Innovative and Sustainable Groundwater Management in the Mediterranean

D1.2 SECOND TECHNICAL REPORT

PART B

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Glossary

BU	Boğaziçi Üniversitesi,
CERTE	Centre de Recherches et des Technologies des Eaux,
CDP	Communication and Dissemination Plan,
D	Deliverable,
DMP	Data Management Plan,
DSS	Decision Support System,
EGU	European Geosciences Union
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (The German Agency for International Cooperation),
GUI	Graphical User Interface,
FIS	Fuzzy Inference System,
HRMS	High-Resolution Monitoring Sensors
IST-ID	Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento,
MED	Mediterranean,
RCP	Representative Concentration Pathway,
SWOT	Strengths, Weaknesses, Opportunities and Threats,
TUC	Technical University of Crete,
UFZ	Helmholtz-Zentrum für Umweltforschung,
UNIPR	Università degli Studi di Parma,
UPV	Universitat Politècnica de València,
WP	Work Package.

Executive Summary

The overall objective of the InTheMED project is to implement innovative and sustainable management tools and remediation strategies for MED aquifers (inland and coastal) in order to mitigate anthropogenic and climate-change threats by creating new long-lasting spaces of social learning among different interdependent stakeholders, NGOs, and scientific researchers in five field case studies. These are located at the two shores of the MED basin, namely in Spain, Greece, Portugal, Tunisia, and Turkey.

InTheMED will develop an inclusive process that will establish an ensemble of innovative assessment and management tools and methodologies including a high-resolution monitoring approach, smart modelling, a socio-economic assessment, web-based decision support systems (DSS) and new configurations for governance to validate efficient and sustainable integrated groundwater management in the MED considering both the quantitative and qualitative aspects.

The second technical report contains the description of the work progress carried out by the seven scientific teams from Portugal, Spain, Germany, Italy, Tunisia, Greece and Turkey, for the second half of the project, from September 2021 to February 2023. Furthermore, this document analyses the objectives of the project and the degree of fulfilment of each of them and revises the expected impacts, the Exploitation and Dissemination Plan and The Data Management Plan. A third technical report will be written to summarize the work done throughout the whole implementation of the InTheMED project.

1. Explanation of the Work Carried Out by the Beneficiaries and Overview of the Progress

The second technical report details the work completed by the seven scientific teams that form InTheMED from September 1, 2021 to February 28, 2023. The specific objectives and the degree of fulfilment of each of them are analysed, the work carried out for each WP is described and the interconnection between the different teams is displayed. Tables 1 and 2 summarize the deliverables and milestones completed during the current reporting period.

Table 1. List of completed deliverables in the second reporting period

Code	Deliverable Name	WP	Submission date
D1.3	Annual Meeting 2022	1	2022/09/30
D1.4	Data Management Plan v2	1	2022/03/31
D2.2	Report on the existing of historical groundwater data on the MED region	2	2022/08/22
D3.2	Report on surrogate models in the case studies	3	2022/05/31
D3.3	Data Archive containing the downscaled climate projections in the case studies	3	2022/10/25
D4.1	Report on the social-economic system characterisation, stakeholder mapping and water governance for selected case studies	4	2021/09/21
D4.2	Report on the participatory systems mapping and the conceptual model	4	2022/03/31
D4.3	Report on the numeric simulation model including model input files	4	2022/11/28
D5.2	Report on the procedure for the capacity building and the selection of the main hot spots	5	2022/08/29
D5.3a	Report on the appropriate innovative remediation process developed	5	2023/02/21
D6.1	Report on the development of the innovative DSS tool	6	2022/03/28
D6.2	Report on the results of the DSS for the case study sites	6	2023/03/02
D7.3	Report on synergies with groundwater initiatives in the Euro-MED region	7	2022/09/28
D7.4	Report on mid-term workshop	7	2022/03/31

Table 2. List of completed milestones in the second reporting period

Code	Milestone Name	WP
M2.1	Knowledge exchange about each aquifer and main groundwater issues, existing datasets and further needed monitoring in each case studies drafted	2
M2.2	Review of existing groundwater data in the MED region conducted	2
M2.3	First draft of groundwater trend analyses performed	2
M3.2	Evaluation of the performance of the surrogate models implemented in the study case	3
M3.3	Development of a web repository with the results of the climate change evaluation	3
M4.1	First Living Lab guiding problem identification and system characterization	4

M4.2	Second Living Lab scrutinizing and refining the conceptual model	4
M4.3	Development of the numerical model	4
M5.2	Review of the procedure for the capacity building of hot spots and stakeholders	5
M5.3a	First draft of the innovative remediation strategies performed	5
M6.1	Initial DSS algorithm at an operational level	6
M6.2	Preliminary results of the DSS for the case study sites	6
M6.3	First draft of the Atlas of maps	6
M7.3	Synergies with other initiatives in the Euro-MED region identified and in place	7
M7.4	Mid-term report drafted	7

1.1. Objectives

Pillar 1: Strengthening the Understanding of Groundwater Functioning and Trends

OBJ-P1-1 Identification of the Most Important Groundwater Problems in the MED Region

Surveys were conducted for all five case studies to define problems and acquire information on leading issues, hotspots and existing remediation strategies. Additionally, interviews and workshops were held with key stakeholders to build consensus around the conclusions drawn. The major problems identified revolve around the overexploitation of aquifers and anthropogenic pressure, which cause groundwater level decrease (Requena-Utiel, Grombalia, Konya), groundwater contamination (Grombalia, Castro-Verde, Tympaki) and saltwater intrusion (Tympaki). Furthermore, a database of over 9,500 piezometers from Greece, Italy, Portugal, Spain, France, Tunisia and Turkey has been developed. From a regional perspective, in most cases, monitoring wells show no significant changes in groundwater levels. However, there are hotspots of depletion, especially around irrigation areas that require attention and could benefit from the insights and tools developed by InTheMED.

OBJ-P1-2 Investigation of the Long-Term Groundwater Trends

Data from Greece, Italy, Portugal, Spain, France, Tunisia and Turkey were collected and processed. Trends have been analysed for Italy and Turkey to further investigate the trends and controlling factors at a regional scale. For Spain, Portugal and Italy, longer time series have been used to characterize the most common groundwater level development in the region. Controlling factors such as precipitation patterns, hydrogeology, proximity to irrigation and urban areas have been studied for the different development patterns. Results suggest that

precipitation is the main controlling factor for those wells with no significant trends, while irrigation is the most common in wells where significant changes happen.

A meta-analysis of current research funding and outcomes has been performed to reinforce the systematic monitoring and data sharing of the MED region. Overall, it was found that after 2008 there is more funding for scientific research related to water issues in the Mediterranean. Up to 3,500 research articles deal with groundwater with topics like groundwater pollution, coastal aquifer management and climate change models.

OBJ-P1-3 Application and Taking Benefits of the Innovative High-Resolution Monitoring Approach (HRMA: Allowing Near Real-Time Monitoring) at the Five Case Studies

Three In-situ AquaTROLL-500 High-Resolution Monitoring sensors (HRMS) were installed in Grombalia (Tunisia). These sensors measure temperature, nitrate and water depth and offer real-time readings visualised on an online synchronised remote platform managed by the supplier. The data they collect is of high quality and frequency, enabling the identification of fleeting events that may go undetected by conventional monitoring systems with lower frequency. In 2019, State Hydraulic Works in Turkey set up HRMS in 122 groundwater observation wells in Konya Closed Basin. The data from those sensors have been used to calibrate the hydrogeological model of the Konya Closed Basin. Installing HRMS in Requena-Utiel (Spain) was not possible because of the chosen sites' degradation and difficulties accessing them (private land); as a counterpart, the Spanish Water Authority, in its recent Action Plan for Groundwater, has devoted a substantial budget to modernise the current observation network, and in Castro-Verde (Portugal) due to the lack of communication with the owner of the mining site.

The preliminary geostatistical electrical resistivity inversion method developed in the first half of the project was applied to the data set from Castro Verde (Portugal). Besides, the geostatistical modelling of Tympaki (Greece) was performed jointly by IST-ID and TUC teams by applying a novel geo-modelling methodology based on geostatistical simulation and Bayesian model averaging. Also, preliminary tests of geophysical inversion with deep learning (i.e., variational auto-encoders) were performed in Castro Verde (Portugal). These activities were not originally planned. UNIPR and IST-ID teams are developing geophysical monitoring for complex groundwater systems in a pilot case using a sandbox.

Pillar 2: Improvement of Groundwater Resilience and Security in a Social Learning Process

OBJ-P2-1 Incorporating Groundwater Management Within a Broader Socio-Economic Context to Improve Water Resources Resilience Through Stakeholder Workshops and Dynamic Simulation Modelling

Two participatory modelling workshops were organized for Konya (Turkey) on September 30, 2021, and February 17, 2022, adopting the group model building approach. Subsequently, the researchers developed the seed model generated in the workshops. The model aims to simulate the behaviour of key variables within the socio-economic system over time and analyse their response to potential agricultural and groundwater-related policies and environmental scenarios.

OBJ-P2-2 Raising Awareness in Society and Among Concerned Stakeholders to Improve Groundwater Management Through the Implementation of a Multi-Actor Participatory Approach in the Selected Case Studies in the MED Region

The BU team organized two workshops in Konya (Turkey) on September 30, 2021, and February 17, 2022, to bring various stakeholder groups together to discuss groundwater-related issues and potential leverage points in the system to improve groundwater management. The UPV team, in cooperation with the PRIMA project eGROUNDWATER, organized a Living Lab in Requena-Utiel (Spain) on March 4, 2022, with local stakeholders to analyse groundwater unsustainability in the region and brainstorm possible measures, technological needs, and the design of tools.

OBJ-P2-3 Identification of Groundwater Problems and Implementation of the Appropriate Feasible Preventive Mitigation Options Through Sustainable Learning Processes

The first part of this objective intersects with OBJ-P1-1. The surveys mentioned above allowed us to know the main water users and contaminants and evaluate the remediation strategies. In Grombalia (Tunisia), those main users have been asked to participate in capacity-building and technical training sessions for sustainable integrated water management. These meetings aim to raise stakeholder understanding of the anthropogenic pressure caused by their activities and to look for various potential remedies. They served as a roundtable to discuss and present the feasible preventive mitigation options and viable remediation solutions by the project teams.

In Grombalia (Tunisia), the electrochemical treatment technologies, mainly advanced oxidation processes (AOPs), have been developed and optimised at laboratory scale for the textile industry. In Castro Verde (Portugal), the IST-ID team has proposed to strengthen the groundwater's quantitative and qualitative real-time monitoring network and implement new treatment technologies in the mining industry. In Requena-Utiel (Spain), the UPV team has developed an innovative smart model to support stakeholders and managers in assessing the impact of groundwater extraction in a climate change context and recommended reducing pumping and pushing for the modernisation of groundwater control networks. In Tympaki (Greece), the TUC team has proposed an optimized pumping scheme to maintain the water table at a level that could repel the saltwater intrusion front. In Konya (Turkey), the BU team continues to organise a series of living lab sessions to work on the relationship between groundwater supply and demand and is developing a seed model that will reveal the long-term outcomes of proposed policy scenarios.

Pillar 3: Development of Sustainable Management and Remediation Strategies

OBJ-P3-1 Establishment of Adaptable and Sustainable Management Strategies Through the Combination of HRMA, Tailored Model Results, Socio-Economic Assessments, Bottom-Up Management and Remediation Strategies, an Innovative Fuzzy WebDSS Tool, and Effective Communication Dissemination Strategies

HRMS in the coastal aquifer of Grombalia (Tunisia) are employed to enhance the low frequency of the existing aquifer monitoring network, improve the current database with accurate daily data, and identify hotspots requiring immediate intervention. Indeed, the data collected from November 2021 until today has allowed us to detect the drying up of a monitoring well and to identify a significant drawdown of the water table accompanied by a deterioration of its quality. These data have been shared with the local authority to help them make the right decisions in response to the problems identified (WP2). Smart and simplified models for the five case studies aimed to help with management strategies were developed (WP3). A dynamic simulation model was built for the scenario-based socio-economic assessment of management strategies with stakeholder involvement for Konya (Turkey). This model is aimed to serve as a learning environment when used for policy analysis with large stakeholder participation (WP4). Bottom-up remediation strategies are being developed in Tunisia for industrial activities based on multi-criteria decision analysis (WP5). The DSS tool is under development and will enable

the visualization of the results for each scenario and the comparison of the results among alternative scenarios. The term “scenario” refers to a set of user-defined input variables and is related to the climatic conditions, land uses, and applied pumping rates. Therefore, it will contribute to better communication of the results to the broader audience (WP6). The communication and dissemination plan ensures that all activities are documented and shared with relevant stakeholders through virtual brochures, posters, and factsheets, peer-reviewed papers, and oral presentations in conferences, webpages, and social media (WP7).

OBJ-P3-2 Prediction of the Effects of Future Climate and Anthropogenic Changes, and How They Can Be Mitigated by Stakeholder-Suggested Preventive Options Using Smart Modelling

A data archive containing the future climate projections at the case study scale was developed to be used as input to the smart model to assess the effect of climate change on the groundwater resource. Moreover, the dynamic simulation model for Konya (Turkey) helps analyse the behaviour of key system variables under various environmental scenarios and policy options in the medium term. Preventive options could be applied by sensitising stakeholders to the need to strengthen the state's efforts to properly manage local water resources and by supporting them technically in the implementation of proposed remediation strategies.

OBJ-P3-3 Advice to the Most Polluting Industries at Selected Sites to Reduce Their Discharge Loads Through the Adoption of a Local Water Management Concept and the Implementation of the Best Available Technologies in the Market for the Appropriate Treatment of their Effluents

Two proposals are suggested to reduce the polluting load of industrial activity. 1) Introduce electrochemical treatment technology in polluting activities such as the textile industries that could remove a large amount of organic matter and reduce the concentrations of inorganic elements to reduce the discharge of polluted waste, introduce eaters in water receptor media and propose innovative treatment fitting with reuse standards. 2) Strengthen the qualitative and quantitative monitoring network of the supplied and discharged water by introducing HRMS tools in groundwater quality assessment in straight collaboration with public institutions (CRDA) and sharing with them in situ data (temperature, nitrate and piezometry).

Pillar 4: Reinforcement of the DSS, Communication and Dissemination Activities

OBJ-P4-1 Development of an Innovative and Easy-to-Use Fuzzy WebDSS tool Benefiting from the Real-Time Measured Data Using Specific Sensors and Modelling Results to Reinforce Early-Warning and Ensure the Real-Time Groundwater Characterization and Optimal Decision Making

Currently, a Graphical User Interface (GUI) is being developed for the smart models of the case studies. The goal is to provide end-users with 0a way to easily query the smart model and visualize the results according to the input parameters of their choice. Additionally, in one split screen, the end-users will have a comparison option between two scenarios (e.g., current and future conditions) for the same case study site. For these two user-defined scenarios, the results of the piezometric heads will be assessed through a fuzzy rule to indicate the most affected areas based on the user's inputs and sort these areas into classes of significant variation of groundwater level, medium variation of groundwater level and low variation of groundwater level. Once finalized, the tools will be available through the InTheMED website as a Fuzzy WebDSS tool.

OBJ-P4-2 Promotion of InTheMED Results and Improvement of its Regional and International Visibility Through the Participation in High Level International Conferences, Reinforcement of Open Data Access – Opting in the Pilot Open Research Data in Horizon 2020 – and Integration of Different Initiatives Targeting the MED Region.

The results of the project were disseminated and communicated in different forms. Seven peer-reviewed papers were published in international journals and 35 oral communications at several international conferences were delivered. We held several living labs in the field with relevant stakeholders and participated in 10+ workshops, exhibitions and information days in events related to sustainable groundwater management. We continue our efforts to link with other MED initiatives. One example of disseminating the results obtained under the project's scope was the participation of the UPV team as the InTheMED Project Coordinator in the workshop 'Groundwater: facing a common challenge 2022' promoted by CETAQUA - Water Technology Centre. This webinar is the result of a joint venture of several PRIMA projects: GOTHAM, RESERVOIR, eGROUNDWATER and InTheMED. The methods already developed under the scope of the project were shared with the community through their upload under FAIR principles into the project data repository at the ZENODO platform[1].

[1] https://zenodo.org/communities/inthemed/

InTheMED promoted the webinar 'Groundwater: facing a common challenge 2022' between several PRIMA Projects and we are holding an EGU 2023 session ('EGU session - HS8.1.9, Sustainable Groundwater Management in Water Stressed Regions') dedicated to sustainable groundwater management focused on the results of the project.

Regarding the development of remediation strategies (WP5), it is intended that the upscaling task will work in consonance with ongoing projects at Grombalia, particularly the A-Reset project (help for water sector reforms in Tunisia), which is being carried out with the technical assistance of the German Agency for International Cooperation (GIZ) and was developed by the Tunisian Ministry of Agriculture. The industrial sector of the Grombalia river basin is assisted under this project's framework to improve integrated and sustainable water resource management. The InTheMED project team contributes to reinforcing and supporting the project's efforts.

1.2. Explanation of the Work Carried per WP

1.2.1. WP1: Innovative Project Management

The UPV team, being the Project Coordinator and WP1 leader, continues to carry out the tasks to promote active and efficient participation and communication with all project participants. This team is in charge of reviewing all deliverables and ensuring their consistency and compliance with the InTheMED design format and the provisions of the DMP. The second version of the DMP has been delivered (more details about it can be found in section 3). Each team has contributed to the smooth execution and management of the project at the national level in its financial, administrative, and scientific aspects, which supported the integral management of the project.

In addition to the frequent virtual meetings, the following main meetings were held in person:

- InTheMED Midterm meeting: March 22nd – 24th, 2022, in Valencia (Spain).
- Second InTheMED Annual Meeting: September 12th and 13th, 2022, in Chania (Greece).

1.2.2. WP2: Innovative Monitoring and Data Analysis in the MED

The UFZ team, WP2 leader, completed Task 2.2. The UFZ team reviewed and collected groundwater data from the MED region and with help of the UNIPR, BU and TUC teams, the UFZ team obtained and processed data from Italy, Turkey and Greece. Regarding Task 2.3, the UFZ team has analysed trends in groundwater level data to understand the temporal and spatial distribution of significant changes in groundwater storage of MED countries. The UFZ team has also studied the most important drivers behind the different typical behaviours of groundwater level change, linking them to precipitation and irrigation areas. Concerning Task 2.4, The UFZ team reviewed the current state of research regarding groundwater for MED region countries and available funding for research in the area.

Furthermore, the IST-ID team applied the geostatistical geophysical inversion methodology developed in the first half of the project to Castro Verde (Portugal) and, in collaboration with the TUC team, applied the geostatistical methodology combining stochastic sequential simulation and Bayesian model averaging to model the spatial distribution of the saltwater intrusion in the Tympaki Basin (Crete).

1.2.3. WP3: Innovative Smart Modelling in the MED

The UNIPR team, WP3 leader, completed Tasks 3.2 and 3.3 and is carrying out the activities related to Task 3.4. For Task 3.2, specific surrogate models addressing the problems of each pilot site were built. For Grombalia (Tunisia) and Castro Verde (Portugal), the UNIPR team developed a data-driven surrogate model based on long-time historical data. For Requena-Utiel (Spain), the UPV team evaluated the random forest algorithm in a range of problems to support the selection of the smart models to be used in the study cases. The Spanish team reviewed the numerical model of the Requena-Utiel aquifer and built and validated its smart model. For Tympaki (Greece), the TUC team implemented a space-time regression Kriging method to establish a surrogate model for the numerical simulation model. For Konya Closed Basin (Turkey), the UNIPR team implemented a surrogate model using an artificial neural network based on the complete numerical model developed and calibrated by the BU Team that simulates one-dimensional water flow through the vadose zone as well as the groundwater flow through the aquifer system. For Task 3.3, the UNIPR team developed a data archive containing the future climate data downscaled and corrected at the case-study scale.

The future projections obtained from an ensemble of EURO-CORDEX climate models under two emission scenarios (RCP4.5 and RCP8.5) were provided.

Additionally, and apart from the objectives of the WP3 indicated in the proposal, the IST-ID team developed a deep-learning method to act as a proxy of a full geostatistical geophysical inversion. The technique combines deep variational autoencoders with stochastic optimization algorithms. The method has been applied to a synthetic case study.

1.2.4. WP4: Innovative Governance and Socio-Economic Assessment in the MED

The BU team, WP4 leader, completed Tasks 4.1, 4.2 and 4.3. The BU team continued to work on the socio-economic assessment of Konya (Turkey) and performed the following activities. The first workshop of the living lab was organized on September 30, 2021, with 26 participants from 14 institutions. It aimed to build trust between the research team and the stakeholders and to build consensus on the problem definition. The second workshop of the living lab was organized on February 17, 2022, with 20 participants from 10 institutions. This workshop's objective was to build a seed model to be used as a basis for the socio-economic assessment. Additionally, the UPV team continued interviewing stakeholders, reaching six Irrigation Communities, two municipalities, an industrial groundwater user (bottling company) and an individual groundwater user (winery) and updated the document D4.1 Stakeholders Questionnaire: Requena-Utiel Case Study. On March 4, 2022, in collaboration with the Spanish team of the PRIMA eGROUNDWATER project, the Living Lab in Requena was celebrated.

The BU team developed a dynamic simulation model for the Konya aquifer (Turkey), including relevant aspects of the system, as discussed in the workshops. Moreover, a field trip was organized on January 15-18, 2023, to share initial model results with prominent stakeholders in the field and validate the model behaviour. To that end, the research team organized six meetings with selected stakeholders.

1.2.5. WP5: Innovative Remediation Strategies in the MED

The CERTE team, WP5 leader, accomplished Tasks 5.2 and 5.3a. The CERTE team developed water remediation solutions to overcome the pollution problems related to industrial textile activities in Grombalia (Tunisia). Indeed, several sampling campaigns were carried out to analyse the industrial water in the different stages of the process, which allowed to test several

sustainable treatments (electrochemical treatment) alternatives on the textile effluents and to develop a comparative study highlighting the high-performance and advantages of the electrochemical treatment technology compared to the industrial process used in situ. In addition, parallel research studies at laboratory scale were carried out to develop water remediation technologies to remove bio-recalcitrant compounds and toxic compounds residual and antibiotics from wastewater and to promote the safe reuse of treated wastewater. Furthermore, the CERTE elaborated a survey to acquire information regarding the principal and specific problems of the rest of the case studies in Requena-Utiel (Spain), Konya (Turkey), Tympaki (Greece) and Castro-Verde (Portugal). The teams corresponding to each case study, UPV, BU, TUC and IST-ID teams, suggested potential remediation actions to mitigate the previously identified problems.

1.2.6. WP6: Innovative Decision Support Systems in the MED

The TUC team, WP6 leader, is working on the development of the Decision Support System. Regarding its socioeconomic criteria, cost-benefit analyses have been conducted for each case study based on the data provided by the rest of the teams and regarding environmental criteria, the smart models developed in the WP3 are used. The effort is focused on building a GUI based on the compilation of the smart models. Specifically, for the Tympaki aquifer, the piece-wise linear optimization based on the computational flow model has also been conducted for the current situation and climate change scenarios. The results are visualized in maps that will be available to the interested stakeholders.

1.2.7. WP7: Innovative Dissemination and Communication in the MED

The InTheMED website[2] has been frequently updated by the IST-ID team, WP7 leader, and has been the main hub for the InTheMED community to share relevant news about the project. As part of the communication and dissemination activities, the project members have been actively promoting the project and the results already obtained, seven peer-reviewed papers were published in international journals and 35 oral communications at several international conferences were delivered. These efforts included the dissemination of the project through news posted on institutional websites (they can be found on the InTheMED website[2]). The

[2] https://inthemedprima.com/

information from the website is complemented with a fair presence on social media networks: Twitter[3], LinkedIn[4] and Facebook[5]. These platforms are regularly updated with information related to the project. Furthermore, an effort has been made to interact with accounts from other PRIMA projects.

1.3. Impact

The expected impacts as stated in the proposal for all WPs continues to be relevant and all the proposed objectives are expected to be achieved.

2. Update of the Plan for Exploitation and Dissemination of Result

The Communication and Dissemination Plan did not require an update. All the activities related to Exploitation and Dissemination were carried on during the actual reporting period. These activities included the mid-term workshop and the annual project meetings, which were held in a hybrid format (virtual and in-person). Living labs happened in the field with relevant stakeholders. The results were also published as scientific publications and oral communications at international conferences.

3. Update of the Data Management Plan

The second version of the DMP was delivered on March 31, 2022. This updated version answers specific topics that remained unresolved in the first version. It includes an exhaustive description of data collected and produced by InTheMED (summary, type and size), the preferred keywords, a clear explanation of how to make all data openly accessible and a new chapter describing the responsibilities towards data management for the Project Coordinator, each partner team leader and the Dissemination and Communication Leader.

[3] @InTheMED_PRIMA
[4] https://www.linkedin.com/in/inthemed-prima-5690461ba/
[5] https://www.facebook.com/inthemedPRIMA

4. Follow-up of Recommendations and Comments from Previous Review

After the first technical report review and following the insights and recommendations of the external evaluator, various deliverables were revised and reuploaded to the repositories.

D1.4 Data Management Plan

The second version of the DMP exposes more clearly the open accessibility of the data used and generated by InTheMED, emphasising that the data provided by the Turkish government can only be used for the purposes of the project and not be shared.

D2.1 Report on the Integrated and Innovative High-Resolution Monitoring Strategies in the Different Case Studies

Due to the situation induced by the SARS-CoV-2 pandemic, changes were made in relation to the initial proposal and these are exposed in the second version of this document. Given the difficulties in finding suitable locations to install HRM devices in Castro Verde (Portugal), it has been decided to shift to geophysical data to characterize the site. Geophysical data will be used only in the Portuguese and Greek case studies. Also, in the Spanish site, there has been a shift from the installation of new devices to taking advantage of the renewal of the existing Spanish monitoring network.

D3.1 Identification of the Surrogate Models to be Applied in the Case Studies

To respond to the comments of the review, the benefits of surrogate modelling compared to numerical models and their applicability, the data used to generate the models, and the different types of surrogate modelling were included.

D4.1 Report on the Social-Economic System Characterisation, Stakeholder Mapping and Water Governance for Selected Case Studies

The response document to the review of the first technical report answers the questions that arose about this task. It was clarified that the tasks of WP4 will only be performed in the case studies of Turkey, Spain and Tunisia, as reported in the proposal and that only the first step of the social-economic characterization will be carried out in Spain and Tunisia, given the complexity of such characterization, led by the BU team, and the need to interact personally, in their own language with the stakeholders involved. It was also indicated that a survey was

performed in Spain, a report of which is in the Zenodo repository (although with restricted access).

D5.1 Report on Site Characterization and Hot Spot Identification

The second version of deliverable 5.1 includes a clear definition of the concept adopted for hotspot and a more thorough SWOT analysis was redacted for all the case studies following the SWOT analysis already provided for the Requena-Utiel (Spain).

5. Deviations from the Proposal Submitted

After receiving a positive midterm evaluation and the approval of the first periodic report, InTheMED was granted an extension of six months, delaying the final date of the project to August 31, 2023. The revised Gantt chart proposal included in the first technical report was accepted and there have been no substantial delays in the tasks with respect to this schedule.

5.1. Tasks

Task 2.1: Implementation of an Innovative High-Resolution Monitoring

Initially, three HRMS were going to be installed in three abandoned piezometers in Requena-Utiel (Spain). However, the delays induced by the SARS-CoV-2 pandemic, the degradation of the old piezometers together with the difficulties to access them because they are in private land, prevented the installation of the sensors. The lack of these piezometers has not affected the development of the WP3 tasks. The same has happened in Castro Verde (Portugal), it was not possible due to lack of communication with the owner of the mining site where the aquifer is located. Therefore, in Castro Verde only geophysical data was used.

Task 6.2: Results of the DSS for the Case Study Sites Under Future Scenarios

There has been a slight delay in the delivery of D6.2. The current document is the first version obtained for one of the five climate change models being studied for Tympaki (Greece). The results for all five climate change models will be included in the second version, which will be delivered promptly.

Initially, a first attempt was performed to train a Fuzzy Inference System (FIS), which integrates all the involved criteria used in the decision-making process. The training data were the cost-benefit analysis data for the socio-economic assessment and the data results of the groundwater simulation optimization model (environmental criterion). This attempt was not successful even if several alternative approaches were used. In parallel with the FIS system, a second attempt was performed, as an alternative option, to incorporate the fuzzy characteristic in the DSS tool. This approach was the "bound and decomposition method" (Jayalakshmi and Pandian, 2012)[6] in conjunction with the piece-wise linear groundwater optimization approach. The method was applied to the optimization problem set for the environmental criterion, but the results were not encouraging. More specifically, the algorithm could not give a final solution for the problem set. Currently, a new approach is being investigated. As the piezometric head is the primary criterion that is common in the analyses of all the study sites, a fuzzy rule based on obtained simulation results will be set. A new algorithm tool is been developed that can have as input the simulated results of two different scenarios (e.g., current groundwater levels and groundwater levels years later considering climate change scenarios) and by using a fuzzy rule to create a map that classifies the variations of groundwater level as of significant, medium, or low importance. This result is a Fuzzy WebDSS map according to the suggested scenarios that will be shared with stakeholders. Based on that categorization, stakeholders can decide about the kind of measures that they have to take, the areas where these measures must be applied and the time horizon in which to implement them.

5.2. Use of Resources

In the case of the UPV team, since HRMS were not installed, the resources allocated to this task will be assigned to pay the contracted researchers' salaries during the extension of the project.

[6] M.Jayalakshmi, P. Pandian, A New Method for Finding an Optimal Fuzzy Solution for Fully Fuzzy Linear Programming Problems, International Journal of Engineering Research and Applications (IJERA) ISSN: 2248-9622 www.ijera.com Vol. 2, Issue 4, July-August 2012, pp.247-254

The number of person-months committed by each partner team for the second reporting period (from September 2021 to February 2023) is listed in Table 3.

For the UPV team, there was an error in the introduction of the hours worked for WP1 and WP3, so the values shown in Table 3 are the official data but not the actual ones. Correcting this error, WP1 is 12.40 person-months and WP3, 19.05. WP1 has exceeded the staff effort specified in the proposal; since the UPV team is the Project Coordinator, project management has involved more work hours than anticipated. The WP3 exceeds the person-months planned, although it has not implied any additional cost. On the contrary, the staff effort reported for WP2 is lower than planned due to the impossibility of installing the HRMS. For the rest of the WPs, the proposal's provisions are maintained.

For the UFZ team, the work distribution continues as planned. During the second period, the work was focused on WP2 in the analysis of the groundwater data. The reporting responsibilities and dissemination in the form of presentations and posters in conferences are distributed in WP1 and WP7.

For the TUC team, it is expected that by the end of the project, the person-months for WPs 1, 4 and 7 to be as planned, for WPs 2, 3 and 5 to exceed by a small amount and for WP6 to be greater than anticipated. The TUC team is the leader of WP6 and most of the staff is focused on its successful development. Many master students have worked in WP6; therefore, their salary could not exceed a specific threshold set by the Finance Office of TUC based on internal regulations. As a result, this led to higher values of person-month, within the planned budget.

For the IST-ID team, the predicted and actual total person-month is similar. While WPs 1, 2, 3 and 7 exceed the number of planned resources, this fact was compensated by the use of smaller resources in WPs 4, 5 and 6. The increase in resources is due to the extra activities that were not planned in the original proposal (e.g., the geophysical modelling in the Greek aquifer) but are being developed under the scope of the project. The use of fewer resources in WPs 4, 5 and 6 than expected is mainly due to the lack of communication with the owner of the mining site of the Portuguese case study.

For the CERTE Team, the person-months for WPs 2, 3, 4 and 6 did not exceed what was planned, while for WP1 and WP5 it did. The CERTE team is the leader of WP5 and the number

of working hours is higher than anticipated, which is explained by the effort that has been put into ensuring the achievement of its objectives without exceeding the budget allocated for personnel costs.

For the UNIPR and BU teams, there are no deviations between the actual and planned person-months.

Table 3. Summary of staff effort for the second reporting period compared to the proposal (36 months)

		WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total person-month
UPV	Proposal	11.65	4	17	3	1	4	5.23	45.88
	Actual	19.9	2.93	11.55	1.3	0.83	2.87	2.63	42.01
UFZ	Proposal	2.5	15.13	2.5	1	2.5	1.5	3	28.13
	Actual	1.17	8.19	0	0	0	0	2.34	11.7
TUC	Proposal	2.46	3	22.9	1.97	5.97	29.4	5.25	70.95
	Actual	1.39	3.11	8.81	0.20	2.54	22.90	0.52	39.48
UNIPR	Proposal	3.3	4.6	29.2	1.2	1.4	1.0	3.3	44.0
	Actual	1.7	3.1	15.6	1.2	0	1.0	1.5	24.1
IST-ID	Proposal	2.73	15.37	2.82	2.34	5.60	5	11.73	45.49
	Actual	2.00	20.20	5.72	0.50	1.00	1	15.25	45.67
CERTE	Proposal	2.5	5.0	2.0	4.0	30.0	1.5	2	47
	Actual	5.2	1.1	0.3	0	16.1	0	0.7	23.5
BU	Proposal	3	4	21	39	5	4	5	81
	Actual	1.6	2.5	13.5	22.5	2.8	2.3	2.7	47.9