Deliverable

Project Acronym: PRECIMED

Project full Name: Precision Irrigation Management to Improve Water and Nutrient Use Efficiency in the Mediterranean Region

2nd Annual EC report

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Content

Summary

This report includes all the scientific reporting details corresponding to the activities performed during the first twenty-four months of the project. As described in detail in the following sections, the project is being implemented correctly with some changes due to the situation the world is suffering from the pandemic and some other changes that have led us to request a non-cost 6-month project extension in order to achieve the project's objective in a satisfactory way. The consortium is in continuous contact and three meetings have been held for the sharing of all the progress and decision making. In addition, the Mid-term evaluation meeting has recently been held.

1. Explanation of the work carried out by the beneficiaries and Overview of the progress

This report aims to review the tasks carried out during the first two years of project. As described in detail in the following sections, the project is being implemented appropriately, besides some forced changes already mentioned in previous reports, as a consequence of the global situation caused by the pandemic.

Regarding project progress, as it will be shown in this document, all deliverables are updated and presented on the scheduled dates.

Last month, on 26th October 2021, the consortium met virtually on the occasion of the Second-Year meeting. On this meeting, all project partners presented the status of their work to the consortium and some conclusions and next steps were established in order to achieved the project objectives.

1.1 Objectives

PRECIMED project is developing a Standards-based Decision Support System (DSS) to improve the efficient use of water, nutrients and energy. For this, the consortium integrates the knowledge on fertilisation and irrigation of Mediterranean crops with innovative information and communication technologies (ICTs) to develop sustainable fertigation strategies and recommendations on irrigation scheduling, that will have low environmental impact and will be economically profitable.

PRECIMED 's DSS integrated platform is being developed for end user's easy access, to manage water and fertilisers through web interfaces from anywhere with an Internet connection using mobile phone, tablet or PC. The DSS web-based platform collects a large amount of crop and environmental data that is processed and analysed in real time in order to provide recommendations to farmers regarding the best irrigation and fertilisation practices.

The platform also offers service management and remote actuations to improve the lives of Mediterranean farmers, saving water and fertilisers in a region with significant problems of water stress and soil pollution. The challenge is to create stronger bridges between the two areas of the Mediterranean basin, which is composed of EU and non-EU countries: Spain, Greece, Tunisia and Algeria. In this sense, the consortium is made up of SMEs, research centres, universities and end users that will collaborate to validate the solution for subsequent commercialization.

The main objectives are presented in table 1.

Table1: Main objectives of PRECIMED project

Objective number	Measurability	WP	Period for accomplishment					
			M6	M12	M18	M24	M30	M36
O1	To Improve Water and Nutrient Use Efficiency (**WUE and NUE**) in the Mediterranean Region by using intensive ICT solutions	2,3,4,5	**X**	**X**	**X**	**X**	**X**	**X**
O2	To facilitate **the interchange of technology and best goods practices between EU and non-EU Mediterranean countries** in order to improve the water and nutrient use efficiency in all the Mediterranean Region	2	**X**	**X**	**X**	**X**	**X**	**X**
O3	To develop and validate (in different demonstration farms) **a Standards-based Decision Support System for data-driven irrigation/fertilization management** that evaluates the medium-term evolution of crop nutritional status, soil salinity, yield and fruit quality and safety, optimizing the water and fertilizers needs and the energy costs at farm level.	3,4	**X**	**X**	**X**	**X**	**X**	**X**
O4	**To ensure that the project activities and outcomes reach the relevant target groups**, especially end-users (farmers), thus enhancing the market uptake of PRECIMED's solutions.	5	**X**	**X**	**X**	**X**	**X**	**X**

1.2 Explanation of the work carried per WP

The planned activities have been carefully designed to achieve the project goals and most importantly, to deliver maximum socioeconomic impacts, transfer of knowledge, and deal with challenges in the agricultural sector. PRECIMED project is organized in 5 work packages.

1.2.1 WP1 Project Management

WP1 aims to enable efficient coordination and guide the project partners for achieving the overall project objectives while following the directives set by the EC in the PRIMA grant agreement and the consortium regulation provisions set by the consortium agreement.

The WP leader is CSIC.

T1.1 Team and project coordination.

A general coordination has been proposed in order to synchronize the project more effectively. This includes the project management by the Project Coordinator (PC), assuring technical coordination on the level of subproject leaders, assuring interaction between the different WPs and the quality of intermediate project results. Furthermore, this coordination also covers tasks such as, the preparation, organization, administration, minutes and follow-up of scheduled meetings:

- Management of the consortium: legal, contractual, ethical and administrative matters.
- Organization of the Kick-off meeting (19/11/2019), First year annual meeting (15/10/2020) and Second year annual meeting (26/10/2021).
- Perform day-to-day management as efficient administrative support.
- Overall management and coordination of the project, ensuring that the project stays focused and that there is a good cooperation and coordination between all work packages.
- Organization of the Mid-term evaluation meeting (23/11/2021).

The PC has performed all communication with the PRIMA Secretariat. The PC is running the day-to-day project coordination with the support of the PMT (Project Management Team).
Within this task, during the first 18 months of the project, deliverables have been revised and submitted by the PC to the PRIMA Secretariat via PRECIMED Smartsheet and distributed among the consortium partners. From that date onwards, deliverables are being upload on MEL platform. The PC with the support of PMT has been actively involved with all management and technical parts with respect to the submissions of the deliverables.

T1.2 Management of activities between the consortium members

This task is led by the Quality manager (QM), and the activities are:

- Development of a Quality Assurance Plan (QAP). This was reflected in the deliverable D1.2.
- Quality monitoring of the execution of WPs and tasks.
- Managing any quality issue with respect to the project and establishing actions (preventive or corrective) when necessary.

T1.3 Project Progress reports' technical coordination

This task comprises the technical coordination at project level, supervising all the deliverables carried out during these first two years and the flow of technical information.

T1.4 Financial and Administrative coordination CSIC

In this project there is no financial coordination by CSIC, as each partner is funded directly by its own national funding agency. Therefore, it is up to each partner to meet the financial objectives set out in the project for each year and for each task. Each partner will be held accountable to comply to the legislative and financial requirements and regulations of its own country where appropriate. The Administrative Manager is in charge of the necessary actions for the achievement of a fair and effective internal administration within the consortium to meet EC requirements. In this sense, the actions carried out during the first 24 months have been:

- Designing and maintaining partner specific templates for the deliverables and the presentation of the meetings.
- Implementing and maintaining the internal platform (Dropbox) for information exchange and email lists.
- Administrative support to all partners on an individual level for any needs that may arise.

During this period, the PC had to communicate with the Project Officer to request changes in delivery dates and other issues that arise in the day-to-day running of the project. Actually, a project extension of six months has been evaluated, mainly due that several tasks were postponed (mostly during the first year when the pandemic began) making difficult the validation of the DSS, scheduled for the last year of the project.

1.2.2 WP2 Establishments of end-user's requirements

The aim of WP2 is to establish the characteristics and issues related to the agricultural crop production in the Mediterranean basin and the requirements that must be recognized.

The WP Leader is UTH.

T2.1 Identification of farmers participating in the project and establishment of experimental approach in the pilot farms.

The assessment of pilot farms for the design of the PRECIMED DSS has been focused on identifying the requirements of the farms and the farmers, analysing nutrients' and water availability management in the context of climate change, taking into account the impact of irrigation technologies on the productivity of water and fertilizers use efficiency, and defining the most interesting system suitable for each one of the pilot farms included in the assessment, concerning the type and the number of sensors required to manage water and fertilizers in each case study.

To carry out this task, at the beginning of the project, several meetings were held with farmers, cooperatives and agricultural partners from the local farms within targeted regions characterized by episodes of extreme rainfall/drought, mild temperatures, irregular topography, and nearness to large water bodies are characteristic. In this area, farming is intensive, highly specialized, and varied in the kind of crops raised. PRECIMED is developing pilot activities in the main Mediterranean farm types (greenhouse and open field) counting with farmers from the design phase with different farm sizes and characteristics. This way, the results of the project

could be extrapolated to other regions of the Mediterranean basin, aiming to improve farmers' needs by optimizing farm resources.

The most important requirements identified in the pilot farms were:

- A weather station in each pilot farm, as well as devices for the monitoring of soil water content and irrigation water quality.
- Improving the application rates and the timing of fertilizers.
- Defining an irrigation scheduling program for field crops and crops in greenhouses taking into account the different irrigation strategies.

According to the needs of each pilot farm, it was identified and selected the quality and number of sensors and telecommunication devices (i.e. data-loggers & Cyber Physical Systems gateways) and different experimental devices were installed. In terms of experimental approach at farm level, for the evaluation of the DSS, the selected pilot farms are ready to test different irrigation strategies on open air on citrus and potato crops in Algeria; olive trees, bean and peas crops in Tunisia; pomegranate and pear trees in Spain, and cucumber and tomato crops (under greenhouse conditions) in Greece. Upcoming, an experimental protocol will be developed, considering the previous research works on different irrigation management effects on crop physiology and nutritional value of fruits, already identified in deliverable D4.2.

T2.2 Analysis of nutrients and water availability and management in the context of climate change.

An intensive review of previous scientific results and information obtained from previous R&D work and related projects on agricultural conditions in the Mediterranean Region has been carried out. The following factors have been considered in particular: soil, substrate, plant material, atmosphere, water resources and quality (surface water, underground resources, etc.), irrigation systems (agronomic design, application efficiency and distribution uniformity), irrigation-related performances (irrigation scheduling, failures in the irrigation system, economic losses, water use efficiency, etc..) and fertilizers application. Therefore, the challenges to be considered in PRECIMED DSS have been identified.

In the frame of this task and Deliverable 2.2, WP2 leader proposed to contact an Editor for the development of a special issue in a scientific Journal. All partners would be able to submit a manuscript for peer review and the synthesis of the manuscripts will be D2.2. However, this was not finally put forward and each partner elaborates a part of the deliverable related to the expertise and knowledge of the team without necessarily publishing this material elsewhere. The work is progressing smoothly, and the work collected from some partners is formed in scientific papers and is published in scientific journals as presented below:

- Nikolaou, G., Neocleous, D., Kitta, E., Katsoulas, N., 2020. Implementing sustainable irrigation in water-scarce regions under the impact of climate change. Agronomy, 10(8):1120. https://doi.org/10.3390/agronomy10081120.
- Nikolaou, G., Neocleous, D., Kitta, E., Katsoulas, N., 2021. Advances in irrigation /fertigation techniques in greenhouse soilless culture systems. Advances in horticultural soilless culture (ed. Prof Nazim Gruda, University of Bonn, Germany). ISBN (pdf): 978-1-78676-438-6.
- Bañón, S., Ochoa, B., Bañon, D., Ortuño, M.F., Sánchez-Blanco, M.J. 2020. Assessment of the Combined Effect of Temperature and Salinity on the Outputs of Soil Dielectric Sensors in Coconut Fiber. Sustainability 2020, 12, 6577; doi:10.3390/su12166577.
- Nikolaou, G., Neocleous, D., Christou, A., Polycarpou, P., Kitta, E., Katsoulas, N., 2021. Energy and water related parameters in tomato and cucumber greenhouse crops in semiarid Mediterranean regions. A review, Part I: Energy and microclimatic parameters. Horticulturae, 7(12), 521; https://doi.org/10.3390/horticulturae7120521

- Nikolaou, G., Neocleous, D., Christou, A., Polycarpou, P., Kitta, E., Katsoulas, N., 2021. Energy and water related parameters in tomato and cucumber greenhouse crops in semiarid Mediterranean regions. A review, Part II: Irrigation and fertigation. Horticulturae, in press

In addition, CEBAS-CSIC prepared an article for a Spanish informative journal (Horticultura, -in Spanish), describing the most innovative aspects of the PRECIMED project:

- Ortuño, M.F, Alarcón, J.J. 2021. Proyecto PRECIMED: Transformación digital del sector agroalimentario de la Región Mediterránea.

T2.3 Assessment of each agricultural farm linked to practical feasibility of irrigation scheduling based in sensing plant and soil water status.

In parallel to the analysis of results obtained in T2.1 and T2.2, this task will identify the main important farmer requirements for each specific pilot farm. In this way, the work in progress aims to define the most interesting quality and number of sensors required for each case study and the better telecommunication devices needed to upload the sensor-reading to the cloud. For this purpose, the partners have already deployed the sensor networks for data collection in the different pilot farms in order to prove the practical feasibility of irrigation scheduling based on sensing plant and soil water status. The required hardware arrangement (sensors and device-to-web data logger) configuration and testing is ongoing.

The deliverable 2.1 which makes reference to this task, was delivered on month 22, after its extension was approved by the project officer. The rest of the deliverables of this WP are well advanced and their delivery date foreseen is M36.

1.2.3 WP3 Decision Support System Development

The aim of WP3 is to perform the Decision Support System (DSS) development. The goal of these activities is to deliver a demonstration prototype at the end of the project that fits perfectly the farmers needs assessed throughout the project.

The WP Leader is ODIN.

T3.1 Design and Development of IoT-data management platform with cost-effective devices for optimized irrigation scheduling.

This task addresses the cost-effective data acquisition and remote actuation with wireless gateways connected to an IoT-standards-based platform through Internet. The task leads to develop a FIWARE-based platform supporting edge/cloud computing and the integration of three subsystems (i.e. data acquisition, data processing and end-users services) in the context of precise irrigation and fertilization. Moreover, the FIWARE-based platform employs and integrates outcomes of the EU FIWARE project, like the ORION Broker, open and standardized lightweight IoT-data protocols such as MQTT, CoAP or even REST services based on HTTP, as well as NGSI to facilitate the acquisition, integration and exchange of massive data with Cyber Physical Systems (CPS) gateways.

There were analysed different types of connections with irrigation sensors and actuators, LPWAN (Low-Power Wide Area Network) networks (i.e. Sigfox, Lora, 5G, NB-IoT) and Internet protocols (i.e. IPv6, 6LoWPAN, etc.) between CPS gateways and IoT-based platform and so all the deployed CPS gateways are connected to the platform thanks to the use of the best lightweight chosen protocols.

In this architecture, low level operations that require minimum latency and high reliability in the communication with legacy sensors/actuators are executed at CPS gateways. The intermediate management level is the edge computing plane, which includes a set of NFV-powered monitoring and control modules in charge of

orchestrating the CPS gateways in the same crop. At this layer, data fusion and aggregation are carried out to offload BigData analytics performed in the cloud. The edge plane enables the cloud part of the DSS platform to serve multitude of heterogeneous crops. The edge control modules are virtualised through NFV techniques that allow their instantiation at the field or at the cloud. These modules communicate with CPS gateways using IoT communication protocols such as MQTT or CoAP. MQTT is especially considered, given that it is more addressed to the management of industrial processes, however, CoAP is also supported for non-critical monitoring tasks not involving control.

So far, climate and soil sensors corresponding to the Miraflores Irrigation Community in Jumilla (Murcia), and the experimental field of CEBAS-CSIC in Santomera (Murcia) have been deployed and connected thanks to the use of CPS gateways with wireless LPWAN communication to the IoT platform developed and deployed by ODIN. These provide temperature and humidity of the substrate. Additionally, two weather stations provide extensive information of the environment such as air temperature, relative humidity, rainfall, the wind speed and ETo, to name a few, have been integrated.

On the other hand, the greenhouse information provided by UTH has also been integrated in the platform thanks to the development of a specific software adapter. The information provided by the greenhouse comprises climate parameters, such air temperature, relative humidity, solar radiation and vapour pressure deficit (VPD). An IoT system for the data transfer from UTH to ODIN has been developed (www.precimed.eu).

In order to control the fertigation inside a greenhouse, the transpiration of the crop has to be estimated. Furthermore, for soilless crops grown in a substrate, the drainage rate and the electrical conductivity of the drainage solution will have to be considered in the DSS.

At INRAA and OPTIM pilot farms, the information related to the climatic data and soil water content is not integrated directly on the platform. This will be done after complete the installation of the required devices, as the Drill and Drop soil moisture probes and the weather station.

Regarding to the open air conditions, the control of irrigation will be based on water balance and plant water status methods. For water balance method, parameters related to daily root depletion, precipitations, evapotranspiration and the total and readily availability water need to be integrated in the DSS.

Finally, this platform will take advantage of the BigData models identified in T3.2 and implemented in T3.3.

As a mayor outcome of the work carried out in this task, Deliverable D3.1 “IoT-based platform with cost-effective gateways for optimizing irrigation” was presented on month 16.

T3.2 Models to determine fertigation management in greenhouse and in open air.

Data recorded in the field and in the greenhouses related to soil and crop status and the weather forecast (see task 3.1.) is used to develop irrigation/fertilization scheduling models with the goal of developing optimal irrigation/fertilization scheduling programs enhancing water and fertilizers efficiency. In this sense, a group of equations needed for the models has been identified and organized so that both irrigation and fertilization in both open air and greenhouses models could be developed. In this context, the deliverable 3.2 “Integrated models of irrigation and fertilization for open-field crops and greenhouses” that describes the methodology that will be followed and the mathematical expressions that will be used to estimate the fertigation needs was presented on M24, following the approval of the extension requested.

These models concern major greenhouse crops such as tomato and cucumber crops, and several fruit orchard crops and aim to enable growers to use more effectively advanced technical systems for optimal irrigation and nutrient management. The concept for fertirrigation management in greenhouse crops can be summarised into the following four steps. 1) At the first stage, the crop nutrient needs in relation to dry matter production (DMP), are calculated. Any changes in DMP as the plant grows or when there is biomass removal due to harvesting or

leaves and stems pruning, are taken into consideration daily. 2) At the second stage, the crop water needs, as a function of crop transpiration, are estimated. 3) Then, the fertiliser and water that need to be applied in total are estimated and adjust the fertirrigated solution based on the cultivation daily needs. 4) Lastly, the fertigated solution recipe is adapted based on any changes in the crop biomass and/or climatic conditions and weather forecasting.

Regarding to the concept of irrigation scheduling and fertilization planning, can be summarized as follow: Computing the daily water depletion and then calculate the required net irrigation when the threshold of soil water content is reached. Several levels of soil water content thresholds for irrigation triggering can be allowed in function of the irrigation strategies adopted.

Regarding to the fertilization, the reasoning of NPK fertilisation will be based on soil fertility crop extractions.

T3.3 Development of BigData algorithms for irrigation and fertilization services for decision support of precision irrigation and fertilization.

This task aims to design and implement Big Data/DeepLearning/optimization algorithms for irrigation and fertilization services of decision support. It considers the irrigation and fertilization models designed in T 3.2 and provide dedicated analytic interfaces for end-users (e.g. timing and amount of irrigation according to weather forecast, irrigation system constraints, etc.). ODIN will integrate the measurements collected in the platform developed in T3.1 and the models presented in T3.2, to provide the information needed for fertigation management.

In parallel, OPTIM is developing a second approach for fertigation management based on the latest developments in machine learning and neural networks. Regarding this aspect, several studies have noted the relevance of soil moisture prediction in irrigation environments.

The prediction soil moisture might capture possible ground-water variations otherwise difficult to capture, thus avoiding inefficient irrigation decisions

A typical scenario of irrigation prediction involves three main steps:

1- Collection of Weather and Soil Data
2- These data help predict in the second step, the soil moisture
3- So that in the 3rd step, we predict the irrigation requirements

This way, a Machine Learning model for soil moisture prediction is proposed, which can be used to efficiently to manage irrigation scheduling. Furthermore, soil moisture prediction is a time-series forecasting problem, meaning that there is time-dependency between observations of soil moisture. However, past studies dealing with soil moisture prediction largely used feed forward type of Artificial Neural Networks (ANN), which ignores the temporal-dependency nature of time series data. Contrastingly, Recurrent Neural Networks are a special type of ANNs which have the ability to store neurons' outputs between different timesteps, making them more suitable for time series processing. This particularity of RNNs lead to its adoption in some soil moisture prediction studies. In the case of OPTIM, the suitability of hybrid CNN-LSTM model for time-series soil moisture forecasting is being investigated.

Then, a traditional LSTM model in several preliminary experiments to determine ideal values of aggregation period and number of time steps was used. Moreover, we developed two other variants of LSTM, namely Bi-LSTM and CNN-LSTM, to assess their performances. Each model achieved significant results with Mean Absolute Errors.

Furthermore, CNN-LSTM and Bi-LSTM proved to be more robust than classic LSTM on unseen data. Although OPTIM has designed an efficient and generalizable soil-moisture prediction model, additional datasets may be needed to further validate the model's generalization ability.

To further start this task and to investigate to this topic, OPTIM prepared a peer review conference paper:

- Malek Frej, Rima Grati, Khouloud Boukadi (OPTIM). Acceptation of conference paper indexed SCOPUS, DBLP and Springerlink (18th International Conference on Information Technology - New Generations (ITNG 2021)) entitled "CropWaterNeed: A Machine learning approach for Smart Agriculture"

In addition to that, OPTIM has submitted a journal paper (under review) in a peer review journal:

- Bamoray, Rima Grati, Bassem Bouaziz, Khouloud Boukadi and Faiez Gargouri, Machine Learning-Based Irrigation Scheduling in A special issue of Agronomy, "Applications of Deep Learning in Smart Agriculture"
- Malek Frej, Rima Grati, Khouloud Boukadi, "Plant disease prediction using Deep Learning: A systematic literature review" in Applied Intelligence

OPTIM has submitted a conference paper (under review) in a peer review conference:

- Emna Ben Abdallah, Malek Fraj, Rima Grati and Khouloud Boukadi: "Machine learning based approach for smart irrigation via stacking" in ICSOC conference (Ranked A)

1.2.4 WP4 Validation and Demo of Decision Support System

The aim of WP4 is to test the PRECIMED performance in field conditions, evaluating its performance and versatility under different agricultural conditions and detection of potential aspects that could be improved in order to increase the irrigation accuracy.

The WP Leader is OPTIM. This WP started on M13.

T4.1 Deployment and validation of the DSS system in the different agricultural exploitation.

In the frame of T4.1, during the first year of the project, UTH deployed the sensor system in one of the two pilot farms (UTH-pilot farm) and started collecting data in a greenhouse with tomato plants. The data will be used for the validation of the DSS, as soon as the relevant methodology and set of equations and algorithms is finalized (in the frame of T3.3) and included in the DSS. The collection of data at UTH-pilot farm continued also during the second year of the project. The data will be used to evaluate two scenarios: the water and nutrients used by a conventional management practice (as will be shown by the collected data) and the water and nutrients consumption if the management strategy proposed by the DSS was followed.

Nevertheless, to evaluate and validate the DSS in practice, experiments will be carried out during the third year of the project. These experiments started in Agroktima Kalliantzis-pilot farm with a cucumber crop from M25 and will continue until M35. In addition, the DSS will be also validated in UTH-pilot farm in a tomato crop from M28 to M36. For the validation and test of the DSS in the two pilot farms, two treatments will be applied: 1) a conventional fertigation strategy where irrigation scheduling will be performed as commonly done in the region and the fertilisation recipe changes two to three times during the cultivation period, according to the growth stage of the crop, and 2) the fertigation management will be based on the PRECIMED DSS where the irrigation scheduling and the fertilisation recipe will change per day (for irrigation scheduling) or week (for the recipe) according to the predictions of crop needs from the PRECIMED system approach.

Besides, the information provided by the sensors and weather station deployed in both Jumilla and CEBAS-CSIC experimental field are being collected for the validation of the DSS. Continuous climatic data and soil water content by the use of Diviner 2000 is collected in Algeria and it will be also used for the validation of the DSS on irrigation scheduling, However, INRAA noted some problems related to the climatic data reliability collected at farm 2 (potato farm) what incurs in the need of fix the equipment as soon as possible.

OPTIM proposed to use the climatic data collected at the pilot farms to simulate the soil water content using the big date technique and consequently the development of an irrigation scheduling. This way can be seen as a second approach for irrigation scheduling.

The deliverable "D4.2 Identification of different irrigation managements strategies on crop physiology and nutritional value of fruits" has been documented/developed, describing the physiological response of the species of interest of this project to different irrigation strategies in order to evaluate the agronomic performances of a given irrigation strategy.

T4.2 Demo and evaluation of the DSS performance in agricultural farm according to plant physiology parameters and crop nutrient status in open air crops and horticultural crops under greenhouse conditions

Once deployment and validation of the DSS system in the different agricultural exploitations have been done, task 4.2 will be carried out. This task should have started in month 18. However, COVID restrictions have led to a delay in the application of the system in practice that is carried out in the T4.2 task.

1.2.5 WP5 Communication, Dissemination and Exploitation

The aim of WP5 is to increase the impact of the project through the wide dissemination of project outcomes. Communication activities will also actively support the involvement of end-users in particular for iterative design and development process and business model formulation.

The WP Leader is INRAA.

T5.1 Communication and Dissemination activities

During the project evolution, different communication and dissemination actions have been carried out:

- Design of the logo of the project (INRAA)
- Design, development and update of the official website for the PRECIMED project (INRAA). In the first time, the official registration was made as the subdomain name: https://www.precimed.inraa.dz, nevertheless the consortium agreed to change this subdomain to https://www.precimed-prima.org. The main information included are: Presentation of the project, Workplan, Public deliverables, Scientific Publications and Some scientific activities related to the field experiments. In October 2021 the website is visited by 4785 visitors.
- Create a social media and update (Facebook and Twitter) (UTH). Some important activities associated to the project experimental devices were published by the consortium like: Measurement Devices of plant water stress (CSIC), Soil water content measurements and automatic weather station to collect climatic Data (INRAA), Microclimate station to monitor the climatic and the water status of crop and Hydroponic system developed by UTH. Facebook page reached 3,067 from 1 January to 24 October 2021.
- Create a Forum (LinkedIn) (UTH). The statistic showed 42 subscribers.
- Leaflet for the Project (UTH).
- 2 Newsletters for the Project in 2020 (UTH)
- Workshops
- Preparation of Dissemination material in French and English
    - ✓ 12 banners and 2000 leaflets developed by UTH ready to be distributed
- Participation to the national Day of the extension by the presentation of:

- ✓ The project leaflet.
- ✓ Poster titled "Precise Irrigation Using ICTs"

Other dissemination activities:

- Juan Antonio Martínez Navarro (ODIN) has been invited as Guest Editor for a Special Issue entitled "Digital Transformation in the Agriculture Sector" in an open access journal "Electronics" (ISSN 2079-9292; CODEN: ELECGJ, IF 2.412).
- Juan José Alarcón (CEBAS-CSIC). Case Study: PRECIMED Project. PRIMA Conference (Partnership for Research & Innovation in the Mediterranean Area), CSIC. 24 January 2019. Madrid (Spain).
- María Fernanda Ortuño (CEBAS-CSIC). Case Study: PRECIMED Project. PRIMA Conference (Partnership for Research & Innovation in the Mediterranean Area), UPCT. 12 February 2020. UPCT, Cartagena, Murcia (Spain).

In the frame of these tasks, two deliverables were delivered during the first year:

- D5.1 Communication and Dissemination Plan. This deliverable focuses on the development of a dissemination strategy, including the design and production of necessary material, the development of communication tools (logo, website, social media, brochures, newsletters, leaflets, posters and banners) and the organization and implementation of various communication activities (main events) (UTH).
- D5.2 Data Management Plan. This deliverable focuses on how to manage the data and information developed during the project, in order to describe all procedures for keeping and disseminating PRECIMED results (CSIC)

T5.2 Exploitation and IPR management of the project's results

In the frame of tasks T5.1 and T5.2, the deliverable D.5.3 was presented on M22, after the extension of its delivery date was accepted. This deliverable defines some key terms and explains what can be achieved concerning the dissemination and exploitation of results during the project and presents the design and production of the necessary material, the development of communication tools and the organization and implementation of various communication activities (UTH).

T5.3 Sustainability Plan

Under this task, an intermediate sustainability plan was generated (D5.4). This plan describes the activities aiming to increase awareness of the stakeholders on the project and its activities focused on the development of a Decision Support System (DSS) to improve the efficient use of water, nutrients and energy (INRAA).

1.3 Impact

The main impact foreseen by PRECIMED is to improve the farm productivity through the reduction of costs and the increase of the crop yield with a solution that minimizes the environmental impact due to the sustainable use of resources (water, fertilizers and energy consumption) and reduce the laborious human tasks while feasible business models are generated for the different farming scenarios.

At midterm report of the project, there are no defined indicators to analyse the impact of the project. The impact will be analysed at the end of the project as set out in the proposal. Nevertheless, it could be noted that the consortium is interacting with the relevant stakeholders from the very beginning in order to aid in the Digital Transformation of the European Agri-Food Sector based on the rapid adoption of advanced IoT technologies, data science and smart irrigation. The farm digitalisation started already in the pilot farms where sensors and IoT devices are installed to transfer in real time data to PRECIMED platform so that the process of data analysis and decision support are effectively developed. In this way PRECIMED will impact a range of stakeholder groups

along the agro-food ecosystem: farmers, businesses, citizens/society, public authorities and external communities.

In the frame of PRECIMED, 7 pilot farms have already been deployed and 9 stakeholders are engaged. In addition, 10 direct employments have taken place already.

In relation to the project communication, the project social media networks and project website are increasing the number of followers and visitors, as more activities are being developed and consequently disseminated to reach the different target groups.

2. Update of the plan for exploitation and dissemination of result (if applicable)

Due to the pandemic, research and innovation projects has been forced to increase their visibility and dissemination via internet. As already mentioned above, PRECIMED project has already several communications channels running, as the project website and the different social networks. In this sense, the communication plan (D5.1) was updated by adding some new aspects related to the actively participation in the dissemination of the results of the project and in the structure to follow of the posts on social network to increase the impact of our activities.

The preliminary Plan for Dissemination and Exploitation of results (D5.3) was delayed in order to consider another alternative Dissemination and Exploitation plan, taking into account the restrictions imposed by the COVID-19 pandemic and the measures taken for its control. So, the public events planned, as organizing workshops, presentation of the results at Conferences, Open Day and a Final Conference, have been changed. In fact, the virtual meetings or online exhibitions are retained for organizing these events.

3. Update of the data management plan (if applicable)

During these first two years of the project, no cases have been identified that are subject to changes in the management plan.

4. Follow-up of recommendations and comments from previous review(s) (if applicable)

On 23 November 2021 was held the Mid-Term Evaluation Meeting, in which PRIMA Project Officer, an independent expert evaluator, the project coordinator (PC), the Work Package leaders and the representatives of the PRIMA National Funding Agencies participated.

During the mid-term meeting PC delivered a short presentation highlighting the most significant advancements/achievements of the project, the constraints faced, and any other aspects concerning the development of the project. Then there was a discussion period, in which the expert evaluator shared comments, suggestions, and questions on the implementation and the scientific aspects of the project. However, to date, we have not yet received the final version of the midterm evaluation report.

Among the comments received and recommendations to be taken into account are related to the tasks of commercialization of the solution resulting from the project. Due to the COVID pandemic, testing activities with farmers and potential users of the platform have been delayed, so it is required to focus on this issue in the coming months in order to validate the DSS as soon as possible. This will verify the usability of the product or if changes or improvements are needed. In addition, it was emphasized at the meeting that it is necessary to give value to the novelty of the solution and the innovation that is intrinsic to it.

The consortium noted that it is continuing with the solution and the activity approved in the project.

5. Deviations from the proposal submitted (if applicable)

Some partners have exposed some deliverables should be delayed and other changes from the proposal.

5.1 Tasks

The organization and coordination of other aspects of PRECIMED project that unexpectedly required priority caused a delay in the delivery of the D1.1, D1.2, D5.1 and D5.2 deliverables. However, this delay did not disturb the overall pace of the project employment. In the same way, there were some deviations due to COVID-19 pandemic, what incurred a delay of some deliverables. Deliverables D2.1, 3.2 and 5.3, already exposed above, were requested for extension and approved following the procedure and as it was mentioned all of them were presented on time on their new date.

PRECIMED consortium requested no-cost extension of the project for six months until 31/03/2023 due to the impact of the coronavirus pandemic.

The consortium decided that in order to achieve the project's objective in a satisfactory way, this requested 6-month extension would be necessary. All partners support the proposed extension.

There are some situations or tasks that are impacting the timing of the project over the end date:

- Partners agencies delay. The elegilibility of costs from UTH started 4 months later the beginning of the project. This means that UTH will need at least 4 months of extension of the project in order to have the time to use the budget as planned.
- COVID restrictions. Due to COVID restrictions, the interactions with the farmers, needed to carry out task 2.3, have been postponed. In addition, restrictions have led to a delay in the application of the system in practice that is carried out in the tasks of WP4.
- Material stockpiling and successful implementation. There have been delays in the purchase of materials necessary for the execution of tasks 3.3. and 4.1.

As a consequence of these alternations, the work packages WP1 "Project Management" and WP5 "Dissemination" are extended for a correct coordination and overall coherence of the project.

For all of the above, tasks delayed beyond the end of the project are the following: T2.3, T3.1, T3.3, T4.1, T4.2, T4.3 and those corresponding to WP1 and WP5.

In the Mid-term Evaluation Meeting the extension of the project was approved by the National Funding Agencies of PRECIMED partners.

5.2 Use of resources

Deviations on the pilot farms:

- The farming scenario 4 will be tested in UTH pilot greenhouse instead in the greenhouse described in the proposal since it is not operational anymore.
- INRAA change in their pilot farm 2, adding a glass greenhouse dedicated to the hydroponic production of potato seeds. However, the greenhouses are currently weakly equipped and the different devices as heating and cooling systems or the fertigation equipment need to be fixed and completed.
- CSIC has changed the crops that were indicated in the initial proposal. At present, pomegranate and pear trees will be worked on in the field.

- OPTIM have had to discard the proposed pilot farm, as it was located in a lockdown region (due to COVID-19). The current pilot operates on 12 hectares with irrigated olives, almonds, nectarine and peach.

Other deviations:

- Due to the pandemic, the annual consortium meeting scheduled to take place in Algeria was held virtually on October 26, 2021.