam construction.

### Results

The obtained suitability map gives as result that the two analyzed underground dam fell within suitable areas, confirming a good site selection through traditional knowledge criteria. Furthermore, the NDVI time series comparison shows the presence of healthy vegetation after the underground dam construction, testifying an increase of water presence.

More studies should be carried out on other sites, but these first results can be considered promising for the integration of local knowledge use in the procedure selection of optimal sites for underground dam construction.



## **Rainwater harvesting monitoring through Remote Sensing in Jordan**

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**Keywords: Water harvesting, NDVI, Jordan, Drylands, Remote Sensing**

### **Objectives**

Water scarcity is one of the biggest challenges that the Kingdom of Jordan is facing nowadays. This is due to the natural aridity that characterises the Region, as well as to an high rate of natural population growth, together with huge arrivals of refugees. Hence Water Harvesting (WH) represents a valid solution to the problem of water shortage in the country. A key aspect for the implementation of water harvesting methods is represented by the selection of the best sites. Although, adequate monitoring is often lacking, so it is generally problematic to check the effectiveness of the structures employed and, consequently, it is difficult to create a proper methodology for the assessment of land suitability for water harvesting realization. Many forms of water harvesting have been traditionally used throughout the centuries in Jordan. Thus the objective of the study is to develop a model for assessing the efficaciousness of water harvesting interventions in time using remote sensing approaches.

### **Methods**

Multi-year satellite images are used to monitor the effect of differences in water retained in the soil due to water harvesting interventions. Vegetation health is a key indicator for the effectiveness of WH, as it can be expected to improve when additional water is retained in the soil. The Normalized Difference Vegetation Index (NDVI) is a graphical indicator used to determine the vegetation health through the spectral reflectance measurements acquired in the visible (red) and near-infrared regions. Changes in vegetation, due to increased water retained in the soil due to water harvesting interventions, can therefore be measured by differences in the NDVI calculated from satellite images. Hence, the proposed procedure is applied to the Yarmouk basin, in the North of Jordan where water harvesting interventions have been realized since many years.

### **Results**

The results will allow to identify which sites, and thus which biophysical land characteristics, are optimal for WH implementation, allowing a better planning throughout the years. More tests should be carried out on other sites, but these first results can be considered encouraging for the identification of the influence of water harvesting interventions on water infiltration and retention.



## **Fate of cadmium accumulation in a high-contaminated area using microtopography map in 3-D numerical modeling**

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**Keywords: Soil contamination, Phytoremediation, HydroGeoSphere**

### **Objective**

The Agro Aversano and Litorale Domizio Flegreo area (largest portion of the Campania Plain) is of national interest since orchards interspersed with highly urbanized areas have been recently become well-known for the illegal dumping of industrial and other waste materials. The level of illegal dumping is so severe that this area will long show the effects of environmental degradation. Illegal waste disposal is still very intensive and includes burying waste in cultivable areas, roads, construction yards, and natural caves. Unfortunately, there is an urgent need to understand the consequences of contaminant transport into the deep aquifer driven by water percolation in the vadose zone. Although the Council of Campania Region will adopt soon cleaning up interventions of the contaminated illegal dumping sites for environmental and landscape rehabilitation, there is high concern for abandonment of contaminated cultivated areas. Contrary to other heavy metals, Cadmium (Cd) is of considerable environmental concern. Industrial and agricultural applications of cadmium include the production of batteries, alloys, and pigments and chemical fertilizer and pesticides. Poplar is an accumulator of Cd and, therefore, is suitable to remove it from contaminated soils. Nevertheless, direct determination of Cd in poplars roots is an expensive, time-consuming and destructive activity. To circumvent the drawbacks of conventional direct approach, scenario-based strategies obtained by using advanced hydrological modelling tools, like the HydroGeosphere (HGS) model, have been developed to virtually test phytoremediation in terms of contaminant transport in a 3D environment.

### **Methodology and results**

In the present work, phytoremediation is evaluated by combining the HGS model with a fine resolution Digital Elevation Model (DEM), generated by Unmanned Aerial Vehicle (UAV) – photogrammetry. To achieve this aim, two different scenarios have been compared: the former is characterized by bare soil (BS), while the latter considers poplar plantation (PP). The study area is an experimental field of about 4500 m<sup>2</sup> located near the town of Trentola Ducenta (CE). A total of 23 soil samples were collected on a regular grid of 25 x 25 m in order to determine Cd concentrations according to the EPA 6010C 2007 protocol. The HGS numerical simulations pertaining to BS, used as benchmark, and PP scenarios were run in order to understand the contribution of phytoextraction on Cd removal from the experimental area. Cd grid point-values were first converted in an interpolated area and, then, arranged as initial concentration on the soil surface. In the PP scenario, the poplar plantation scheme was considered by setting up a rectangular grid of 500 x 1000 cm. The beneficial effects of phytoextraction increase the removal of Cd by about 46% when compared to BS-scenario. In this way the roots absorption decreases the prospect to route Cd down the soil profile and up to the unconfined aquifer. Moreover, the results compare the spatial re-distribution of Cd in both scenarios. The scenario-based approach coupled to high resolution DEM represents a promising technique for assessing the phytoremediation of heavy metals by reducing the operational costs and time.



## **Drainage channels under pressure from invasive animal species: investigation on the regional and local impact of Coypu (*Myocastor coypus*) damages**

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**Keywords: Soil, Erosion, Myocastor Coypus, Nutria, Drainage network, River**

### **Objectives**

The distribution of the Coypu (*Myocastor coypus*) in Italy and other countries of the world makes it one of the most invasive species in the world. Numerous studies have established the effects of this invasive species on various ecosystems. Despite the induced criticalities, the available information about damages to riverbanks is mostly limited to local knowledge and maintenance reports, and eroded volumes remain rarely quantified.

This study concerns an analysis of the distribution of the Coypu in Veneto (Northern Italy), an area where recent reports suggest a drastic expansion of the animal, to the point of raising bitter encounters between farmers, conservationists, landowners and politicians.

### **Methods**

Interviews with local authorities in charge of wild animals (thus also Coypu) management allowed to identify the regional impact of the animal. A further investigated challenge was the local quantification of the riverbank damages. To this point, this study considers different sections of drainage canals, where coypu burrows were present on the channels' bank. The purpose was to show the effectiveness of a low-cost photogrammetric approach, the Structure-from-Motion (SfM), to model surface burrowing damages and to quantify the related erosion. Thanks to this technique it was possible to create high-resolution 3D models of the riverbanks, starting from imagery acquired with a smartphone camera. It was possible then to determine the volume of the animal-induced erosion.

### **Results**

The results show how there is an evidence of the expansion of the animal in most of the Region. However, the information available from regional and local Authorities never covers the actual amount of erosion induced by the animals. The SfM photogrammetric technique could overcome this problem. It is indeed a flexible and low-cost way to determine, with a suitable accuracy, the distribution of erosion along channel branches. Further research could allow the creation of an index of erosion region-wide, and to determine the severity of damages as classified according to Coypu relative abundance ratings when available.



## **Above- and below-ground biomass of *Moringa oleifera* Lam. and *Ricinus communis* L. grown in clayey soils**

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**Keywords: biomass model, Ricinus survival, Moringa survival**

### **Objectives**

The aim of this work is to quantify and make inferences between above- and below ground parameters of *Ricinus communis* L. and *Moringa oleifera* Lam. to understand their capabilities to survive in clayey soils, and to assess growth rate and biomass production under critical growth conditions.

### **Methods**

We studied 20 plants in field conditions during 12 months. After this period, plants were fully excavated to measure both above and below ground biomass. For each plant in the plots we measured monthly survival, plant height, root collar diameter, the number of branches, maximum crown spread, number of leaves, and the leaf area. We recorded root biomass as a function of the distance from the stem, root distribution, and root architecture along the soil profile. With the correlated data, two models to estimate root biomass and volume distribution were developed.

### **Results**

Results showed that both species had the same survival rate and reached maturity in less than one year, even though *Ricinus communis* L. matured in a quarter of time than *Moringa oleifera* Lam.. Below ground biomass is highly correlated with above-ground parameters such as root collar diameter, height and crown width. Root pattern depth distribution of both species followed a sigmoid model with 90% of the root volume in the upper 50 cm of the soil. However, *Moringa oleifera* Lam. produced a shallower and thicker root system with a volume of 4.6 dm<sup>3</sup>, while *Ricinus communis* L. roots only occupied 0.8 dm<sup>3</sup> and developed more oblique and sinker roots to maintain its denser crown. Moringa lateral root extent was 67 cm longer on average than Ricinus. The product of root diameter collar by the crown-width for Moringa and stem base by plant-height for *Ricinus communis* L. were the best estimators for below ground parameters. Both species show a good development in a clayey and compacted soil.



## **Case study: recovery of mariana-mg brazil's degraded area**

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**Keywords: Degraded area, Recovery, Iron mine spoil.**

### **Objectives**

The failure of the dam holding iron ore mining waste in Mariana, Minas Gerais, Brazil caused a large environmental, social and economic impact. It directly affected other municipalities, affected the fauna and flora along the Rio Doce basin. Aquatic and terrestrial species were affected and especially aquatic ecosystems devastated. The basin is inserted in the Atlantic Forest, one of the most important tropical forests in the world, a hotspot of biodiversity.

### **Methods**

A study of the continues loss of the sediment deposited in the Bento Rodrigues area was carried out.

### **Results**

The modeling indicated an average loss of material in the region of 17.1 ton/ha/year. Continues sediment erosion can cause silting of rivers, and, in addition, as the composition of the sediment is unknown it may negatively affect plants and animals. There is a need for an action to contain the mineral waste so that it does not transfer to other places, damaging other areas as well.



## **Leaf Area Index from Landsat-8: review and comparison of existing algorithms applied to mixed agricultural and forest areas.**

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**Keywords: LAI, Landsat-8, Remote Sensing**

### **Objectives**

The use of remote-sensed data in agriculture and as source of input data for hydrological modeling has become very important in recent years. In particular, several methodologies have been developed to qualitatively and quantitatively investigate the vegetation condition, leading to the setup of different vegetation indexes. Among them, Leaf area index (LAI) is one of the most important quantity governing the physical and biological processes of plant canopies and soil water consumption.

In this study we present a comparison of the most popular models used to retrieve LAI applied in a study area located in Capitanata region (Southern Italy), where five dominant land use classes have been analyzed in their space-time variability.

### **Methods**

An extensive literature review has been performed, leading to the choice of six algorithms to be tested in Capitanata region (1. LAI-WDVI, 2. LAI-EVI, LAI-NDVI: 3. Beer, 4. Caraux-Garson, 5. Peterson, 6. Nemani-Running). Five predominant land uses have been selected (Forest, Mediterranean scrubland, Wheat crops, Pasture, Olive grove).

Landsat-8 images, from 2013 to 2016, with 30m of spatial resolution, have been collected and pre-processed in order to work with reflectances data with no cloud coverage. For each image, six LAI maps have been generated.

A statistical analysis has been performed on the available dataset through Matlab software. In particular, the analysis covered three test cases: i) for each land use class, the six LAI patterns during 2014 (the only year with at least one image per month); ii) for each LAI model, the pattern of the five land use class; iii) for each land use class, the LAI trend in July and in December within the period 2013-2016.

### **Results**

The performances of the six LAI models were determined based on: a) the seasonal trend during the year and b) the bias with respect to literature values; and c) the statistical dispersion of each class.

Without a specific ground-truth calibration, the best performing model is the Caraux-Garson. All other methods evidence a high sensibility to the surrounding soil and to the empirical parameters used.



## The production of traditional pasta: a case study in Tuscany

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**Keywords: Life Cycle Assessment, environmental sustainability, pasta production**

### Objectives

The major pasta industries have started to evaluate the impact of their production through the Life Cycle Analysis (LCA) and, in some cases, even through the Environmental Product Declaration (EPD®), according to ISO 14040 and 14025 standards, making information on the environmental impact of pasta production widely available. For smaller producers instead this process is not always easy to access, especially for niche products such as those made from traditional processes or old wheat varieties, so there is scarcity of this data in the reference databases for environmental analysis also because systems of food production are strongly national or site specific.

The scope of this work is therefore to make a detailed analysis of the life cycle of the entire process of high quality pasta production following the traditional process and with the use of an old wheat variety in an Italian agricultural farm, with the purpose of highlighting the most critical steps on an environmental point of view together with possible solutions aimed at reducing their impact.

### Methods

The analysed chain of pasta production included the following stages: durum wheat cultivation, milling of durum wheat to obtain semolina, pasta production and packaging, transportation and distribution, use and waste and pallet disposal.

The inventory data were collected in three firms located in Central Italy: Montepaldi farm (Firenze, Tuscany, Italy) for wheat cultivation, Molino Silvestri (Torgiano, Umbria, Italy) for wheat milling, Pastificio Artigianale Fabbri (Strada in Chianti, Tuscany, Italy) for pasta production. Using these data, an LCA according to the ISO 14040 standards was carried out: particularly, the food chain was modeled through the Gemis software, setting a functional unit of 1kg of dried pasta.

### Results

The results have highlighted that the analysed traditional chain causes more reduced environmental impacts than these associated with the industrial chains. Critical points are the transports between the firms and in the distribution phase, together with the final use of the product. Moreover, with the aim to reduce the emissions of 1.982 kg of CO<sub>2</sub>eq per kg of dried pasta, several improvements along the chain have been suggested.



## **Life cycle assessment and environmental evaluation of agricultural mechanisation: potentiality, unsolved issues and possible interactions.**

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**Keywords: environmental impact, sustainability, machinery field operations, data collection**

### **Objectives**

Agriculture is responsible for a considerable environmental impact and mechanisation is related to a share of these negative effects. Although, in the last decades, standardised and extensively accepted methods for environmental impact assessment were developed, their application to mechanical field operations is still limited. This is due, on one side, to the difficulties for inventory data collection -that are site and time dependent- and, on the other side, to the carefulness of machinery manufacturers that are developing concerns about the consumer (farmer) perceptions. Nevertheless, without the possibility of assessing the impact it is impossible to quantify the reductions achievable with new machines and innovations in technologies

This study is focused on the application of Life Cycle Assessment (LCA) approach to the environmental impact assessment of machinery field operations. More in details, the aim of this study is twofold: 1) to show how LCA can be useful to analyse, from an environmental perspective, the different machinery field operations; 2) to discuss limits and unsolved issues of this approach applied to mechanisation aiming to the identification of possible solutions.

### **Methods**

The Life Cycle Assessment (LCA) is a standardised method adopted worldwide for quantifying the potential environmental impacts of processes for products or services during their whole life cycle using a holistic approach.

There are four steps in LCA; the second is Life Cycle Inventory (LCI) data collection, in which the flow of materials and energy from the studied systems and the environment are identified and quantified. These data cannot be always directly measured, and depend on pedo-climatic (e.g., soil texture and water content), site-specific (e.g., field shape, slope) and logistic (e.g., annual working time) variables. To overcome this problem specific database have been developed, from which the processes concerning different field operations can be retrieved. However, it must be considered that the processes present in the database only rarely consider the same pedo-climatic and logistic conditions and, consequently, do not allow for achieving trustful results. The different processes can be modified and made reliable using measured data or information estimated with models able to consider the site-specific characteristics.

### **Results**

The outcomes of this study show how the use of reliable local data concerning working time, fuel and lubricant consumption, type and age of tractors, emissive stage and combustion emissions deeply affect the environmental results. This data reliability permits also to quantify the potential environmental benefit when technologies that permit an efficiency improvement are used.



## **Developing a new tool for assessing environmental emissions of tillage operation**

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**Keywords: LCA, Environmental emissions, Agricultural practices, Machinery**

### **Objectives**

In order to assess the environmental impacts of agri-food systems, life cycle assessment (LCA) based approaches have been extensively applied to different food products. The results of such kind of studies often indicate that the agricultural phase is the most impacting life cycle stage of such systems. During this stage, direct and indirect emissions of agricultural field operations can contribute largely to the various impact categories. However, these operations have received relatively scant attention in LCA studies and the available databases of LCA software do not provide sufficient data for accurately calculating pollutant emissions of agricultural operations. The objective of this study is to develop more detailed and specific datasets for estimating environmental emissions associated with direct and indirect pollutants related to agricultural practices in different conditions.

### **Methods**

This paper on one hand reviews the data available for the production stage of agricultural machinery and equipment, including production of materials, manufacturing, transportation, repair and maintenance. On the other hand, diesel fuel and oil consumptions of different agricultural practices including tillage, planting, cultivation, harvest and post-harvest operations are calculated using existing formulations.

### **Results**

Detailed dataset for different agricultural operations are developed in order to get a better estimation of direct and indirect environmental emissions associated to these operations. Overall the results will allow LCA practitioners to develop more specific and precise environmental analyses of agri-food systems.



## **Carbon storage assessment in Valle Camonica forest ecosystems: the first step to promote a local voluntary carbon market for climate change mitigation**

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**Keywords: Forest inventory, Forest typology, Carbon storage, Voluntary carbon market, Climate change mitigation**

### **Objectives**

Voluntary Carbon Markets (VCMs) are currently developed worldwide. In Italy, the scientific aspects concerning the processes of greenhouse gas emissions and storage in forest ecosystems have been investigated but, up to now, there are only few existing experiences which give an economic value to such processes. Thus, the objective of this study was to propose an innovative approach to estimate, for the first time, the total stored carbon in Valle Camonica (Lombardy Region) forest ecosystems. The tool, based on past and present situation, give also the possibility to analyze future scenarios, based on different forest management practices, evaluating the opportunity to develop a local VCM, operative engine for a low-carbon emissions economy.

### **Methods**

The first step of the study was the definition and the collection of the forest inventory data related to each forest typologies (approx. 60) defined in 44 Forest Plans (FPs) of Valle Camonica (growing stock; current annual increment; forest area; volume of cut wood biomass) and their organization in a database. Applying an innovative approach based on IPCC methodology, the total carbon storage and its variation over the time, were estimated in: (i) aboveground biomass, (ii) belowground biomass, (iii) deadwood, (iv) litter.

Four different scenarios have been analyzed: (i) business as usual (BAU; historical analysis from 1984 to 2016), (ii) BAU future perspectives (BAU<sub>F</sub>; from 2017 to 2029, by which the user can simulate carbon storage variation as an effect of tree cuts), (iii) sustainable (SST; historical analysis, to evaluate the increase in carbon storage within each ecosystem pool due to the usage - from 1984 to 2016 - of improved forest managements practices (such as, for example, forest government change), (iv) SST future perspectives (SST<sub>F</sub>; identical to the second scenario but considering to improve forest management practices).

### **Results**

The results obtained showed that, in areas where it's possible, the conversion of aged and/or abandoned coppice to tall trees promoted, in each ecosystem pool, a higher carbon storage. Applying this government conversion, more wood per unit of area can be obtained. This additional wood biomass could be cut and used for energy purposes, supporting the reduction of fossil sources use, and thus contributing to an indirect environmental local decarbonization and a multifunctional forest resources utilization as well.



## Monitoring mangrove forest in the South coast of Sancti Spíritus province (Cuba) through Landsat 8-OLI images.

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**Keywords: mangrove forest, remote sensing, monitoring**

### Objectives

In the coastal zones of tropical and subtropical regions, fragile ecosystems like deltas, mangrove woods and swamps, among others, are widely diffused. The National Hydrographic Basin Council of Cuba promotes the river basins as basic unit for an integrated management of hydric resources aiming to maximize social and economic wellbeing, without implicating negative impacts on vital ecosystems. This research, part of a wider PhD project carried out at UNIVPM of Ancona, has focused on Zaza River basin (Central region of Cuba) where, as consequence of inefficient management of water resources to meet agricultural and civic needs, the mangrove forest suffers a significant decay. For the environmental services offered by mangrove forest, that support ecological equilibrium in coastal areas, the monitoring of mangroves is very important for promoting an effective management of coastal ecosystems of this basin. The specific objectives of research are: 1) characterise environmental issues affecting the mangrove forest. 2) analyse relationships between phenology and spectral behaviour of species that shape the mangrove forest. 3) define an effective approach leading to classify the mangrove forest by RS techniques. This way it could be defined a model for monitoring environmental diseases of mangroves in all costal area of Cuba island.

### Methods

Remote Sensing is a fundamental tool for monitoring and implementing conservation strategies of natural and semi-natural areas. For the purposes of this research a multi-temporal set of Landsat-8 OLI images (Path-14, Row-45) from November 2014 to December 2015 were acquired. As stated by many scholars, spectral behaviours within the growth season of tree species may improve the detection of forest ecosystems by satellite images. Nevertheless, the assessing of spectral separability among mangrove species, according to the same authors, is very limited in literature. The collection of ground truths in order to represent tree species growing in the mangrove forest, therefore, was the first step carried out in the study area. The second phase of research was dedicated to analyse the spectral behaviour of each species within a selected set of multitemporal images by taking in account phenology. Finally, in order to classify the mangroves forest/species some different approaches were tested.

### Results

More than sixty plots of mangroves, each of one hundred square meters, were monitored by describing a set of site parameters according to the Protocol for the monitoring of mangrove ecosystems (Menéndez et al., 2003, 2006). The phenology of different mangroves species was compared with reflectance in the corresponding pixels, both for mono-temporal and multi-temporal Landsat 8-OLI images, with respect to Visible, NIR and SWIR spectral regions. This allowed to build diagrams showing the spectral behavior of each species of mangrove. This represents an unique result in the panorama of mangrove forest detection by Landsat 8-OLI images in the South coast of Cuba. Finally, a selected set of ground truths were used to test different methods of classifications, like the classical supervised and the unmixing classifications.



## The use of Unmanned Aerial Systems (UAS) for wildlife monitoring

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**Keywords: Monitoring, UAS, Wildlife**

### Objectives

There are many methods to estimate wild ungulate populations. One of these is represented by observations from points lead usually employed in medium-low covered forest areas. This method is subject to some limitations, such as the risk of double counting and the necessity to a high number of operators due to the small size of the observable areas. Such limitations could be reduced by integrating the method with the use of Unmanned Aerial Systems (UAS).

This study reports some experiences carried out mainly to check the suitability of UAS use in the specific case of Roe deer (*Capreolus capreolus*), in particular:

- the possibility to identify animals in open areas in relation to the type of camera, the flight altitude and the type of vegetation cover,
- the possible disturb caused to animals by the noise emitted from the rotors of the aircraft and the flight altitude,
- the extension of the analyzed surface area at dusk as it is the most suitable time for wildlife detection.

### Methods

The investigation was conducted in various areas with a high density of Roe deer and in the absence of disturbing elements. The Aircraft used were a Yuneek Q500+ quadcopter equipped with a CGO2+ gimbal camera and an experimental custom quadcopter designed and manufactured to specification, with autonomous flight on waypoints uploaded from a pc and equipped with a small thermographic camera.

The first experimental phase concerned the definition of technical parameters useful to characterize the research system. For this purpose, the acoustic emission of the aircraft (dB) and pics of the underlying soil area were recorded at intervals of 10 meters up to 70 meters above the ground.

In the second phase, operating flights were carried out on an area of around 90,000 m<sup>2</sup> consisting of seven contiguous open areas separated by hedges and woody plants.

The ability to fly over the natural visual barriers (land orography, tree, hedges, etc.) allowed to conduct a census over all the study area, despite the size of the locations. Only two operators can do all the flights in an average time of about 10-15 minutes with a speed of approximately 3 m/s.

### Results

Using this technique a small number of operators can scan a much wider area in comparison to the traditional observations from the ground.

The analysis of the aerial pics taken at dusk from 50 to 60 meters has identified many Roe deer grazing in different open areas and has verified the absence of any alarm reactions to the passage of the aircraft.



## Evaluating the Impact of Measured versus Predicted Solar Radiation on Reference Evapotranspiration

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**Keywords:** Solar radiation, Reference evapotranspiration, Penman-Monteith

### Objectives

The ASCE-EWRI Penman – Monteith equation is the most commonly accepted method for estimating reference crop evapotranspiration ( $ET_o$ ), developing crop coefficients, and calibrating other  $ET_o$  methods. Net radiation ( $R_n$ ) is the main driving force of evapotranspiration and is a key input variable to the Penman-Monteith equation. Usually net radiation is estimated through the determination of solar radiation ( $R_s$ ). However the measurement of  $R_s$  are not often available due to specific required installation standards and relatively high cost of the sensors. This paper aims to elaborate relationships between solar radiation and other meteorological parameters that can be easily measured (max temperature, min temperature, mean temperature, relative humidity) in order to fill the gap of the measurements lack.

### Methods

Linear and nonlinear regression multivariable models will be used and evaluated to provide statistical significant relationships between solar radiation and other meteorological parameters. Furthermore, the proposed models will be validated through the use of measured values and final values of reference evapotranspiration estimated by the models will be compared with the ones derived with the use of measurements of  $R_s$ . Automatic meteorological stations located in Central Macedonia (Greece) will be the source of the data sets used in this analysis.

### Results

The main findings showed that computed values of solar radiation using the proposed approach can be a quite reliable alternative in case where measured values are not available according to the results.



## Land use change multi-approach assessment in a interregional context in South Italy

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**Keywords: Land use change scenarios; spatial-multicriteria decision analysis; landscape metrics; ecosystem services; erosion risk**

### Objectives

According to international and EU policies, complementary approaches for landscape and environment values assessment, in land use planning, are an essential prerequisite on a supra-regional scale. Study area is an area in transformation, now also affected by the institution of the Matese national park, between Campania and Molise regions. In this context, appropriate management policies and land use change (LUC), in favor of bio-energy crops, may help to create new economies and new spatial development perspectives aimed to change negative trends such as erosion risk, socio-economic problems and environmental impacts.

The work intends to present a possible physical-mathematical approach for pragmatic determination of the predictable consequences for LUC environmental effects, through empirical analysis, simulation models and objective diagnosis, as support for the decision makers, already in the *ex-ante* evaluation stage.

### Methods

Tools used in the framework adopted are GIS processing and spatial decision support analysis (ILWIS and ArcGIS software) for LUC scenarios construction. LUC possible impacts assessment on environmental components, was evaluated through science shared approaches of Ecosystem Services considering Habitat Quality and Soil Risk with Invest software, and of landscape metrics such as Patch number, Patch density, Simpson Index, through FRAGSTAT software.

### Results

From the framework three scenarios are delineated. First scenario (Scenario 1) refers to the current development trend. Second scenario (Scenario 2) the energy crops spatial allocation is foreseen in areas with the highest LUC degree. The third scenario (Scenario 3) concerns land abandonment and downgrade in the same areas of scenario 2. Ecosystem services values of habitat quality and erosion risk in Scenario 2 showed highest improvement, in contrast to scenarios 1 and 3. On the other hand landscape metrics highlighted greatest risks of landscape homogenisation and mosaic structure simplification, just in Scenario 2. Consequently integrated assessments enforce for further investigation on LUC spatial distribution and for corrective and mitigation measures that would be applied.



## Study of greenhouse gas emissions in Cuban agroproductive systems

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**Keywords: greenhouse gas emissions, agriculture, agro ecological farms, energy efficiency**

### Abstract

Agriculture is the second source of global greenhouse gas emissions. It is therefore a challenge to maintain or increase food production, while reducing the level of greenhouse gas emissions. The main goal of this work was to compare agro ecological farms and the conventional ones with respect to their GHG emissions, energy efficiency and agricultural productivity and to identify agricultural practices related to them.

The indicators and the methodologies used in the research was designed by a multidisciplinary team according to their own experiences and the IPCC 2006 Guidelines. These methodologies allowed quantification of carbon in soils and in trees, the assessment of energy efficiency and to include sociological tools to compile the information on farms. In this study was included a total of 103 farms distributed in 9 provinces of Cuba. Subsequently the farms were classified according to their management as organic farms, in transition to be agro ecological farm and conventional farms.

The results showed that the main source of greenhouse gas emissions was the application of nitrogen fertilizers, followed by the management of organic residues mainly in rice cultivation. The organic farms represented 6% of the sample, the conventional ones 71% and the transitional ones 22%, where, the conventional farms emitted 6 times more than the organic farms mainly the nitrous oxide, and were less efficient, but to the Were the ones that produced the most food in the study. On the other hand, the farms in transition to be agro ecological ones, emitted only twice the GHG emissions that the organic ones and produced the same amount of food that the conventional farms and of effective form, since they made a better use of the biomass incorporated to the soils, and of the high external inputs of greenhouse gases. This typology of farms in transition to be agro ecological is the main proposal of this work for policy makers and farmers, who have the challenge of producing food in Cuba and reducing greenhouse gas emissions from agricultural management.



## Environmental analysis of the construction of a "tendone system" for table grapes

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**Keywords: Table grapes, Tendone system, Plastic materials, LCA**

### Objectives

Italy is in third place in the world ranking for the production of table grapes with 1.4 million tons. The Puglia region produces about 70% of this amount through the cultivation of 35,000 hectares. This production takes place with the aid of the "tendone system" which is a structure consisting of wooden or concrete piles, and steel cables. This structure supports the plastic covering materials that can be fixed anti-hail nets and / or mobile rolling films. The "tendone systems" utilize plastic coverings material in order to obtain anticipated (transparent film), conventional (anti-hail plastic net), postponed productions (plastic net and plastic film).

The knowledge of environmental loads generated by the table grape production is interesting because, in addition to normal agricultural practices, involves the use of other materials from the technosphere and specific installation practices. The aim of this work is the analysis of the environmental profile of the orchard construction phase for table grapes by means LCA (Life Cycle Assessment). A research project that involved 26 farms producing table grapes, allowed collecting relevant data concerning the production cycles, the technique of construction, the materials used for "tendone systems".

### Methods

This study uses the Life Cycle Assessment (LCA) methodology to determine the environmental impact of a table grapes production with the use of "tendone-systems", carried out according to standard UNI EN ISO 14040-44. Life Cycle Assessment can be a decision making tool for government officials, industries or society to evaluate a product's environmental impact. Interview in farms have supplied the primary data for the inventory of this production. The Gabi7 software and Ecoinvent 3.1 database were used for inventory and processing of collected data. The analysis covered only the phase of installation of the tendone-system (from cradle to installation analysis).

The adopted functional unit was 1.0 ha of prepared agricultural surface for growing table grapes, covered with a tendone-system.

### Results

The method of evaluation of environmental burdens was CML2001 (Centre of Environmental Science, Leiden, Netherlands). The results have provided the environmental burdens produced by the construction and installation of the tendone-system. A comparison between the tendone-system for the conventional production (plastic nets), anticipated (transparent film), and postponed (plastic net and plastic film) productions was also realized. The increased amount of plastic used for the cover and the relative disposal causes greater environmental burdens. The carried out analysis is the first step in the overall evaluation of the production of table grapes by means of tendone-system.



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## **TOPIC 10**

### ***BIOSYSTEMS ENGINEERING AT URBAN AND SUBURBAN SCALE***



Hydrological behavior of different green roof growth media and drainage layers under high intensity rainfall events <i>Bettella F., D'Agostino V., Bortolini L.</i> .....	256
On the tree stability risk <i>Giambastiani Y., Preti F., Errico A., Guastini E.</i> .....	257
Alternative methods for weed control in urban areas <i>Peruzzi A., Benvenuti S., Roveta G., Fontanelli M., Frascioni C., Martelloni L., Pirchio M., Raffaelli M., Abou Chehade L.</i> .....	258
A model for enhancing food sovereignty in urbanizing regions through technology-driven sustainable agricultural intensification <i>Taylor, J.R.</i> .....	259
LCA environmental parameters of green roofs: a comparison of results and an overview on data quality <i>Bibbiani C., Fantozzi F., Gargari C., Campiotti C.A.</i> .....	260
Bees as biological indicators of air quality in a urban context <i>Costa A., Veca M., Barberis M., Tosti A., Notaro G., Tangorra F.M.</i> .....	261
Green walls as passive technology for enhancing buildings energy efficiency <i>Blanco I., Campiotti C. A., Vox G., Schettini E.</i> .....	262
Urban green spaces for urban resilience to climate change <i>Leone A., F. Gobattoni, R. Pelorosso, F. Recanatesi, M. N. Ripa</i> .....	263
Urban agriculture on green roof in Rio de Janeiro City (Brazil) <i>Alberto M.A., Carneiro B.C.A., Silva L. P.</i> .....	264
Biosystems engineering for cooperation projects with developing countries <i>Russo G., Vecchiotti L., Scarascia Mugnozza G., Castellano S.</i> .....	265



## Hydrological behavior of different green roof growth media and drainage layers under high intensity rainfall events

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**Keywords: green roof, laboratory tests, Curve Number, water retention.**

### Objectives

This study investigates and identifies the hydrological characteristics of single layers constituting a green roof, verifying the applicability of the Soil Conservation Service *CN* method for the hydrological characterization of the layers. The research is a starting point for identify the hydrological characteristics of a green roof based on the proprieties of single growth and drainage layers.

### Methods

Laboratory tests were conducted to analyse the hydrological behaviour of different components of green roofs: three drainage/storage layers and four growth media were tested. The materials used to set up the green-roof samples were selected from those suitable for green roofs as devised in the climate conditions of interest (Venetian Plain), except for one of the drainage/storage layers, which was specifically designed during this study. A rainfall simulator was assembled and used to equally distribute an exact amount of rainfall over the samples. Two rainfall constant intensities lasting 10 minutes were simulated. The weights of sample and drainage tank, collecting the runoff, were recorded every 30 seconds for a continuous measurement of rainfall, runoff and amount of rainfall stored in the green-roof layers.

### Results

Data obtained from the laboratory tests allow to identify the water retention capacity (*WRC*) of the samples and to calibrate the *CN* method accordingly. The laboratory tests show that the single green-roofs components (drainage storage layers and growth media) behave similarly when affected by high intensity rainfall. Layers accumulate the rainfall water and do not produce runoff until the moisture condition reaches values close to the maximum *WRC*. The fitted *CN* values are generally high, evidencing that single green-roof layers can reach *CN* values comparable to those of traditional black roofs but also provide a substantial delay of the runoff response thanks to their *WRC*.



## On the tree stability risk

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**Keywords: root, tree bracing, stability, wind**

### Abstract

There is growing interest in developing models for predicting how root anchorage and tree bracing could influence tree stability. This work presents the results of different experiments aimed at evaluating the mechanical response of plate roots to pulling tests. Pulling tests have been executed with increasing soil water content and soil of different texture. Different types of tree bracing have been examined for evaluating its impact on plant stiffness. Root plate was anchored with different systems for evaluating the change in overturning resistance. The first results indicate that soil water content contributed to modify both the soil cohesion and the stabilizing forces. Wind effect, slope stability and root reinforcement could be better quantified by means of such a results.



## Alternative methods for weed control in urban areas

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**Keywords: flaming, steaming, bio-herbicides, *Taraxacum officinale***

### Objectives

Weed control is always a difficult task in urban hard surfaces and the use of chemical herbicides is not always allowed by the public institutions and is often unwelcome by the citizens. Thus the objective of this research is to test flaming, steaming and bio-herbicides as safe and sustainable alternative methods for weed control in urban areas.

### Methods

*Taraxacum officinale* was selected as ideal experimental weed because is common and difficult to eliminate. Their seedlings sensitiveness (grown in pots) was tested using three different treatments:

- open flaming with a specific test bench;
- steaming with professional electric steam generator (power 2.4 kW; flow rate 3.12 kg h<sup>-1</sup>) equipped with a lance with a proper cylindrical diffuser;
- acetic acid solution (20%)

Each method was tested using three different doses:

- flaming: 31, 52, and 156 kg ha<sup>-1</sup> of LPG;
- steam: 2032, 4063 and 8126 kg ha<sup>-1</sup>;
- acetic acid solution: 75, 150, 300 kg ha<sup>-1</sup>

The treatments were tested on two different weed development stages, 3-4 leaves and 10-12 leaves. Weed number and weed leaf area were assessed.

### Results

*T. officinale* was sensitive to all the different treatments when treated in the earlier development stage, despite the dose adopted. The later stage showed a variable resilience depending on the dose. The resilience is virtually due to the totipotent cells in the crown. Steaming was the most effective (plant mortality close to 100%). Flaming did not kill the plants but affected significantly their development. The results of the acetic acid were in between the other two treatments.

According to the results obtained in this experiment, steaming, flaming and acetic acid showed to be effective in the control of *T. officinale*. Moreover, the results highlighted that all the three methods could be used within an integrated weed management approach.



## **A model for enhancing food sovereignty in urbanizing regions through technology-driven sustainable agricultural intensification**

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**Keywords: Food systems planning, Sustainable intensification, Controlled environment agriculture, Urban agriculture**

### **Objectives**

With a population density almost twice that of Italy, the U.S. state of Rhode Island offers a potential model for sustainable food systems development in urbanizing areas in the U.S. and Europe. Though state governments have established a regional goal of meeting 50 percent of food needs locally by 2050, local foods provide only 1 percent of Rhode Islanders' caloric needs. Attaining even partial food sovereignty will demand a dramatic increase in production. Because of development pressures, any such increase will need to come from technology-driven productivity gains on the existing land and sea base and the utilization of underutilized spaces, e.g., urban lands. However, existing levels of agricultural intensification are unknown, and no model has been developed to assess the state's production capacity under different intensification scenarios. This paper presents results from an ongoing project to develop a spatially explicit model taking into account existing intensification levels, local social, economic, and natural resources, and production constraints. Similarities in regional constraints and resources—including urbanization, strong regional identity and commitment to local food, and opportunities for terrestrial and marine system integration—argue for the potential relevance of this U.S.-based project to Mediterranean food systems.

### **Methods**

A combined mail and online survey of a stratified sample of Rhode Island's 1,200+ food producers assessed existing practices and levels of intensification and impediments to the adoption of advanced production technologies. Qualitative interviews were conducted with key stakeholders to identify additional constraints and opportunities for intensification. Social and natural resources, including existing and potential sites of food production, were mapped in ArcGIS using existing or novel data sets. Based on survey and interview responses and geospatial data, three alternative scenarios of production intensification were developed in ArcGIS.

### **Results**

Survey and interview results indicate significant impediments to sustainable intensification include energy costs, insecure land tenure, a lack of capital, and a lack of appropriately-scaled technology for small-scale producers. Existing intensification levels are relatively low. Comparison of the three alternative development scenarios indicates substantial progress toward food sovereignty could be achieved through adoption of advanced production technologies and expansion of urban and peri-urban agriculture. Doing so, however, will require substantial economic investment.



## **LCA environmental parameters of green roofs: a comparison of results and an overview on data quality**

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**Keywords: greenroof, LCA, energy saving**

### **Objectives**

This paper presents the environmental performance of six greenroof solutions currently available on the Italian market and highlight the lack of information, both environmental and thermal, that are necessary to run a complete and specific assessment. The paper also aims to demonstrate how LCA could support producers in designing more efficient and low impact greenroofs, selecting materials based on their environmental profile over their life cycle and taking into account potential reuse of recycle at the end of life.

### **Methods**

The environmental assessment of the six greenroof solutions has been carried out and reported according to European Standard EN 15804:2012+A1:2013 "Sustainability of construction works - Environmental product declarations - Core rules for the product category of construction products". The assessment is cradle to gate, based on a 1sm declared unit. The energy performance of the roof, as a building element, has been calculated according to D.M. 26/06/2016 "National guide lines for the energy certification of buildings". Six different greenroof solutions have been assessed separately and five different scenarios, based on the different U limits as defined in D.M. 26/06/2016, has been created for each solution. Results have been expressed as EN 15804 parameters describing environmental impact and resource use.

### **Results**

The paper demonstrates that, despite a large interest in greenroofing that is currently considered to be a sustainable and energy saving solution for both cold and warm climate, no specific information and no data are available for designers and LCA practitioner to assess its environmental and energy performance accurately.

Results show that the insulation layer is primary responsible for both the energy and environmental performance of the greenroof and therefore, taking into account the LCA profile of the insulation material during the design stage is a crucial step to guarantee a low impact construction. Moreover, new vegetative substrate now available on the market, are generally presented as more sustainable when, in fact, LCA demonstrates the contrary.

Therefore, a comparison among seven different medium currently available on the market has been carried out. Results have been significantly affected by a large lack of specific LCI data.



## Bees as biological indicators of air quality in a urban context

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**Keywords: air quality, bees, atomic absorption, lead, nickel, cadmium concentrations**

### Objectives

The aim of this research, supported by the municipally district of Milano, was to evaluate the air quality in Milano during the EXPO period, through the study of pollutants measured on bees, as bioaccumulators, reared in a beehive in the urban territory.

### Methods

A beehive located in the Triennale area, in Milano, was considered. The trial was conducted since May to October 2015. Every two days, bees found dead in the beehive were collected and took to the ASL Prevention Laboratory to evaluate the concentration of Lead, Cadmium and Nickel on their body through atomic absorption analysis. In the same period, data about atmospheric dust (PM<sub>10</sub> and PM<sub>2.5</sub>), levels of Lead, Cadmium and Nickel, measured by the nearest control unit in the town (through gravimetric method), were daily downloaded from the ARPA website. To evaluate the effect of atmospheric pollutants measured on bees body and to estimate the animal ability to work as a biological pollution indicator, data were pooled and submitted to variance analysis (Proc GLM, SAS 9.4).

### Results

Environmental data showed a clear relationship of PM<sub>10</sub> and metals in the air. The comparison between atmospheric and animal data has revealed a tight relation, with linear dependences for animals and atmosphere. For example, when the concentration of atmospheric lead exceeded the value of 4 ng/m<sup>3</sup>, bees "carried" about 0.7 mg/kg of lead, when the lead atmospheric concentration was higher than 15 ng/m<sup>3</sup>, lead on bees body was more than 0.9 mg/kg ( $y=0.1006x + 0.573$ ,  $R^2=0.98$ ). A similar relationship was also detected for Nickel concentration, 2.1 ng/m<sup>3</sup> of atmospheric Ni corresponded to 0.3mg/kg of Ni on bees ( $y=0.062x + 0.2618$ ,  $R^2=0.98$ ).

The comparison of these data, particularly the concentrations of lead and nickel, has shown that these animals could serve as environmental "low cost" sentinels to assess the air quality in a city like Milan, where concentrations of fine particles and pollutants can induce serious health problems to citizens.



## Green walls as passive technology for enhancing buildings energy efficiency

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**Keywords: urban heat island, surface temperature, vertical greenery system.**

### Objectives

The urban heat island (UHI) effect implies higher urban area air temperatures compared with ones in the surrounding rural areas, with differences of about 5-6 °C. The use of green roofs and green façades is a passive technology that produces several local and urban scale benefits by lowering buildings surface temperature, heat transfer through the building components and urban air temperature; it also provides thermal insulation for buildings in cold season. Nevertheless a lack of literature on experimental data in the Mediterranean region exists. A field test was carried out in Bari (Italy) in order to overcome this issue. This paper aims to examine the effects of two different climbing evergreen plants used as passive systems on building walls during the warmest and coldest months of 2015.

### Methods

The experimental test was carried out at the University of Bari (Italy, 41 ° 05 'N, 16 ° 53 'E) during 2015. Three vertical walls, facing south, were made with perforated bricks; each wall was equipped with a sealed structure on its backside for reproducing a building in scale. One vertical wall was covered with *Pandorea jasminoides variegated* and the second with *Rhynchospermum jasminoides*, the third wall was left uncovered and used as control. Several climatic parameters concerning the walls and the ambient conditions were collected during the experimental test by means of a data logger and sensors.

### Results

During the warmest month of 2015 (July), the maximum surface temperature on the control wall was higher during the hottest hours of the day than the temperatures recorded in the same hours for the two green walls, with differences up to 5.6 - 5.7 °C.

During the coldest month of 2015 (January), the minimum surface temperature of the control wall was lower during the coldest hours of the day than the temperatures recorded in the same hours for the two walls covered with plants, with differences up to 2.5 – 2.7 °C.



## Urban green spaces for urban resilience to climate change

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**Keywords:** sustainability of cities, urban green, urban drainage

### Abstract

Besides their social values, urban green spaces provide the resilient cities with fundamental ecosystem services: i) improvement of soil permeability and consequent increase of heavy rainfall absorption and of runoff water quality; ii) reduction of air temperature highest values and mitigation of urban heat island effect; iii) production of biomass for renewable energy production or agricultural reuse; iv) creation of stepping stones to complete the local ecological network thus reducing the artificial surfaces.

Urban green can nowadays be considered a real urban infrastructure with equal, or even higher, value and meaning than other infrastructures. The green structure must perfectly respond to these requirements thus becoming a prior technological and planning challenge.

The present paper investigates the capacity of green structures to satisfy some specific needs such as hydraulic safety of the territory and the protection of runoff water quality. The effectiveness of a different distribution of bio-retention surfaces within urban areas, made up of totally impermeable surfaces, has been evaluated. The elaborations have proved the following results:

- 1 Runoff reduction implying a lower hydric load filling urban sewerage, peak discharge retarding and lower flood risk.
- 2 Increase in groundwater recharge.
- 3 Recovering of a relevant volume of water, now reusable to irrigate the green structure itself.
- 4 Increase in evapotranspiration which contributes to regulate urban microclimate.
- 5 Improvement of water quality through bio-retention and the resulting filter effect due to vegetation.

These effects allow to make any transformation of urban areas resilient from the hydrological point of view, this way overcoming the outdated (static) standard provided in D.M. 1444/1968.



## Urban agriculture on green roof in Rio de Janeiro City (Brazil)

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**Keywords:** Urban Agriculture, Green Roof, Lettuce, Rio de Janeiro, Brazil

### Objectives

The objective of this work was to develop a productive agricultural system on roofs of social interest buildings, adapted to tropical climate conditions, allowing the urban population to produce food in a previously unusual (and often adverse) space for these purposes.

### Methods

The experiment has been developed in the terraces of Haroldo Lisboa Building located at the , Campus Maracanã, Rio de Janeiro, in the Southeastern Region of Brazil, South America. Different modular configurations, in an agricultural parcels fashion of productive elements are being studied and experimented. These involved mainly planting over the surface of corrugated fiber cement sheets, supported by a metallic bench with adjusting incline (simulating the same roofs often found in social interest informal communities in the city), with different substrate layer depths and space between plants. The species tested was the "Amanda" curly lettuce (*Lactuca sativa* L.), which were grown in an open environment (without any type of protection) in 3 cycles of approximately 32 days each, after transplanting of the seedlings (between July and November 2016, winter and spring in the Southern Hemisphere) for the evaluation of the treatments. All the plants were harvested by cutting the stem at the substrate level, with the removal of the dried and stained leaves from the base of the plants. And then, counting of the total number of plants, taking the weight of the green fresh mass of each plant in a commercial scale, and also the stem diameter, using a pachymeter. The data computed are being submitted to statistical treatment that includes the "F" test of ANOVA and, possibly, the test of Tukey-Kramer

### Results

In all cycles and in all treatments, the plants were well developed (with up to 220 g), high commercial use (above 90%), high productivity in relation to the area used (up to 6.500 g m<sup>-2</sup>), volume of substrate used (up to 530 g L<sup>-1</sup>) and efficient in terms of water footprint. The mortality rate of the seedlings was nearly zero. No correlation was found between the two parameters (mass and stem diameter) used to evaluate plant performance. The diameter of stems did not prove to be a reliable index, since in high density planting such these, although each plant presented a good commercial fresh mass and a compatible canopy growth, they generally did not develop a good stem diameter.



## **Biosystems engineering for cooperation projects with developing countries**

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**Keywords: Food factory, water treatment**

### **Objectives**

The Centre "For Development Cooperation (CPS)" of the University of Bari aims to carry out cooperation projects with developing countries. Cooperation activities were carried out in Meru district (Kenya). A project was addressed to the construction of a pedestrian bridge that had previously collapsed, preventing the population and farmers from delivering and selling the agricultural products to the "Meru Herbs" fair trade organisation. This organisation, founded by a cooperative of farmers, sells organic products such as tea, chamomile, karcadè and jams around the world through the distribution of fair trade. A second project was carried out in order to provide Meru Herbs with a water purification system. Before the implementation of the project the production of foods was obtained using water boiled with boilers using wood.

### **Methods**

The cooperation projects were realized in the Meru region of Kenya, on the eastern slopes of Mount Kenya. The University of Bari's activities included: the hydrological study of Kitheno River; site visits to Kenya; design of the bridge; courses for the staff of Meru Herbs on the cultivation of chamomile; protection of river banks by means of natural engineering works; financial reporting; dissemination activities. The construction of the bridge was carried out by the workers of the professional school of the Salesians of Embu (Kenya) and its construction was completed in 2012.

Two systems for water treatment were designed and their installation was concluded in 2014; one system, with a capacity  $0.3 \text{ m}^3\text{h}^{-1}$ , was designed for the exclusive service of Meru Herbs production, a second smaller unit, with a capacity of  $0.1 \text{ m}^3\text{h}^{-1}$ , equipped with a UV rays system, was designed for drinking water supply for the farm's staff and the people living around the farm.

### **Results**

The construction of the bridge allowed about 2500 farmers to get to Meru Herbs location, in order to deliver the agricultural products to the company. The new bridge has withstood all the floods of the river. The result of the installation of the water treatment systems was to provide drinking water both for the canned food production and for the company workers. As a fallout of the project it should be noted that the population of the nearby village can take drinking water by filling water containers at the Meru herbs organisation.

### **Acknowledgements**

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