Water Efficiency & Climate Resilient Agriculture

International Conference

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Book of Abstracts

Dear Colleagues,

During the past year, a group of devoted people worked hard and with great enthusiasm to prepare this event and welcome you in Chania, Greece for the International Conference “Water Efficiency & Climate Resilient Agriculture”. Unfortunately, due to COVID-19 and considering the safety of our participants, the AgroClimaWater Conference will take place via teleconference and we will not have the pleasure to meet you in Chania.

We would like to express our pleasure for having the chance to be informed about your research achievements on the field of Water Resources Management and Climate Change Effects on Agriculture.

This international conference is one of the final deliverables of the LIFE14 CCA/GR/000389 – AGROCLIMAWATER.

Many thanks to the LIFE programme and co-workers for their hard work.

Kind regards,

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Sustainable fruit tree orchard management to improve water use efficiency - climate change effects

Cristos Xiloyiannis

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Agriculture uses up to 70% of global fresh water through irrigation. The prevailing climate changes will increase the water demand by crops (increase evapotranspiration) contributing to increasing uncertainties for the future availability of fresh water. Hence, increasing water use efficiency by sustainable orchard management is crucial for food production and from the environmental point of view. The relationship between orchard management and the ability of soil to deliver a set of ecosystem services (including water supply to crop) is mediated by its carbon content. Consequently, under low SOC concentration some soil structure and functions are impaired. Increasing SOC would be beneficial for soil water storage and in turn for crops. Hence, increasing soil water holding capacity might contribute to reducing the irrigation needs and increase productivity in rain-fed areas. Nowadays, an integrated view of agriculture combines the provision of food and fiber with additional functions and services to the extent that an ecosystem service approach has been proposed as the future of land evaluation. The regulating services, relevant to climate change mitigation, that agriculture might provide include the overall reduction of emissions of greenhouse gases (GHG). Orchards managed under sustainable way act as “sink” for the carbon balance. The long term of adoption of sustainable agricultural practices increased SOC, organic-N, soil microbial biomass and biodiversity, and yield, with benefits to the whole agro-ecosystem stability. To increase water productivity, at farm level, is also necessary to increase the efficiency of irrigation system, the plant Water Use Efficiency (WUE) and optimize the irrigation management.

Promoting water efficiency and supporting the shift towards a climate resilient agriculture in Mediterranean countries – LIFE AgroClimaWater

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The purpose of this paper is to highlight the main goal of the project LIFE AgroClimaWater. The LIFE AgroClimaWater project's main objective is to promote water efficiency and support the shift towards climate resilient agriculture in Mediterranean countries through the development of water management adaptation strategies in three Farmers' Organizations (FORs) in two areas in Crete, Greece (Platanias and Mirabello) and one in Basilicata, Italy (Metapontino). The key objectives are:

a) Development and implementation of Water Management Adaptation Strategies at FORs level.
b) Determination and application of agricultural practices that increase water efficiency in the cultivation of perennial crops.
c) Establishment of pilot farms adapted to water scarcity.
d) Building adaptive capacity of farmers and FORs to climate change: information, awareness and training.
e) Informing and raising awareness of competitive water users regarding climate change impacts, on a sub-basin level.
f) Dissemination of the proposed strategies to be implemented by farmers and FORs in the target areas and other areas facing similar climate challenges.
g) Incorporation of the project's results in the European and national environmental, climate change and agricultural policy and legislation.

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This work has been elaborated in the framework of the LIFE AgroClimaWater project (LIFE14 CCA/GR/000389) which is gratefully acknowledged. The paper is dedicated to the memory of George Michalopoulos, who was the inspirer of the present work and LIFE AgroClimaWater project.

LIFE AgroClimaWater project: environmental impact and water use of sustainable fruit orchards in Mediterranean area

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Climate change is gradually affecting regional and global food production. Warming temperatures and intensity of extreme weather events may lead to significant reductions in crop yields. The LIFE AgroClimaWater project provides adaptation management strategies to increase water productivity in fruit orchards, reducing pollution and resource use. The increase of water use efficiency was achieved through a sustainable irrigation strategy based on the integration of the daily soil water balance with soil moisture measurements (from 0 to 90 cm depth). The monitoring of the soil profile contributes to optimize irrigation volumes, avoiding nutrient loss and percolation in the deep layers. The experimental sites of fruit orchards have been divided into two plots: one managed with sustainable practices (no-tillage, supply of organic fertilizers, mulching of pruning residues, cover crops and guided irrigation, controlled water stress) and another one conventionally managed (weeding, distribution of mineral fertilizers, empirical irrigation). Effectiveness of good agricultural practices (GAPs) applied in sustainable plots was assessed by performance indicators as Water Use Efficiency (WUE), Water Footprint (WF), Nutrient Use Efficiency (NUE) that were compared to conventionally managed plots. Results revealed that the sustainable irrigation strategy leads to a more than 30.0% decrease in the WF, a more than 20.0% increase in the WUE and a nitrogen use efficiency (NUE-N) greater than 1.5 times in the sustainable orchards compared to that conventional ones. Moreover, the sustainable management has a beneficial effect on natural resources (soil and water) conservation and restoration, implementing the water productivity of the agro-ecosystem and highlighting the mitigation role of agro-ecosystems.

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This work has been elaborated in the framework of the LIFE AgroClimaWater project (LIFE14 CCA/GR/000389) which is gratefully acknowledged. The paper is dedicated to the memory of George Michalopoulos, who was the inspirer of the present work and LIFE AgroClimaWater project.

An integrated framework for efficient irrigation water use and pricing in Greek rural areas

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The efficient use of irrigation water constitutes he most important issue for agricultural production in Mediterranean farming systems. In Greece, irrigation water is used through a collective and a private approach. The latter predominantly requires proper licensing from competent authorities, while the former involves the establishment of Local Land Reclamation Organizations (TOEB) in charge of implementing measures for effective water use and payment of relevant fees. This communication proposes an integrated framework for the collective management of irrigation water in a Greek rural area. In particular, the presentation focuses on a technical irrigation work in the Regional Unit of Florina, in Northern Greece. The construction is funded by the State in order to support the prevailing production pattern (annual arable crops) and minimize pressures on local water reserves, as part of the area is designated as Natura 2000. The proposed framework examines the possibilities of embedding characteristics of Public-Private-Partnerships to TOEB in order to provide flexibility and increase the effectiveness of water management. In addition, a broader framework for the socioeconomic analysis of irrigation works is proposed, which is based on Cost-Benefit Analysis and on a combination of market and non-market valuation (linear programming and contingent valuation respectively) with stakeholder analysis and participatory approaches. This framework also expands to the proposal of a methodological approach for the effective pricing of irrigation water under this type of collective management bodies, which will take into account potential environmental pressures caused by excessive water consumption. Issues regarding the data requirements for this approach are discussed and relevant mechanisms are proposed. In order to inform the smooth implementation of the framework, specific regulatory adjustments and requirements are pinpointed, including farm financing, land use and ownership, training and advisory services, as well as external drivers which could influence the efficiency of irrigation water use and management (climate change, market trends etc.).

Effect of irrigation practices upon yield and fruit quality of four grapefruit (Citrus paradisi Mac.) cultivars

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In general, the annual irrigation demand for grapefruit optimum production is rather high. Limited water resources and increased irrigation cost, swift farmers towards the implementation of various irrigation regimes which affect the fruit quality. Two strategies of irrigation were applied during the phase of fruit growth in 30-year-old citrus trees (*Citrus paradisi* Mac.) crafted with four varieties (cv. Marsh SRA 8, cv. Shambar SRA 22, cv. Frost Marsh, cv. Ruby) grafted onto sour orange (*C. aurantium* L.). For both strategies, all optimum agricultural practices were applied (fertilization, pruning, weed control). For the control strategy the trees were irrigated every week at 100% ETc (T1), while for the second irrigation strategy the trees were also irrigated every week, but at 60% ETc (T2). At harvest time tree yield was estimated, along with fruit quality characteristics and commercial parameters of citrus fruit quality in order to estimate the impact of the applied irrigation strategies. For all the studied varieties, strategy T1 increased significantly the tree yield and the net weight of the fruit, retained the desired by the market commercial equatorial diameter of near 10 cm. Also, under the effect of T1 irrigation strategy all varieties produced fruits with reduced rind thickness, significantly higher juice content, and sweeter flavor since the TSS/TA ratio and the maturation index had significantly increased. The main effect of the T2 strategy (60% ETc) was a significant increase of commercial and nutritional attributes like Total Soluble Solids (TSS), citric acid, ascorbic acid (Vitamin C) content, and phenolic content. The latter attributes are severely affected by water shortage and tend to increase as a response to drought stress conditions. The results lead to the conclusion that in mature grapefruit trees, optimal irrigation practice provided a grower better fruit yield, and superior commercial attributes, while slight water shortage enhances the grapefruit with specific nutritional elements preferred by specific group of consumers.

Practices for improving agricultural Water Use Efficiency in tree crops - the LIFE AgroClimaWater case study

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The aim of this work was to improve the water efficiency of tree crops and save water, using as a case study irrigated and rainfed orchards in Crete – Greece, under good agricultural practices. The study is a part of LIFE + AGROCLIMAWATER project, which aims to develop a climate change adaptation strategy for agriculture and prepare the agricultural sector for adapting to climate change. The selected pilot farms represent the most typical crops in Crete (olive and citrus trees), as well as the typical soil, landscape, and agricultural practices differentiation for each crop. Each pilot farm has been divided into two parts, the first one is used as a control part, while the other one as the demonstration part where good agricultural practices (GAP) were applied. In order to evaluate the results for three consecutive years of implementation (2017, 2018, and 2019) of the suggested agricultural practices for saving water, the following performance indicators were estimated: the water use efficiency (WUE) and the economic water productivity (EWP). In most of the fields, the results indicate that water-saving and crop yield can be significantly improved based on the above-suggested practices. Thus, these indicators can verify that the implementation of the GAP could have positive results under different or even extreme climate conditions.

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This work has been elaborated in the framework of the LIFE AgroClimaWater project (LIFE14 CCA/GR/000389) which is gratefully acknowledged. The paper is dedicated to the memory of George Michalopoulos, who was the inspirer of the present work and LIFE AgroClimaWater project.

Is Climate Changing? Are the Impacts Significant for Hydrometeorological Hazards and Water Resources in Agricultural Watersheds?

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It is common today to consider that climate is expected to change or even climate change is present and evident. There are, however, interpretations of data and model results that question the strength or even the existence of climate change. The issues of historical variability of climate, climate change forcing, quality of atmospheric circulation modeling, discrepancies between global observations and model results, uncertainty of the climate modeling, uncertainty of socio-economic scenarios or emissions pathways and sensitivity of climate models are presented and discussed. Nevertheless, a changing climate leads to changes in the frequency, intensity, spatial extent, duration, and timing of climate extremes, and can result in unprecedented extremes. Changes in extremes can also be directly related to changes in mean climate, but changes in extremes of a climate variable are not always related in a simple way to changes in the mean of the same variable, and in some cases can be of opposite sign to a change in the mean of the variable and the changes vary from one geographical region to another. It is imperative in climate change impact studies to consider the strengths and weaknesses of climate modeling projections and to focus on certain geographical areas. Examples of such climate change impact studies on hydrological extremes, i.e. extreme precipitation, peak flows and droughts are presented and discussed. The impact of water management practices and climate change on the availability of surface and water resources are also discussed. The presentation of changes in hydrological extremes and water resources due to climate variability change is made with special reference in agricultural watersheds of southeastern Europe and Greece.

Geoinformatics and multi-criteria decision analysis in landslides hazard mapping: a case study from western Crete, Greece

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Landslides are a natural disaster with diverse physical and anthropogenic variables being responsible for their occurrence. Those can occur as rock-falls, translational, lateral or rotational slides and debris flow. The majority of the landslides usually take place after short-term intense heavy rainfall or prolonged rainfall during the winter that increase soil saturation, as a result of the large accumulated water quantities. This can create surface instability and subsequent landslides phenomenon. This study focuses on the assessment of the landslide's occurrence in western Crete, which took place after the unprecedented rainfall during February 2019. High spatial resolution satellite imagery was used, before and after the heavy rainfall period, in order to record and map the horizontal displacements of the surface through their longitudinal comparison. The methodological framework has outstripped large-scale landslides and several other with smaller scale. In situ validation confirmed numerous landslides that were detected from the satellite imagery analysis. Ground-truth also highlighted the instability and failure of agriculture graduated terraces, characterizing the mountainous terrain of the region, mainly due to lack of supporting walls. These man-made features failure have changed in many cases the landscape and leading to forthcoming erosion and surface runoff, which will cause further surface degradation in the region. Also, a number of ancillary datasets such as geological, geomorphological, land use maps and other anthropogenic factors were acknowledged within a multi-criteria decision analysis (MCDA) procedure in order to evaluate their interrelationship with the allocated landslides and their relevance degree to causing the triggering of the landslide's phenomenon. The derived spatial information is quite helpful to the evaluation of landslides vulnerability. The use of new technologies in the mapping of natural disasters, that accompany severe weather events, can offer valuable knowledge to pre- and post- disaster assessment and help the associated local authorities to decision making support on disaster risk reduction.

Estimation of carbon, water and energy fluxes between ecosystems and the atmosphere with the eddy covariance technique – The case of a forest plantation

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The study and accurate estimation of mass and energy fluxes between the ecosystems and the atmosphere are crucial within the scope of the assessment of their overall performance, their contribution to the global carbon and water cycle, and their adaptation to the ongoing climate change. Terrestrial ecosystems absorb CO2 through photosynthesis, a process that is referred to as Gross Primary Productivity (GPP), while at the same time they release H2O through evapotranspiration. The eddy covariance technique is a micrometeorological method that is considered as the only well-established method that provides real-time measurements on the ecosystem level, with a great range of applications, including natural and agricultural ecosystems. The aim of this study is to provide a case study for the application of the method for the estimation of carbon and water fluxes in a planted forest in the Lignite Center of Western Macedonia, an area that is greatly disturbed from mining activity and now is under reclamation process. The main planted species is Robinia pseudoacacia. In the study area, an eddy flux tower has been installed and provide real-time accurate CO2, H2O, meteorological and energy fluxes from July 2019 until today, under the framework of the project "COFORMIT". With the combination of the tower measurements and the application of remote sensing methods, based on satellite imagery, we are able to extrapolate the tower's results to a far greater region of plantations. Our results indicate that the combination of the eddy covariance technique with remote sensing methods can provide a very robust and useful tool for the study of CO2 and H2O fluxes on ecosystem level and can meet many applications, both on natural and agricultural ecosystems.

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Discharge for natural streams based on Manning equation using fuzzy transformation method

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The aim of this paper is to utilize the fuzzy transformation method in order to solve a practical problem of hydraulic engineering which described by Manning's equation. The parameters of the problem present uncertainties as to their true-real values and with the help of fuzzy logic and the fuzzy transformation method, which generally used for simulation and analysis of system with uncertain parameters, it is possible to include those uncertainties in the final calculations. In this case, it is desirable to find the discharge in open rectangular and trapezoidal channels, placing more emphasis on different uncertainty rates of the Manning roughness coefficient, for natural streams, while the rest of the parameters remain with a constant or zero uncertainty rate. Taking different α-cut levels, showed that the application of the methodology gave realistic and reliable results, presenting with great accuracy the changes/variations in the water discharge for different types of open natural channels. In this way, a possible underestimation or overestimation of the actual physical condition is avoided by helping the involved decision makers to have a more comprehensive view regarding the water availability, thus making better management plans.

Response of a contaminated aquifer to water resources management scenarios: The case of Lake Karla aquifer

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Nitrate contamination of groundwater is a common problem in agricultural watersheds. Groundwater contamination problems require an integrated modeling and management approach. In this paper, an integrated water resources modeling system has been developed and proposed for the simulation and management of groundwater nitrate contamination. The modeling system consists of coupled distributed models, namely, a monthly hydrological model, UTHBAL, an agronomic model (GEPIC), a groundwater model (MODFLOW), a lake/reservoir operation model, UTHRL, a lake/reservoir-groundwater interaction model (LAK3) and a groundwater contaminant transport model (MT3DMS). The modeling system has been applied to Lake Karla watershed, Thessaly, Greece. Lake Karla is an agricultural watershed which expands to 1663 km2 and its aquifer covers an area of about 500 km2, in the low elevation plain of watershed. The study watershed is an area of great importance with intense and extensive cultivation of irrigated and rain-fed crops. The natural lake existed in the watershed was drained in 1962. Following the drainage of the lake, intensive farming, unsustainable use of groundwater and intensive use of nitrogenous fertilizers has led to quantity and quality degradation of groundwater. Irrigated agriculture accounts for about 98% of the total amount of water consumption in the watershed. Lake Karla has, quite recently, been restored through the construction of the homonymous reservoir. The reservoir is designed to supply irrigation water to the fields around the reservoir and replace groundwater pumping. This study investigates the Lake Karla aquifer response regarding its qualitative status under various agricultural and water management strategies. These strategies apply crop rotation based on nitrogen fertilizer loadings, which are in accordance with the requirements of Nitrates Directive, 91/676/EEC and the Water Framework Directive, 2000/60/EEC and the operation of the new reservoir of Lake Karla. The results show that under the current prevailing climatic conditions the nitrate concentration in the groundwater is significantly reduced below the 25 mg/L threshold value throughout the study aquifer. It is found that crop restructuring and nitrogen fertilization management practices along with the full operation of the reservoir may offset and reverse the groundwater degradation problems.

An Integrated Modeling System for the Simulation and Management of Degraded Water Resources of Coastal Agricultural Watersheds: The case of Almyros basin, Thessaly, Greece

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Most coastal agricultural watersheds face a series of problems because of their location and the irrational and unsustainable water resources management and agricultural practices. The problems encounter coastal agricultural watersheds are the overuse and degradation of groundwater, the limited use of surface water, nitrate pollution of groundwater, seawater intrusion, etc. Many coastal watersheds face these problems around the Mediterranean basin and in Greece, for example, agricultural watersheds in Chalkidiki (e.g. Moudania and Havrias watershed), in Thessaly (e.g. Almyros basin), in Peloponnese (e.g. Argolida basin) and elsewhere. These problems are complex and need an integrated approach of understanding, modelling and management. In this paper, an integrated modelling system for the simulation and management of water resources in coastal agricultural watersheds is presented. The integrated modelling and management system consist of a series of coupled models: a surface hydrology model (UTHBAL), a groundwater model (MODFLOW), an agronomic model (GEPIC), a groundwater contaminant transport model (MT3DMS) and a seawater intrusion/aquifer salinization model (SEAWAT). The modelling system could expand to include a reservoir/lake operation model (UTHRL) and a model for the hydraulic interaction of reservoir/lake with the groundwater (LAK3) to simulate surface water storage works. The integrated modelling system is applied on the coastal agricultural Almyros basin located in the southern Thessaly Water District, in Greece. Almyros basin encounters problems of quantitative and qualitative degradation of water resources, mainly of the groundwater resources, due to unsustainable overuse of groundwater and the limited use of surface water, nitrate pollution and seawater intrusion. These problems are intense and man-made. The current status of water resources in the study basin is simulated for the period 1991-2018 and alternative water resources and agricultural management scenarios for the improvement of the status of water resources are investigated. The modelling system has been calibrated against measurements for the period 1991-2009 and validated for the period 2013-2015. Especially, the calibration results for the groundwater model (MODFLOW) indicate that the Nash-Sutcliffe model efficiency, the Pearson correlation and the Index of Agreement are, on average, 0.970, 0.977 and 0.993, respectively and the same statistical measures for the validation period are 0.977, 0.990 and 0.994, respectively. The results indicate that the water balance of Almyros basin is negative leading to lowering groundwater table, sea water intrusion and degradation of groundwater quality. Agricultural and water resources management measures will be modelled and proposed to minimize and/or overturn the water resources degradation in the basin.

Effects of sowing date, rainfed cultivation with supplemental irrigation, soil moisture and wind force on Coriander (Coriandrum sativum L.) yield and quality performance by applying new agro-technologies (GIS, GPS, Precision Agriculture, TDR-soil sensors, Geostatistical models, soil and hydraulic analyses) at an experimental field in Central Greece

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The aim of the present study was to determine the effects of sowing dates, rainfed cultivation with supplemental irrigation, soil moisture and wind force on Coriander yield (Coriandrum sativum L.), yield components and essential oil contents. In the study were used new agro-technologies (GIS, GPS, Precision Agriculture (PA), soil and hydraulic analyses, Geostatistical models for yield and soil's moisture modeling and geospatial GIS mapping of moisture profile at coriander's root zone). The experiment was conducted at the farmland of Gaiopolis campus-University of Thessaly at Larisa city (Central Greece). Soil samples at depth 0-30 cm were collected and analyzed to determine SOM (Soil organic matter) content, soil's texture, structure and classes, soil's hydraulic properties (Plant Available Water, Field Capacity, Wilting Point), pH and CEC (Cation exchange capacity). A Global Positioning System (GPS) receiver was used to identify the sampling locations. Coriander is an annual herbaceous crop of the Apiaceae (Umbellifera) family and it is known to be a native plant of Mediterranean region, Western Europe and Asia. The seeding took place for the two years study on two different sowing dates on October and November, applying 20 kg ha−1 of Coriander seed in a row distance of 40cm. Two doses, basic and surface fertilization (A dose=66.67kg P2O5 and B dose=74.44kg N per hectare) were applied. The size of each experimental unit was 1.8m2 with four replications. The study area is characterized by a typical Mediterranean climate with cold winter, hot summer and low precipitation in spring and summer. Two levels of rainfed cultivation with supplemental irrigation (IR1=372.6mm and IR2=757.8mm) were applied. Soil's moisture was measured with TDR-sensors. Control of weeds was performed manually. Essential oil content determination was performed by extraction from seeds with hydro-distillation using Clevenger apparatus. Results of soil analysis revealed that the soil of the experimental field was characterized as Sandy Clay Loam (SCL), SOM was 1.70%, bulk specific gravity of soil was 1.42g cm-3, the Plant Available Water was 0.12 cm cm-1, the pH at (1:5) soil/water extract was 7.10 and the cation-exchange capacity (CEC) of soil was 19.3 cmol kg-1. The ANOVA statistical analysis (P=0.05) results revealed that the two main sowing dates (first week of November[best] and last week of October), the irrigation treatments, TDR-GIS soil's moisture maps for coriander's root zone and the prevailing wind force at stage of seeds maturity significantly affects Coriander's dry seed yield, essential oil contents and plant's Umbel heights.

Assessment of potential climate change impact on orchards' water management in three Mediterranean watersheds

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The viability of agricultural sector in Mediterranean Region is directly connected to water resources availability since irrigation is mandatory for many crops in order to maintain sufficient crop yields. Climate models' projections indicate that Mediterranean region is expected to face significant water scarcity problems, mainly as the result of above-the-average precipitation decrease, but also because of air temperature increase. Therefore, the assessment of climate change effects in agricultural water management is essential in order to design adaptation strategies and thus maintain sustainability of the agricultural sector in the Mediterranean. The aim of the present study is to investigate the potential effects of climate change in the water management of three Mediterranean watersheds, in which orchards are dominating. Two of the watersheds are located in Crete Island (Tavronitis, Havgas-Milatos), Greece and one watershed are located in Italy and it is part of Agri river basin. Data from state-of-the-art Regional Climate Models (RCMs) under RCP4.5 and RCP8.5 emissions scenarios were used as the basis for the assessment of climate change impact on orchards' water management in the three aforementioned watersheds. The precipitation and air temperature data were spatially downscaled and then net irrigation requirements (NIR) and water stress factors (WSF) were calculated for three periods: 1971-2000 (historical period), 2031-2060 (near future) and 2061-2090 (distant future). According to the results, average annual precipitation change was found to be highly variable for all the three watersheds ranging from about +10% to less than 50%. Nevertheless, and despite the increased average annual precipitation and the corresponding increase in effective rainfall, average NIR were found to be increased by up to 36.4%. This is due to the combined effects of increased ETc due to increased air temperature and decreased effective rainfall due to decreased precipitation. Overall, the period 2061-2090 was found to present higher climate change impact compared to 2031-2060, while from the three watersheds, Havgas-Milatos watershed demonstrated the highest precipitation decrease and NIR increase.

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Precision Irrigation for climate change adaption: the case of olive groves

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Empirical irrigation scheduling usually leads to water overuse, resulting in substantial loss of water, environmental problems and conflicts with other sectors (urban, tourism), especially under climate change. Precision irrigation supports end-user's decisions with regard to how much to irrigate and when and is uniformly applied across the field minimizing environmental risks. In the present study precision irrigation was applied in olive orchards of three cooperatives in Crete, Greece. The olive orchards were irrigated empirically resulting in great fluctuations in the total amount of applied water per season, ranging from 54 to 825 mm. Moreover, although the majority of the farmers used localized irrigation system (drippers or micro sprinklers), the interval between irrigations was long (10-20 days) and the irrigation dose quite high (20-55 mm). Precision irrigation was applied using Zen-Irriware software for the calculation of water needs of olive trees in real time. The Zen-Irriware utilizes weather forecast in order to adjust irrigation, reduce crop risks (plant damage) and improve yield (quantity and quality) using GSM controller and sensor communication. Using weather forecasts, the available on-line data from existing meteorological stations and tailor-made algorithms, the Zen-Irriware calculates crops irrigation requirements. The software supports algorithms of different ET calculation methods. In this case the modified Penman Montieth method with hourly time step is used. The algorithm is developed according to FAO proposed methods, taking into account crop characteristics (age, growth stage, etc), soil type, irrigation system, water quality and availability, as well as the last irrigation details. Also, the software has the ability to support deficit irrigation in case of limited water availability. The system automatically informed the farmers via email or SMS when and how much water to apply for each parcel, creating the corresponding messages in the user's account. The results showed that the application of precision irrigation in olive orchards in a region without water availability problems resulted in significant water saving (30-160%) compared to the applied practice (empirical irrigation) and if the farmers follow the software guidelines about irrigation time and irrigation quantity, according soil water balance method, there is an optimization of soil moisture during the irrigation period. On the other hand, farmers' response was low, ranging from 20 up to 50%.

Promoting Companies and Universities Cooperation to Enhance Sustainable Water Management in Eastern Mediterranean though Innovative Educational Approaches

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Water-scarce countries in the Eastern Mediterranean require sustainable water management for their welfare. Climate change models forecast higher temperatures and more intense rainfall events while the pressure on the current water resources is expected to be exacerbated. These new conditions will require the utilization of new innovative methods by the new generation of water managers in order to achieve water sustainability. The WaSec project aims to develop science-based water management teaching and training material that will be taught through distance learning. This project involves 13 partners including universities, a public organization and private companies from six countries (Cyprus, Greece, Jordan, Netherlands, Palestine and Spain) and is funded by the European Commission through the ERASMUS + Program. The selected ten courses that are being developed are: a) Water Quality, b) Integrated Water Resources Management, c) Hydrology and Hydrogeology, d) Water and Wastewater Treatment and Reuse, e) Climate Change & Water Sustainability, f) Water Policy and Governance - Transboundary Basins, g) Water Energy Food Nexus, h) Entrepreneurship and Innovation in Water, i) Special Topics in Water Resources and j) Master Thesis. The courses developed incorporate the latest technologies on water management, as well as new pedagogical approaches (interactive exercises, use of videos, social networks, flexible learning path, blended courses etc.) to enhance learning capacities. A Network of water professionals from the region has been established to reach the companies, public authorities and universities cooperation. The Network meetings are every six months to provide feedback on the material developed by the project. This will lead to teaching and training material that are practical and applied and not just science based and should lead to skilled and attractive graduates for the job market. Finally, the companies and public authorities will be active in the courses since they will be providing real-life

water case studies, presenting seminars on their projects and/or providing practical placement opportunities to further promote entrepreneurship. Overall, the graduates of the WaSec program will have the scientific background but also the practical knowledge to implement sustainable water management under climate change conditions. This should promote water sustainability in the region and enhance welfare.

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Developing a framework to enhance urban riparian areas ecosystem services

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The congregation of people in urban setting has and will continue to impact the conservation of natural ecosystems. Riparian ecosystems are particularly prone, as many cities and towns are built along rivers and streams. The vegetation and functions of riparian areas in urban environments are usually degraded or destroyed. The sustainable management of urban waterways and their riparian areas can provide many ecosystem services, such as reducing water pollution, recreation and relaxation areas and mitigation of the urban heat island effect and climate change. This project assessed the current condition of the riparian areas of Drama to develop a management plan to enhance their functionality and ecosystem services. Initially, GIS was utilized to develop the spatial database of the wider urban setting including suburbs and rural areas (weather data, landcover, soils, roads, protected areas, etc.). The datasets were used in order to simulate the hydrologic cycle and stream discharge of the main urban streams and torrents through the application of a hydrologic model. Furthermore, UAV images were able to monitor the vegetation and morphological changes after flood events that caused erosion and deposition. The next step included the field monitoring of the urban waterways. Specifically, field measurements in the urban riparian areas were taken in regard to vegetation, stream channel condition (using visual protocols) and stream water quantity (discharge measurements), on the urban streams and torrents that run through Drama. The simulated hydrologic cycle results found that 56% of the precipitation becomes evapotranspiration, 28% groundwater (shallow and deep), 10% surface runoff and 6% lateral flow. Preliminary results indicate that urban streams and torrents have different hydrologic regimes; ephemeral, intermittent and perennial flows. In addition, based on the visual protocols most riparian areas are of low quality and need restoration efforts. Images taken by UAVs allowed to map the streams and torrents vulnerable areas to erosion or deposition. Once all the measurements are finalized a management plan and conservation practices will be developed to enhance the urban riparian areas. This plan and practices provide a framework to be adopted in other Mediterranean cities.

Preparedness against Droughts and Floods under Climate Change - The case of Crete

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Droughts and Floods are natural hazards in opposite direction with respect to the underlying hydrological regime. However, they may occur in the same region at the different times or even in times closely to each other.

Obviously, the nature of droughts and floods are totally different with respect to the time of occurrence, the duration of each event and the way they affect anthropogenic and natural systems.

Climate Change seems to disturb the magnitude and the frequency of these events. In Crete and other eastern Mediterranean islands due to climate change we expect:

a) A slight lower trend of the mean of water availability (from precipitation)
b) Higher spread of water availability (more floods and more droughts)
c) Higher water demands (mainly crop water demands)

The new conditions are expected to deteriorate due to gradual change from low water consuming crops to high value crops with high water requirements, the increase of tourism, and the higher demands of municipalities.

Having as the example the island of Crete, in order to withstand this additional pressure caused by climate change, the following preparedness and planning directions should be followed:

a) Extend water storage facilities
b) Investigate optimal utilisation of brackish karstic springs
c) Plan for infrastructures and pipelines to areas of intensive agriculture
d) Design and build small structures in the upper zones of the river basins aiming at controlling flood discharges
e) Organize preparedness plans to combat droughts and water scarcity (including a drought monitoring and forecasting system, and an effective administrative and organisational structure).

Mitigation of the effects of climate change in the agricultural sector of Cyprus, through more efficient water use and optimization of benefit

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Agriculture is one of the economic sectors that will likely be hit the hardest by climate change, since it directly depends on climatic factors such as precipitation, temperature and sunlight. Water scarcity has a major impact on agricultural productivity and in many cases, it constitutes the main criterion for the continuation of an agricultural activity, with all the environmental, social and financial consequences that farmland abandonment may bring, especially in rural areas. In particular, the agricultural sector of Cyprus faces increasing challenges, as the island's water resources are very limited and particularly susceptible to the impacts of climate change. In addition to the climatic factors, Cyprus' agriculture is affected by many structural obstacles that reduce the productive capacity and the competitiveness of agricultural holdings, such as natural landscape restrictions and fragmented agricultural plots. Cyprus also faces geographical barriers, since it is an island country with no land borders and is relatively far away from its European peers. As total profit highly depends on the pattern of agricultural cultivation, the aim of the present study is to define the optimum cultivation pattern of the main agricultural crops in Cyprus, including grains, grapes, vegetables and fruit trees, for maximizing the net economical profit under land and water use constraints. A Linear Programming Model is set up, with the objective to maximize the net profit of the most important annual and perennial crops. As for the constraints, these are the limitations on land and water availability, under four different Scenarios, provided that production secures existing consumption of: 1) domestic products, 2) domestic and imported products, 3) domestic products but under a 40% decrease in water availability and 4) domestic products but limited to only traditional, tropical and subtropical crops and under a 40% decrease in water availability. The results indicate that when using an optimum cultivation pattern, the economic benefit increases compared to the present status of cultivation by 120%, 62%, 20% and 48%, based on Scenarios 1, 2, 3 and 4, respectively.

Can plants tolerate drought stress with epigenetic effects; A case study for Medicago sativa varieties

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Water availability has a direct impact on development and survival of plants, as water is a fundamental molecule involved on plant's development and survival. Drought stress affects multiple metabolic pathways and is controlled by multiple genes with various functions and several transcription factors. Recent studies provide evidence that besides the genotype; plants exhibit a quicker response to drought which is associated with epigenetic modifications. DNA methylation (which is the addition of a methyl group in a cytosine without alteration in gene sequence) is one of the primary mechanisms that involves in biotic and abiotic stresses in plants and can be inherited across generations. In this study, two different varieties of Medicago sativa were subjected to two drought stress episodes in order to study global methylation changes in the DNA and to unravel possible epigenetic memory events in relation to better adaptation. Results revealed significant differences for the two varieties according to their epigenetic profile and gave an insight in order to facilitate which cultivar respond better under water deficit conditions.

Cost and effectiveness of in-season strategies for coping with weather variability in Pakistan's agriculture

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Crops are vulnerable to weather hazards throughout the growth season, with periods of heightened risk described as critical moments. Farmers have a number of ex-ante and in-season options for coping with these events, and ex-post adjustments to farm-household portfolios to further limit the impact on livelihoods if these options fail. Adaptation-related research has focused mainly on ex-ante or ex-post coping strategies, because in-season approaches tend to be seen as a given, meaning their cost effectiveness is ignored. Based on detailed survey data collected from 287 households in four of the main cropping systems in Pakistan, this study evaluates the impact pathways of hazards and the cost effectiveness of in-season coping strategies. This study also shows how compounding and cascading impacts can lead to conflicts in the allocation of time, land, labour, machinery and other resources in multi-crop systems. Yield losses varied by 10–30% for 43% of the cases and by 31–50% for another 39%, with the most severe losses caused by the compounding effect of two hazards in one crop season or if both crops in a multi-crop rotation were affected simultaneously. In-season coping options were mostly restricted to the early crop stages and constrained by a short window of time for the response. The application of in-season coping strategies resulted in a yield recovery of 40–95%, with an additional cost of 4–34% of the value of recovered yield. The major critical moments identified were the harvest season, with farming often affected by un-seasonal precipitation, and the germination stage, with an additional high risk for low temperatures at high altitude. A better understanding of the differentiated risks and effectiveness of in-season coping strategies could support the promotion of sustainable crop production in similar agro-ecologies. Moreover, the effectiveness of present-day coping strategies, rather than the use of coping approaches itself, could signal a potential ability to adjust to future climate change.

Sustainable hop production in Slovenia by using bioplastic twine adopted in project LIFE BioTHOP

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Slovenia is the sixth largest hop producer in the World, after the US, Germany, China, Czech Republic and Poland, representing 2-3 % of global hop production. Hop plant is dioecious, perennial, climbing plant. In one season, it can grow up to 7 m high and needs guiding twine for support. The common use of polypropylene (PP) twine in Slovenia is a significant environmental issue. There are about 23,000 tons of hop biomass after harvest produced every season, treated as a waste because being intertwined with plastic twine. Introduction of 100 % biodegradable and 100 % on site compostable bio-plastic polylactic acid (PLA) twine within the project LIFE BioTHOP is offering better solutions for hop growing sector. It is made of various natural/renewable sources of starch and degrades into CO_2, water and biomass when appropriately composted. Hop biomass after harvest contains 18 % of organic mass and 1 % of total nitrogen. The ratio between carbon and nitrogen is 13: 1 when composting stems and leaves and 23: 1 when composting only stems. Its composition of nutrients is promising as a good input material for composting. In autumn 2019 composting trials with different treatments took place in the Lower Savinja valley in Slovenia to determine the most suitable approach for on-site composting of hop biomass after harvest with PLA twine. Chemical composition, germination index, microbial respiration and total microbial population were studied to evaluate the biochemical properties of the compost. In 6 months, the compost has reached the mature phase. The twine had loosened its strength and had been partially degraded. The compost had earthy smell and had no phytotoxic effect on seed germination. These are promising results for the reuse of an organic material, previously considered as a waste. Using BioTHOP PLA twine instead of PP reduces CO_2 emissions and enables use of nutrients to partially supplement mineral fertilizers. Calculations on contribution of PLA use in reducing emissions related to Climate Change, will also be presented.

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Adaptation of olive groves to climatic challenges and potential mitigation through sustainable management

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The main aim of the LIFE+ OLIVECLIMA project is to trial the introduction of new cultivation practices for tree crops in order to find a cost-effective means of mitigating and adapting to climate change, through the increase of carbon sequestration by soils, and reduction of greenhouse gases emissions. In the framework of the project, three olive-growing regions were selected for application of various cultural practices. The pilot regions concern olive orchards in Messinia prefecture (Farmers Group Nileas), Lasithi prefecture (Union of Cooperatives Merambello), and Heraklion prefecture (Union of Cooperatives of Peza Union). This paper describes sustainable olive crop management practices that were comparatively applied in 120 olive groves in Greece for 5 years with the participation of three farmers groups. Organic materials recycled in the olive groves during the present study were valuable sources of carbon, nitrogen, phosphorus, and potassium. Carbon content was highest in pruning residue (53.8-54.2%) while all materials studied were considered rich in C ranging between 41.9–46.2% (compost) and 34.9–42.5% (three-phase olive mill waste-OMW). The highest content in nitrogen was detected in compost (2–2.45%)

followed by pruning residue (0.93–0.99%) and OMW (0.03–0.1%). Adoption of modified pruning also had important contribution toward sustainable management of olive trees. Sustainable pruning resulted in a well-balanced ratio between vegetative growth and fruiting (balanced, every year, in order to eradicate biennial bearing). Significant fluctuation in olive yields was observed in the first years of the project while yields were gradually stabilized by applying sustainable crop management.

Utilizing new agro-technologies and precision agriculture for advanced soil, water, fertilizer and irrigation application, digital mapping and management decisions at farm level

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The farmers and agricultural agencies demand for information on the soil, water and irrigation resources to support the establishment of agricultural policies for these resources and for fertigation management has grown exponentially in the last years. In order to fulfill their requirements, a new generation of new agro-technologies (GIS, GPS, Soil Moisture Sensors, Precision Agriculture (PA) methods, Geostatistical models, soil and hydraulic analyzes, etc) of soil, water, fertilizer and irrigation information, digital soil, water and irrigation databases has to be initiated. These new agro-technologies are utilizing state of the art data (farm and laboratory) collection and spatial interpolation techniques for advanced agricultural (soil, water and irrigation) digital precise GIS mapping for improved management decisions at farm level. The present study investigates the field application of new agro-technologies utilizing GIS spatial modeling-digital mapping approach of soil's N (inorganic), P (Olsen), K (exchangeable), pH, organic matter (SOM), CaCO3, plant available water (PAW), soil texture (sand, silt, clay) and sensors soil moisture of a Triticum durum crop field. The experiment was conducted at the farmland of Gaiopolis Campus-University of Thessaly at Larisa city in Central Greece. Soil samples (0–30 cm) were collected in a Grid pattern to determine by laboratory methods and sensors measurements the soil's texture, structure and classes, N, P, K, pH, SOM, CaCO3, PAW, Field Capacity and wilting point water content. Next to soil moisture measurements, soils' and hydraulics' properties determination was the application use of Precision Agriculture and various geostatistical predictive models (Kriging, CoKriging, etc) for spatial Interpolation and digital GIS mapping. The predictive models were used as the base for Nitrogen, Phosphorus, Potassium, pH, soil's organic matter, Calcium carbonate, plant available water, soil texture (sand, silt, clay) and sensors soil moisture modeling and digital GIS mapping at farm field level. Results of PA methods, geostatistical modeling and GIS mapping revealed that the best predictive models and digital maps were obtained as the output of CoKriging models with various auxiliary variables. The Modeling Prediction Errors were fluctuated as: MPE=-0.0035–0.0122, MSPE=-0.0068–0.0145, RMSSE=1.0021–2.3204. The Mean Square Deviation Ratio (MSDR) ranged from 0.9127 to 0.9815. New agro-technologies and utilization of soil, water, fertilizer and irrigation digital information applied at the farm level, can be used for digital precise modeling-GIS mapping with high accuracy for precision agriculture applications and better irrigation and fertility decisions for the farmer's benefit

Soil organic carbon modeling and digital GIS mapping using various soil and hydraulic auxiliary variables and new agro-technologies (GIS, GPS, Precision Agriculture, Geostatistics, soil and hydraulic analyzes) at farm level

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The study presents a spatial modeling and digital GIS mapping approach of soil's organic carbon (SOC) predictive correlation with various soil and hydraulic auxiliary variables. These measured variables were the soil's plant available water (PAW), field capacity (FC), wilting point (WP), pH, Electrical Conductivity (EC) and soil texture of a *Triticum turgidum* crop field. The experiment was conducted at the farmland of Gaiopolis Campus-University of Thessaly at Larisa city (Central Greece). Topsoil samples (0–10 cm) were collected in a Grid pattern to determine SOC content, soil's hydraulic properties (PAW, FC and WP), soil's texture, structure and classes, pH and EC. A Global Positioning System (GPS) receiver was used to identify the sampling locations. A total of 60 topsoil samples were used to determine soil texture by the Bouyoucos hydrometer method. Soil organic carbon was analyzed by chemical oxidation with 1 mol L^{-1} $K_2Cr_2O_7$ and titration of the remaining reagent with 0.5 mol L^{-1} $FeSO_4$. The FC and WP were measured with the porous ceramic plate method placed into a container that is pressurized with 1/3 atm for FC and 15 atm for WP. Soil's pH and EC were determined in a 1:5 soil/water extract by using a glass electrode with pH meter for pH values, and a conductivity sensor for EC values. Precision agriculture methods (grid pattern analysis, XYZ GPS positioning, sensor measurements, process and analysis of multisource data, high spatial resolution modeling) and geostatistical models of CoKriging Interpolation were used as the base for SOC modeling and GIS mapping at field level with 7 (treatments) different auxiliary variables: PAW, FC, pH, EC and Soil's Clay, Silt and Sand Contents. Using a developed coupling statistical algorithm in the GIS, the modeling Prediction Errors of map accuracy (MPE, MSPE and RMSSE) and the Mean Square Deviation Ratio (MSDR) as a map quality measure were calculated. Results of PA and geostatistical modeling-GIS mapping revealed that the best models-maps are: a) the output of SOC with PAW (MSDR=0.9872), and the output of SOC with EC (MSDR=0.9753). This method of CoKriging Interpolation can be used for spatial digital modeling-mapping with high accuracy and quality for precision agriculture applications and better agro-management decisions on irrigation, plant nutrition, fertilization and yield issues.

Reducing Aquatic Footprint of cotton Cultivation, by developing a decision support system using satellites and sensors

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Agriculture in relation with climate, is are one of the key issues nowadays as climate change influences greatly agriculture. This paper presents the structure and key features of a decision support information system that will cover the major time and money consuming problem related to cotton cultivation, which is the issue of irrigation. Water consumed by agriculture, has a great environmental footprint. Dealing this specific issue requires integrated management, both in terms of environmental protection and economical sustainability. The creation and usage of a decision support system for cotton cultivations, based on remote sensing and in-situ data is an urgent need for cotton cultivations, but also for modern agriculture in general, as it will save natural resources and at the same time will reduce costs. The proposed system can be utilized in order to reduce significantly the use of irrigation water, decreasing in turn the cotton cultivations aquatic footprint. The main objective of this information system is to provide a valuable consulting tool for the agronomist and the farmer, to support their daily activities, having in mind the minimization of the environmental footprint of cultivating cotton. The presented information system will combine the use of innovative means of data recovery from IoT sensors, remote sensing data, as well as agricultural models predicting phenological stages and other parameters related to the quality and risks of cotton cultivations. Farmers will have access from their personal computers and mobile devices, through a user-friendly web application.

Water governance in three Mediterranean Farmers' Organizations towards the development of water management adaptation strategies

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Water governance at any level of administration is crucial to ensure equitable, economically sound and environmentally sustainable management of water resources. LIFE AgroClimaWater project promotes water efficiency and supports the shift towards climate resilient agriculture in Mediterranean countries through the development and implementation of water management adaptation strategies at three Mediterranean areas through Farmers' Organizations (F.ORs). To this end, a water governance scheme is proposed, aiming to a more effective implementation of the water management adaptation strategy by the F.ORs. The proposed water governance consists of five main Governance Actions (GA), which include a set of actions and measures that need to be implemented by the F.OR's management. Within this context, our paper aims to introduce an integrated water governance scheme that can be applied at F.OR's level. Key elements to achieve equitable and transparent water governance are the five main Governance Actions proposed: (a) compliance with legal requirements related to water use, (b) identification and monitoring of the interrelation of water with other resources, (c) internal and external transparency and raising awareness on water topics, (d) emergency preparedness and response plan addressing accidents, security incidents, emergency situations, disasters etc., and (e) accounting and reporting mechanisms to promote economic transparency. For the efficient implementation of each of these GAs an action plan is presented, including a set of actions as well as the monitoring mechanisms that are used during their implementation. The proposed mechanisms were developed after extensive discussion and consultation with the F.ORs, in order to ensure effective and realistic action plans. The responsibilities for the implementation of the action plans are shared by three departments within its F.OR, namely the departments of a) legal matters, b) communication with river basin's committee and c) water managementτ. Finally, the implementation of proposed water governance in the frame of LIFE AgroClimaWater in three F.ORs (two located in Crete, Greece and one located in Basilicata, Italy) is presented and the lessons learnt are discussed. Overall, the proposed integrated water governance scheme constitutes a valuable tool for the F.ORs towards adaptation to climate change in terms of water efficiency.

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Διακυβέρνηση νερού και αγροτικός τομέας

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Οι πολιτικές διαχείρισης των νερών που εφαρμόσθηκαν στη μεταπολεμική περίοδο στην Ελλάδα και καθόρισαν σημαντικά τη διακυβέρνηση μπορούν να διακριθούν σε τρεις περιόδους. Πρώτη περίοδος μέχρι το 1987, όπου με στόχο την ανάπτυξη της αγροτικής παραγωγής ως κύρια χρήση του νερού καθορίσθηκε η Αγροτική, Δεύτερη περίοδος από το 1987 μέχρι το 2003, με την εφαρμογή του νόμου-πλαίσιο 1399/87, ο οποίος συνέδεσε όλες τις αναπτυξιακές δράσεις με την προστασία του περιβάλλοντος και εν γένει των υδάτων δίνοντας προτεραιότητα στην ύδρευση και στο περιβάλλον. Η τρίτη περίοδος, 2003-σήμερα, αφορά στην εφαρμογή της οδηγίας 2000/60/ΕΚ με κύριο στόχο την προστασία των υδάτων και την επίτευξη της «καλής κατάστασής» τους με συγκεκριμένο πρόγραμμα μέτρων και χρονοδιάγραμμα. Σήμερα, πολλά προβλήματα που σχετίζονται με το νερό μπορούν να αποδοθούν στην αποτυχία της διακυβέρνησης στα πολλαπλά επίπεδά της και όχι στην καθαυτή έλλειψη του πόρου. Επιδιωκόμενο είναι η χρηστή διακυβέρνηση των υδάτων η οποία μπορεί να συμβάλει σημαντικά στην αντιμετώπιση των μελλοντικών προκλήσεων στον τομέα του νερού, και θα επιτευχθεί με τον ορθολογικό σχεδιασμό και την εφαρμογή πολιτικών που θα αξιοποιήσουν τα οικονομικά και περιβαλλοντικά οφέλη από την αειφόρο διαχείριση του νερού. Οι πολιτικές αυτές θα είναι βιώσιμες μόνο εάν είναι συνεπείς, εάν εμπεριέχουν άμεση εμπλοκή των ενδιαφερόμενων μερών, εάν έχουν διαμορφωθεί από καλά σχεδιασμένα ρυθμιστικά πλαίσια, μα προπάντων εάν βασίζονται σε επαρκείς και προσβάσιμες πληροφορίες, στη διαφάνεια και σε περισσότερο αποκεντρωτικά συστήματα.

Μέθοδοι και Συστήματα Βέλτιστης Διαχείρισης - Εξοικονόμηση Ενέργειας στα Υδροαρδευτικά Έργα του Ο.Α.Κ. Α.Ε.

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Η βέλτιστη διαχείριση των υδατικών πόρων και η εξασφάλιση της διαθεσιμότητάς τους (ύδρευση-άρδευση) όπου και όταν απαιτείται προϋποθέτουν σύγχρονες μεθόδους διαχείρισης των υποδομών νερού (φράγματα, αντλιοστάσια, δίκτυα). Η ανάπτυξη των έργων ΑΠΕ και η μείωση του περιβαλλοντικού αποτυπώματος στις υποδομές αυτές αποτελεί προτεραιότητα για τον ΟΑΚ Α.Ε., συμβάλλοντας παράλληλα στην επίτευξη των εθνικών ενεργειακών και περιβαλλοντικών στόχων.

Διαχείριση Αρδευτικού Νερού & Κλιματική Αλλαγή -Εφαρμοσμένη Έρευνα από το Ινστιτούτο Ελιάς Υποτροπικών Φυτών & Αμπέλου στην Κρήτη – Το παράδειγμα του LIFE Agroclimawater

Κουργιαλάς Νεκτάριος

ΕΛΛΗΝΙΚΟΣ ΓΕΩΡΓΙΚΟΣ ΟΡΓΑΝΙΣΜΟΣ "ΔΗΜΗΤΡΑ"- ΔΙΕΥΘΥΝΣΗ ΑΓΡΟΤΙΚΗΣ ΕΡΕΥΝΑΣ, Ινστιτούτο Ελιάς, Υποτροπικών Φυτών και Αμπέλου

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Στο πλαίσιο της συγκεκριμένης διάλεξης θα παρουσιαστούν αποτελέσματα του Ευρωπαϊκού έργου LIFE Agroclimawater σχετικά με την αποτελεσματικότητα της εφαρμογής γεωργικών πρακτικών με στόχο την εξοικονόμηση νερού και την αποτελεσματική προσαρμογή των δενδρωδών καλλιεργειών στις επιπτώσεις της κλιματικής αλλαγής. Θα παρουσιαστούν αποτελέσματα που επαληθεύουν ότι η εφαρμογή των προτεινόμουν πρακτικών θα έχει θετικά αποτελέσματα υπό διαφορετικές ή ακόμη και ακραίες κλιματικές συνθήκες διασφαλίζοντας την βέλτιστη παραγωγή και εξοικονομώντας ταυτόχρονα υδατικούς πόρους. Επίσης θα παρουσιαστούν δράσεις του Ινστιτούτου Ελιάς, Υποτροπικών Φυτών και Αμπέλου, σε επίπεδο Περιφέρειας Κρήτης, που στόχο έχουν τη βιωσιμότητα και τη βελτιστοποίηση της απόδοσης των δενδρωδών καλλιεργειών σε ακραίες κλιματικές συνθήκες με τη χρήση νέων τεχνολογιών (γεωργία ακριβείας).

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Poster Presentations

Use of ornamental plants in constructed wetlands for greywater treatment

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Water scarcity is an important issue of concern in Aegean islands, Greece. Small scale (household-level) natural greywater treatment systems and specifically constructed wetlands (CWs) were tested in this study, as a sustainable long-term solution to tackle water scarcity. CWs could be an economical and energetically efficient method to treat greywater on-site. However, the commonly used reeds as vegetation are not favorable when CWs are applied in houses or buildings. In this study, we have explored the use of ornamental plants as vegetation in vertical flow constructed wetlands (VFCW) for greywater treatment. VFCW is the type of CWs with lower area requirements and higher organic carbon removal efficiency compared to other types of CWs while the use of ornamental plants could improve the aesthetic and acceptability of the system. Three different ornamental plants (Pittosporum tobira, Hedera helix and Polygala myrtifolia) were used as vegetation in pilot VFCWs on Lesvos, an Aegean island in Greece. The treatment consisted of three replicates and a control for each ornamental plant species. The beds of the CWs were filled with three successive layers of materials: coarse gravel (10cm), fine gravel (10 cm) and sand (40cm). The initial Hydraulic Loading Rate (HLR) with synthetic greywater was 74mm/d for 141d after transplanting, after which the HLR was increased to 110 mm/d during the last 30 days of the experiment. Influent and effluents were sampled weekly for a period of 3 months and analyzed for pH, Electrical Conductivity (EC), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Phosphorus (TP) and Total Suspended Solids (TSS). Total Coliforms (TC) and E. coli were measured two times during the experiment, for each HLR used respectively. Results showed that the three examined ornamental plants survived under the “extreme” conditions (poor soil media, no fertilization and only greywater irrigation). In addition, high removal efficiencies were recorded for all examined parameters, for both HLR used respectively (BOD: 89 and 90%, COD: 97 and 95%, TSS: 95% for both phases and TP: 97 and 63%). The quality of the effluent met the criteria for wastewater reuse according to the Greek national guidelines. Although the removal efficiencies were extremely good, no significant difference could be detected between the ornamental plants and the control for the applied HLRs, thus we can have concluded that the examined ornamental plants can be used in CWs to improve the aesthetics and thus to increase the system’s acceptability by the users.

Impact of monthly changes of rainfall erosivity and cover management factors on soil loss estimation for Crete Island, Greece

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Soil erosion is a major environmental process caused by water or wind. It is a growing problem in Greece and particularly in the island of Crete, the biggest Greek island with great agricultural activity. The advances in geospatial technologies such as geographic information systems (GIS) and remote sensing, as well as the wide spreading of use of corresponding data, has significantly accelerated the development of several methods/models over time enabling the assessment of soil erosion loss. Nowadays, a number of different models is detected in the relative research studies. In the majority of them, data representing the soil erosion-influencing conditions of a given region like its climate, topography, soil regime, and surface coverage are analyzed. On this basis, an empirical model namely Revised Universal Soil Loss Equation (RUSLE) was developed. By a GIS-based implementation, RUSLE model integrates a number of water erosion factors for estimating soil loss rate. According to the type of primary data used for their creation, these factors are separated to the following five: rainfall erosivity (R-factor), soil erodibility (K-factor), slope length and steepness (LS-factor), cover management (C-factor), and support practice (P-factor). The present study has as main objectives: (a) to estimate the soil loss rate by water-caused erosion for the island of Crete between January and December for the years 2016 and 2019, as a result of RUSLE model implementation, and (b) to explore the impact and the correlation of intra-annual variability of C and R-factors and their temporal interactions on estimated soil loss rate, by handling these factors as monthly changing and the others (K, LS and P-factors) as static during the whole year. In this frame, sensitivity analysis was performed in order to check the sensitivity of model to changing environmental factors. The five key factors of model were generated by using GIS and remote sensing-based techniques and data. Specifically, rainfall data at a high temporal scale resolution for R-factor, soil data for K-factor, digital elevation model (DEM) of 30 m spatial resolution for LS-factor, satellite (Landsat-8 OLI) imagery data of 30 m spatial resolution for C-factor and land cover data for P-factor were exploited. The estimated rates were cartographically visualized as maps presenting the spatio-temporal patterns of soil loss for the study area on a monthly basis.

Avocado maturation in western Crete as an indicator of climate change in cool subtropical areas

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Crete is located in the north border of the subtropical zone, where climate changes are intense. Therefore, factors sensitive to climate changes will affect various crop parameters. In avocado crop, dry matter and oil content are the main factors of fruit maturity, harvesting time and flavor quality. So, harvesting time as indicated by dry matter according to each variety, data of dry matter and oil concentration of the years 1990-1991 and 2016-2019 were compared in western Crete. The area was divided into three regions according to harvesting time; 1: late, 2: early, 3: middle. The analyses were occurred on fresh fruit kept on +5o C in less than 30 hours from harvesting. The results revealed that the dry matter on fresh avocado fruit increased during the last three years. Specifically, Fuerte and Zutano in regions 2 and 3, Bacon and Fuerte in region 2 had statistically important increase in 2019 compared to 2017. The dry matter of Fuerte variety had the highest rate in 2019 in regions 1 and 2, compared to the years 1990-1991-2017, although, not statistically important. In addition, oil concentration of Fuerte (region 1) in 2019 almost doubled in comparison to 1990 and 1991. It turns out that the harvesting time in the most common avocado cultivars is getting earlier in some regions and cultivars, compared to previous years. On Zutano variety the time of harvesting on region 2 is dropping from 20-Nov in 1990, to 29-Oct in 1991 and 14-Oct in 2019. Accordingly, on Fuerte variety on region 1 harvesting time was 19-Dec on 1990, 13-Dec on 1991, 27-Oct on 2017 and 12-Sep on 2019. Although dry matter and oil concentration follow different progressions in avocado maturation, they are representative indicators of the climate effect on avocado crop and the changes that happen in the cool subtropical areas, as Crete. It needs further study to examine whether climate changes will affect other parameters on avocado crop, such as flowering to harvest time and cultivars order of harvest.

Salinization and alkalization as degradation soil problem at south part of Danube Lowland (Slovakia)

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Salinization is an increasing environmental problem in ecosystems. The assessment of total dissolved solids (TDS), pH, electrical conductivity (EC), exchangeable sodium percentage (ESP), alkalinity and the concentrations of main ions data make possible for identification of salinization and alkalization degree. The salt-affected soils occur in the south part of Danube Lowland (Slovakia), where the dry and warm summer climate, evaporation soil water regime and mineralized groundwater create convenient conditions for development and spreading of the saline and alkaline soils. This part is the most productive agricultural area of Slovakia. Groundwater is putting down as one of the most important aspect of soil salinization and alkalization. It is known that these facts impact adversely on vegetation and crops, so there is a reason why it is important to solve this problem. Groundwater are here supplied by infiltrating Danube water. Groundwater levels hydromorphically influenced the soil cover development and some chemical particularities connected with their mineral content and hydrothermic regime. Saline soils are widespread in some localities reflecting the predominance of sodium in groundwaters and soil solutions. Sodicity and alkality is shown to be a latent problem in saline soils where deleterious effects are evident. The contribution used the monitoring data from the period of years 1989 – 2006. We collected soil samples and samples of mineralized groundwater at the area mentioned above. It was subsequently carried out their analysis to determine total dissolved solids (TDS), electrical conductivity (EC), pH, cation exchange capacity (CEC), sodium adsorption ratio (SAR). In selected locations, salt content and sodium exchange has reached the limit and slightly above-limit values. The results show that in all monitoring localities it is in motion both the process of salinization, by indicated above-limit residue values and EC values, both alkalization process indicated by above-limit values of ESP and pH. In areas where ESP stands at 5-20%, alkalization is the dominant process. From groundwater quality indicators, monitored in the period 1989 - 2006 in selected locations, come out that during this period the groundwater quality decline in terms of salinization and alkalization. Concentrations of majority of those indicators have increasing trend, as well as SAR and EC values.

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