Book of Abstracts

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Past Conferences

"European Federation for Information Technology in Agriculture, Food and the Environment"

The first EFITA was held in 1997. The conference facilitates participants form over 25 countries worldwide dealing with knowledge sharing and thinking on the future of ICT technologies within the agri-food and bio-resource sectors. EFITA conferences include ICT demonstrations, digital poster presentations, plenary sessions, breakout sessions in various topical areas (e.g. remote sensing, robotics, farm management information systems, data mining and analysis, agri-food and biomass chains, as well as ICT-agri education and professional issues), special sessions, and technical tours to exceptional paradigms of ICT applications in real-life primary production.

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1999 – Bonn (DE) - Gerhard Schiefer
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2003 – Debrecen (HU) - Miklos Herdon
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2009 – Torino (IT) - Sjaak Wolfert
2011 – Prague (CZ) - Pavel Simek
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2015 – Pozman (PL) - Jerzy Weres
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2019 – Rhodes (GR) - Dionysis Bochtis

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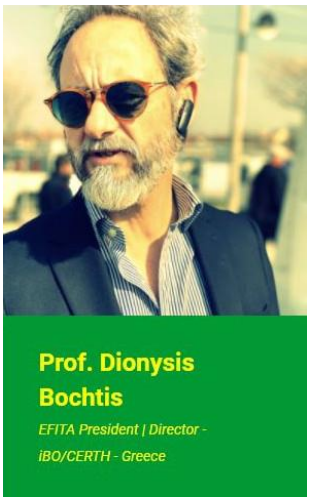

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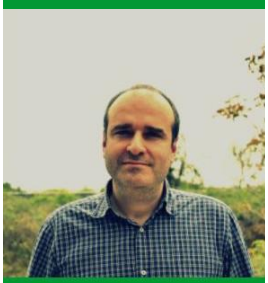

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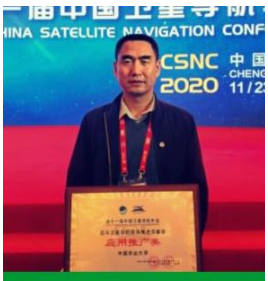

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Conference Topics

Sensors
Wireless sensor networks
Remote Sensing and GIS applications
Bio-sensors
Physical and Chemical sensors
Optical sensors

Data
Big data management
Data mining
Data visualization
Data and Knowledge Management
Metadata and data standards
Ontologies for agriculture
Knowledge bases and Knowledge repository services
Web of Data and Open Data
Image processing

Decision
Modelling and Simulation
Prediction models
Multi-Agent systems
Planning tools
Environmental ICT management systems
Farm management systems (FMIS)
Decision Support Systems

Action
On-line farm services
Web applications
Cloud computing applications
Monitoring Robots, Action Robots
Machine embedded ICT tools

Cross-cutting Themes
Social Networking in agriculture
e-agribusiness
ICT and business
Rural economies and ICT policies for rural development
Traceability tools
Human-Computer Interaction
Open topic

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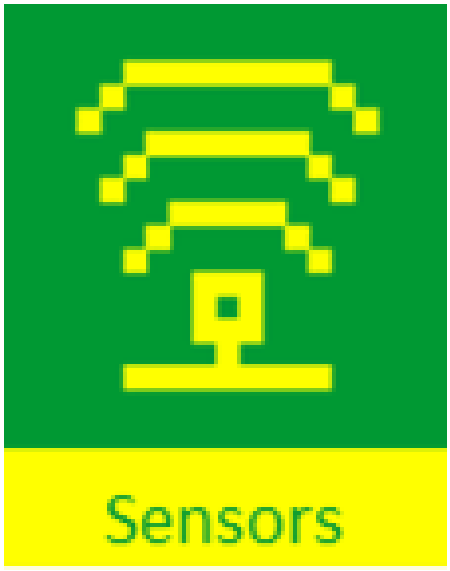
Sensors

Bibliometric review on the use of Internet of Things technologies to monitor the impact of wind on trees and forests

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ID: 110
Topics: Wireless sensor networks, Physical and Chemical sensors, Open topics
Keywords: bibliometric review, Internet of Things, monitoring, tree, windthrow

The presence of trees has numerous health benefits for urban populations. Nevertheless, as a consequence of inadequate maintenance, many trees fall each year. This research aims to conduct a bibliometric review on the use of Internet of Things (IoT) technologies for monitoring trees, considering both agricultural and urban environments. The Scopus database was used. The keywords used were: tree, forest, wind, windfall, windstorms, drag, IoT, accelerometer, and anemometer. The following search filters were applied to improve the results: (i) language of the paper (English); (ii) areas of study (12 main areas involving agricultural sciences and engineering, among others); and (iii) time interval for publications (2010 to 2020). The abstracts and titles were then analyzed, removing papers that were not relevant, resulting in 313 papers. These represent state of the art in the leading international events and journals related to the theme. Then, two analyses were performed: (i) analysis of metadata related to the papers, such as authors, publication venue, country of origin, and the number of citations; and (ii) clustering analysis of the words of the abstracts and titles of the papers, generating a chart with the main clusters and the keywords linked to them. The first analysis showed that: (i) this research area is growing, with a 16% increase in the number of published papers between 2019 and 2020; (ii) the most important areas of study were: agricultural and biological sciences, environmental sciences, and earth and planetary sciences; and (iii) the most relevant journal is Ecology and Forest Management. Regarding the second analysis, it was observed the existence of three clusters. Cluster 1, called “Wind Impact”, represents the impact of winds and storms on forests and trees. Its main keywords were: windthrow, storm, coniferous tree, disturbance, forest ecosystem, regeneration, mortality, ecosystems, forest dynamics, and reforestation. Cluster 2, called "Variables and experiments", represents the experiments carried out in the field and in laboratories to estimate the impacts of winds and storms on trees and forests. Its main keywords were: forestry, wind, forest, wind velocity, tree, turbulence, drag coefficient, drag, anemometer, experimental study, wind direction, and turbulent flow. Cluster 3, called “Forest management”, was mainly related to different ways of managing the damage caused by winds in the forests and assessing its risks. Its main keywords were: forest management, damage, storm damage, risk assessment, boreal forest, wind force, and wind damage. The main gap observed is that few papers used IoT technologies as tools for preventive or corrective action regarding winds and storms' impacts on trees and forests. This could prevent or reduce the damage from these occurrences. Besides, few papers were found considering the urban environment, with the vast majority focusing on cultivated forests. Finally, it was found that practically all papers focused on the study of coniferous trees, predominant in the northern hemisphere. Two gaps were found: (i) lack of studies considering trees and forests typical of the southern hemisphere; and (ii) lack of studies that use IoT technologies to monitor trees and forests.

Light penetration properties of visible and NIR radiation in tomatoes applied to non-destructive quality assessment.

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ID: 111
Topics: Optical sensors, Image processing, Prediction models
Keywords: imaging spectroscopy, spectral imaging, chemometrics, near-infrared spectroscopy

Tomato is an important food product and it is of great interest to develop non-destructive quality assessment methods for this product. Using the visible and near-infrared (NIR) spectroscopy,

the sugar content, acidity and even the taste can be estimated through the use of chemometric methods (e.g. partial least squares regression). In the case of reflection spectra, which is the common modality for imaging spectroscopy, the question arises how much of the interior of the tomato contributes to the measured spectra. An experiment was done with tomatoes of four different types, beef tomato, classic round tomato, cocktail tomato and snack tomato. The tomatoes were sliced at different thicknesses and imaged on a 98% reflective white background and a 4% reflective black background. Spectral images were acquired with VNIR (400-1000nm) and NIR (900-1700nm) imaging spectrographs. The difference between the spectra with a white and black background was used to determine the relationship between the wavelength and the light penetration depth. Results show that at wavelengths between 600 and 1100 nm light penetrates the tomatoes up till a distance of 20mm. The relation more or less follows the law of Lambert-Beer. This relation was the same for all four types of tomatoes. These results help the interpretation of chemometric models based on reflection (imaging) spectroscopy.

Classification of irrigated and rainfed croplands in Vojvodina Province (North Serbia) using Sentinel-2 data

Mirjana Radulović[1], Stefanija Stojković[1], Branislav Pejak[1], Predrag Lugonja[1], Sanja Brdar[1], Oskar Marko[1], Dragoslav Pavić[2], Vladimir Crnojević[1]

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ID: 112

Topics: Remote Sensing and GIS applications, Data mining
Keywords: Irrigation, Sentinel-2, Random Forest, Water Management

In the 21st century, the establishment of efficient water resource management is crucial for ensuring world water and food security. Irrigation is a significant artificial process in the hydrological cycle and presents the only way to balance between mentioned issues, where collecting knowledge is essential for developing adaptive and sustainable strategies. Considering that, the precise information about the spatio-temporal distribution of irrigated fields on a national scale is thus the initial key step for agricultural water resource management.

With a high spatial, spectral, and temporal resolution, Sentinel-2 provides new possibilities in this field. This research focuses on using multispectral satellite imagery and advanced machine learning models for detecting irrigation and rainfed fields on a plot scale. Dry year images during irrigation season were used for vegetation indices calculation for three crop types: maize, soybean, and sugar beet. These three databases were used separately for training the Random Forest classifier. The results showed high overall accuracy for each three crops where soybean reached the highest 0.91, maize 0.89, while sugar beet reached 0.76. According to the results, the assumption is that the difference in accuracy between crops could be caused by the difference in the geospatial characteristic of the area, amount of data, omission in labeling crop types and rainfed fields.

Irrigated agricultural fields present a challenge for classification and mapping considering the heterogeneity of the area, climate impact, and diverse crop types. This study showed that classification could be done using Sentinel-2 images, but further analysis including climate and soil data could improve the classification. This methodology has the potential to produce an annual irrigation map which is very important information for optimizing water use and making sustainable agricultural policy.

Integration of proximal sensor data with satellite images through signal processing on graph

Marko Milan Kostić[1], Marko Panić[2], Branisav Pejak[2], Vladimir Crnojević[2]

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ID: 117
Topics: Remote Sensing and GIS applications, Optical sensors, Data visualisation
Keywords: Proximal sensing, remote sensing, interpolation, data filtration

Understanding the causation of vegetative components variation using sensing technology is quite promising in the agriculture domain. Different types of sensor platforms have been rapidly developing over the last decade with the aim to provide instantaneous and worthful information to the grower. Regarding plant growth conditions evaluation, remote and proximal sensing are the most common techniques that provide information on nutrient deficiency, biotic stress such as pests and diseases as well as abiotic stresses, allowing Precision Agriculture. Differences in working principles of both sensing platforms provide different output data for mapping in terms of spatial resolution and measurement noise. For a proper fusion of information coming from remote and proximal sensors for the evaluation of the crop condition, an inevitable step is the reduction of present noise in the measurements and data alignment. In this study, we address the problem of integration of two types of measurements coming from optical satellite Sentinel 2A and multiband optical sensing device Plant-O-Meter (POM) for remote and proximal sensing of the crop respectively. Presenting both measurements as signals on graphs, we utilize two procedures on the graph: filtration and clusterization in order to achieve noise removal and registration of data with different spatial resolutions. This result indicates that properly preprocessed POM measurements exhibit strong potential for accurately assessment of plant canopy condition.

A Method Comparison Study Between Open-Source and Industrial Environmental Loggers

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ID: 118
Topics: Wireless sensor networks, Data and Knowledge Management
Keywords: Statistical Agreement and Similarity, Open-Source loggers, Environmental Monitoring

Open-source software and hardware can be implemented in almost every field that includes technology and automations. We will address the issues of Agreement, Reliability and Precision of open-source devices against industrial equipment during an agricultural experiment at the experimental greenhouses of the University of Thessaly, Velestino, Greece. Open-source alternatives are low cost, user-friendly and can be applied to the equipment according to the needs of the scientist and a huge community that supports the users. On the other hand, industrial choices are most of the time rigid when it comes to modifications and the cost forbids conducting experiments that require specialized equipment. However, industrial equipment is fully tested and reliable. Agreement and Similarity analysis will be performed between an open-source Arduino compatible environmental data logger and an industrial weather station.

Agreement and Similarity evaluation is proven to be the most efficient and trustworthy method comparison analysis when it comes to comparing two or more devices, methods or treatments. Many publications that compare devices, methods or treatments use the correlation coefficient, MSE or other metrics that have been proven to be misleading. Furthermore, the usual metrics will never reveal the source of disagreement while combining plots like Bland-Altman, Trellis and Scatter enriches an agreement study and provides a complete review about both sources of agreement and disagreement. Various agreement indices fortify the quality and reliability of the analysis and are chosen according to the experiment's parameters. The most appropriate agreement and similarity measures used here are TDI (total deviation index) and CCC (concordance correlation coefficient). Other measures are also investigated and justified why they are not appropriate for the specific experimental setting.

A pilot experiment was first conducted for the comparison of the two devices measuring air temperature. There was significant evidence for data heteroscedasticity. Solutions include longitudinal, mixed-effects and measurement error data models that were appropriately adapted to meet research goals of this study. A pipeline for analysis in similar settings that can be used as guideline for research purposes and the development of software for its implementation is the ultimate goal of this study.

A survey on the use of Internet of Multimedia Things for precision agriculture & the agrifood sector

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Ionian University, Greece;

ID: 123
Topics: Wireless sensor networks, Data and Knowledge Management, Decision Support Systems
Keywords: Internet of Multimedia Things, Internet of Things, Precision Agriculture, Agrifood Sector, Survey, Open Research Directions

A combination of a plethora of factors, including (but not limited to) the man-made climate change crisis, the world's positive population growth, the ever increasing penetration and ubiquitness of ICT in almost all aspects of life as well as the requirement for qualitative & quantitative nutrition of the contemporary humans all lend themselves to the amalgamation of contributing domains that is Precision Agriculture.

Technologies such as the so called Internet of Multimedia Things (IoMT) provide for an intermediary layer of distributed and *in-situ* sensing and processing of information that supersedes the common IoT (e.g. temperature, humidity, and solar radiation) sensors found in most agrifood's scenarios by providing near real-time multi-modal interrelated information based on which a wealth of more advanced agrifood decision support scenarios can successfully be met.

Accordingly, in this work, we are motivated by the recent devopments in ICT in order to address existing and new challenges of the agrifood domain. The work's contribution is in collecting, processing, homogenizing, and drawing "bird's-eye view" conclusions from research for the IoMT, Agrifood, and Precision Agriculture domains, as well as their intersection.

Initially, we present various definitions of the three domains of IoMT, Agrifood, and Precision Agriculture that act as pillars to our work. Each of these domains is then extensively discussed as to its constitutent characteristics as well as their interrelation to the theme of the work.

Subsequently, we present the most influential and recent works for each of the three domains of IoMT, Agrifood, and Precision Agriculture, both as distinct directions as well as in conjunction, whenever such works exist.

Then, we present existing works using IoMT for precision agriculture in agrifood by means of categorization of both challenges and solutions following a "compare and contrast" methodology.

Based on the aforementioned, we then compile a detailed list of open research directions that further research on the domain may draw upon. The work is concluded by a summarization of the motivation & contribution of the work, a concise description of the key findings therein, as well as potential future ameliorations to our work.

Prescription maps for precision olive growing

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University of Palermo;

ID: 126
Topics: Remote Sensing and GIS applications, Farm management systems (FMIS), Decision Support Systems
Keywords: prescription maps, GIS, precision farming, precision fertilizer

Since the beginning of the twenty-first century, there has been an increase in the agricultural area used for olive growing and in Extra Virgin Olive Oil (EVOO) consumption. Olive growing is one of those crops in which precision agriculture has been little applied both for the architectural characteristics of the plant and for its limited diffusion on the planet characterized by its specific pedoclimatic needs. The aim of the study was to apply precision agriculture to a young olive tree field aimed at building prescription maps for fertilizers distribution at variable rate (VRT). Georeferencing was performed using S7-G Stonex instrument with RTK differential correction, in order to obtain the maximum precision (centimeter). Each single plant was georeferenced by simultaneously recording its morphological parameters: trunk circumference,

trunk height, number of branches, foliage diameter, etc. Then, soil and leaves were sampled in order to investigate its pedology variables and the nutrients present. The pedological analyzes were: texture, pH, electrical conductivity, CaCO3 percent, organic content and nitrogen concentration. The foliar analyzes consisted in determining: N, K, Ca, Fe, Mn, Mg, B, Zn, Na, Cu. The fertilization plan was subsequently determined by applying the nitrogen balance method. The maps created will be used for variable-rate fertilization through the use of a tractor and fertilizer spreader connected via the ISOBUS system.

Awareness-raising and capacity building through a scalable Automatic Water Harvest Monitoring System to improve water resources management in Monteverde community, Costa Rica.

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ID: 143

Topics: Wireless sensor networks, Environmental ICT management systems, Rural economies and ICT policies for rural development

Keywords: Wireless, data visualisation, watersheed, water recharge, climate change

Water harvesting projects are useful in the effort to preserve water resources, however, it is necessary to quantify and validate the benefits generated by these harvesting systems to scale the value of the water resource. Therefore, a scalable prototype with information and communication technologies (ICT) has been developed in a water harvesting system to quantify the inflow and outflow in the collection and distribution systems.

The measurement and data handling methodology were performed automatically using low-cost 32-bit microcontrollers which are used in Espressif's development boards, Wi-Fi-connected flow sensors, software tools, and graphical user interfaces. The prototype of the automatic monitoring system for water harvesting (AMSWH) was implemented in Monteverde Institute (MVI), Costa Rica, within the framework of a project called: Unitary biosystems for the protection of water resources in Monteverde, Costa Rica, as social project at the University of Costa Rica.

Monteverde represents in its cloud forests one of the most fragile ecosystems in the face of climate change. This ecosystem only represents 1% of the world's forests. Located on the continental divide, Monteverde is considered a key water recharge zone for the Pacific slope with serious water scarcity issues, and Caribbean slope where it becomes one of the main water supplies for the Arenal reservoir (hydroelectric largest dam in the country).

Monteverde is also well-known as tourist destination visited by more than 250,000 visitors a year which generates a great demand for water on the few local water sources. Aware of this situation, Monteverde's residents have a strong commitment to environmental sustainability and the IMV plays a fundamental role in both local and international education through its academic programs, community initiatives, and applied research projects. The purpose of AMSWH is to promote water-harvesting systems in Monteverde community by demonstrating the system and its quantifiable benefits in water use. In this case, the MVI's water harvesting system will capture rainwater for use in toilets, vegetable gardens and washing machines, thereby reducing the consumption of drinking water in the institute and finally the surplus water will be carried into a water seeding system.

Given the above, the objective of this project is to achieve a viable product of an automatic monitoring system to quantify the amount of rainwater that it is harvested, used and sown for its scaling for studies in various fields in the community. The AMSWH seeks to precise the mass balance through ICT using low-cost solutions. Sensors were used to measure flow in inlet and outlet pipes and water level in storage tanks, a data communication system based on the microcontroller Tensilica Xtensa 32-bit LX6 and the Blynk development platform to create an Android application to show the dynamism of the mass balance in real time.

The implementation of the AMSWH in the MVI has been positive and it is expected to improve the system for its scaling up to showcase the benefits of this biosystem in the management of water resources, where the adoption of ICT is fundamental through education to promote development of management models.

A proposal for a teaching-learning strategy to strengthen Geomatic concepts and tools in the Biosystems Engineering career at the University of Costa Rica

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Universidad de Costa Rica, Costa Rica;

ID: 144
Topics: Remote Sensing and GIS applications, Decision Support Systems, Open topics
Keywords: teaching-learning strategy, Geotechnology, Geomatic, curricular design, software engineering

The curricular design of an academic program requires a strategic balance that ensures the different knowledge, abilities and skills for graduates prepared to enter a global workforce. Its construction is based on participatory schemes among teachers, students, employers from private or public sectors related the professional guild and society. The discussion and construction is complex focused on attributes and professional skills are of the utmost importance.

The Biosystems Engineering career at the University of Costa Rica has had an important discussion process in the last thirteen years, due to the natural evolution of the Agricultural Engineering career to Biosystems Engineering. Today the development of information and communication technologies (ICT) have influenced this professional profile. The digital transformation supported by the ICT has a transversal consideration in the curriculum design in order to enhance the analysis of the complex problems with innovation and ethical entrepreneurship.

Therefore, the academic program of Biosystems Engineering faces challenges in its curricular design due to its new holistic vision in its professional practice, where a balance must be considered between development and conservation. In principle, a solid preparation in the basic courses of engineering and computer science and telecommunications, enables great opportunities in the different concentrations in Biosystems Engineering, such as Bioprocesses, Bioenergy, Irrigation, Drainage, Basin Management, etc. The spatio-temporal analyzes that these concentrations demand are complex by themselves, but even more so, these technical elements linked to social and environmental issues in pursuit of sustainable development. The benefits of geomatics tools facilitate multidisciplinary teamwork scenarios for the analysis of spatial-temporal problems, but these require leadership for their breakdown into components and systematization to be able to be analyzed, modeled and simulated.

The introductory course of Geomatics for Biosystems engineering has developed a teaching-learning strategy that allows developing skills in applying the knowledge of Geomatics tools to solve problems. Its learning axis is centered from the analysis of problems of case study proposals using software engineering tools leading to the design of the geographic database, modeling and validation in the field. The study cases are evaluated throughout the course by means of advances, which in adaptive teaching process on concepts and development of skills in geomatics tools is provided along the semester. The capacities that are promoted are in systematization tools to identify, formulate, investigate, analyze and propose solutions to problems addressed with the generation of scenarios for decision-making.

The results of the proposal teaching-learning strategy have been positives. Students value the strategy due to the approach to the reality of the country's problems, besides the geomatics flexibility assessment for potential solution scenarios, empowering students as future etic engineer embedded in their socioeconomically environments.

VIS-NIR spectroscopy for drip irrigation clogging discrimination and quantification: a new methodology.

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ID: 147
Topics: Physical and Chemical sensors, Optical sensors, Prediction models
Keywords: drip irrigation, clogging, visible and near infrared spectroscopy, sensor, partial least squares regression

Drip irrigation is one of the most performant irrigation technique that ensure an efficient water use. However, its major drawback is its maintenance. Drip irrigation emitters are highly sensitive to clogging, which reduce both irrigation performance and uniformity. Three main clogging types are distinguished: physical, chemical and biological. As they are caused by different elements, the associated maintenance operations needs to be adapted to the clogging type. Therefore, identify and quantify these clogging types is crucial for the drip irrigation system management. Currently, there is no reliable method to identify and quantify the clogging types that would allow a better management of the equipment. This study propose a novel and non-destructive method based on Visible and Near Infrared (VIS-NIR) spectroscopy coupled with multivariate analysis modelling for clogging discrimination and thickness estimation. Four representative clogging materials (kaolin, bentonite, sand and calcium carbonate) were placed in glass cups at different thicknesses. Water was added to reach a sample height close to the drippers' channel height (that range between 0.8 and 1.3mm). VIS-NIR spectra were acquired on the samples on a 2mm spot. The thickness measurement was done using Optical Coherence Tomography (OCT) that avoids the effects of water and give 3D images of the samples. After preprocessing of the spectra, two multivariate methods were used: Partial Least Squares Regression (PLSR) and its modification Partial Least Squares with Discriminant Analysis (PLS-DA). PLS-DA modelling was used on all samples for clogging material discrimination. The PLS-DA model showed encouraging results by being able to predict with 96.97% accuracy all classes of clogging materials, corresponding to only 1 sample associated to the wrong class. PLSR models were then established for thickness estimation. The PLSR models, established for each clogging materials, were able to estimate the thickness with a precision comprised between 132 and 164µm depending on the clogging material. The difference seems mainly due to the physical properties of the clogging materials and their behaviour in presence of water. This precision is also a limit for clogging detection and thus, clogging could be detected at a height that represent around 10% of the dripper's channel total height. This work proves the potential of VIS-NIR spectroscopy for clogging discrimination and thickness estimation. VIS-NIR spectroscopy can also offer the possibility to acquire spectra in situ. However, several limits subsist before on-field application of this method. In this study, biological clogging have not been included and should be taken account before further application. In addition, the current acquisition scale of 2mm is not adapted to drippers' channels and the specific localisation of the clogging in the channels. Nevertheless, the recent advances in low-cost and portable spectrometers are giving positives perspectives of development for this method. Then, the use of VIS-NIR spectroscopy and multivariate analysis models is very promising to respond to the needs in current drip irrigation clogging studies. Such method, adapted to on-field measurement, would be of major interest to anticipate maintenance operation for drip irrigation equipment and ensure both their well-functioning and durability.

Turgor measurement in mango leaves with inductive and capacitive sensors and its comparison with trunk dendrometer measurements

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ID: 159
Topics: Wireless sensor networks, Physical and Chemical sensors, Environmental ICT management systems
Keywords: Mango trees, turgor, LoRa system, capacitance, inductance

Mango is one of the main fruits grown in Mexico that are exported worldwide. Dendrometers have been used to optimize water usage and in the last two years' small and cheap turgor sensors were designed and installed in fruit trees. Different capacitors were designed and its dielectric changed with leaf water content, so changes were noted during evapotranspiration. Also Hall sensors were installed in leaves to study the effect of water during mango production. It was found that capacitance tend to be more sensitive than inductance. Higher changes were noted during midday when the temperature was hot.

Machine learning techniques in agricultural flood assessment and monitoring using EO and hydromorphological analysis

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Topics: Remote Sensing and GIS applications, Image processing

Keywords: flood assessment, remote sensing, data processing, machine learning fuzzy set theory

Floods are among the most catastrophic natural disasters causing important and/or permanent damages to infrastructures and crops and livestock. Agricultural flood monitoring is important for food security and economic stability. In the future, climate change could exacerbate these phenomena by increasing the frequency of extreme and adverse meteorological events. Flood mapping could also serve other stakeholders and purposes such as risk management, land use and land management, emergency planning.

Remote sensing (RS) is widely recognized as a unique source of data as it provides synoptic view over large areas. The constellation of Sentinel satellites is part of the Copernicus Earth Observation program led by the European Commission and operated by the European Space Agency.

In this study, we propose a method to synergistically combine different types of data and processing techniques in order to achieve greater, more consistent and robust mapping accuracy compared to traditional approaches based on segmentation of single water/spectral index. The major long-term objective is to lay the foundation of an automated algorithm for mapping flooded areas requiring less a-priori sets and, above all, capable to cope with choices taken under imprecise information, compared to more traditional methods proposed in the literature.

Data used are multi-temporal Sentinel2 data, orthophotos of 0.5m resolution, DEM of 5m resolution and ancillary land cover / use maps. Three sites were selected for algorithm set up and the assessment of mapping products that is areas affected by flooding during August / September 2020. The areas are located in Evia / Politika area, Cephalonia Pilareon municipality and Thessalia plain. The sites have been used for algorithm set up where training and testing pixels were extracted for i) definition of the “standing water”, ii) test of different multi-source soft integration operators and iii) validation of algorithm performance. Sites were selected to cover different conditions of standing water in order to capture variable spectral characteristics: flooded area is due to extreme heavy rainfall, river bed and flooded cotton fields.

The application has as a result estimates of the total arable land that has been affected, that is, to find the percentage of land that is covered by the floods. In this work we developed an algorithm to automatic map flooded areas from multispectral S2 MSI images based on fuzzy set theory. Since the use of multisource data is recognized as the way to achieve improved global and regional water mapping, we propose an approach to integrate multiple spectral features. Rather than making an a-priori selection of the best (or a few) water indicator(s), we exploited redundancy provided by multiple spectral features. Machine learning is carried out with operators that can flexibly aggregate inputs of different nature: spectral indices, H/V, other types of data such as surface elevation gradient, single spectral bands, hydro morphologic parameters etc. The algorithm has been tested with input features taking into account the temporal dimension (pre – post event change detection) to further enhance flooded area mapping accuracy.

Soil moisture profile modelling-mapping using a TDR multisensor system, GIS, soil analyzes and precision agriculture on a corn farmfield, for improved irrigation and fertilization decisions.

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Topics: Remote Sensing and GIS applications, Physical and Chemical sensors, Farm management systems (FMIS)
Keywords: Geostatistical modelling on yield of corn (Zea mays L.), 2-D TDR-GIS Soil moisture mapping, GIS and Precision Agriculture, drip irrigation modeling, Soil and hydraulic analyses.

The agricultural agencies and farmers demand in semi-arid regions for information on the water, wastewater and soil resources to support the establishment of agricultural policies on irrigation and fertigation management has grown exponentially in the last years. In order to fulfill their requirements, a generation of new agro-technologies (GIS, GPS, Soil Moisture Sensors, Precision Agriculture (PA), Remote Sensing (RS), Geostatistical models, soil and hydraulic analyzes, etc) of soil, water, fertilizer and irrigation digital information databases has to be initiated. These agro-technologies are utilizing state of the art data collection (field, GIS, RS and laboratory), spatial interpolation techniques and decision Support Systems for advanced agricultural (soil, water, fertilizer and irrigation) precise digital GIS mapping for improved management decisions. The present study investigates field applications utilizing GIS-RS, PA and spatial modeling-digital mapping approach of groundwater quality, of soil's N (inorganic), P (Olsen), K (exchangeable), pH, organic matter, $CaCO_3$, plant available water, field capacity water content, soil texture and TDR multisensory soil moisture data and 2 D rootzone mapping on corn (*Zea mays L.*). Results of modelling revealed that utilization of soil, water, fertilizers and irrigation digital information can be used for precise geostatistical modeling-GIS mapping with high accuracy for improved resources and irrigation management.

Construction of an observatory, as a management tool decision, valorization and sustainable preservation of the resources of aromatic and medicinal plants

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Topics: Remote Sensing and GIS applications
Keywords: Observatory, Medicinal and aromatic plants, sustainable management, human sensor [GPS], Albania

Today, the actors of the aromatic and medicinal plants (AMP) sector are facing several problems related to the management, exploitation, marketing and valorisation of these resources. To deal with these problems, it is essential to have reliable information in time and space on the state of these resources, their location and the quantity extracted. The methods used such as botanical and spatial observation, applied today on the AMP and biodiversity in general have their technical limitations, in human and financial resources. Consequently, the setting up of an observatory database allowing the mapping of habitats and other quantitative and qualitative data constitutes a tool of primary importance. Only an operational observatory, as a knowledge base and decision support tool, will enable managers to manage and preserve more efficiently the AMP resources and the other actors of the sector to sustain their activity. The objective of this presentation is to build an AMP monitoring model based on two very important sources of information: GPS traces of plant collectors and historical data derived from inventories produced through the method of the botanical inventory which proceeds by samples. To realize this model, we used GPS tracks for the plant collector Tilia tomentosa, known as silver linden, and historical inventory data of the year 1988. The results show that the experimental model of the database enables the storage, processing and cross-referencing of historical data with the GPS geographic information provided by collectors. The results expressed by the database, in cartographic and statistical form, constitute for the actors of the AMP value chain, a very important information for the protection and sustainable management of resources of the AMP.

Human activity signatures through multi-sensor data fusion for enabling safe human-robot interaction in agriculture

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Topics: Wireless sensor networks
Keywords: human-robot interaction, human activity signatures, multi-sensor data fusion, agriculture

Arguably, human-robotic synergetic systems constitute an innovative approach for the purpose of addressing the challenges originated from the unpredictable and complex agricultural environment. In fact, by combining the cognitive human characteristics of thinking, perception, decision making and acting with the repeatable accuracy and strength of robots a plethora of advantages can be seen, including reconfiguration system flexibility, workspace minimization and improvement of the quality of services. Towards providing a safe human-robot interaction, the present study focuses on the activity recognition of workers, which is a key aspect of such kind of collaborative ecosystems. Reliable capture of human activity recognition requires a wide range of data based on sensors' measurements, since purely vision-based techniques can be affected by visual disturbances. In this experimental study, five wearable VICON IMeasureU Blue Trident sensors were attached to the chest, cervix, lumbar region as well as left and right wrists of 20 participants. These sensors contain tri-axial accelerometers, gyroscopes and magnetometers. As far the participants are concerned, 13 male and 7 female participants, having no history of musculoskeletal disorders, were selected to perform a specific task outdoors: (i) Standing still till the start signal is given; (ii) Walking a specific distance; (iii) Bending down to grab a crate; (iv) Lifting the crate from the ground up to an upright position; (v) Walking back the aforementioned distance by carrying the crate; (vi) Placing the crate onto a robot. Two unmanned ground vehicles were used (Husky and Thorvald), which are commonly used in outdoor agricultural environments, corresponding to a deposit height equal to 40 and 80 cm. Concerning the crate, it was either empty or contained weight plates with a total mass (crate and plates) equal to 20% of the mass of each participant. Each sub-case was carried out three times and in a randomized order at each individual own pace, which corresponds to 12 efforts for each participant and 240 in total. An instructed five-minute warm-up was performed prior to the experimental sessions to avoid possible injuries. These experiments provided a large dataset that was made publicly available. Due to the inclusion of a number of different parameters, pertaining to genre, height, weight and age of the participants as well as the loading heights on robots, a large variability was captured regarding the collected data. This variability can be a very useful input for machine learning algorithms, aiming at recognizing the activity "signatures" of the workers, and future ergonomic analyses.

Autonomous UGV-based weed detection system for vineyards

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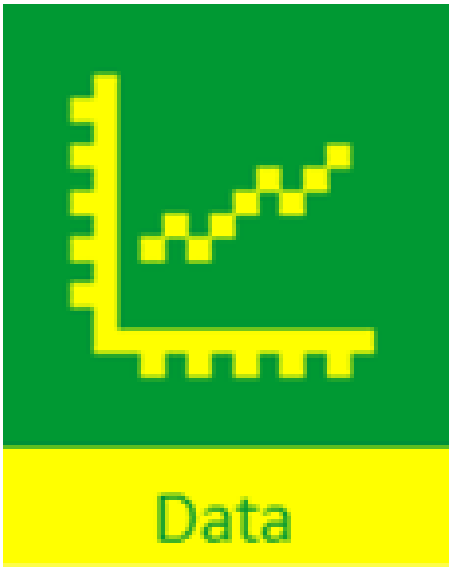
ID: 194
Topics: Optical sensors, Image processing, Monitoring Robots
Keywords: weed detection, vineyard, RGB-D camera, UGV, surface registration

In the last years, the use of robotics technology in agriculture is constantly increasing. Robotic platforms are the application of automation and robotics in agriculture field to relieve manual and heavy tasks from workers. These devices have already started to transform many aspects of agriculture and are hesitantly finding their way to the market. Therefore, robotic solutions which can provide alternative routes to weed management may provide a transformational

enabling technology to mitigate against biotic and abiotic stresses on crop production, for example automatic weeding robots are the preferable substitute for chemical herbicide to remove weeds. One of the most impacting abiotic factors in agriculture are weeds, causing important yield loss in every cultivation. Integrated weed management coupled with the use of robotic platforms (UGVs), allows the effectively weed management, us a beneficial methodology for the environment. The detection of weed spots in a cultivation can be achieved by combining image acquisition by UGV and further processing by specific algorithms. These algorithms can be used to weeds control by autonomous robotic systems via mechanical procedures or herbicide spray.

The weed management is one of the major challenges in viticulture, as long as weeds can cause significant yield losses and severe competition to vines. One of the cheapest and effectiveness method remains the weed control with chemicals; however, several adverse effects and risks may arise. Different methods like tillage, thermal method, mulching and cover crops can be included in weed control strategy, depending on the environmental conditions, soil and crop. As it is known, the mechanical methods are the most cost-effective weed management methods in vineyards.

Monitoring weed in different vineyards will provide a useful database for understanding the weed management practices. In this direction, this paper presents a system for a weeding detection robot. The objective is to be enabling the weed detection robot to navigate autonomously between the inter-row spaces of crop for automatic weed control, reduce labor cost and time. In this paper, various of image processing techniques with the implementation of an RGB-D camera was examined in order to: i) detect the path between two rows of vineyard and ii) allocate the weeds based on various a priori characteristics. As a pre-processing state, the real time data from the RGB-D camera transformed into different color spaces in order to denote the noise that could occur. Subsequently, the examined algorithms and techniques tested in numerous of aggregated data from real vineyards with different levels of weed development. Finally, the developed algorithm tested by implementing it on a UGV platform with promising results.


Data

Using a multi-state modelling (MSM) approach to predict dairy calf health status using on-farm precision technology data

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Topics: Data mining, Prediction models, Decision Support Systems
Keywords: calf health, motion sensors, behavioural data, real-time monitoring, multi-state modelling

Application: Mean motion index, drinking speed, daily live weight and birth weight were found to be important variables for predicting calf health, with evidence to suggest it is potentially easier to predict calf illness after the third week of life.

Introduction: Calf mortality is a major issue within the UK livestock sector (Rioja-Lang et al., 2020), with dairy heifer mortality rates observed up to 12% in the first month of life (AHDB, 2018). Farm-based automatic monitoring systems collect behavioural and physiological data in real-time offering the opportunity for earlier detection of health issues. This study explored the application of MSM for predicting calf ill-health from data obtained from on-farm precision technologies matched with base metadata and health records.

Material and methods: Feeding behaviour and activity data was collected via automatic feeders and IceRobotics® IceQube® sensors from sixty group housed Holstein-Friesian calves over the first ten weeks of life. Birth weight, gender and daily live weight was recorded and a daily health status derived from health records for each calf. To capture the time characteristics observed in the activity data, "summary measures" were derived (Plate et al., 2019). To explore data leading to an event (healthy/sick), time-lagged data was engineered. The predictive capability of MSM was explored using RStudio (Version 1.3.1056). The Likelihood Ratio Test was applied to determine covariate inclusion in the model. The probability of a calf moving from healthy to sick was derived using the MSM package. Hazard Ratios with 95% confidence intervals (CIs) were produced per covariate for each state transition. Performance was evaluated using the confusion matrix, sensitivity & specificity and the area under the Receiver Operator Characteristic curve (AUC).

Results: The MSM classifier identified the mean motion index, drinking speed, daily live weight and birth weight as important. The prevalence plot suggests it is potentially easier to predict calf health after third week of life . The Hazard Ratios suggest an increase of 1Kg in daily weight is associated with 11% less risk of moving from healthy to sick ($p<0.05$); an increase of 1 unit of mean motion index is associated with 4% less risk of moving from healthy to sick ($p<0.05$). Validating the classifier on unseen data gave an AUC score of 0.86.

Conclusion: Combining real-time data captured from precision technologies with an MSM approach aids the prediction of calf ill-health thus facilitating earlier intervention via individualised treatment.

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Validation of a 3D imaging device to measure new morphological phenotype on ewes

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Topics: Image processing
Keywords: 3D imaging, ewes, precision livestock farming, body measurement, sensors

Monitoring of body condition and/or morphological changes is essential for optimal management of ewe health and welfare, but also production and reproduction performance. However, due to implementation difficulties (handling, workload, skills and training), body condition scoring is rarely implemented on commercial farms. Modern technologies based on three-dimensional (3D) shape analysis combined with electronic identification could address this issue. The purpose of the present study was to develop, test and validate a device that can record and analyze 3D body shapes of shorn ewes. Manual measurements on 12 Vendéen breed ewes (gold standard) were compared to measurements from the 3D images. Height at withers (HW), chest circumference (CC), chest depth (CD) and chest width (CW) were registered. Correlations between 3D device and manual measurements were 0.37 for HW, 0.80 for CC, 0.80 for CD and 0.82 for CW. For the 3D system, the repeatability standard deviation ranged from 1,53E-03 to 1.65 (coefficient of variation (CV) from 1,54% to 3,77%) and the reproducibility standard deviation ranged from 2,36E-04 to 0,77 (CV from 0.3% to 1.17%). Repeatability values are very close between the two methods, and 3D device measurements are more reproducible than manual measurements. In the future, automatic determination of ewes body condition score thanks to this technology will be tested, as well as the possibility of measuring new phenotypes such as the volume or the surface, which are of many interest in ewe selection and production.

Digital agriculture infrastructure in the USA and Germany

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Topics: Data and Knowledge Management, Farm management systems (FMIS), Rural economies and ICT policies for rural development
Keywords: rural data network, network coverage, alternative data transmission

Agriculture worldwide is undergoing a transformation process towards the integration of digital process and production chains. The development of the necessary infrastructure for data transmission will be compared and analysed using the examples of Germany and the USA (Corn Belt).

The current development of smart farming is also strongly characterized by the fact that data and information can be easily shared between different partners. This can be control data for fully autonomous tractors, results from in-situ sensors in the field, application rates for implements derived from satellite data or the transmission of production data to trading partners.

The fact that data is collected directly on the working machine, processed there and the information is converted directly into decisions is less and less the case, due to increasing complexities and amounts of data on the one hand and the need for 3rd party information and complex algorithms for decision making on the other. Data is increasingly being collected at different points and times, blended with existing data, processed by different parties and then forwarded as information to different points for later analysis. To enable this development, the infrastructure for data transmission plays a crucial role.

In this study, we will focus on three sub-areas of this infrastructure network. The first part is between the cloud and the farm. Rural areas in particular are characterized by poor network coverage and low transmission rates. In many rural regions of Germany, no data rate ≥16 Mbit/s is available. In individual regions, not even ≥ 2 Mbit/s are available. The data rate in rural regions of the US are often even lower (≥ 3.5 Mbit/s.).

The second sub-area is data transmission between farm and field/tractor. Here the discussion is between data rate, range, penetration, cost and energy demand of different transmission technologies. LPWAN systems (e.g. LoRa, Mioty, Sigfox etc.) are on the rise. They combine low-power and low data rates with high range, therefore making them effective for many use cases of stationary sensor deployment in agriculture.

A third category blends in between the mentioned technologies. In the US these transmission technologies (e.g. TV whitespace) are suitable to build a bridge/backbone between regional locations of a farming operation. With medium data rates and very high ranges, they are suitable to connect LPWAN-based wireless sensor networks from remote locations to an internet backbone on a farmer's home base. Streaming technologies like what is used by Netflix are being adopted in the US by some Precision Agriculture vendors but many farmers in the US gather data via an iPad while in the field and upload this data after they return to their home office.

The investigations in the USA and Germany will be used to analyse the various problems of data transmission infrastructure for low, medium and high data rates. Finally, the results will be compared and opportunities and risks will be identified.

Semantic Segmentation of Tomato Sepals on Hyperspectral Images Using Deep Learning

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Topics: Image processing, Decision Support Systems

Keywords: deep learning, hyperspectral imaging, semantic segmentation, tomato sepals

Tomato is one of the most widely grown vegetables with high moisture and nutrient content. Hypersensitivity of tomato to storage conditions such as humidity and temperature causes its high susceptibility to infection by pathogenic fungi that has the utmost influence on potential post-harvest losses and supply chain efficiency. Tomato sepals are very fragile regions. A necrosis type of cell damage at the tomato sepals, influenced by storage conditions, becomes the entry point for fungal spores. Therefore, segmentation of tomato sepals from hyperspectral images is a crucial step in designing an automated system for sensitivity assessment of tomato to fungal infection with minimal human intervention. Achieving highly precise segmentation of the sepal tips can drastically improve the precision of predictive models for early assessment of risk on undesired fungal growth. In this study, we investigate the state-of-the-art deep learning architectures to identify which architecture provides the most precise segmentation of tomato sepals from hyperspectral images. The analysis is conducted on a dataset consisting of 36 hyperspectral images with 224 spectral bands that cover the range from 900 to 1700 nm (near-infrared range) with a spectral resolution of 3nm. The images are captured six days before the fungal infection becomes visible by the eye. A ground truth labeling of the region of interest is done using the pseudo-color image derived from all available spectral bands. We compared the performances of three neural network architectures for the segmentation task: our novel optimized fully convolutional neural network (oFCN) developed in [1] and the other two that are ones of the most applied architectures for semantic segmentation: U-net [2], and Seg-net [3]. For each network the same training procedure was adopted, i.e., the same division on training, validation, and test data was utilized. The performances of models were estimated based on the F1 score, the sufficient number of epochs to reach the optimum and the required trainable parameters during the training procedure. The most precise segmentation with the least demanding memory resources is reached using oFCN with a 91.59% F1 score after 78 epochs, then U-net with 75.23% after 150 epochs and Seg-net 43.39% after 46 epochs.

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Depth image selection based on posture for calf body weight estimation

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ID: 119
Topics: Image processing
Keywords: Cattle, Calf, Weight estimation, Image processing, Depth camera

We are developing a system to estimate body weight easily by using calf's depth images taken in a loose barn. To estimate calf body weight, it is necessary to collect depth images of a single calf from which the body parts can be properly extracted. However, most of the depth images automatically taken in a loose barn are not likely to meet the conditions, because several or none of the calves are in the depth images, or the calf's postures are not suitable to extract body parts. This paper proposes a method to automatically select only the depth images appropriate for body weight estimation. In this method, in order to increase the number of depth images for calf body weight estimation, we also select the depth images with a walking calf as well as those with a stationary, upright one. First, depth images with a single calf are extracted by using radio frequency identification (RFID) tags. Then, the calf area is extracted by using background subtraction and contour detection with a depth image. Finally, to determine usable depth images, we detect and evaluate calf's postures such as the angle of the calf to the camera and the slope of calf's dorsal line. To evaluate the efficiency of our method, mean absolute percentage error (MAPE) was used for calf body weight estimation. The MAPE was 12.45 % when selected depth images through our method were used for estimating calf body weight. From this result, we have confirmed that the weight can be estimated even with the depth images of a walking calf, and also that our method selected depth images effectively

Predicting crop productivity zones for increasing fertilizer use efficiency: A Bayesian hierarchical model for spatio-temporal sets of remote sensing, meteorological, and on-farm data

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Topics: Data mining, Prediction models, Decision Support Systems
Keywords: spatio-temporal variability, decision support system, hierarchical models, Bayesian analysis

Previous studies have shown correlations between remote sensing data and in-season productivity zones. However, these studies may have been subject to bias, as they lacked adjustment for spatio-temporal structures. The presented research addresses this gap by examining the effects of: i) previous seasons crop yield, ii) both previous and in-season normalized difference vegetation index (NDVI), and iii) meteorological variables, on the prediction of in-field yield productivity zones of winter wheat before the 2nd fertilizer dressing. The Bayesian hierarchical model (BHM) utilized mapped yield data derived from three years at 96 locations inside a field experimental plot area. A novel screening algorithm of raw datasets from yield sensors validated the yield data. Model building and computation were performed and evaluated in the 2019 growth season. A conditional auto-regressive (CAR) model was used to model the spatial association of crop yield. Specifically, the co-variates used for the modelling was: NDVI measurement in 0 to 1 week prior fertilizer application, NDVI measurement between 1 and 3 weeks prior fertilizer application, global radiation in 0 to 2 weeks prior fertilizer application, growth degree days (GDD), and cumulative precipitation.

The ratio between a zone specific and the highest predicted in-field yield productivity level was multiplied with the economic optimum N rate, such that plots with estimated low yield potential received less fertilizer.

The measured dry matter and %N of grain from 8 large scale plots that received 133 kg N/ha at the 2nd dressing approximately 3 month before harvest was used to analyzed the residuals

of yield (predicted yield–measured yield). The residuals ranged from -73 to +342 kg grain/ha, with the model posterior means having a tendency to overestimate yield. The model posterior mean yield variation across plots was correlated to measured yield by R^2 = 0.71, and with a Pearson correlation coefficient of 0.845, a strong correlation can be concluded for the single field test. Due to negligible differences in crop growth between plots of uniform and BHM based variable N rate application, the partial balanced nitrogen use efficiency[i] and the nitrogen uptake efficiency[i] measurements did not result in significant differences.

The BHM quantified the spatial and temporal uncertainty in the covariates of observed yield response distributions, however more and longer period of historical field data, would improve model performance. The developed BHM allows for incorporation of auxiliary co-variates. Furthermore, it allows for productivity estimation repeatedly during crop tillering and stem elongation. As a result, the developed non-linear model enables the estimation of the effect of environmental conditions on end-of-season winter wheat yield. For example, excessive draught during tillering has a pronounced negative effect on the end-of-season winter wheat yield. The model may have included evapotranspiration, mechanistic crop models for water use efficiency and evapotranspiration. Based on the obtained results and improvement possibilities, the BHM has potential for integration with decision management. The project was supported by the Danish GUDP and ICT-GRI.

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An easily-installed method of estimation of soybean yield based on meteorological environments with regression analysis

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ID: 130

Topics: Data mining, Prediction models

Keywords: Regression analysis, Data mining, Smart farming

A simple method for estimating soybean yield under an ideal environment in Japan is proposed. Several models that simulate soybean have been proposed in other countries; however, adaptation to Japanese species directly is difficult in terms of climatic and regional characteristics. Besides, they often require variety-specific information or various environmental information, and sometimes hard to simulate. Therefore, we attempt to create a simple simulation model with meteorological environment data as the main input to the model. The proposed model ignores the features that need setting for each cultivated field and is composed of a statistical model instead of a physiological analysis for the sake of brevity. Although the prediction accuracy of the model needs to be improved, we can use it as a decision support system for soybean cultivation since it requires only location information and easy to introduce for many farmers.

Integrating Ambient Intelligence Technologies for Empowering Agriculture

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ID: 146

Topics: Data visualisation, Multi-Agent systems, Human-Computer Interaction

Keywords: precision agriculture; ambient intelligence; smart greenhouse; smart seedbed; augmented reality;

This work blends the domain of Precision Agriculture (PA) with the prevalent paradigm of Ambient Intelligence (AmI). AmI has the potential to create human-oriented Intelligent Environments, whose primary goal is to satisfy the needs of the people living/working in them; hence, it can enhance the interaction between farmers and their greenhouses and support their daily Agricultural activities, whilst improving the quality and quantity of cultivated plants by employing state-of-the-art technologies. The term “Intelligent Greenhouse”, became prevalent the past quinquennium, and refers to greenhouses that focus on minimizing their carbon footprint, permitting the creation of self-regulating cultivation environments, automating several agricultural activities, etc., rather than enhancing the User Experience (UX).

This paper will present the Intelligent Greenhouse and the AmI Seedbed of ICS-FORTH, which target a wide range of agricultural activities starting from planting the seeds, caring for each individual sprouted plant up to their transplantation in the greenhouse, where the provision for the entire plantation lasts until the harvesting period. In more detail, the AmI Seedbed comprises of a metal bench on which various sensors measure air temperature and humidity, and a robotic system able to perform actions like dibbling and planting of vegetable seeds in well-prepared pots with soil substrate, precise irrigation of each individual pot, and growth stage calculation (height) through image analysis. The Intelligent Greenhouse is a small-scale (approximately 25m2) experimental gable-type greenhouse covered with polycarbonate cover sheets, and equipped with various sensors, actuators, and custom-made artefacts. The installed sensors permit the monitoring of internal and external conditions (e.g., air and soil temperature, solar radiation, external weather conditions), as well as the assessment of specific parameters of each plant (e.g., fruit weight). Additionally, the employed actuators can be controlled via appropriate software, permitting users to manually control them, and enabling the greenhouse to automatically change its status so as to optimize its interior conditions based on sophisticated decision-making mechanisms.

Aiming to enhance UX and offer an innovative interaction paradigm, on the pathway in front of each cultivation zone, custom-made control panels are installed to allow users to view the zone’s current status, and -if needed- adjust its actuators. Moreover, intuitive and user-friendly applications were designed and developed targeting PCs, Tablets, Smartphones and other technologically-enhanced artefacts (e.g., smart refrigerator), so as to enable remote and on-site management of multiple dispersed greenhouses and seedbeds. Additionally, following the advancements in the domain of Augmented Reality (AR), and considering their benefits towards PA, the mobile applications foster such technologies, so as to offer advanced visualizations regarding the greenhouse’s conditions.

This paper after describing the design process that led to the construction of the Intelligent Greenhouse and the AmI Seedbed, it will briefly present their specifications and the functionality of the accompanying applications. Moreover, it will report how the AmI Seedbed undertook the tasks of planting cucumber seeds and caring for them on a daily basis until their transplantation in the greenhouse, which in turn maintained ideal internal conditions leading to a significant quota of harvested cucumbers.

The Common Greenhouse Ontology: an ontology describing greenhouses, their components, and measurements inside the greenhouse

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Abstract
Topics: Ontologies for agriculture
Keywords: Ontology, Semantic Alignment, Data Interoperability, Greenhouse observation, Knowledge model

Modern greenhouses have many systems that continuously measure properties of the greenhouse and its crops. These measurements are stored in different kinds of databases, which has consequences for how this data and its metadata can be used. The databases can have different formats and contents, and therefore cannot be queried together without manually combining the relevant data. In this paper we introduce the Common Greenhouse Ontology. It

provides a standard for sharing data on greenhouses and their measurable components. It also provides semantic alignment of different databases. The ontology was created using input from experts in the horticultural domain and it incorporates existing ontologies, such as SSN, SOSA, and OM. It complies with existing ontology standards and implemented in the Web Ontology Language (RDFS/OWL), using the Resource Description Framework (RDF). The ontology was evaluated using competency questions, reasoners, and SPARQL queries. The results of the evaluation show that the Common Greenhouse Ontology is an innovative solution for data interoperability and standardization, and an enabler for advanced data science techniques over larger databases.

MULTIPASS: Interest and feasibility of a consent management ecosystem for the exchange of farmers data

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Topics: Big data management
Keywords: farm data, data management, consent, transparency, chain of trust

To meet farmers expectations regarding the control of their data and the transparency of the uses that are made of it, the MULTIPASS project stakeholders, cofunded by the French Ministry of Agriculture, have proposed an interoperable ecosystem for managing farmers' consents making data exchanges secure.

The various components of this ecosystem have been developed in the form of fully functional prototypes and tested on use cases for the animal and plant sectors. The guarantee of interoperability between the different consents managers is provided by a router which constitutes the central point of the ecosystem. Its standard interfaces allow data consumers to list (by right holder, by beneficiary, etc.) or verify the consents given regardless of the system in which they are managed.

The need to collect prior consent for any use of agricultural data has been highlighted by farmers and their professional representatives through agricultural principles and good practices. A consents management ecosystem equips agricultural data principles with a solution for managing consents and ensures the control and sustainability of consents by their registration in a dedicated tool, transparency and completeness by the federation provided by the router, and security and trust by the auditability of consent systems.

The interest and feasibility have therefore been demonstrated, but the MULTIPASS project also makes it possible to specify the limits to the use of this consents management ecosystem in certain cases (interoperability, access to data for research and innovation, and lack of trust between actors). The project also reviews the work that remain to be done on the typologies of uses and data that characterize consents, on IT tools to ensure that the one who registers a consent is indeed the one for whom the consent is given (identity providers), and the flawless technical documentation which will facilitate broad support from software editors.

It is now necessary to industrialize with the identified investors the prototype and the concepts developed and to apply the achievements of the MULTIPASS pilot project to more numerous use cases.

How agricultural digital innovation can benefit from semantics: The case of the AGROVOC multilingual thesaurus

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ID: 152
Topics: Data and Knowledge Management, Ontologies for agriculture, Knowledge bases and Knowledge repository services
Keywords: AGROVOC, Linked Open Data, FAIR principles, Thesaurus, Controlled Vocabulary

Since the 1980s, the Food and Agriculture Organization of the United Nations (FAO) manages and publishes the AGROVOC Multilingual Thesaurus, which covers all the FAO's areas of interest in more than 40 languages. Up to 25 national and international organizations worldwide are supporting the language and thematic coverage of AGROVOC through an editorial community. The thesaurus also incorporates three specialised subsets: LandVoc for concepts related to land governance, ASFA for Aquatic Sciences and Fisheries, and FAOLEX for legislative and policy concepts in the FAO's areas.

Compliant to the most popular Semantic Web standards, AGROVOC is available online as a Linked Open Data set - using RDF (Resource Description Framework) and SKOS (Simple Knowledge Organization System) as structural basis - and it is aligned to other vocabularies and thesauri. Currently, AGROVOC has more than 38 000 concepts and 800 000 terms which are related through a hierarchical system based on skos:broader and skos:narrower. The basis of the concept model behind AGROVOC is that each concept is identified by a URI. Additionally, AGROVOC is the key element to produce FAIR data in food and agricultural sciences, and beyond. The FAIR principles [https://www.force11.org/group/fairgroup/fairprinciples] state that data must be (F)indable, (A)ccessible, (I)nteroperable and (R)eusable. This is to support knowledge discovery and innovation, data and knowledge integration, and promote sharing and reuse of data, which focuses more on data intensive research and sharing data across the data value chain [http://www.fao.org/3/cb2838en/CB2838EN.pdf]. AGROVOC contributes to enhance the (I)nteroperability of data (I2).

The AGROVOC technical infrastructure is based on a comprehensive ecosystem of tools for users and editors to provide access to the data by both humans and machines. AGROVOC is a stable and reliable resource, which is continuously expanded by the activity of the curators and the editorial community. Editorial rules and guidelines have been defined and are continuously evaluated and revised to facilitate the work delivered by the multilingual and distributed community of editors. Improvements in the underlying technology have led to improvements in content representation. Automatic tools support consistency checks and thus enable editors and curators to further enhance the quality of AGROVOC.

AGROVOC can be used to enable agricultural digital innovation in different ways: Linking AGROVOC concept URIs from data sets or other resources like bibliographic records and annotations of research data and text corpora allows to unambiguously define concepts. Reliance on this common URI set implicitly links all these resources to each other effectively integrating them into a global, interoperable data space. We will present use case examples illustrating technical implementation and the value and impact of that approach - among others within an agricultural advisory system for horticulture currently developed in a project at KTBL. Apart from data integration, concept labels available in multiple languages support the internationalisation of applications and information systems.

This presentation aims to illustrate the recent developments in the context of AGROVOC and to present use cases where it has contributed to enhance the interoperability of data shared by different information systems.

Drought periods identification in Ecuador between 2001 and 2018 using SPEI and MODIS data

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Topics: Big data management, Remote Sensing and GIS applications, Image processing
Keywords: Drought, SPEI, NDWI, Remote sensing, Ecuador.

Drought is a natural phenomenon in which rainfall values are below normal in a specific region over a long period. This phenomenon is responsible for several impacts in the environment, agriculture, society and economy. Remote sensing is a powerful tool to monitor drought at different spatial and temporal scales, also in inaccessible areas. The main objective of this study is to identify periods of drought in Ecuador between 2001 and 2018 using the Standardized Precipitation Evapotranspiration Index (SPEI) and the Normalized Difference Water Index (NDWI) derived from MODIS data.

Ecuador is on the latitude 0°0'0" and it is officially divided into four regions. This research is focused in the regions belonging to continental Ecuador (256,370 km^2): Coast, Andean and Amazon areas characterized by a climate with two marked seasons: the dry season (June-November) and the rainy season (December-May).

Firstly, the SPEI at a six-month scale was used and then the Runs theory (duration, severity and intensity) was applied to identify periods of drought. Secondly, the MOD09A1 MODIS product was used to calculate the NDWI to obtain the areas affected by drought.

In the study period, 2005 and 2018 were identified as dry years, and particularly 2005 resulted the driest year at the regional level. The drought period had durations of 10, 13 and 6 months, respectively in the Coastal, Andean and Amazon regions, being the coastal region affected by the higher drought intensity, -1.43.

In the drought period of 2005 using the NDWI and pixels with values less than 0.3 were classified as affected by drought and the most affected month was October, which affected 32.36% of the total surface of continental Ecuador and the second affected month was September with 30.45%. The use of SPEI together with the Runs theory is a powerful tool to identify drought periods along time. It is important to identify the month (October) and the areas most affected (Coast region) by this natural threat in order to be able to take preventive measures in the future, knowing that the sector of first necessity is the agricultural sector.

Mobile application for fruit Identification using deep learning

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Topics: Image processing
Keywords: Computer vision, Deep learning, mobile application, image processing

This paper describes building android Mobile app with the use of deep learning that captures fruit pictures in order to classify them by type,in addition to provide explanation of Convolutional Neural Networks.

The impact of weather forecast uncertainty on greenhouse energy demand and cost prediction

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Topics: Big data management, Modeling and Simulation, Decision Support Systems
Keywords: Greenhouse horticulture, Statistical uncertainty, Weather forecasting, Energy efficiency

In greenhouse horticulture weather forecasts are used to predict energy usage to aid the buying energy on the open market. However, weather forecasts contain inaccuracies which inhibits the certainty of energy use predictions, which can lead to errors in energy buying, and a lower economic efficiency. To mitigate the risk of energy mis-buying this study proposes a

methodology to quantify the impact of weather forecast error on greenhouse energy demand predictions.

Within this methodology the 'forecast' energy use was calculated using the KASPRO greenhouse model (de Zwart, 1996) and a five day weather forecast of outside temperature, windspeed and radiation (MeteoConsult, 2019). The 'actual' energy demand was estimated using weather recordings of the same quantities, period and location as the forecasts. The 'actual' and 'forecast' energy use were compared to compute the prediction error. This was repeated using multiple overlapping sets of forecasts from October – December 2019, forming an error distribution.

These error distributions showed that the inclusion of weather forecasts resulted in a consistent overestimation of greenhouse gas and electricity demand. In addition a data based sensitivity analysis was done. This showed that the misprediction in the electricity demand was contributed to most (with a mean relative error of 6.13%) by errors in the radiation forecast and that gas demand misprediction was caused mostly from errors in the windspeed (18.0%) and outside temperature forecast (17.2%). The methodology presented here can help improve greenhouse management by allowing the grower to adapt their buying strategy to acceptable risk levels of over or under buying greenhouse energy considering the uncertainty in the weather forecast.

Design of linked open data to track input use in food production

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Topics: Ontologies for agriculture, Web of Data and Open Data
Keywords: RDF/OWL, food ontology, food production, agricultural inputs, pesticides

Initiatives aimed to open and link data can make data themselves more useful, improving the flow of information in value chains. However, Linked Open Data (LOD) are not yet widespread in all sectors of the economy. The food and agriculture sector would benefit from LOD since it is facing issues and challenges related to food quality and food safety, both in global and local value chains.

LOD would support autocompletion mechanisms in the context of compliance-driven processes, helping food chain actors to break free from time-consuming manual entry and manual check. This innovation would benefit several food value chain actors, as well as public stakeholders. The advantages of this paradigm include e.g.: primary food producers can obtain better advice and support on decisions related to agricultural activities; food distributors and processors may be able to more easily match food and input requirements to input usage regulations and production standards; consumers can easily access a broad range of information associated with the food they purchase.

Several attempts to promote data openness resulted in important, albeit partial, results. The objective of this work is to design an ontology (a knowledge-based schema) describing public pesticide registers issued by government agencies and ministries, so that pesticide characteristics contained therein (i.e., active ingredients, product properties, authorisation and revocation dates, to name but a few) could be easily accessible, interoperable, and jointly usable by food supply chain stakeholders. The aim is to take advantage of data science tools to overcome information gaps that characterise agriculture and food systems today.

Methodologically, a set of formal logic tools have been used within our domain of interpretation (*pesticides*). Firstly, to design the ontology, a number of design patterns for reverse-engineering the data and the original product classification scheme have been applied and a RDF knowledge graph has been obtained. Then, the re-engineered scheme has been implemented as an OWL ontology schema. Following the eXtreme Design methods, the reverse engineering has been guided by the definition of several *competency questions*, which have been also reused to run unit test against the ontology and the knowledge graph, in the form of SPARQL queries. The knowledge scenario so-obtained reveals relevant pieces of information describing food production inputs that can benefit many food chain actors and stakeholders, favouring, for example, product labelling consistency checks (e.g., preventing the use of non-compliant or expired pesticides), and product eligibility checks, according to a

particular farming approach. Finally, the provision of this type of LOD building with RDF and OWL technology can prepare the ground for the further development of tools and applications for data traceability in the food value chains.

An Ontology based approach for Regulatory Compliance of EU Reg. No 995/2010 in Greece

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Topics: Ontologies for agriculture, Environmental ICT management systems, Decision Support Systems
Keywords: Illegal wood trade, EU Reg. No 995/2010, regulatory compliance, ontology engineering

Illegal logging has always been considered as a major impact environmental and social global concern, as it is directly associated with deforestation and climate change. Nowadays, EU Regulation No 995/2010 has been successfully enforced to impede the placement of illegally produced timber within EU markets, and therefore toefficiently enhance sustainable forest management and restore ecosystem balance. However, EU 995 regulatory compliance and enforcement itself is quite complex, since it requires long term conformity, on a common basis for various heterogeneous groups and communities of stakeholders, on a global, even beyond EU, rule regulation framework.To make things worse, such a framework must be applied to the entire supply distribution chain, and for a wide variety of wood products, ranging from paper pulp to solid wood and flooring. Hence, in such complex and multivariate information environments, an ontological approach can more efficiently support regulatory compliance and knowledge management, due to its openness and richness of semantics for representing, analyzing, interpreting and managing such kind of information. In this paper, a rule based regulatory compliance ontology is proposed, which fully captures EU Regulation No 995/2010 concepts and compliance rules and guidelines, as well as the Greek legislation governing wood trade. The proposed ontology can be the basis for a computerized system providing automated support for illegal wood trade monitoring EU regulation information provision and audit information storage and analysis.

From fragmented research data to unified research insights: the GUARDS protocol, ML and the power of data partnership

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Topics: Metadata and data standards, Ontologies for agriculture, Prediction models
Keywords: Agronomic ontologies, data management, standardization, modeling

Background: Agronomic research involves managing data from different streams, such as experimental data, sensors, climatic data or aerial imaging. Researchers allocate significant time resources into unifying these fragmented data layers into a coherent structure. Typically, only a fraction of the data which were collected to address the research hypotheses are actually used for the analysis or the publication. The remaining data, which are scientifically valid, are in many times left unused. More funding opportunities brings new personnel, new hypotheses which lead to more fragmented files. In all, the fragmented nature of the data layers encompassing agronomic research limits researchers to generate new insights from their hard-earned data. There is a need to provide researchers with tools to automatically standardize data from different sources, for both ongoing and legacy trials. This can allow robust insights based on a wide range of parameter space.

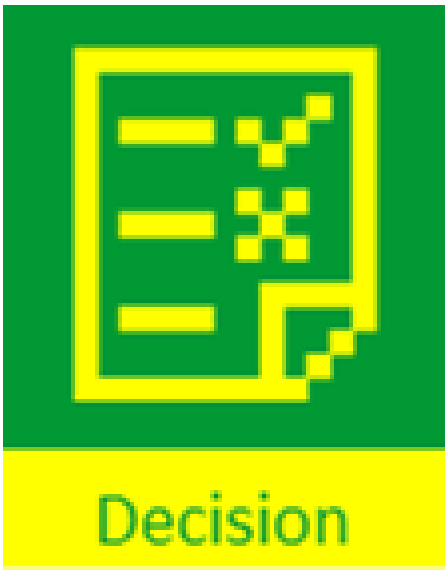
Methods: There are several research data management platforms available for researchers, such as the GARDIAN by CGIAR, or DataOne. Here we want to present Axiom – a new platform developed by Growers Tech LTD. Axiom is a database of harmonized and standardized agronomic data covering multiple crops and production environments. Using ML algorithms, the platform can ingest any agronomic data - from tabular data, to journal manuscripts, to sensor readings, GIS layers or Ariel images. The ingestion process uses an

in-house agronomic ontology engine termed GUARDS – Growers Universal Agronomic Research Data Standard. GUARDS library is uniquely generated in a bottom-up approach and expands as more data are accumulated in the system. ML algorithms are now being developed to automatically classify new data to existing GUARDS concepts. Based on the axiom database we established the axiom Open - a community of researchers donating agronomic data and have access to data shared by other community members. The platform allows users visual dashboards where data can be queried, and statistical tests can be performed. The ability to have access to standardized and curated research-grade data shared by other community members allows unprecedented opportunities to explore new research questions, as well of creating new research collaborations.

From fragmented files to a corn yield prediction model:

To demonstrate the potential of such a platform we have used corn data from 3 different sources – University experiments, demo plots and farm management data. All data (+7500 yield data points) were standardized and harmonized in the Axiom platform. The data were enriched with relevant weather parameters (rainfall, GDD). Using R and relevant libraries, a machine learning algorithm (XGBOOST – an ensemble of decision trees) was used to predict corn yield based on multiple explaining covariates. The calibrated model was successfully applied to an independent validation dataset, resulting with an RMSE error of 1.2 Mg/Ha and a mean prediction error of 10%.

In conclusion, there is a large potential for tools that help researchers standardize and unify their data. These procedures help researchers fulfill the full potential of both legacy and current research efforts, allowing to integrate insights from different experiments and sources.


Decision

Investment in information and communication technology (ICT) in agriculture and soybeans price stability: China

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ID: 101
Topics: Prediction models
Keywords: Information and communication technology(ICT)in agriculture, Investment, Chaos, Elliot Waves, the Golden Ratio

The basic aims of this paper are : firstly, to create the simple chaotic soybeans price growth model that is capable of generating stable equilibria, cycles, or chaos; secondly, to include investment in ICTs in agriculture in the model ; thirdly, to discovere a sequence of Elliot waves in soyabeans market in China in the period 1991-2015 ; and thirdly, to analyze the effects of investment in ICTs in agriculture on local stability and equilibrium value of soybeans price in China in the period 1991-2015. Investment in information and communication technologies (ICTs) in agriculture improved both the productivity and soybeans price stability. This paper confirms the existence of the stable convergent fluctuations of soybeans price in China in the observed period. Also, the golden ratio can be used to define the equilibrium soybeans price in the presented chaotic model.

A review of the state-of-art, limitations and perspectives of machine vision for grape ripening estimation

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Topics: Prediction models, Farm management systems (FMIS), Decision Support Systems
Keywords: grape ripeness estimation, machine vision, harvesting robot, image analysis, sustainable agriculture

Machine vision has recently gained considerable acceptance for agricultural related tasks. The technological improvement in hardware provides sensors that combine high performance and reasonable pricing, while innovative software design provides algorithms that can support effective real-time artificial vision systems.

Towards this end, machine vision has been employed to in-field practical applications for the assessment of grape ripeness. Grape harvesting based on grape ripening stages estimation increases the sustainable production of grape fruit products across three main directions: (1) improvement of the quality of harvested grapes due to homogenous ripened and equally fresh fruit, (2) reducing at the post-harvest waste along the supply chain and (3) reducing the production costs and human labor due to sustainable resources management.

This work highlights the most recent machine vision methodologies and algorithms proposed for estimating the ripening stage of grapes. Destructive and non-destructive methods are overviewed, for in-field and in-lab applications. Integration principles of innovative technologies and algorithms to agricultural agrobots, namely *Agrobots*, are investigated. Critical aspects and limitations in terms of hardware and software are also discussed. This work is meant to be a complete guide of the state-of-the-art machine vision algorithms for grape ripening estimation, pointing out the advantages and barriers for adaptation of machine vision towards robotic automation of grape and wine industry.

Non-destructive estimation of grape ripeness in Syrah variety via VNIR–SWIR spectroscopy

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Topics: Modeling and Simulation, Prediction models, Farm management systems (FMIS)
Keywords: vis–NIR; SWIR; feature importance; wine grapes; explainable artificial intelligence

Spectroscopy is a widespread technique used in many scientific fields such as in the food production. The use of hyperspectral data and specifically in the visible and near infrared (VNIR) and in the short-wave infrared (SWIR) regions in grape production is of great interest. Due to its fine spectral resolution, hyperspectral analysis can contribute to both fruit monitoring and quality control at all stages of maturity with a simple and inexpensive way. This work presents an application of a contact probe spectrometer that covers the VNIR–SWIR spectrum (350–2500 nm) for the quantitative estimation of the wine grapes' ripeness. A total of 110 samples of Syrah (also known as Shiraz) variety were collected over the 2020 harvest and pre-harvest seasons from Ktima Gerovassiliou located in Northern Greece. Their total soluble solids content (ºBrix) was measured in-situ using a refractometer. Two different machine learning algorithms, namely partial least square regression (PLS) and random forest (RF) were applied along with several spectral pre-processing methods in order to predict the Brix content from the VNIR–SWIR hyperspectral data. Additionally, the most important features of the spectrum were identified, as indicated by the most accurate models. The performance of the different models was examined in terms of the following metrics: coefficient of the determination (R^2), root mean square error (RMSE) and ratio of performance to interquartile distance (RPIQ). The values of R^2 = 0.90, RMSE =1.51 and RPIQ = 4.41 for PLS and 0.92, 1.34, 4.96 for RF respectively, indicate that by using a portable VNIR–SWIR spectrometer it is possible to estimate the wine grape maturity in-situ.

Calculating the Tree Crops' CO_2 Removal Capacity: Algorithm, Tool and their emerging potentials

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ID: 109
Topics: Planning tools, Decision Support Systems
Keywords: carbon dioxide balance, removal capacity, tree crops, climate change, algorithm

In the context of the EU R&D project LIFE CLIMATREE (LIFE14 CCM/GR/000635), www.lifeclimatree.eu, a specialized algorithm (CO_2RCA: CO_2 Removal Capacity Algorithm) was designed and developed to calculate the annual CO_2 balance of tree crops, which reflects the capacity of tree crops to remove CO_2 from atmosphere. More specifically, CO_2RCA calculates the annual balance between the mass of CO_2 which is removed from atmosphere throughout the biological cycle of the tree to produce new wood and fruits biomass, the mass of CO_2 which is stored into the soil beneath the tree and the mass of CO_2 which is emitted to atmosphere by the applied agricultural practices. Moreover, it calculates, and also takes into account in the calculation of the CO_2 balance, the annual CO_2 gain which results by the application of "green" agricultural practices. CO_2RCA's design principles provide calculation of the tree crops' carbon balance which is strictly related to atmosphere's CO_2 (CO_2 related carbon). Based on the CO_2RCA, a tree crops' CO_2 Removal Capacity Calculation Tool (CO_2RCCT) was designed, developed and tested. CO_2RCCT was applied at pilot scale to 5 tree species [Olive (*Olea europaea*), Apple (*Malus domestica*), Orange (*Citrus sinensis*), Peach (*Prunus persica*) and Almond (*Amygdalus communis*)] in three south Mediterranean countries [Greece, Italy, Spain]. A series of "green" alternative agricultural practices are incorporated in the CO_2RCCT providing by this way results regarding the efficiency of these practices in terms

of “climate” performance and the degree that they affect the overall CO_2 Annual Removal Capacity of the tree crops. Based on the extracted results, it is concluded that tree crops are proved to be of significant importance for the regulation of the climate, acting as a Climate Change mitigation measure. A series of rising potentials for using the CO_2RCA and the CO_2RCCT appear to be significantly promising regarding the expected impacts on the climate, the sustainable agricultural development and the economy. CO_2RCA and CO_2RCCT can provide the required data to the relevant stakeholders (farmers, agronomists, policy/decision makers, financial institutions) to adopt or/and develop practices, policies and financial tools respectively, to enhance the development of the agricultural sector within the context of climate change mitigation, in a sustainable and simultaneously viable way.

Adoption factors and the impact of System of Rice Intensification adoption on rice yields: an analysis in the upland region of Central Vietnam

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ID: 114
Topics: Modeling and Simulation, Data mining, Rural economies and ICT policies for rural development
Keywords: : System of Rice Intensification, adoption factors, yield, endogenous treatment effects, Vietnam

Adopting new technology to agricultural production is crucial to increase productivity and improve rural household’s income. The System of Rice Intensification (SRI) method is an approach to increase rice yield, reduce the required inputs, and friendly with the environment in many countries in the world. The application of the SRI model has fundamentally and comprehensively changed the current rice production status of farmers to ensure food security and improve farming practices. The aim of this article is to investigate factors that influence the adoption of SRI and the impact of SRI adoption on rice yields the upland region of Central Vietnam. Based on the survey data collected in Quang Nam and Thua Thien Hue provinces, the result of this research indicates that the age of interviewees has a negative effect on the adoption SRI method, while the number of family labor has a positive sign. To investigate the impact of SRI adoption on rice yields, this article applied the endogenous treatment effects model (ETE) with the aim to treat the endogeneity problem of SRI adoption variable by using instrumental variable (IV). The outcome results showed that the adoption of SRI has an increased impact on the yield.

Rice contract farming: an overview from Vietnam

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Topics: Multi-Agent systems, Rural economies and ICT policies for rural development
Keywords: contract farming; perception; participation; preferences; rice; Vietnam

Due to climate change and the increment of demand for high-quality food, improving linkages between smallholders and companies to produce efficiently and sustainably in the agricultural sector become an urgent-important issue. Moreover, small households are facing a number of production and marketing constraints. Therefore, contract farming has been proposed as a relevant measure for small-scale farmers in developing countries to cope with the constraints. As a developing country, Vietnam has also implemented contract-farming policies since 2002 to solve these constraints in order to develop the agricultural sector, especially rice production. Regarding these policies, paddy will be sold through contract over 50% by 2010; the rice industry is directed toward producing high-quality rice to improve the value and competitiveness for developing Vietnamese rice brand by 2020 with the vision to 2030.

However, up to now, these targets have not been completed, rice output sold via contract was only 10.88% in 2019; rice planted area under CF accounted for 1.78% with the participation of 5.33% of total paddy cultivation households. This study aims to give an overview of rice contract farming in Vietnam to enrich the data and information about contract farming in terms of farmers' perception, participation, and preferences.

Evaluating Critical Factors Affecting the Success of Rural Development Projects in Vietnam using Structural Equation Modelling Approach

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Topics: Decision Support Systems, Rural economies and ICT policies for rural development
Keywords: RID project; success factors; success criteria; Structural Equation Modelling (SEM); Vietnam

Rural infrastructure development (RID) projects have been always received high priority from Vietnamese government as its contribution to rural development. However, the investigation of factors influencing the success of RID projects has long been overlooked. This research aims to identify critical factors that influence the success of RID projects in Vietnam context.

Based on reviewing the current literature, list of success criteria and success factors were identified for the survey instrument. A questionnaire survey was conducted with various groups of RID project stakeholders to identify their perception on the determinants of RID project success.

Multivariate Data Analysis was utilised to process the survey data. The Exploratory Factor Analysis (EFA) results identified five critical success factors and three success criteria of RID projects. Structural Equation Modelling (SEM) was then used to investigate the influence of the project success factors on identified success criteria. Results showed that all five success factors had a positive relationship with one or more of the success criteria.

Understanding these success factors could allow project stakeholders to take precautionary steps to identify foreseeable problems. It also helps project managers to prioritize their attention on scarce resources to ensure the success of RID projects.

Prediction of corn and sugar prices using machine learning, econometrics, and ensemble models

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Topics: Modeling and Simulation, Prediction models
Keywords: Agricultural prices, Econometrics, Ensembles, Machine learning, Price prediction

Agricultural products value chains are essential for producing and distributing food, medicines, clothes, among many other products. Two of the most important agricultural value chains worldwide are the sugar and corn chains. One vital activity on these chains is to predict the prices of the agricultural products correctly. It impacts decision making and revenue generation for all agents in their supply chains. Therefore, improving these predictions' quality is critical for improving the revenue generated throughout the chains and increasing their sustainability. Nevertheless, most of the literature on time series analysis for price prediction focuses on the stock market. Traditionally, econometrics models such as autoregressive integrated moving average (ARIMA), seasonal ARIMA (SARIMA), and SARIMA with exogenous factors (SARIMAX) are used for this prediction. This paper explores the use of several state of the art machine learning models for predicting the daily prices of corn and sugar in Brazil in relation to the use of traditional econometrics models. For corn, daily prices from 2004 to 2019 were considered. For sugar, daily prices from 2003 to 2019 were considered. The following models were implemented and compared: ARIMA, SARIMA, support vector regression (SVR), AdaBoost, and long short-term memory networks (LSTM). An in-depth hyperparameters analysis for each model and the implementation and evaluation of ensemble models

considering the SVR, AdaBoost, and LSTM models was conducted. All the models were evaluated on the test set, composed of the whole year of 2019, considering four metrics: mean absolute error (MAE), mean squared error (MSE), root mean squared error (RMSE), and R2 score. It was observed that, even though the prices time series for both products differ considerably, the models that presented the best results were: (i) SVR, with an MAE of 0.287 for corn and 0.430 for sugar; (ii) ensemble of the SVR and LSTM models, with an MAE of 0.335 for corn and 0.458 for sugar; (iii) ensemble of the AdaBoost and SVR models, with an MAE of 0.395 for corn and 0.476 for sugar; and (iv) ensemble of the AdaBoost and LSTM models, with an MAE of 0.425 for corn and 0.500 for sugar. The econometrics models presented the worst results for both products for all the four metrics considered. All models presented better results for predicting corn prices in relation to the sugar prices, which can be related mainly to its lower variation during the training and test sets. These results indicate that the use of machine learning models and ensembles of those models could improve agricultural products prices prediction results. This has important implications for both researchers and practitioners. The methodology used can be implemented for other products. Future work is related to: implementing other machine learning models, using unsupervised learning to improve pattern detection, implementing deep reinforcement learning models to allow for autonomous decision making, and evaluating other datasets and periods.

Modelling digital circular economy framework in the agricultural sector. An application in Southern Italy

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Topics: Modeling and Simulation
Keywords: Agriculture, Circular Economy, Survey, Data, Indicators, Digital Framework.

Linear economy is a conventional model based on the "take-make-consume-waste" approach, conversely circular economy (CE) focuses on the circular approach to the energy and materials use, providing environmental, economic and social benefits for the stakeholders involved in production, distribution and consumption chains. The fundamental transition from a linear economy to a CE requires a large amount of data to increasing knowledge of consumption of natural resources and negative externalities. Among the economic sectors, agriculture strongly contributes to the consumption of resources (e.g. water and energy), to the greenhouse gas emissions and waste (e.g. wastewater) generation. The data required to optimize the transition to CE are often disaggregated, difficult to find, out of date and complex to consult by some agricultural stakeholders. The scientific literature associated with this emerging and new topic presented a shortage of papers (Klerkx, et al., 2019). To address this gap we presented this analysis regarding the third topic group, subsection (modelling and simulation). The aim of this research is to identify a data-set model in order to enable stakeholders to know the most suitable sustainability indicators and finally to implement the best CE model. We used a variety of digital sources, including bibliographic platforms, international and digital tools, EU and regional regulations. The methodological path includes the following phases: a) questionnaire administration to a sample of stakeholders for mapping the lack of data for planning the CE in the agriculture; b) manipulation and analysis of data; c) building of a set by replicable sustainability indicatorsto modelling a digital virtuous framework towards a CE. The results obtained thought the survey can be used for the definition of regional policy strategies and interventions.This new framework can improve the stakeholders' decision-making process (Wolfert et al., 2017), achieve a CE approach, lead to a greater cooperation in the agricultural supply chain. Furthermore, the application of this CE knowledge model enables to overcome obstacles in data procurement (Newton et al., 2020). Additionally the building of a replicable framework allows to widespread a digital learning and soft culture among stakeholders, creating a virtuous network to be implemented in the Mediterranean area. Scholars, stakeholders and public administration can use this framework to design a common language of data collection, identify the information gaps to be filled and plan CE strategies in agriculture. This research is conducted for the MoDEC Apulia project in collaboration with the Agriculture

Department of the Regione Puglia with the aim of strengthening the capacity building of public administrations.

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From tactical crop management to strategic farm management: the progress of the SmartAgriHubs project in France

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ID: 135
Topics: Decision Support Systems
Keywords: crop management, tactical decision, strategic decision, digifermes

While the challenge of sustainable management of agro-ecosystems is becoming more and more important, its implementation remains complex, particularly because of the increasing variability of climatic and economic hazards. Many farmers are looking for Decision Support Tools (DSTs) to optimise their practices and farming strategies. To this end, two Flagship Innovation Experiments (FIE) of the French cluster are being developed as part of the SmartAgriHubs project. This project, funded by the European Horizon 2020 program, brings together more than 160 European partners from the whole agri-food sector. It aims at accelerating the digitalisation of European agriculture by promoting an ecosystem of innovations dedicated to sustainable agricultural production.

Among the existing digital solutions, DSTs support users in their decision-making process by integrating multiple data and models in addition to already existing information coming from farmers and advisors and based on field observations. Like any tool, their implementation must be relatively easy and intuitive in order to be directly operational for users. Digital technologies must allow to access, at a low cost and in real time, information that make it possible to accurately characterise the state of crops and the production system as well as the conditions and environment in which they evolve.

There are tactical and strategic DSTs. Questions related to tactics are generally addressed in the short term to achieve acceptable production objectives, based on criteria defined by farmer and advisers. Strategic questions are most often addressed in the medium and long term to assess the impact of the means of production, i.e., to test different system management scenarios and evaluate them based on strategic operating criteria defined by the farmer.

To respond to specific requests from agricultural stakeholders, two FIEs of the French cluster are both optimising and upscaling a digital innovation to assist farmers in their tactical or strategic decision-making process.

The DIGI-PILOTE FIE aims to optimise farmers' practices through real-time monitoring of wheat crop needs. More specifically, this tool helps in the tactical management and optimisation of fertilisation and irrigation of the targeted plots.

The second FIE, STRATE-GEEK, is developing a web tool dedicated to the design and evaluation of innovative and multi-performing cropping systems. The tool carries out a multi-criteria evaluation of cropping systems, on arable and mixed crop and stock farms, from an economic, environmental and technical point of view (SYSTERRE®). It helps farmers in their decision-making via an analysis of the sustainability of cropping systems.

To assess the effectiveness of these solutions, French partners rely on a Digital Innovation Hub (DIH), the DIGIFERMES® network, which experiments and evaluates new digital

technologies in various production contexts: in different regions, in conventional and organic systems, and in mixed farming systems as well as field crops. DIGIFERMES® are full-scale farms and experimental stations. They can be considered as both production tools and laboratory farms. These open, collaborative, and instrumented digital farms benefit from the expertise of engineers and technicians of the institutes involved in DIGIFERMES®' network.

A Decision Support System for the wheat crop daily monitoring to help farmers manage irrigation and nitrogen inputs– The Digi-pilote PROJECT

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Topics: Decision Support Systems
Keywords: wheat, data assimilation, crop model, remote sensing, monitoring tool

Farmers are more and more dealing with unpredictable climatic conditions. To face these constraints that can alter the level of production in terms of quantity and quality, they must precisely control their production throughout the year. Therefore, to facilitate this monitoring, farmers need a decision support tool to manage their farming activities, for nitrogen and water supply. Indeed, it is often difficult for growers to find a window to apply nitrogen or water at the right place and at the right time, even more with climate change.

In order to overcome these difficulties and to accompany the French cereal sector, the DIGI-PILOTE Flagship Innovation Experiment (FIE) is included in the SmartAgriHub project. SmartAgriHubs is a project financed by the European Union under the Horizon 2020 instrument and brings together a consortium of well over 164 partners in the European agri-food sector. The project aims to realise the digitisation of European agriculture by fostering an agricultural innovation ecosystem dedicated to excellence, sustainability and success.
In this context, DIGI-PILOTE seeks to develop a Decision Support tool based on a crop model coupled with remote sensing data in order to follow the wheat state during the cropping season. A first version of the tool, named e-Pilote, was tested on durum wheat in South East of France under Mediterranean conditions in about 20 farms between 2018 and 2020. The partners of the FIE, Arvalis-Institut du végétal, ACTA – Les instituts techniques agricoles, ACTA Digital Services, AgDataHub, Groupe Provence Services and La Coopération Agricole want to make it functional automatically and usable for wheat to extend its use at a national scale. The main objective of this tool is to help farmers in the daily technical management of their crop. With this web app, the farmer will automatically receive an alert which advises him about the state of his fields and the necessity to perform a technical operation.
During the 3 years of the project, the entire IT ecosystem necessary for the operational implementation of the tool has been developed:

i) Assimilation of remote sensing data into a crop model;

ii) Development of APIs linking interfaces and calculation engines;

iii) Improvement of the e-Pilot web interfaces. In parallel, work was carried out to validate the interest of assimilating satellite data (LAI and Chlorophyll) in the CHN crop model, developed by ARVALIS, for the daily monitoring of wheat farm fields.

Finally, full-scale tests, on i) a national network of experimental plots (e-Repères Carnot project) including Digifermes to assess the added value of the solution from a technical and economic point of view, and ii) on a network of farmers to assess the use value directly on the farms, have demonstrated the value of this approach and encourage to consider the deployment of commercial offers by 2022.

Use of predicting model to forecast the appearance of rust and purple spot in Asparagus

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Topics: Modeling and Simulation, Prediction models, Decision Support Systems

Keywords: Asparagus officinalis, disease forecast model, Puccinia asparagi, Stemphylium vesicarium

The system of precision agriculture has been introduced in European countries in the last decade of the 20th century. It spreads rapidly in order to reduce chemical inputs (pesticides-fertilizers) in agricultural industry. So far, the introduction of this system in agriculture demonstrates the significant contribution to the protection of consumer health, to produce quality and safe agricultural products, to increase the economic performance of farm and environmental protection. Plant protection is probably the most important and also the most difficult part of these systems. In particular, regarding the management of pests and diseases, forecasting models assist producers in estimating the possibility of disease in their crops and in the selecting and timing of preventative applications. The aim of this study was to develop and evaluate the accuracy of weather-driven models for predicting infection by *Stemphylium vesicarium* and *Puccinia asparagi* in asparagus located in Agrinio, Greece. The predicted period of disease onset was then compared with the actual one. The results showed that the models correctly indexed infection periods for both diseases. Also, the indexes were fits very good with the intensity of the symptoms of the diseases in unsprayed plants. This work indicated that the forecasting model can be used to predict infection by *S. vesicarium* and *P. asparagi* in asparagus and to schedule fungicide applications. Thus, growers in Greece could spray their asparagus only when the model predicts a risk for infection. Further investigations should be conducted to correlate the level of risk with *S. vesicarium* and *P. asparagi* in asparagus incidence in order to determine when fungicide sprays are economically justified.

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Use of predicting models to forecast the appearance of bacterial canker of kiwifruit

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ID: 139

Topics: Modeling and Simulation, Prediction models, Decision Support Systems

Keywords: Disease forecast model, Kiwifruit, Pseudomonas syringae pv. actinidiae

The system of precision agriculture has been introducedin European countries in the last decade of the 20th century. Regarding the management of pests and diseases, forecasting models assist producers in estimating the possibility of disease in their crops and in the selecting and timing of preventative applications.

The main aims of this study was to evaluate the accuracy of weather-driven models for predicting infection by bacterial canker (*Pseudomonas syringae* pv. *actinidiae*) in kiwifruit orchard located in Pella, Macedonia, Greece.

The following model was used:

If LWh=0 or RH<81% then print "NO RISK" (where, LWh=hourly leaf wetness, RH=relative humidity)

If LWh=1 or RH>81% then: =((-0,000003*T^4)-(0,00011*T^3)+(0,00201*T^2)+(0,0541*T)+0,247) (where T=hourly temperature). The model runs in temperatures between -6 to 25^{o}C.

Model accuracy in predicting the day of infection was evaluated by comparing actual and predicted times of symptom appearance. A telemetric meteorological station (Neuropublic S.A., Information Technologies & Smart Farming Services, Piraeus, 18545, Attica, Greece) was established to record weather data, which were used to run the models. The model was operated hourly, starting from the 1st of April and ending on the 30th of June using hourly leaf wetness and hourly temperatures as driving variables for calculating. The date of the first of observation of the symptoms (in young leaves) is used to verify the prediction of the model, while the final intensity of the symptoms was recorded 15-20 days later by calculating the percentage of infected leaves to a sample of 100 leaves randomly selected from each of 10 trees in total. The period of possible appearance of the disease was calculated on each day when Risk (LW, T) > 30, considering the incubation period. The model predictions ranged from 0 (when Risk= 0) to 100 (when Risk = the highest possible value). A commercial kiwifruit orchard (cv Hayward, 15 years old trees) was chosen to record the appearance of leaf spot symptoms. The disease was in an endemic form in this orchard. Selected trees did not show any symptom of the disease before starting the trial. The trees (kept unsprayed) were inspected twice per week to determine the time of symptom onset. The trees were carefully inspected for the appearances of the first symptoms, which were dark spots, appearing on the upper surface of leaves, mainly in the low canopy. Inspections stopped after the appearance of the first disease symptoms. The model was judged to have provided an accurate prediction when the observed symptom onset coincided with the time interval predicted by the model.

The model predicted risk >30 from21st to 25th of April with an index of 47. The first seasonal symptoms of the disease appeared 15 to 20 days after the first infection was predicted by the model, which was at the end of the incubation period. The intensity symptoms (percentage of infected leaves) were 21% with an average of 1.1 spots per leaf.

This work indicated that the forecasting model can be used to predict infection by *Pseudomonas syringae* pv. *actinidiae* and to schedule fungicide applications.

Conceptual framework to integrate economic drivers of decision-making for technology adoption in agriculture

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ID: 145

Topics: Modeling and Simulation, Farm management systems (FMIS), Decision Support Systems

Keywords: Profitability; agricultural management; sustainability; cost; efficiency

As the growth of sensors and software becomes operational, agriculture's management and decision making grapple with the selection of technologies from a broader range of options to increase productivity, efficiency, and profitability. Generally, technology adoption for agricultural applications pursues a more efficient use of inputs, while production costs are constrained and yields maximized. This scenario can be empirically driven by the decision-makers' beliefs rather than an effective benefit-cost evaluation. Hence, a framework that helps decision making on adopting technologies in major cropping systems is pursued in this study. The proposed framework is built upon the evaluation of the profitability on technology adoption of cropping production systems (18 for corn, two for wheat, and one for each: soybeans, sunflower and sorghum). Analytics of the production cost involving higher-efficiency estimations on diesel, labour, irrigation (when applicable), fertilizer, herbicide, interest rate, repair cost, ownership, field efficiency and seed were used to simulate cost reduction and its effect on total operating costs. The estimations made also included higher income from higher yields, such as those expected through biotechnology adoption, slow release fertilizer, irrigation, which are expected to increase efficiency. For instance, considering a tractor equipped with a more efficient engine, the limits per 1% less consumption varied from 0.15 to

0.32 USD ha^{-1} among corn scenarios. The proposed framework allowed interpretations regarding optimal scenarios for technology adoption. For example, irrigated scenarios of corn are able to pay more for technologies of all studied variables, except for those aimed at lowering herbicide application. Also, investing on technologies to increase production is less likely to pay off in scenarios lacking economic incentives such as higher yielding years when grain prices are low.

Crop Water Availability Mapping in the Danube Basin based on Deep Learning, Hydrological and Crop Growth Modelling

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Topics: Modeling and Simulation, Remote Sensing and GIS applications, Prediction models
Keywords: Sentinel-2, cloud processing, crop type classification, water use efficiency, water availability

The Danube region like much of Central Europe was hit with several drought years in the near past. Water availability and irrigation possibilities become ever more important as climate change makes weather extremes more likely and temperature records in late winter and early spring keep being set. These changes in environmental conditions are one of the most challenging issues of this century as they directly affect agricultural production and with it food security.

Population growth, increased food consumption and the challenges of climate change will increase over the next decades. Measures to stabilize and sustainably heighten the efficiency of agricultural production thus need a new level of information quality. Which is where this study comes in: Set within the Horizon 2020 project ExtremeEarth, the issues of water availability and water demand for agricultural production as well as the water use efficiency of said production are addressed. The goal is to support irrigation management decisions by combining big data EO analysis with water balance and crop growth modelling within European pilot catchments.

In this paper, results for a part of the Danube Basin spanning four countries (Germany, Austria, Hungary and Slovakia) for the years 2018 and 2019 will be presented. In this region, different geographic characteristics from the cold and humid Alps to the warm and more arid regions in the East show the varied impact of the drought years.

Within the study, we combine the experience and advances in Cloud Computing and European platform infrastructures to pre-process dense time series of optical multispectral Sentinel-2 data that are then analyzed with state-of-the-art techniques from Machine Learning / Deep Learning techniques to derive a crop type map. We model the crop growth and with it the water stress the different crops suffered and calculate the Water-Use-Efficiency (WUE) using physically-based models for crop parameter retrieval and crop growth modelling. Finally, we use hydrological modelling to assess water availability over the whole season, including the water from snowfall that is available as river run-off in summer and could potentially support irrigation measures. Thus, we can compare crop water demand to available water resources to assess how irrigation measures could potentially mitigate drought conditions under climate change while still staying sustainable. Impact on natural ecosystems can also be assessed in our approach. In summary, our work is a step towards understanding the needs and demands of water management in the Danube Basin in the future.

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Identification and modeling carbon and energy fluxes from Eddy Covariance time series measurements in rice and rainfed crops

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ID: 155
Topics: Modeling and Simulation, Prediction models
Keywords: Gross Primary Production, flux tower, energy fluxes, time series analysis

The understanding of the CO2 fluxes between biosphere and atmosphere is essential for assessing the carbon cycle and its influence on global climate change. Gross Primary Production (GPP) represents the C uptake of ecosystems through photosynthesis and it is the largest flux of the global carbon balance.GPP estimations are necessary to assess the dynamics of the global carbon cycle and to plan a sustainable management of ecosystems.

While climate exerts a strong influence on ecosystems carbon, water and energy fluxes, the ecosystem itself is responsible for strong feedback processes to climate. Energy and water exchanges are determinant for understanding the feedback processes between the atmosphere and the land surface functioning in different ecosystems and ecoregions at several scales.

In the last decades, the Eddy Covariance (EC) technique has been established as a valid method to measure meteorological variables as well as carbon, water and energy fluxes between ecosystems and the atmosphere. The high temporal resolution of EC measurements makes the statistical time series analysis (TSA) an excellent method to analyze and study these data. TSA in the time and frequency domains provides tools and methodologies to model and forecast these variables and their relationship based on their dynamics.

Our overall objective in this research was to identify and model the GPP dynamics and its relationship with meteorological variables and energy fluxes based on time series analysis of EC data in two different agroecosystems, a Mediterranean rice crop in Spain and a rainfed cropland in Germany. The specific objectives were: (1) to assess the dynamic relationships between meteorological variables and energy fluxes with GPP in the two crops and, (2) to model GPP based on the relationships identified.

Preliminary results showed that there was a significant relationship between meteorological variables and GPP allowing modeling GPP based on them. In addition, the crops exerted an important influence on the energy and water fluxes dynamics. In Germany, latent heat was coupled to GPP during all growing season until harvest, while in Spain latent heat cycle responded to an interaction of factors and did not follow entirely the GPP dynamics.

Developing a method to simulate and evaluate effects of adaptation strategies to climate change for wheat crop production: a challenging multi-criteria analysis

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ID: 157
Topics: Modeling and Simulation
Keywords: climate change, wheat, multi-criteria analysis, crop model, epidemiological model

To face Climate Change (CC), plant sectors focus on the development of cropping and breeding strategies that limit the impacts of increasing abiotic stresses on production. This often overlooks plant health risks that are either directly induced by CC, or indirectly through adaptations of agricultural practices. In this context, the project "crOP disEase Response to climATE change adaptation", aims to address this issue for wheat, sunflower and potato by evaluating the impacts of possible adaptation strategies to climate change on three pilars: production, environment and plant health risk. The methodology was developped, impleminted and tested on wheat crop.

The first step was to precisely define adaptation strategies to potential environmental stresses that will probably be experienced by wheat crop in the next decades. Different agronomical levers (also called "factors") have been selected: Compensation for limited water resources using different irrigation approaches or mulches in order to maintain soil moisture; avoidance of unfavourable conditions shifting sowing dates or mobilizing different varietal earliness. Because of their potential important impact especially on disease development, other factors

have been taken into account: tillage, varietal resistances to diseases and nature of previous crop.

The prospective impacts of the selected strategies on the pilars production, environment and plant health were simulated by mobilizing climate change, crop and disease models. These models were combined in a seamless way to simulate many effects of adaptation strategies considering and two CC scenarios, either the moderate Representative Concentration Pathway (RCP) 4.5 or the alarmist RCP 8.5. All combinaisons of the studied factors were used as inputs together with the two RCP scenarios and each year between 1970 and 2100 which resulted in more than 3 000 000 simulations. Used outputs consisted in indicators regarding the three pilars (e.g., yield and nitrogen grain content for production, disease risks relative to septoria tritci blotch, rusts, eye spot and fusarium head blight for plant health etc.). In order to focus on tendencies, we chose to work with averaged subsets of years corresponding to three differents periods recent past (1970-2000), near future (2020-2050), far future (2070-2100). Exploratory analysis were performed at this stage to visualize outputs and identify expected and unexepected a priori effects of factors. This allows to highlight necessary compromises to reach a good level of adapation to CC (eg. Antagonist effect of sowing date on potential yield and sparing use of fungicides).

To identify promising strategies more easily, the outputs need to be agregated into one criterion using multi-criteria analysis (adaptation relevancy to CC). DEXi software was used to build the multicritera analysis model (a qualitative decisionnal tree). Special attention was paid to define relevant weights and to create qualitative critera from quantitative outputs. Clustering methods were applied on the best scenarios (with high adaptation relevancy to CC) in order to characterize the diversity of promising strategies.

This flexible method allows to deal with different locations, soil types, decisional trees with contrasted criteria weights and can be served as support to discuss with actors of the wheat production sector.

Precision apiculture for honey production monitoring and control

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ID: 162
Topics: Decision Support Systems
Keywords: Precision Apiculture, Arduino, honey production

The innovative technologies of precision agriculture can be applied today to different productive sectors of agriculture in order to optimize crop production and to improve the quality of the final products. One of these is beekeeping, a very important sector both from an environmental and a production standpoint. The production of honey depends on many factors, some of which are environmental factors such as temperature, relative humidity and wind. The aim of this study was the design of a Precision Apicolture System (PAS) platform for monitoring and controlling the main environmental factors, both inside and outside the hive, in order to assess their influence on the honey daily production. The PAS was designed by the Department of Agricultural, Food and Forest Sciences of the University of Palermo and consists of an Arduino board with Atmel Microcontroller (ATmega2560) with 8 bits. PAS is a platform capable of continuously recording and monitoring the following parameters: temperature (° C) inside and outside the hive, and quantity of honey produced (kg). The tests were carried out in a cultivated field with French honeysuckle plants in full bloom. The results obtained confirm the accuracy of the data recorded by the PAS platform, providing a valid decisional support to the operator (Decision Support System).

Sensitivity of Greek agri-food companies in sustainability issues

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ID: 168
Topics: Environmental ICT management systems

Keywords: sustainability reports, climate change, sustainable production and consumption, sustainable development goals

Recently, the world has been faced with a variety of environmental, social and economic problems. The effects of climate change and the lack of resources are constantly intensifying, while at the same time the impact of industrial production becomes an international issue. Undoubtedly, this global paradigm and relevant social and economic challenges require joint efforts at international level. During the past decades, a number of companies in Greece have undertaken initiatives towards sustainable development by adopting “green” practices. This work presents the findings of a survey that has been conducted in 2020, which investigates the extend of business contribution to the United Nation’s 17 Sustainable Development Goals (SDGs). Research was based on the analysis of sustainability reports published by agrifood companies in Greece. The key findings of the survey show that issues related to environmental protection, societal well-being, and citizens’ quality of life, attract an increasing level of awareness in the Greek agrifood sector. Issues such as climate change, as well as sustainable production and consumption are becoming topics within companies day-to-day agenda.

Capturing and evaluating the effects of the expansive species Ailanthus altissima on agro-ecosystems at the Ionian Islands

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ID: 177

Topics: Planning tools, Environmental ICT management systems, Decision Support Systems
Keywords: Remote Sensing, Geographic Information Systems, decision making, AHP

There are a significant number of agricultural systems with rich and special biodiversity characterized as High Nature Value Farming Systems (HNV) in the Ionian Islands region. These agro-ecosystems cover a significant area in this area and are distinguished in olive groves and vineyards that in some cases cover a significant part of the protected areas (Natura 2000 and SPA). There are solid olive groves but also a large number of scattered trees or clusters as well as vineyards which are largely identified as high quality wine produce. Finally, there are smaller but extremely important examples of HNV such as the Englouvi plateau in Lefkada.

On this notion alien expansive species are a serious threat to these systems which produce the danger of spreading unwanted vegetation on agricultural land, while their risk is also identified and recognized in Community legislation on biodiversity protection (Annex II of Article 6 of the CFP Regulation). A very dangerous area-expanding type of weed the ailanthus tree (Ailanthus altissima), which now threatens the natural environment, including crops (olive and viticulture) in the Ionian region, is the research subject that this work negotiates.

In this study, we propose a method to survey the spread of ailanthus tree in olive groves and vineyards (HNV areas) on the scope of evaluating the considered agro-ecosystems based on the importance of ecosystems and ecosystem services that provide and preparation of a management plan for HNV areas. We used GIS, RS, IT and communication technology to capture the level of threat and develop effective response plans through a fuzzy synthetic evaluation system.

More specifically, we created land cover / land use maps based orthophotos of 0.5 resolution (SENTINEL-2) which where overlayed by geospatial data (polygon type vectors) from Corine 2018 and ILOT. All of the study area was analyzed and produced mapping products indicating the affected sites at the Ionian region. The proposed decision support procedure was built through an evaluation index system and applying AHP (analytic hierachy process) that is then supported by SWOT analysis process. The results will be publicly available web platform at a future point of our research.

The initial findings of the study are crucial to identify the possible interactions between the parameters alien specie’s spread that lead to the construction of specific models and corresponding evaluation scenarios. In the case of the Ionian region, the lack of data has

created difficulties in the past during the process of the issue. We produced continuous data and comparable information on the subject, which is expected to enhance the on-site research outcomes and further support public evaluation of the studied agro-ecosystems.

A theoretical framework for multi-hazard risk mapping on agricultural areas considering artificial intelligence, IoT, and climate change scenarios

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ID: 180
Topics: Modeling and Simulation, Planning tools, Environmental ICT management systems
Keywords: Artificial intelligence, Climate change, Environmental monitoring, IoT technologies, Multi-hazard risk mapping

The impacts of global warming led to an increase in extreme climate events, such as floods, droughts, and heatwaves. These events cause crop losses, environmental damage, soil nutrients loss, economic impacts, and social impacts in agricultural areas. However, few research in the literature address the impacts of those extreme climate events on farms, considering multiple hazards and heterogeneous data. Many of the systems and models for evaluating extreme events are focused on only one task: event forecasting or ecosystem monitoring. It is worth mentioning that most of the literature is also focused on the economic impacts due to climate change. However, environmental damages and social effects tend to be neglected. This work proposes a data-driven theoretical framework for addressing: (i) extreme climate events prediction through multi-hazard risk mapping using remote sensing, artificial intelligence, and hydrological models, considering multiple hazards; and (ii) environmental monitoring using on-site data collection and IoT technologies. The framework considers the possibility of evaluating multiple climate change scenarios for improving decision-making in terms of Government policies and farm planning. Its primary focus is on ecosystem assessment and ecosystem sustainability, also aiming to improve decision-making processes and the ecosystem's resilience. Its main requirements are gathered based on a literature review, and its features and design are compared with several relevant models in the literature. Its main inputs are: (i) openly available satellite images; (ii) openly available official socioeconomic data; (iii) historical weather data; (iv) drought and flood-related news on the specific agricultural areas; (v) climate change simulations on different scenarios; and (vi) on-site data collected by IoT technologies. The main models that are part of the framework are: hydrological models, machine learning and deep learning models, image segmentation models, and GIS software to develop the multi-hazard risk maps. IoT technologies, such as wireless sensor networks, are an integral part of the monitoring task. Two critical hazards for sustainable agriculture will be explored in this work: droughts and floods. Several essential metrics that can be evaluated, considering both supervised and unsupervised metrics and key performance indicators considering the triple bottom line aspects, are also proposed. The framework also adopts a multi-hazard (considering several hazards) and multi-risk (considering several relevant stakeholders) and can be used for the simulation of different scenarios, an essential task for improving decision-making. The framework considers and describes the different stages of the data lifecycle. A multi-hazard index is also proposed for ranking the different zones by their vulnerability. To the best of our knowledge, this is one of the few works in the literature that proposes the use of heterogeneous data sources and the integration of heterogeneous models to develop multi-hazard risk maps explicitly focused on agricultural areas. It can be implemented to evaluate multi-hazard risks in several rural regions. Lastly, a modular-based approach is used allowing adaptation for different situations and available data. Future works are related to: framework implementation and its evaluation on several case studies on different areas, crops, and climate change scenarios, and a stakeholder evaluation of its applicability.

Rainfed vs supplemental irrigation modelling and 2D GIS moisture rootzone mapping on yield and seed oil of cotton (Gossypium hirsutum, var. Armonia) using Precision Agriculture

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ID: 181
Topics: Modeling and Simulation, Remote Sensing and GIS applications, Physical and Chemical sensors
Keywords: Geostatistical modelling on yield and oil of cotton, 2-D TDR-GIS Soil moisture mapping, GIS and Precision Agriculture, Rainfed cultivation with supplemental drip irrigation, Soil and hydraulic analyses

Cotton is considered as the world's biggest non-food crop and makes half of the world's textiles, oil, cattle food, explosives, organic fertilizer, towelling, paper, banknotes, fishing nets, tents, nappies, wallpaper, bandages, surgical sutures, rope and sheets, etc. The aim of the present study was to determine the effects of rainfed (IR1) and rainfed plus supplemental drip irrigation (IR2), and fertilization treatments (Ft1: N-P-K= 91.00-19.62-37.35 $Kg \cdot ha^{-1}$ and Ft2: N-P-K= 71.40-13.08-24.90 $Kg \cdot ha^{-1}$) on cotton (*Gossypium hirsutum*, var. Armonia) yield, and seed oil content by applying new agro-technologies (TDR-sensors for soil moisture (SM), GIS, Precision Agriculture, soil-hydraulic analyses and Geostatistical models) for yield and SM root zone geospatial modelling and two-dimensional GIS mapping. Soil's pH was determined in a 1:5 soil/water extract, while pH value was measured by using glass electrode and a pH meter. Soil organic matter was analysed by chemical oxidation with 1 $mol \cdot L^{-1}$ $K_2Cr_2O_7$ and titration of the remaining reagent with 0.5 $mol \cdot L^{-1}$ $FeSO_4$. Soil's Nitrogen inorganic forms were extracted with 0.5 $mol \cdot L^{-1}$ $CaCl_2$ and estimated by distillation in the presence of MgO and Devarda's alloy, respectively. The water available (PAW) for plant growth is the difference between soil's Field Capacity (FC) and wilting point (WP) water contents. The FC and WP water contents were measured with the porous ceramic plate method placed into a container that is pressurized with 1/3 atmospheres (about 5 psi) for FC and with 15 atmospheres (about 225 psi) for WP. Using the parameters found from measurements and laboratory analyses (which were digitally mapped in a GIS geodatabase environment) as input auxiliary variables, we delineated soil moisture profile digital two-dimensional 2D-GIS maps of cotton's root zone with the help of spatial analysis and the use of a GIS software. With appropriate daily soil-water content sensor measurement, soil moisture profile digital 2D-GIS mapping, accurate estimated daily crop ETc and monitoring of system inflows (irrigation amount, effective rainfall and groundwater contribution) and estimated surface outflow, a reliable daily soil-water balance model was developed at farm level for the crop. The two-way ANOVA statistical analysis (P= 0.05) results revealed that the irrigation treatments (IR1:rainfed, IR2:rainfed plus supplemental irrigation [best]) and the fertilization treatments (Ft1: [best], Ft2:) significantly affects cotton's yield and seed oil content. Supplemental irrigation, using a limited amount of water, if applied during the critical crop growth stages of cotton, can result in substantial improvement on yield (+234.12 %) and seed oil content (+126.44 %).

A web platform for the collective empowerment of citizens on the participatory management of waste biomass and cooking oils

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ID: 189
Topics: Environmental ICT management systems
Keywords: biomass waste, cooking oils, web platform, awareness, empowerment of citizens

Domestic biomass waste and waste cooking oils present critical categories of waste and need special treatment. Quantities of collected waste biomass can be massive, thus presenting a problem for waste management authorities, while cooking oils are characterized by a very high residual value and therefore present a significant challenge for the sustainability of waste management schemes. Of course, the public participation in the management of the two waste streams is vital for the success of any relevant initiative. In this light, based also on the streams' importance, both in terms of their exceptional environmental and economic effects, a web

platform has been developed, targeting to the collective empowerment of citizens on the participatory management of waste biomass and cooking oils. Specifically, the The project uses Information and Communication Technology (ICT-IoT) to develop an integrated participatory system for the efficient activation of the wide public and the optimal collection of household waste biomass and cooking oils.

The SMARTREC project is funded by the Green Fund (public-law entity reporting to the Hellenic Ministry of Environment, Energy and Change) under the "Natural Environment and Innovative Actions 2020" programme.

SMARTREC: A tool for the optimal management of used cooking oils

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ID: 190
Topics: Environmental ICT management systems
Keywords: used cooking oils, ICT tool, optimal management, routing

According to the European Biomass Industry Association, used cooking oils are oils and fats that have been used for cooking or frying in the food processing industry, restaurants, fast foods and at consumer level, in households. In European Union, the potential for the separate collection of used cooking oils is approximately 8 litters per capita per year. This may result to massive figure of collected waste cooking oils, which may reach up to 4 million tons, more than seven times higher than the current collected amounts. Moreover, following the trend over the past years, the aforementioned figure is expected to increase at a rate of 2% annually. The potential is therefore very promising, taking also into account the high remaining value of waste cooking oils. However, in order to achieve targets and increase the level of collection from current, relatively low rates, collection infrastructure needs to be improved. To that end, in the framework of the SMARTREC project, an easy-to-use tool has been developed for the optimal management of waste cooking oils. Through the ICT-based tool, users can declare available quantities and get information and instructions on the optimal management of the generated waste. The tool is accompanied with a gamification application to enhance citizen participation in the waste recycling system.

The SMARTREC project is funded by the Green Fund (public-law entity reporting to the Hellenic Ministry of Environment, Energy and Change) under the "Natural Environment and Innovative Actions 2020" programme.

Circular Agriculture using Precision Farming

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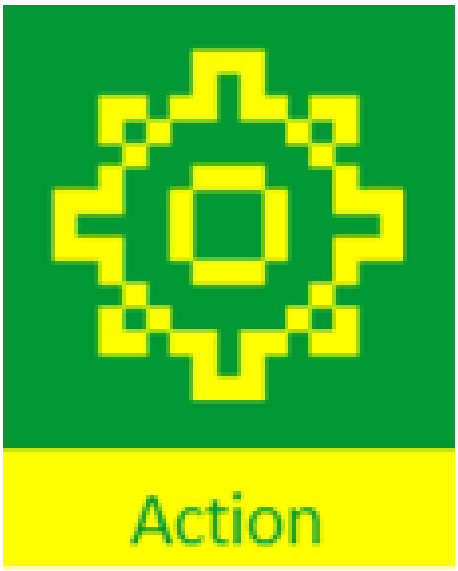
ID: 192
Topics: Environmental ICT management systems, Farm management systems (FMIS)
Keywords: bioeconomy, circular agriculture, precision farming, fertilization, sustainability

Climate change is major threat for natural environment the following years and there is a need to reduce the greenhouse gas emissions. In addition, agriculture contributes for about 10% of the greenhouse gas emissions and up to 95% of the emissions of ammonia in the European Union. In order to reduce greenhouse gas emissions, new approaches, such as circular agriculture, should be adapted and new technologies that can minimize inputs for crop production must be developed and utilized. Circular Agriculture is a modern agricultural management concept which promotes the reuse of all resources that can be used by the production system itself. The utilization of such systems directly leads to minimization of agricultural waste, while their application can reduce nutrient and water losses and emissions such as greenhouse gasses. In this study, a holistic system for circular agriculture is proposed to be applied at small-medium vertical production dairy farms. It involves integrated soil fertility management of maize which combines the use of appropriate amounts of organic and inorganic fertilizers together with green manure and good agronomic practices. In addition, integrated water management can be used with different irrigation levels and deficit irrigation

as well as fixed partial root zone drying to increase efficiency of water management. Precision farming technologies are utilized in conjunction with Internet of Things (IoT) sensing systems, in both crop and animal production processes, to feed the integrated system with real time data. Thus, in the system being developed, precision field management and smart farming tools applied at every stage of the production chain are connected and interacting with a circular precision management information system which is the heart of the circular's farm ecosystem. This system receives and processes all the information from each subsystem installed at every production level in the farm, and provides the results in simple and manageable form, supporting users taking appropriate decisions. The results showed that cattle manure can adequately provide the nutrients in available form that are essential for plant growth, while enhancing soil water-holding properties, leading to increased productivity of maize. Also, green manure with common vetch can provide adequate amounts of nitrogen which is very important for maize. Therefore, efficient management of natural resources together with integrative crop management approaches can reduce inputs in crop production systems. The benefits of using circular farming systems and digital technology are numerous. More specifically these systems enable monitoring of processes in the production stages, facilitating traceability towards producing certified products. In addition, the use of precision farming can increase the efficiency of the resources' utilization, by appropriately managing fields' spatial variability. Furthermore, by supporting farmers in making optimal management decisions, it can increase the use efficiency of inputs, leading to their reduction, and thus, providing a financial benefit for the producers. Moreover, the circular characteristics of these systems minimize the production of animal waste, diminishes losses of nutrients and agrochemicals and thus reduces the environmental footprint.


Action

A farm management information system for semi-supervised path planning and autonomous vehicle control

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Topics: Planning tools, Farm management systems (FMIS), Web applications

Keywords: smart agriculture; image segmentation; agricultural robot; field registration

The precision agriculture system and its successor smart agriculture (SA) system are considered to play an important role in boosting agricultural productivity, sustainability, and quality. Developing strategies of SA practice, variegating sustainable agricultural systems require the implementation of elaborate management rules. This paper presents a farm management information system (FMIS) targeting to improve the ease of use and sustainability of robot farming systems. The management system integrates the functionalities of field survey, path planning, monitoring, and controlling agricultural vehicles in real time.

Firstly, a Grabcut-based semi-supervised field registration method is proposed for arable field detection from the orthoimage taken by the drone with an RGB camera. Grabcut-based field segmentation method can be implemented without reliance on GPU, which is necessary for other deep learning methods. It partitions a complex field into simple geometric entities with simple user interaction. The field segmentation executes iteratively with few samples of working and non-working areas. Mean Intersection Over Union (mIoU) is employed as the accuracy metric of field segmentation. The average mIou is about 0.9532 when the field size ranges from 2.74 ha to 5.06 ha.

In addition, a desktop software and a web application are developed as the entity of an FMIS. Compared to existing FMISs, this system provides more advanced features in robot farming, while providing simpler user interaction and better results. It allows clients to invoke web services and receive responses independent of programming language and platforms. Moreover, the system is compatible with other services, users, and devices following the open-source access protocol. We have evaluated the system by controlling 5 robot tractors with 2 Hz communication frequency. The communication protocols will be publicly available to protentional users. They can access the web application of FMIS to develop and evaluate new autonomous farming systems.

Complexity and challenges of SOAs and DSS - Examples from the plant protection sector

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ID: 156

Topics: Prediction models, Decision Support Systems, Web applications

Keywords: PAM, Decision-Support-System, Service-Oriented-Architecture, Web application

Digitization in agriculture appears to be widely recognized and accepted. Nevertheless, what can be achieved and what are key challenges? The German research and development facilities ZEPP and ISIP work on the forefront of digitization and developed over 50 web-based Decision-Support-Systems (DSS) in crop protection. These systems assist farmers applying pesticides more efficiently and thus reducing the ecological impact and costs of production means. Technically, our DSS are based on service-oriented architectures (SOA), orchestrating networks of distributed web services. Although the development process of digitization in agriculture, and of SOAs in particular begun in the 1990s, it is still subject to constant technical and regulatory changes. The reliable operation of SOAs has only become possible recently as

high-performance web servers and powerful internet connections become available. Whereas developing lasting DSS requires flexible technical solutions not restricted by rigid frameworks, but also easy handling and immediate benefits. Using the PAM-Service (Production-Means-Application-Manager) as prime example, we highlight today's complexity and main challenges of SOAs and DSS. PAM was developed within four projects and has evolved over the past eight years into a complex DSS linked to numerous background services and databases. PAM aims to automatize site specific calculations of legally required buffer zones between areas treated with pesticides or fertilizer and protected areas (e.g. water bodies, field margins). Several background services, developed by an interdisciplinary consortium, enable PAM to generate digital elevation and surface models from very different data sets and databases or to translate full-text-based pesticide and fertilizer application rules into a machine readable format. Thereby PAM will allow implementation of regulations from multiple legislations such as the Plant Protection Act, the Water Resources Act and Nitrate Directives. These regulation pose, in addition to technical challenges, implementation challenges since they are usually phrased only vaguely and lack suggestions for practical measures. Therefore, PAM was developed flexible and modular, able to incorporate new techniques, methods as well as changing political directives. PAM was originally integrated in Farm-Management-Information-Systems and hence only available for farmers. In order to include other important user groups, such as agricultural consultants, control authorities or politicians, we will extend PAM by web viewer and online tools. The visualization of resulting site-specific buffer zones will improve the understanding of practical consequences of regulations regarding plant protection. At best it will improve communication between all stakeholders and results in more practice-oriented decisions. While PAM gives an excellent example of how technical and regulatory challenges might be overcome, lack of data availability remains the biggest obstacle for such innovations. Although the urgent need for open data policies has been acknowledged since long, implementation is still too slow and patchy - at the expense of environmental protection addressed by the initial regulations and of farmers who have to comply with them.

Production of sea water fertilizer with a remote control system

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ID: 160
Topics: Wireless sensor networks, Monitoring Robots, Machine embedded ICT tools
Keywords: OLMUS, sodium hydroxide, robot, seawater

Sea water is abundant and is full of nutrients known as OSMUS. Many countries are trying to find an alternative to inorganic fertilizers which have become very expensive in Mexico. A robotic system was designed for extracting salts from sea water on a fishing boat. Sodium hydroxide is applied to water within an agitated tank until pH increases to 11. When it arrives to this pH it the salts will deposit and the sodium stays at the top, being removed with a low pressure pump. Clean water is added and sodium hydroxide is added until the salts are removed.

Farm scale greenhouse gas emissions decision support systems

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ID: 163
Topics: On line farm services, Environmental ICT management systems, Decision Support Systems
Keywords: GHG, livestock, emissions, sustainabiltiy, Decision support tolls

The need for communicating high-quality estimates of greenhouse gases' (GHG) emissions to various stakeholders as well as the effect of mitigation strategies at the livestock farm level becomes more and more intense. Furthermore, high quality measurements of GHG emissions (and not solely those) from every possible source at the livestock farm level is practically almost impossible. In this respect, the role of farm-scale GHG-based Decision Support Systems (DSSs) and DS tools is expected to be of increased importance. These tools aim to provide targeted, comprehensible advice to the user for acting in the direction of reducing GHG

emissions from the farming system of interest. The present papers reviews different farm-scale GHG-based decision support tools and characterize them with respect to the emissions included and the factors determining these emissions. Various aspects of the DS tools which are related to the estimation of GHG emissions, the user interface, and their functions were analyzed. Furthermore, the most frequently employed categories of inputs (i.e. categories of parameters but also separate parameters) and outputs (i.e. categories and separate indicators) of the DS tools were selected and checklists regarding the consideration or not of these parameters from the tools have been prepared. In total 15 different DS tools have been reviewed and analyzed. The DS tools were initially grouped based on whether they assess indicators in more than one sustainability pillar. Three groups can have been considered: a) the emissions' calculators which focus on the estimation of various emissions at the farm level; b) tools which deal with supplying the user a multi-pillar view of farm sustainability i.e. estimating indicators for all sustainability pillars and c) tools which provide estimates for two sustainability pillars (emissions' calculators also providing economic values about costs and profits).All DS tools' aspects related to the GHG emissions, their user interface and their functions were discussed using descriptive tables while inputs and outputs with checklist tables. With regards to the descriptive tables, both short and full descriptions were employed. Short descriptions were included for all evaluation criteria and sub-criteria in the tables. For each criterion, the full descriptions included: a) presentations of the various sub-criteria, b) separate evaluation of each tool for each sub-criterion and c) comparative evaluation of the various tools based on each sub-criterion. With respect to the checklist tables, these report the existence (yes) or not (no) of an input or an output for the farm-scale GHG-based DS tools evaluated. Description of the checklist tables includes for each category of inputs and all outputs: a) a presentation of the various types of inputs and outputs, b) the possible selections / choices the user is provided for the inputs and c) an introduction to the way that the inputs affect the outputs.

Configuring Digital Supply Chains for Food Security

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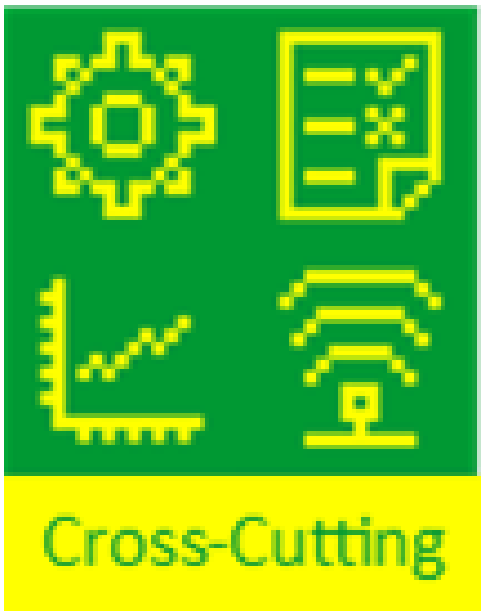
ID: 167
Topics: Cloud computing applications
Keywords: food security, digitalisation, traceability, blockchain

Emerging dietary and nutritional requirements at a global scale highlight the need for resilient end-to-end food networks to match demand to supply whilst ensuring food security at the front of accessibility to safe, sufficient and nutritional commodities. However, lack of data and information visibility across end-to-end operations hinders food security owing to operations misalignment that results to unanticipated food wastage or losses whilst impacting the intrinsic nutritional value of sensitive fresh food supplies. To this effect, digitalisation of supply chains can enable the orchestration of operations and enable advanced visibility and traceability across end-to-end operations. This research discusses key principles of digital technology adoption in supply chains via the data capture and interoperability lenses. In particular, a formalised process and information flow framework is presented to support companies in effectively implementing blockchain technology in their supply chains and promote food security. Finally, we anticipate that food security can be enhanced by incorporating systematic data capture and interoperability into the supply chain decision-making process.


Cross-Cutting

Requirements identification for a blockchain-based traceability model for animal-based medicines.

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Keywords: Livestock, Supply Chain, Medicine, Traceability, Blockchain

The livestock supply chain produces a large amount of data related to the individual animals and the processes of breeding, feeding, maintaining their health, slaughtering, processing, storing, transporting, among others. This information is crucial for the traceability of the products, from the origin of the raw materials used in animal-based medicine production to its final use. In this paper, the heparin medicine's traceability, an important anticoagulant that uses components extracted from cattle lungs and intestines, will be studied in depth. Currently, the registration of the traceability data is conducted in a decentralized manner, and the transformation of data into information allows the traceability of these raw materials, helping stakeholders in the decision-making process. With the implementation of technologies such as blockchain, those traceability systems could become semi-automated, increasing the quality, security, and confidence of the information generated for all agents in the supply chain. This paper presents the essential requirements and activities where information must be collected within the heparin drug supply chain, focusing on the animal raw materials production's importance and requirements. Blockchain technology is proposed as a technology that can increase traceability information security and reliability in relation to the current situation. It also fulfills all the requirements identified if used as part of a traceability system. We conclude the paper by presenting the mapping of requirements, key activities, and the adoption of blockchain technology to support the traceability of raw materials from animals used in heparin production. Ten main processes were identified in the supply chain, distributed in five links: (i) farmers and consultants: planning, breeding, feeding, and health maintenance; (ii) slaughterhouse: slaughtering and packaging and storage; (iii) pharmaceutical industry: production and storing; (iv) distributor, retail, and hospital: distributors and consumption place; and (v) patients consumption. Five services were identified in the supply chain: (i) animal traceability; (ii) raw materials traceability; (iii) production traceability; (iv) distribution traceability; and (v) consumption traceability. These services were further described in fourteen components (necessary for achieving the different levels of traceability). Lastly, those services were further described in forty two traceability points (points in which different technologies and processes must be used to maintain product traceability). The same analysis can be adapted for other animal-based drug supply chains.

Society’s view on agriculture: does digitalization lead to alienation?

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Keywords: social acceptance; consumer survey; choice experiment

Increasingly autonomous machines represent a ground-breaking development in agricultural technology, yet their success depends as much on economics and farmer acceptance as on the approval of society. Rose and Chilvers (2018) advocate for transferring the concept of responsible innovation to agricultural technology to prevent negative societal reactions to the on-going fourth agricultural revolution. Research from Germany during the past decade indicates that such an approach is appropriate as 85 % of the population had no clear opinion on the importance of robots for the agricultural sector (INSFO, 2012) although expert interviews pointed to the importance of public acceptance, or rather the lack thereof, as a barrier to sustainable innovations in the German agricultural sector (König et al., 2012). More recent research shows that the German population is still largely undecided on the use of digital

technologies in agriculture, including autonomous equipment for weed management (Pfeiffer et al., 2020). A farmer survey in Bavaria, Germany, however, has indicated that fear of creating an image of alienated agriculture significantly reduces the intent of farmers to invest in field crop robots (Spykman et al., 2020), pointing to the importance of societal approval for the adoption of autonomous farming equipment.

To better understand the perception of autonomous weed management, the most advanced segment of the crop robot market (Treiber et al., 2019), by the German public, we analyze a discrete choice experiment (n = 675). The attributes cover method of weed management, vehicle type, and changes in consumer price of the end product. This experiment was part of a larger online survey (n = 2.012; Pfeiffer et al., 2020) conducted among the German adult population in June 2018. Through prequotation, the sample is representative of the German population with regard to age, gender, level of education, and size of place of residence. The choice experiment is analyzed using Hierarchical Bayes estimation in Lighthouse Studio 9.5.3 (Sawtooth Software, USA). Four covariates are included in the model. The first two are scores of spontaneous associations with images of a large autonomous tractor and a swarm of small robots, respectively, measured on a scale from -3 to +3. Analogous to Römer et al. (2019), who compared implicit and explicit associations with different methods of crop protection, these covariates allow a comparison of spontaneously formed image associations with stated choice preferences on digital technologies for weed management. Additionally, the covariates “digital farming technologies alienate the farmer from his/her soil” and “family farming structures seem valuable and should be preserved”, each measured on 5-point Likert-scales, are tested. The former corresponds directly to the concern identified in the farmer survey (Spykman et al., 2020), whereas the latter is motivated by the disagreement between society’s romantic view of agriculture and the actual level of technology use on farms in Germany (Zander et al., 2013). The results will provide information about society’s perspective on autonomous cropping equipment under specific consideration of underlying emotional factors.

Tailored digitalization for rural development

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Topics: e-agribusiness, Rural economies and ICT policies for rural development
Keywords: rural policy, innovation, food chain, digitalization

In recent years, the appeal to digitization has become one of the cornerstones of the rural development programs proposed by the main international institutions working in the field of development and agri-food policy. In 2019, 25 EU Member States signed the declaration on “a smart and sustainable digital future for European agriculture and rural areas”, recognizing the potential of digital technologies to tackle urgent economic, social, climate and environmental challenges facing the EU's agri-food sector and rural areas. In the same year the OECD released the study “Digital opportunities for better agricultural policies” and the FAO released the briefing paper “Digital technologies in agriculture and rural areas”. However, together with a broad literature celebrating the role of digitalization in fostering productivity and sustainability in the agri-food sector, some critical voices have emerged, highlighting the possible shortcomings and also the risks of the “digital revolution”.

The paper synthesizes the discourse on digitalization and rural development using a conceptual framework built on the basis of three diverse strains of literature, namely the literature on food regime, on science and technological systems, and on sustainability.

First, the paper provides an overview of the rural development goals set by the European Union (EU) in diverse areas of policy interventions, namely: the European Commission's priorities for 2019-2024; the Common Agricultural Policy (CAP); the Horizon 2020 EIP-AGRI projects. Then, using the proposed framework, a list of digital technologies are assessed with respect to their possible role in achieving such goals.

The results indicate that although narrowing the rural–urban digital divide is important in improving well-being in rural areas, the widespread of many digital technologies along the food supply chain might have negative effects on rural development.

For example, in the agricultural sector technologies such as farm robotics, digital machine-sharing platforms and farm management platforms could have negative effects on small and medium farms in terms of higher unemployment, loss of knowledge of traditional agricultural practices, and higher dependence of farmers on input suppliers and financial sector.

One conclusion of the paper is that in order for rural areas to exploit all the benefits from digitalization, avoiding the associated risks, there should be more agricultural extension services to famers and more open data portals and platforms. This in order to develop technologies specifically tailored for the economic, natural and social environment of rural areas, and therefore able to promote their modernization without giving up their cultural heritages.

Distribution and characterization of *Pseudomonas Syringae* pv. *Actinidiae* from kiwifruit in Greece

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Topics: Open topics
Keywords: Identification, Kiwifruit, Pseudomonas syringaepv. actinidiae

Since 2008, bacterial canker of kiwifruit (*Actinidia deliciosa* and *A. chinensis*) caused by *Pseudomonas syringae* pv. *actinidiae* (Psa) has resulted in severe economic losses worldwide. This disease was identified for the first time in a kiwifruit orchard located in Palios Mylotopos Pella, Northern Greece in 2015. An extensive inspection was carried out on kiwifruit orchards in the areas of Pella, Edessa, Aridea, Agrinio, Velventou, Pieria, Xanthi, Komotini, Arta, the main kiwifruit production areas of Greece, to find trees with suspicious symptoms of Psa. Leaves, canes, flower-buds, fruit, sap and roots were collected from plants of *A. deliciosa* and *A. chinensis* with suspicious symptoms of the disease and transferred to the laboratory of Bacteriology of the Hellenic Mediterranean University. Fragments of symptomatic tissue samples (necrotic spots and/or cankers), were aseptically removed and cut into smaller pieces and macerated in sterile Phosphate buffer (PBS) for about 15-30 minutes. Isolations were performed on nutrient substrates: modified King's B (KBC) medium, nutrient agar with the addition of 1% glucose (NAG) and nutrient Agar with the addition of 5% sucrose (NSA). After incubation at 23-25ºC for 3-6 days, Pseudomonas-like colonies were transferred, re-tested for purity, and maintained at -80°C with glycerol (20%). In biochemical and physiological characterization tests, all isolates were characterized as aerobes, Gram negatives, while none produced urease or reduced nitrates to nitrite or nitrogen. All isolates were evaluated under LOPAT (Levan production, oxidase, potato rot, arginine dihydrolase activity and tobacco hypersensitivity) and GATTa tests, showing the *Pseudomonas syringae* group phenotype (+ - - - +) and (- - - -) respectively. The standard tests with API20 NE strips (BioMerieux) were completed according to the company's instructions, in a limited number of isolates. Selected isolates were molecularly identified by performing colony polymerase chain reaction (colony PCR) with three pairs of specific primers. Duplex PCR with the primer pairs KN-F/R and AvrDdpx-F/R yielded 492 bp and 226 bp amplicons, respectively. PCR with PSAF1/R2 amplified a fragment of 280 bp. Single colonies of the isolates grown on KBC medium were used directly in PCR reaction with final volume of 25 µl. The strains HMU801, HMU807 and HMU823 (previously identified as Psa) were used as positive control, while the strains HMU2222 (*Dickeya solani*), HMU271 (*Pseudomonas viridiflava*), and H2O as negative control. Ten (10) µl of each reaction was analyzed by agarose gel electrophoresis. Twenty isolates from different fields, tested with the above mentioned primer pairs yielded the expected corresponding products as well as the already used reference strains. The Psa-bacterium was isolated and identified only from the area of Pella where its presence was already known and under the supervision and management by the phytosanitary services of the country. In contrast, this pathogen was not isolated from the other investigated areas. Characterization of isolates showed corresponding possibly to the Psa biovar 3 populations which are highly

virulent and currently widespread in many countries. The study is in progress to accurately determine the biovar(s) of the bacterium and to investigate the variability among the isolated bacterial strains.

Evaluation of different chemical and biological products in the control of *Pseudomonas syringae* pv*. actinidiae* on kiwifruit

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Topics: Open topics
Keywords: Control, Kiwifruit, Pseudomonas syringae pv. actinidiae

Greece is one of the most important producers of kiwifruit worldwide. *Pseudomonas syringae* pv. *actinidiae* (Psa) was first isolated and described in Japan in 1984, then in Italy and South Korea on cv. Hayward (*A. deliciosa*). This disease was identified for the first time in kiwifruit orchard located in Palios Mylotopos Pella, Northern Greece in 2015. The most common control method for the disease is the use of chemical products. Copper pesticides are often the first line of defense, especially for growers who prefer biological methods. The copper product works by protecting plants against the development of new infections and copper pesticides are ideally applied before pathogen is visible. Ionic copper, consisting of nanoparticles, is a new form, ensuring better protections of plants from fungi and bacteria diseases due to the direct attachments of copper to the plant. Surfactants provide a powerful means for promoting absorbency, acting either as wetting agents or rewetting agents. The use of surfactants as either wetting or rewetting agents to improve absorbency must be compatible with the presence of chemicals added for other purposes or with other processes subsequent to the absorption itself. Rhamnolipids are synthetic surfactants, produced by *Pseudomonas aeaeruginosa* and they are the most studied biosurfactants due to the potential applications in a wide variety of industries. Rhamnolipids have demonstrated control bacteria that have acquired resistance to commercial chemical pesticides. Another investigation has shown that rhamnolipid can stimulate plant immunity which is considered as an alternative strategy to reduce the infection by plant pathogens. The aim of the present work was to evaluate the efficacy of commercial products (IONIC CONCENTRATED COPPER, MAGNA BLUE, COPROFIX ULTRA), and products under development (RHAPYNAL, INDUSTRIAL CLEANER), in controlling bacterial canker (Psa) on kiwifruit under field conditions.

The experiments were performed in 2 commercial kiwi orchards in the area of Mylotopos-Giannitsa, in which the disease was in endemic form. In each commercial orchard there were 3 replicates of the 3 trees for each treatment. The experimental design was randomized complete block. The first spray was applied on 10thApril and was repeated every 10 days (a total of 4 sprays was applied). The results were collected by recording the percentage of infected leaves in a sample of 100 randomly collected leaves from each treatment as well as the number of spots per infected leaf. ANOVA was used to analyse the data. The means were compared using the Duncan Multiple Range Test method (P=0.05).

The results showed that none of the products tested was able to reduce the number of spots per leaf in the first experimental field. In contrast, the copper products IONIC CONCENTRATED COPPER, MAGNA BLUE, COPROFIX ULTRA reduced the number of spots per leaf in the second experimental field. The results also showed that the copper formulations IONIC CONCENTRATED COPPER, MAGNA BLUE, COPROFIX ULTRA reduced the percentage of infected leaves in both experimental fields. In contrast, the products RHAPYNAL and INDUSTRIAL CLEANER) were not effective against this disease.

Susceptibility of twenty-two kiwifruit cultivars to *Pseudomonas syringae* pv *actinidiae*

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Topics: Open topics
Keywords: Kiwifruit, Pseudomonas syringae pv. actinidiae, Resistance

Bacterial canker is a serious diseases of kiwifruit in Greece and worldwide. The pathogen *Pseudomonas syringae* pv *actinidiae* (Psa) has been isolated from infected trees. The use of resistant cultivars is important in controlling diseases because growers do not expend funds for extraneous control measures such as fungicides. Cultivar resistance can be a useful complementary control measure even where fungicides must be used. Various methods have been developed to screen fruit trees for resistance to bacterial pathogens. Stem inoculation is a very common technique to screen cultivars for bacterial canker resistance. The excised twig assay is also used to determine the resistance of cultivars to bacterial pathogens in the laboratory. Both methods are simple, convenient and allow ample replications. The purpose of this study was to evaluate 22 kiwifruit cutlivars for susceptibility to Psa. Four strains of Psa (biovar 3) isolated from kiwifruit with symptoms of bacterial canker from Pella, Northern Greece were used. The excised twig method was used by adding nutrient agar with 1.5 g boric acid, 8 mg cephalexin and 20 mg cycloheximide per liter, was dispensed in sterile Pyrex jars to obtain a layer of ~10 mm. These were inoculated with the Psa strains and incubated at 25 ◦C in the dark for 7 days. One-year-old dormant shoots, ~50 cm in length and 10–15 mm in diameter, were collected from each of the kiwifruit cultivars tested. Three replicate jars were used for each Psa strain. Two non-inoculated jars were used as the control. In the second experiment, 2-year-old dormant shoots, ~80 cm in length and 2 cm in diameter, were collected from each of the kiwifruit cultivars tested. Segments, ~15 cm in length, were cut from the center of each shoot. They were wounded in the center by removing 6 mm epidermis and inoculated by bacterial cells. There were 3 replicates of 5 segements for each cultivars. Non-inoculated segments were used as control. In both experiments, results were collected by recording the length of necrosis. Both experiments were repeated. The experimental design used throughout the experiments was completely randomized. Data were analyzed by one-way analysis of variance. Treatment means were compared by Duncan Multiple Range Test ($P<0.05$). The results showed that all the bacterial strains were pathogenic. There was no statistical difference among bacterial strains tested. None of the kiwifruit cultivars tested were immune to the bacterim Psa. There was statistical difference in the level of susceptibility among cultivars. The cultivars Sorelli and D495/312 were the most susceptible, while the cultivar A501/44 the most resistant. Based on the above results, the cultivars Sorelli and D495/312 should be not used when a kiwifruit orchards is established in areas where the bacterium Psa is present. In such area, a good choice could be the cultivar A501/44. However, the above results must be verified in field conditions.

Impact of smart irrigation on technical efficiency of farms: Evidences from evaluation of rural development policies in Italy

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Keywords: smart irrigation, rural development policies, panel data, technical efficiency, propensity score

The 2030 Agenda for sustainable development aims, among other objectives, to promote the preservation of freshwater through strategies capable of increasing its efficient use. Agriculture

uses most of freshwater from rivers, lakes and groundwater (70%), however it also causes high impacts due to overexploitation and pollution by pesticides and fertilizers. In order to ensure sustainable use of freshwater for irrigation, the Community Agricultural Policy (CAP) encourages the adoption of crop and irrigation systems capable of improving the efficient use of resource.
Apulia, southern Italy, is the fifth most important agricultural region in the country in terms of both irrigated surface area and irrigation volumes. Its irrigation sector is weak due to low annual rainfall and small hydrographic network. In addition, the area irrigated by the five irrigation consortia is lower than 10% of regional utilized agricultural area (UAA), and the water losses are between 12% and 30% of the water used. Accordingly, the water supplied by consortia is just 31% of the total water used and 23% of estimated needs. Therefore, farmers use mainly private farm wells, whose overuse can lead to progressive salinization of groundwater, negative consequences on soil and crops, and related problem of desertification. Thus, the implementation of smart irrigation strategies by consortia and farms is desirable.
The aim of the work is the impact assessment of smart irrigation on the technical efficiency of farms that joined the measure 121 of the Apulia Rural Development Program (RDP) 2007-2013. In particular, farms producing table grapes and industrial tomato were investigated since Apulia is the leading region in the production of these crops. Furthermore, they are characterized by a higher water demand (4.000-5.000 m3 ha-1) compared to other crops cultivated in the region.
The methodological approach is based on the following steps:
1) identification of the treated group: a panel dataset was defined using both the Administrative database about farms whose irrigation plants were funded by the measure 121 of the Apulia RDP 2007-2013, and face-to-face questionnaire-based interviews; data concerned revenues, quantities and costs of inputs, and efficiency determinants (age of farmers, land fragmentation, climate data, but also the characteristics of smart irrigation plants referred to their components, namely agrometeorological stations, soil sensors and tools for automation of irrigation plant (electromagnetic valves and control units), also for fertigation; panel data referred to three years before (2013-2015) and after (2017-2019) the funding and implementation of the smart irrigation investments (year 2016);
2) identification of the control group: a panel dataset of non-treated farms was defined through face-to-face questionnaire-based interviews;
3) application of stochastic frontier model to panel data for estimating the technical efficiency of treated and non-treated farms;
4) matching treated and non-treated farms using the Propensity Score (PS) integrated by the Difference in Difference (DiD) estimator on defined covariates for the estimation of the Average Treatment effect on Treated (ATT) related to smart irrigation impact.
Results allow ex-post evaluations of rural development programmes and the setting of next policy cycles for the preservation of freshwater.

Blockchain: an economic methodological approach to a new forest material traceability system

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Topics: Traceability tools
Keywords: blockhain, traceability, forest, economic evaluation, forestry certification

Forest certification schemes, such as FSC and PEFC, are voluntary instruments that aim to ensure compliance with sustainable forest management standards. The possibility of tracing a forest product through the entire supply chain has long been possible with the implementation of automatic identification systems. The aim of this research is to assess the economic feasibility, both on the demand and supply side, of the application of a new traceability system for forest supply chains: blockchain technologies.

On the supply side, the costs related to the management of the item (the forest plant) by the nursery until the sale are analyzed. They include the cost of the smart labels used to monitor traceability, the time and cost of the operator to place and manage the item and collect the data.

On the demand side, a monetary economic evaluation method based on stated preferences is foreseen. The application of this method allows to elicit the consumers' willingness to pay a "premium" price, for a product certified and tracked with such a traceability system.

The proposed approach also considers the costs of building the blockchain app used for monitoring forest material. These costs depend on various factors, including for example the cost of implementing the blockchain, the features of the app and the chosen blockchain platform.

The adoption of blockchain technologies allows the creation of a new form of social relationship and trust, where all participants in the network can verify and have total transparency on decisions and transitions. In the forestry sector, this could affect different stakeholders, such as certification bodies, companies and consumers. The fields of application are manifold, as reported in several studies, such as in counterfeit products, to combat information asymmetry or in forest management schemes and different chains of custody.

Molecular and phenotypic diversity of indigenous oenological strains of Saccharomyces cerevisiae isolated in Greece

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Topics: Rural economies and ICT policies for rural development, Open topics

Keywords: Wine, Indigenous Saccharomyces cerevisiae, Yeast strain selection, Wine alcoholic fermentation

In enology, yeasts play an important role in the characteristics of the final product. Furthermore, the Terroir (complete natural environment in which a particular wine is produced) influence on wine is a current topic of discussion in the world wine.

The main goal of this study was the isolation and screening of native winemaking microbial indigenous cultures regarding their technological characteristics

In this context, we explored the biodiversity of the indigenous yeast flora in several representative Greek wine regions by collecting varietal grape samples (Malagousia, Assyrtiko, Vidiano, Agiorgitiko, Moschofilero) both in conventional and biological culture. Spontaneous wine fermentations were carried out by the native microbiota of the grape juice, without inoculation of selected, industrially produced yeast, producing white and red wines, respectively. The indigenous yeast flora, isolated at three phases of these fermentations, was isolated, purified, characterized using different oenological and technological criteria.

The pre-selected native Saccharomyces cerevisiae strains, with the most promising oenological characteristics, were evaluated in microvinifications of Malagousia must at 18°C, and the quality of the produced wines was evaluated and subjected to a sensorial descriptive analysis.

All the vinifications were carried out in stainless temperature controlled tanks capacity 30 l.

The complete selection procedure was carried out over 3 years. This study provides a complete description of techniques for obtaining validated scientific results that can be used by oenologists and researchers in the selection of specific yeasts.

Have city dwellers lost touch with modern agriculture? – in quest of differences between urban and rural population

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Topics: Open topics

Keywords: Digital farming technologies, Modern agriculture, Society, Urbanization

Urban society's knowledge of, understanding of and relationship to modern agriculture is highly questioned among stakeholders in Germany. In agricultural media, these issues are increasingly being taken up and discussed with politicians and the agricultural and food industry how to deal with the urban-rural discrepancy. Frequently, urbanization and the loss of the urban population's connection to agricultural production are given as the main reasons for these discrepancies. Due to assumed alienation of people living in urban areas from the agricultural sector, it is difficult to reconcile the benefits and raison d'être of modern agricultural production with social and environmental issues (e. g., animal welfare, environmental protection, insect mortality). However, there is currently little robust evidence on where exactly perceptions on modern agriculture differ between rural and urban populations.

An online survey of the German population provided two selective subsamples of rural (n=337) and urban residents (n=560). Both samples were examined for differences in sociodemographic characteristics. The urban population has significantly less relation to agriculture (own experience in agricultural sector, personal contact with farmers), and shows a slightly higher level of education. Differences can be measured in specific statements regarding self-stated knowledge of current agricultural methods and given trust in responsible practice of farmers.

Two logistic regression models were designed to indicate the differences between the two subsamples on, a) the general social perspective on agriculture, and on b) the use of digital farming technologies (DFT). Regarding the first model (social perspective on agriculture), it is found that differences through self-stated knowledge on modern agriculture, attitudes toward agriculture, and trust in farmers offer no explanatory contribution to the classification of the respondents to one of the two groups. For the second model (use of DFT), the explained variance by co-variates indicating ‘knowledge on agricultural machines’, several ‘attitudes towards DFT’ and ‘spontaneous associations’ of shown pictures of selected technologies is also low. At least a better knowledge about machines and equipment by the rural population and as well as the respective direction of associations (positive, negative) to pictures of a large autonomous tractor and a feeding robot provide little contribution to the classification.

Finally, it can be concluded, that on basis of the two subsamples no generalized assumption can be made that the urban population is more opposed to the development of modern agriculture based on different attitudes and perceptions in contrast to their rural counterparts. Pointing a blanket finger at the urban population to explain the sector's current societal problems is dangerous. Particularly since, due to increasing urbanization, this is a growing fraction of society that, on average, holds higher income, spends more on food, and demands high-quality food products. Therefore, communication strategies in agricultural should address the entire population to explain state-of-the-art agriculture, and to communicate modern food production and the various system services accomplished by the agricultural sector.

The use of 3D printing in small scale hydroponic systems

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Topics: Open topics
Keywords: 3D printing, hydroponics, aromatic crops, medicinal crops, small-scale system

In recent years, 3D printing constantly attracts attention at an international scale, in the development of customized solutions, tailored in the end-user’s needs, in a of thematic areas and applications. In this context, recent studies have analyzed the advantages of the use of 3D printing technologies in the development of specialized hydroponic systems, for types of crops. 3D printing shows significant advantages, especially in the case of hydroponic system, such as designs with complex geometry that optimize crop development and production. To that end, 3Dpon project examines various alternatives for the exploitation of 3D printing in the hydroponics sector, mostly for small-scale applications (for home or office use), rather than large-scale, industrial systems. Examples of different hydroponic applications for a number of plant species (aromatic, medicinal, local varieties) are analyzed for their efficiency, taking into account different criteria such as efficiency, cost, reusability, aesthetics, etc. This paper focuses on the analysis of the background research in the field, showcasing interesting

paradigms of hydroponics system, while also alternative presenting designs of different *components.*

The 3Dpon project is funded by the Green Fund (public-law entity reporting to the Hellenic Ministry of Environment, Energy and Change) under the "Natural Environment and Innovative Actions 2020" programme