PRIMA

Project proposal (Part II)

Title of Proposal **Strategies for increasing the WATer use efficiency of semi-arid Mediterranean watersheds and agrosilvopastoral systems under climate CHange**
Acronym **SWATCH**

List of participants

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1. Excellence

The Mediterranean regions are subjected to a large variety of climates, ranging from arid to semi-arid with summers characterised by high temperatures and low precipitation (Rana and Katerji, 2000[1]). Recently, for characterizing the climate characteristics of the Mediterranean biome, Deitch et al. (2017[2]) identified nine regions, which differ in mean annual precipitation and percentage of annual precipitation during summer, highlighting the large range of both climate conditions and biome of the Mediterranean region. At the same time the water scarcity highlights the need for careful water resources management and planning in Mediterranean regions (Rana and Katerji, 2000). Over the past century, climate change has been affecting precipitation regimes across the world (Giorgi et al., 2008[3]). In the Mediterranean regions there is a persistent declining trend of precipitation and runoff decreases (Martinez-Fernandez et al., 2013[4]), contributing to a desertification process with dramatic consequences for agricultural and water resources sustainability. Recently, Montaldo and Sarigu (2017)[5] showed that in Sardinia runoff decreased drastically over the 1975-2010 period, with mean annual values 40% lower than the 1922-1974 period (with Mann-Kendall τ values ranging from -0.39 to -0.2). Climate change projections point to an amplification of changes in global precipitation patterns and trends (Giorgi et al., 2008), with further drier trends for the Mediterranean area (Ozturk et al., 2015)[6]. These trends will have dramatic consequences on water resources for both managed (e.g., agricultural) and natural systems. To face the upcoming water crisis, there is a need to develop stronger international cooperation in water research and enhance the resilience of agricultural and natural systems to climate change and trends. In water-limited regions the conservation of water through improving agriculture and environmental management practices is highly needed, and the use of water-efficient and drought-tolerant tree and crop species is a prerequisite. Land planning strategies need to be investigated under both current and future (climate change) scenarios, due to the impact of these strategies on the environment and the water resources. The science to guide such optimizing strategies needs to be improved.

1.1 Objectives

The overarching goal of this research project is to develop and apply innovative methodologies to increase the social-ecological water use efficiency (WUE) of managed ecosystems along the Mediterranean biome and climate types, in the face of drier and more extremes climates. We will focus on a diverse set of seasonally dry ecosystems, spanning a large gradient of mean annual rainfall (from 35 to 935 mm/y) across the Mediterranean biome (Fig. 1). Case studies will examine the Mediterranean Sea basin from west to east and north to south providing the exceptional opportunity to develop, identify and compare water resources management and planning strategies for contrasting climate conditions in the Mediterranean region. The specific objectives are:

[1] Rana G. & N. Katerji, 2000. Measurement and estimation of actual evapotranspiration in the field under Mediterranean climate: a review. European Journal of Agronomy, 13, 2-3.
[2] M.J. Deitch et al., 2017. Characterizing Precipitation Variability and Trends in the World's Mediterranean-Climate Areas. Water, 9(4), 259.
[3] F. Giorgi & P. Lionello, 2008. Climate change projections for the Mediterranean region. Global and Planetary Change 63, 90–104.
[4] Martinez-Fernandez et al., 2013. Modelling long-term fire occurrence factors in Spain by accounting for local variations with geographically weighted regression. Natural Hazards Earth System Sciences, 13, 311–327.
[5] N. Montaldo & A. Sarigu, 2017. Potential links between the North Atlantic Oscillation and decreasing precipitation and runoff on a Mediterranean area. Journal of Hydrology, 553, 419-437.
[6] T. Ozturk et al., 2015. Projections of climate change in the Mediterranean Basin by using downscaled global climate model outputs. International Journal of Climatology, 35, 4276–4292.

OB1: to develop and implement innovative methodologies for EvapoTranspiration (ET) measurements in typical heterogeneous Mediterranean agrosilvopastoral systems and agricultural environments;
OB2: to improve the eco-hydrologic monitoring in ephemeral rivers and wadis along the different Mediterranean biome and climate types, establishing a transnational Mediterranean river monitoring system;
OB3: to develop data assimilation systems for assimilating remotely sensed and field data into ecohydrological models at the watershed or agricultural district scales for optimal characterization of soil water balances (water content, storages and transfers) and the underlying water use efficiency;
OB4: to identify the impacts of contrasting vegetation and crop types on the soil water balance, surface runoff, and water use under current and past Mediterranean climates;
OB5: to predict the impact of future climate scenarios on soil water balance, runoff, and water use;
OB6: to develop a set of land cover change strategies (e.g. forestations/deforestation, use of more water use efficient crops and woody vegetation) for climate change scenarios that optimize the use of water resources and increase the resilience of agricultural and agrosilvopastoral systems;
OB7: to improve the multipurpose and multiuser water resources management and planning systems for the optimization of the water infrastructure (e.g., reservoirs, groundwater recharge, water harvesting) and uses (irrigation, animal production systems, drinking and industrial activities), and management and planning under current and future climate change scenarios while preserving natural ecosystems.
For reaching the above objectives, stakeholders will be actively involved, sharing knowledge, experiences, observations, and findings, throughout the duration of the project and beyond.

1.2 Relation to call and topic

The proposal relates primarily to Topic 1.1.2 and secondarily to Topic 1.1.1. In the following Table we explain how our proposal addresses the challenge and scope of the two Topics.

Table 1. Relation to call topics (the addressed parts of the topics are in bold)

Call Section 2 / Topic 1.1.2: Sustainable, integrated water management	SWATCH proposal
Challenge: **Water sustainability in the Mediterranean region should be ensured by improved technical tools** coupled with socio-economic studies **able to improve the efficiency of water and energy use in certain key regions under present and future global change scenarios. In this sense**, recognizing the water-energy-food synergies and **balancing the potential trade-offs between water and energy use efficiency is required**. *Scope:* **A sustainable water management is crucial in the Mediterranean basin for ensuring efficient multiple water use in irrigation, animal production systems, drinking and industrial activities, as well**	We will define innovative strategies for the water sustainability in the Mediterranean region under current and future climate change scenarios (WP5 and WP6), optimizing the management of water infrastructure (e.g., reservoirs, wells network design) and uses (irrigation, animal production systems, drinking and industrial activities). Strategies will be defined with stakeholders and government authorities, which will be actively involved in the project (three stakeholders will be even partners of the consortium and will contribute with own resources). We will include both water resources management authorities (e.g. ENAS in Sardinia, Water Development Department in Cyprus and Regional Crop

as the preservation of natural ecosystems. This requires efficient governance at different levels: watersheds, districts, national. **This call intends to improve water governance taking into consideration both the socio-economic context and the meteo-climatic trends of the Mediterranean basin, since both of them are considered as important drivers of current and future water resources management. The development of innovative governance strategies, advanced planning methodologies,** appropriate and sustainable treatment technologies **and monitoring tools has to take into account the huge number of physical, technological and socio-economic variables in water management in order to address the ever-growing need for water** and food. **This implies the use of technologies and tools for water accounting systems, including new remote sensing capacities coupled with governance allocation structures based on socio-economic rules for setting the limits for water** and energy consumption	office in Tunisia) and environmental authorities (e.g., FORESTAS in Sardinia, AFORCE in France, Department of Forests in Cyprus and GVA in Spain) because all the management and planning strategies need to preserve the extraordinary natural environments of these regions, which is an economic, environmental and social added value of the Mediterranean region. For improving technical tools for water resources quantification, we propose to develop innovative methodologies and techniques for the quantification, estimation and monitoring of ET, the main loss term of the basin water balance in semi-arid and arid climates (WP2 and WP3). New and advanced technical tools will be developed for monitoring main state variables of energy and water balance at the land surface (new remote sensing observations), and assimilating the observation in real - time data assimilation systems for watershed hydrologic predictions (WP4). We will have the outstanding possibility to investigate the wide range of climates and biome of the Mediterranean basin, including the agrosilvopastoral systems of two main Mediterranean islands located on the west (Sardinia) and east (Cyprus) areas of the sea basin.
Call Section 2 / Topic 1.1.1: Water resources availability and quality within catchments and aquifers	SWATCH proposal
Challenge: The challenges now faced by water planners require a **new generation of water management models that addresses the broad impacts of global changes on hydrological and hydraulic balance at catchment and aquifer level**. **Innovative options and technologies are required to ensure availability of groundwater resources for future generations and in particular to deal with storage and overexploitation, groundwater-dependent ecosystems**, seawater intrusion and salinization, anthropogenic and geogenic contamination of the whole water cycle, and **long-term sustainability**. **On the other hand, surface water bodies in the Mediterranean regions are characterized**	We propose innovative water management and planning approaches for answering the predicted global change impacts on the hydrologic balance. We will develop new techniques and approaches for estimating hydrologic balance terms through both monitoring and modelling. The analysis of climate and land use scenarios will provide the inputs for the water resources management and planning systems to optimally use both surface water (reservoirs and intermittent streams) and groundwater, up to the extreme case study of Wadi Watir in Egypt with extremely dry conditions (mean annual rain of 35 mm). Within the scope of this topic, we will establish a transnational Mediterranean river monitoring

by intermittent streams. The lack of surface water during long periods of time constitutes a challenge to characterize their hydrological regime and the geomorphological and ecological status. *Scope*: **Quantitative analyses on ecosystem services require an in-depth understanding of their underlying processes. To meet this need, it is important not only to use adequate modelling methods, but also to apply effective monitoring tools and research on new methodologies to understand biogeochemical cycles. Particularly important is the development and demonstration of effective monitoring and modelling tools to gather appropriate data and provide forecasting capabilities** across the freshwater to marine salinity gradients. **Developing efficient simulation models is necessary to analyse future scenarios at the spatial scales to be used for natural resource planning and management, and to identify cost-effective strategies and techniques for a rational use of water and protection of land and soil.** There is a need for developing early-warning systems to detect potential pollution transport through the soils and deep vadose zone to groundwater. This research should provide the needed information to support decisions on remediation strategies. **For surface water studies, new methods should be developed to characterise the hydro-geomorphological** and ecological status and degree of human affection **on ephemeral rivers**. **The methodology will address the hydrological regime**, water and sediment connectivity, **geomorphological conditions of river channels and river corridors**, biogeochemical functions and the spatial structure of the plant and animal communities. **In addition, in the semi-arid regions of the Mediterranean basins, floods are not only natural hazards but also renewable water resources.** **There is a need to understand the hydrological processes for the assessment, management and use of floodwaters.**	system for gathering and sharing data. Using the observed data we will calibrate the developed innovative ecohydrological models, and use them for analysing future climate scenarios. We will then predict the impact of future climate scenarios on soil water balance, runoff, and water use and develop a set of water management and land cover change strategies (e.g., water harvesting, small reservoirs, groundwater recharge, desertification, forestations/deforestation, use of more water use efficient crops and woody vegetation) for climate change scenarios that optimize the use of water resources and increase the resilience of agricultural and agrosilvopastoral systems along the Mediterranean biome and climate types. Water resources and environmental planning and management strategies will be developed to protect both water resources and natural environments in the regions and in the watersheds of the typical Mediterranean ephemeral rivers.

Proposals within this topic should allow to quantify a) the processes controlling this recharge, b) long-term recharge quantities (decade to multi-decadal scales) that determine the sustainability of these water resources and c) to translate these results into specific management strategies for alluvial aquifers of ephemeral rivers in Mediterranean regions.	

1.3 Concept and methodology

(a) Concept

The science to guide water resources optimizing strategies needs to be improved. A central element is the role of the vegetation dynamics and their interactions with atmosphere and soil, which need to be accurately quantified through both monitoring and mathematical predictive models. ET is a leading loss term of the root-zone water budget, and in semi-arid regions may reach a yearly magnitude roughly equal to the precipitation. Mediterranean ecosystems are commonly heterogeneous savanna-like ecosystems, with contrasting plant functional types (PFTs, trees and grass) and agricultural systems (e.g., crops) competing for the water use (Scholes and Archer, 1997[7]; Montaldo et al., 2008[8]). Despite the attention these ecosystems are receiving, a general lack of knowledge persists about the relationship between ET and the plant survival strategies for the different PFTs and crops under water stress. Also, their particular response to changing extremes (magnitude and frequency) rather than to changing averages still needs to be addressed, particularly in dynamic models. With this as a rationale, we explore the issue of estimating ET and its relationship with soil moisture (sm).

Land surface models (LSMs) have been developed to simulate mass and energy transfers between the soil, vegetation and the atmosphere, and to update the sm and thermal conditions through time. Due to the tight link between vegetation dynamics (i.e. growth and senescence) and soil water balance, coupled LSM and vegetation dynamic models (VDM) have been developed (e.g., Montaldo et al., 2008) for simulating both soil water balance and vegetation (e.g., grass, trees, crops) dynamics. Current distributed hydrological models enable the prediction of runoff generation and propagation for all the basin sizes (Montaldo et al., 2007[9]). The development of distributed ecohydrological models that couple LSM-VDM and rainfall-runoff hydrologic models will be necessary to investigate the impact of climate change and land cover changes on the basin water balance.

At the same time new technologies allow the accurate monitoring of ecohydrological processes. Remote sensing technologies monitor key LSM variables over large domains, such as land surface temperature (Ts) and leaf area index (LAI), at attractive spatial and temporal resolutions (meters to hundreds of meters and sub-hourly to daily scales). Vegetation indices are estimated from visible and near-infrared bands, and estimates of Ts are obtained from satellite images of sensors operating at the infrared bands. These satellite observations are a powerful tool for both monitoring the ecosystem and the use in combination with

[7]. R.J. Scholes & S. R. Archer, 1997. Tree-Grass Interactions in Savannas. Annual Review of Ecology and Systematics, 28, 517-544

[8]. N. Montaldo et al., 2008. Vegetation dynamics and soil water balance in a water-limited Mediterranean ecosystem on Sardinia, Italy. Hydrology and Earth System Sciences, 12, 1257-1271.

[9]. N. Montaldo et al., 2006. On the prediction of the Toce alpine basin floods with distributed hydrologic models. Hydrological Processes, 21, 608–621.

ecohydrologic models. The monitoring through extended field campaigns remains fundamental for the understanding of the physical processes of the land surface interactions, and for the validation of numerical models and remote sensing images. In addition, ground-based geophysical measurements can effectively extend the available information from the surface to deeper portions of the subsoil (e.g., Ursino et al., 2014[10]; Cassiani et al., 2012[11]) allowing a more holistic knowledge of the soil-plant-atmosphere interactions. Nevertheless, further developments are possible, and needed. For example, the innovative combined use of the eddy correlation technique used in the micrometeorological towers and sap flux sensors (Domec et al 2010[12]) have the potential to accurately estimate the transpiration (T), soil evaporation and the WUE of trees, but sap flux-based method may underestimate high flux rates (Bovard et al., 2005[13]). In Mediterranean regions, upstream watersheds are often characterized by trees grown on shallow soils above fractured bedrocks or cemented horizons, where water uptake of roots in the rock storage can be predominant for ET, up to 70-90% in semi-arid and arid climates (Schwinning, 2010[14]; Eliades et al., 2018a[15]). This is a significant term usually wrongly neglected by ecohydrologists, so that a new challenge in ecohydrology becomes the "ecohydrology of roots in rocks" (Schwinning, 2010). Innovative techniques combine geophysics methods (e.g., ground-penetrating radar and electrical resistivity tomography, e.g., Rodriguez-Robles et al., 2017[16]), water-isotopic methods (Schwinning, 2010) and sapflow sensors installed both in tree roots and trunk (Domec et al., 2010; Eliades et al., 2018b[17]) for estimating transpiration contributions of roots in the rocks. For estimating all ET components, we are proposing an innovative coupled use of these methods for root flux measuring with EC, sm and sapflow sensors.

When fully functional, satellite observations, ecosystem monitoring and ecohydrologic modeling can be combined and used to predict the effects of land use and climate change. Hence, they are crucial tools to develop land cover change strategies (e.g., forestations / deforestations) under current and future climate change scenarios for minimizing the water use and increasing the resilience to climate change of the agricultural and forestry systems. That is the scientific base for improving the multipurpose and multiuser water resources management systems for the optimization of the water infrastructure (e.g., water reservoirs, groundwater recharge structures, water harvesting innovations) and uses (irrigation, animal production systems, drinking and industrial activities) management both for current and future climate change scenarios. Water resources and environmental management systems will start from the existing ones, made available by the stakeholders (water resources and environmental authorities), and will be improved with stakeholder assistance under the commitment of preserving natural ecosystems.

This proposal is an innovative research project, that includes the analysis of basic physics principles and observations (e.g., ET estimates in heterogeneous ecosystem and tree water

[10]. N. Ursino et al., 2014. Measuring and modeling water-related soil–vegetation feedbacks in a fallow plot. Hydrology and Earth System Sciences, 18, 1105-1118.

[11]. G. Cassiani et al., 2012. Noninvasive Monitoring of Soil Static Characteristics and Dynamic States: A Case Study Highlighting Vegetation Effects on Agricultural Land. Vadose zone journal, 11, 3.

[12] J.C. Domec et al., 2010. Hydraulic redistribution of soil water by roots affects whole-stand evapotranspiration and net ecosystem carbon exchange. New Phytologist, 187, 171-183.

[13] Bovard, B.D., et al., 2005. Environmental controls on sap flow in a northern hardwood forest. Tree Physiology 25, 31–38.

[14] S. Scwhwinning, 2010. The ecohydrology of roots in rocks. Ecohydrology, 3, 238–245.

[15] M. Eliades et al., 2018a. The water balance components of Mediterranean pine trees on a steep mountain slope during two hydrologically contrasting years. Journal of Hydrology, 562, 712-724.

[16] U. Rodríguez-Robles et al., 2017. Technical note: Application of geophysical tools for tree root studies in forest ecosystems in complex soils. Biogeosciences, 14, 5343-5357.

[17] M. Eliades et al., 2018ª. Tree Water Dynamics in a Semi-Arid, Pinus brutia Forest. Water, 10(8), 1039.

uptake from roots in rocks) (TRL1), several new concepts (TRL2), including remote sensing observations and innovative ecohydrologic models for data assimilation, and experimental proof of concepts (TRL3), such as land-use strategies for water use optimization under current and future climate change scenarios. At the same time, the final results, optimal water resources management strategies and planning tools, will be available to stakeholders so that the research will be finalized for being applied in the actual management of the valuable water resources of the investigated water-limited watershed and systems (TRL5 and TRL6). At the end of the project, we will produce water resources management systems for operational environment (TRL7) that will be the demonstration part of the project.
Many past and current research activities are linked to the research project. Main previous (P) and current (C) projects are: - IDROSAR: remote sensing soil moisture estimation and data assimilation system (CRP2_708, LR 7/2007) (UNICA, C); -LIFE RESILIENT FORESTS (LIFE17 CCA/ES/000063): Coupling water, fire and climate resilience with biomass production in Forestry to adapt watersheds to climate change (POLIVA, C); -Monitoring and modeling for water resources estimate in the Flumendosa basin under climate and land use change scenarios (CRP2_708, LR 7/2007) (UNICA, P); - Micrometeorological and remote sensing measurements integration within distributed hydrological modelling for the evapotranspiration assessment (FIRB, LR7/2007) (UNICA, P); -CGL2017, CEHYRFO-MED: Incorporation of eco-hydrological criteria and resilience against climatic and fire disturbances in forest planning and management in Mediterranean basins (POLIVA, C); -CGL2014-58127-C3-2-R, SILWAMED: Development of criteria and concepts for an ecohydrologic-based forest management in response to global change (POLIVA, P); -INNOMED: Innovative options for Integrated Water Resources Management in the Mediterranean (Water-FACCE-JPI/ Waterworks2015) (CyI, C); -BINGO: Bringing Innovation to ongoing water management - a better future under climate change (H2020 641739) (CyI, C); -RECARE: Preventing and remediating degradation of soils in Europe through land care (FP7 603498) (CyI, C); -BEWATER: Making society an active participant in water adaptation to global change (FP7 612385) (CyI, P); -ENORASIS: Environmental Optimization of Irrigation Management with the Combined Use and Integration of High Precision Satellite Data, Advanced Modeling, Process Control and Business Innovation (FP7-282949) (CyI, P). -MACACC: Modelling to accompany stakeholders towards adaptation of forestry and agroforestry systems to global changes, Project-ANR-13-AGRO-0005 (INRA, P). PHC Utique projects Evaluation of RCM CORDEX outputs northern Tunisia French research program ENVIMED with HSM Montpellier and University Caddy Ayyad, Morocco (ENIT, P), PEER project of the National Academy of Sciences of USA for the MENA region (ENIT, P).

(b) Methodology
The methodologies are described distinguishing the research activities according to the work programme. The rationale of the individual work packages is given below.

Monitoring of experimental fields and hydrological basins (WP2)
For reaching OB1 and OB2, monitoring is planned in the watersheds and agrosilvopastoral systems. Monitoring is a key aspect of the research project and is a research activity. Both heterogeneous natural environments (Egypt, France, Italy, Spain), managed watersheds (Cyprus, Italy, Spain) and crops fields (Algeria, Cyprus, Tunisia,) will be monitored (Fig. 1). The monitoring activity will be both at the field and basin scales. The case studies (Fig. 1) cover a wide range of spatial scales, climate and ecosystems, both natural and managed providing an extraordinary opportunity of knowledge development and international exchange

along the Mediterranean biome and climate types. Some fields are already instrumented, and some will be instrumented during the project (Table 2).

At the field scale the extended campaigns will estimate ET and its partitioning between bare soil evaporation and transpiration, and WUE and their relationships with sm. The sites are or will be instrumented with (Table 2 for details on instrumentations):

i) raingage, air temperature, wind speed and direction, relative humidity and radiation sensors for typical meteorological monitoring;

ii) eddy covariance (EC) towers to measure energy balance components, CO_2 exchange and ET; Campbell Scientific CSAT-3 tri-axial sonic anemometers and Licor-7500 CO2/H2O infrared gas analyzers will be coupled used for the eddy-covariance based estimates;

iii) Granier-type, heat dissipation sap flux sensors or heat pulse (HRM) sensors for measuring tree transpiration (Domec et al., 2010);

iv) sm sensors (frequency domain reflectometry, FDR, and time domain reflectometry, TDR) - also using innovative wireless connections.

Data will be collected and recorded on dataloggers (e.g., CR3000 Campbell Sci.) at 30 min time step at least. An innovative methodology that uses these instrument observations and a 2D foot-print model (Montaldo et al., 2008) will be developed. LAI measurements will be conducted periodically using Accupar LP80 ceptometer and Licor LAI 2000.

Furthermore, in some of the test sites, geophysical methods (e.g., ground-penetrating radar, GPR, electrical resistivity tomography, ERT, and electromagnetic induction, EMI) and water-isotopic methodology and root sapflow sensors, installed both in tree roots and trunk (Domec et al., 2010), will be used for the assessment of the subsurface settings and the estimation of the water uptake of tree deep roots in rocks. Transects of soil water potential and soil water content sensors will be also installed to control hydraulic redistribution and water flowchanges between pasture (intercanopy) and trees, obtaining an almost 3-dimensional distribution of root water uptake. Finally, using EC observations and the 2D foot-print model, ET components will be estimated and the impact of water uptake of tree deep roots in the rocks on the heterogenous ecosystem will be quantified.

At the basin scale, the proposal will provide the excellent opportunity to investigate basins at differences spatial scales and at different climate conditions. Rain and streamflow will be monitored in all the investigated basins. Because most of the gage stations are already operative, hydrological data will be collected and checked. We will analyze the precipitation and runoff gradient across the Mediterranean basins, and the effect of the typical precipitation seasonality on the runoff in the wide range of basins. Finally, sm and vegetation will be also monitored at the watershed scale. In some representative area of the basins sm will be spatially monitored using TDR portable sensors, and LAI will be spatially monitored using Accupar LP80 ceptometer ad Licor LAI 2000. These observations will be performed during key months for ET (e.g., vegetation growth season, i.e. spring) and used for testing remote sensing observations (WP4).

The case studies are presented in Table 2 and will allow to investigate a rainfall gradient from 35 to 935 mm/year. All research partners will contribute to these activities. It is worth noting that a significant effort will be made by all partners (in particular by UNICA) for increasing the monitoring systems in the African case studies.

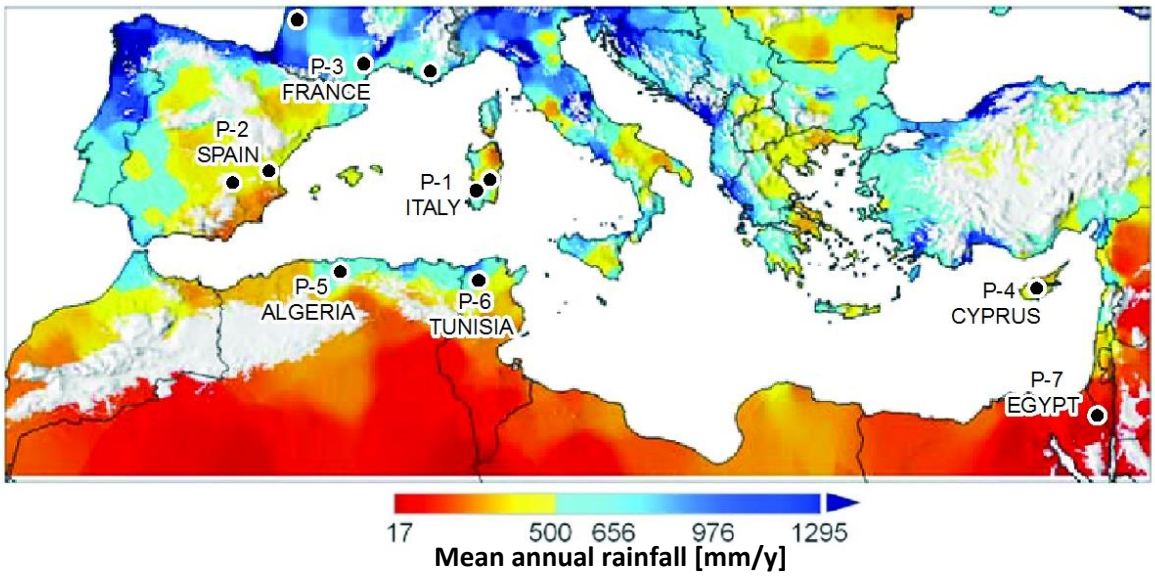


Figure 1. Rainfall in Mediterranean regions and location of the case studies

Table 2. Case studies with their hydrological and physiographic main properties, and monitoring activities.

Case Study, Country, *position*	**Scale/ Area**	**Mean Precip. [mm/y]**	**Principle land uses**	**Monitoring**	**Hydro-agricultural infrastructures**	**Stakeholder**
Flumendosa basin, Italy, *P-1*	watershed 1000 km^2	690	Agricultural, forests	Meteorology, rain, EC tower, sm; streamflow from 1922	3 large dams, irrigation system	ENAS
Orroli site, Italy, *P-1*	field	650	Pasture (grass and wild olives), rocky soil	EC tower from 2003, sm, LAI, sapflow, gas exchange at leaf level	dam	ENAS
Marganai natural Park, Italy, *P-1*	field	780	Forest (holm oaks) agrosilvopastoral, rocky soil	EC tower from 2018, sm, sapflow; geophysics and water-isotopic methods will be used.	LTER Italian site, and European Site of Community Importance (Natura 2000)	FORESTAS, ENAS
Mitidja site, Algeria, *P-5*	Field and watershed (1400 km^2)	500	vegetable crops, fruit trees (citrus, apple) and vines	Rainfall and streamflow. EC tower, sm and sap flow sensors will be installed	dams	National Hydric Resources Agency
Peristerona Watershed, Cyprus, *P-4*	Field and	270-750	Rainfed/irrigated annual/peren	Forest sapflow, irrigation water use, sm,	Groundwater recharge check-dams,	Farmers, Community Councils,

	waters hed 110 km^2		nial cropland; forests	meteorology, streamflow, groundwater. Micrometeorol. instruments will be installed	irrigation diversions, domestic water supply and irrigation boreholes	Water Development Dept., Dept. of Agriculture, Dept. of Forests
Bargou site, Tunisia, *P-6*	Field, waters hed	470	irrigated area, apples, figs, peaches, cherries, pomegranate	Meteorological station and sm. EC tower and geophysics methods will be installed.	groundwater pumping system with irrigation pipelines	Private Farm, Regional Crop office in Tunisia
Wadi Sodga, Tunisia, *P-6*	waters hed 20 Km^2	450	Forest, crops	Meteorological station. Streamflow gage will be installed	ephemeral river	local water management community
Barranco del Carraixet and Espadilla basins, Jucar river basin, Spain, *P-2*	Field and waters hed 128, 20, 43000 km^2	342-470	Forest agrosilvopast scrubland/ abandoned land, intensive agriculture	Meteorological stations, sm sensors, a cosmic ray probe and sap flow sensors, streamflow. EC will be installed	Agricultural land is irrigated either from transfers or groundwater	GVA, Jucar River Water Authority, Public municipality Valencian government
Salles, Puéchabon and Fontblanche, France, *P-3*	field	935, 910, 625	Forest (ICOS sites)	EC tower, sm. Sapflow will be installed	Maritime pine at Salles, live oak at Puéchabon and mixed Pinus and Quercus ilex at Fontblanche (shallow soils)	Smurfit-Kappa Comptoir du Pin, Adaptation des FOrêts au Changement ClimatiquEs (AFORCE)
Wadi Watir basin, Egypt, *P-7*	waters hed 3520 km^2	35	Naturally arid - steep slopes upstream, agriculture downstream	Rain and streamflow. Meteorological station and sm will be installed	5 dams, 2 underground reservoirs, 1 artificial lake, flood diversion dikes at the delta	Water resources research Institute

Ecohydrological modeling (WP3)

LSMs are available from the partners (e.g., UNICA model by Montaldo et al., 2008, TETIS-VEG by Ruiz-Pérez et al., 2017[18], INRA model by Manoli et al., 2017[19]), allowing to simulate

[18] G. Ruiz-Pérez et al., 2017. Calibration of a parsimonious distributed ecohydrological daily model in a data-scarce basin by exclusively using the spatio-temporal variation of NDVI. Hydrology and Earth System Sciences, 21, 6235-6251.

[19] G. Manoli et al., 2017. Competition for light and water in a coupled soil-plant system. Advances in Water Resources, 108, 216-230

land surface flux, energy flux, ET, infiltration, runoff formation, sm, CO_2 budget, LAI dynamics of different species at the field scale. For instance, the ecohydrological model of Montaldo et al. (2005, 2008) couples a traditional LSM (Montaldo and Albertson, 2001) and a Vegetation Dynamic Model (VDM). The LSM of Montaldo and Albertson (2001) is based on the force-restore method (Noilhan and Planton, 1989). The model considers the near surface and total root-zone soil layers, and computes the evolution of Ts, the surface and root-zone sm and the canopy interception water store. The VDM model provides LAI evolution in time, which is then used for the energy partitioning between soil and vegetation as well in the parameterization of turbulent transport and ET and in the estimate of the intercepted water by vegetation cover. Innovative spatially distributed versions that couple LSM-VDM and rainfall-runoff hydrologic models for simulating also runoff propagation at the basin scale will be developed. Runoff propagation along the river network will be computed through a modified version of the Muskingum –Cunge method already used successfully by Montaldo et al. (2004) and Montaldo et al. (2007).
At the field scale the models will be calibrated and validated using the EC tower observations and the monitoring activities (WP2). At the basin scale the model will be calibrated and validated using historical runoff data (WP2), and remote sensing observations (WP4). The model will be also coupled with remote sensing observations (WP4) for surface energy balance computation and actual ET estimate at the basin scale (e.g., TETIS-VEG model in Ruiz-Pérez et al., 2017). A model intercomparison will be done to identify the vegetation, climate and land use features crucial for the correct determination of the key ecohydrological variables. These results will be also used to develop a minimalist model, which will fully include the stochasticity of the hydroclimatic forcing. The goal here is to obtain a computationally-light model to be run for an efficient exploration of the effects of changes in climate conditions (including more frequent extremes), crop features and land use.

Remote sensing and data assimilation (WP4)
The estimate of vegetation indices (LAI) and their classification will be obtained from multispectral images of Landsat (spat. res. 30 m, time res. 16 days), ASTER (spat. res. 15 m, time res. 16 days), Quickbird (spat. res. 1-3 m, time res. 3 days), and SENTINEL 2 (spat. res. 10 m, time res. 3 days). Estimates of Ts will be obtained from thermal infrared bands different for spatial and temporal resolutions: ASTER, Landsat, NOAA AVHRR, and SEVIRI. Ts and LAI estimates from remote sensing will be tested with the observations of the field campaigns. The simultaneous acquisition of field and remotely sensed data allows calibration and validation of algorithms for the retrieval of the products for hydrological modeling, both from field to basin and from hourly to daily scale. Scale effects on variables and parameters retrieved from operative satellite will be analyzed to understand the scale relationship for each variable in order to apply a downscaling methodology. Scale analysis is necessary to use operative satellite information due to the mismatch among their coarse spatial resolution, eddy covariance scale and distributed hydrological model.
The remote sensing observations and monitoring results will be used for developing a data assimilation (DA) system. Montaldo et al. (2007)[20] developed an assimilation framework for assimilating surface sm observations into the LSM for the robust prediction of the root zone moisture using the Ensemble Kalman filter. In the proposed project we will further improve this DA system algorithm for the assimilation of Ts and LAI observations from remote sensors. This data assimilation system will allow for updating the model with available observations, and dynamically calibrate the model through the minimization of the model errors. This

[20] N. Montaldo et al., 2007. Dynamic Calibration with an Ensemble Kalman Filter Based Data Assimilation Approach for Root-Zone Moisture Predictions. Journal of Hydrometeorology, 8, 910–921.

approach will allow for testing the potentiality of the use of Ts and LAI satellite observations for soil water balance estimates. In particular, we will evaluate if the assimilation of these terms (LAI and Ts) is enough for guiding the soil water balance model and if there is the need of a minimum frequency of assimilation or a minimum spatial resolution of the images.

Analysis of land cover change strategies and climate change scenarios (WP5)

Future climate scenarios will be generated starting from historical climate data perturbed following the IPCC future climate scenarios. Hence, first hystorical hydrological data will be analyzed. Following Montaldo and Sarigu (2017) approach, annual, seasonal, monthly and daily statistical series for precipitation, runoff, and temperature will be computed. Then, trends of the hydrologic database will be estimated using the Mann-Kendall non-parametric test (Kendall, 1938; Hensel and Hirsch, 2002), and the Theil-Sen method (Theil, 1950; Sen, 1968) will be used to estimate the trend slopes. The Pettitt test, a method widely used in climate analysis (Zhang and Lu, 2009), will be also used to estimate potential change points of the annual time series. We will also investigate potential correlations between seasonal and annual time series and the North Atlantic Oscillation (NAO), a weather phenomenon in the North Atlantic Ocean that controls the direction and strength of westerly winds and storm tracks into Europe and Mediterranean Sea basin. We will consider the IPCC scenarios of the Fifth Assessment report, focusing on the climate models. We will select the climate models for future scenarios after comparing the models' outputs with the observed data in each investigated region. Only the models able to capture past climate changes will be used in future predictions. Then, we will use an opportunely adapted stochastic generator for accounting the nonstationarity of the processes and the climate changes. A first step will be to use the meteorological stochastic generator developed by Richardson (1981) or a spatial-temporal Neyman–Scott Rectangular Pulses model (e.g., Burton et al., 2008[21]; Camera et al., 2017[22]), but we will not preserve the past seasonal statistical characteristics, which will be altered using the future IPCC climate change predictions.

The use of ecohydrological models, DA systems and IPCC scenarios will allow to: 1) investigate the impact of land cover changes and spatial distribution changes of competing vegetations (e.g. increase / decrease tree distribution) on soil water and CO_2 budgets and water uses using actual climates; 2) investigate the impact of future climate scenarios with increase of CO_2 on soil water balance and runoff, with implications to water uses; 3) develop land cover strategies (e.g., forestations/deforestation, use of more water use efficient crops and woody vegetation) for optimizing the water resources use and increasing the resilience of agricultural and forestry systems using future climate scenarios.

Development of water management and planning systems (WP6)

The results of WP5 will be input of multipurpose and multiuser water resources management system, which will be improved for the optimization of the water infrastructure (e.g., reservoirs) and uses (irrigation, animal production systems, drinking and industrial activities) management under current and future climate change scenarios. Water resources management optimization models (WARGI by Sechi and Sulis, 2009, Hec-ResPRM, and others) will be applied and improved to define the economic efficiency and the optimal water allocation in the water system configurations throughout the evaluation of multiple planning and management rules. For instance, WARGI allows to start from physical system to reach the optimal solution

[21] A.Burton et al., 2008. RainSim: A spatial–temporal stochastic rainfall modelling system. Environmental Modelling & Software, 23, 1356–1369.

[22] C. Camera et al., 2008. Evaluation of a spatial rainfall generator for generating high resolution precipitation projections over orographically complex terrain. Stochastic Environmental Research and Risk Assessment, 31, 757–773.

having the possibility to control all the intermediate phases, easily to update system configuration and to consider different system optimizer. WARGI is already the reference water resources system for the main dam-reservoir water system of Sardinia (Flumendosa-Campidano-Cixerri water system) optimizing the reservoir operations of 20 dams (Sechi and Sulis, 2009[23]). The tool is flexible and will assume a key role in a decision support system to help the users understand the interrelationships between demands and resources for multi-reservoir water systems under water scarcity conditions, as it frequently occurs in Mediterranean regions. The model will be tested in the other regional water resources system (Algeria, Cyprus, Egypt, Tunisia, Spain) in close cooperation with local water authorities. All the scenarios and strategies will be developed under the main objective of preserving natural ecosystems in those Mediterranean areas.

Quantifying benefits and sharing methodologies with stakeholders and dissemination (WP7).

A main part of the proposed project will be the dissemination and explonation activities to stakeholders and scientific community. In particular we will: organize start-up stakeholder meetings in all case studies to tap into the knowledge and experience of all local stakeholders and fine-tune the planning of the monitoring and modeling activities; conduct participatory seminars, by including the multiple actors involved in the making up of water governance territory, to identify acceptable scenarios in view of simulated impacts, among the set of realistic modulations; conduct participatory seminars for discussing possible configurations that are out of current prospective, and to foresee the possible interests / consequences; share methodological developments, by setting a common toolbox where academic partners exchange former and newly developed approaches; deliver monitoring results and disseminate outcomes.

Project results will be made available to the scientific community, to foster the development of multidisciplinary activities focusing on hydrology, climatology, hydraulic construction, environmental sciences, water resources management and irrigation management. Scientific publications in international and national journals, participation to the main international conferences (e.g., EGU and AGU), a final report of the activities and three public workshops (at the start, after 1.5 years and at the end of the project) will be the way to disseminate and communicate the results also beyond the scientific community. A project web site, a “Google” research page and a “Facebook” page will be created for an effective communication and transfer of the results. The project results will have implications in the operative water management of single farmer, irrigation consortia and water basin and environmental authorities. For those reasons, many stakeholders are involved in the project: ENAS (Sardinian water authority), FORESTAS (Forestry authority in Sardinia), REMOC-MENBO (Spain), Jucar River Water Authority (Spain), GVA (Spain), Algerian National Hydric Resources Agency, Smurfit-Kappa and AFORCE (France), Depts of Agriculture and Forestry and Water Development Dept. (Cyprus), Regional crop office (Tunisia), etc. (see Table 2, above, for the list).

A gender analysis of the project participants shows a mixed composition of male and female partners. In the consortium, 3 partners are with female leaders (CyI, GVA, ENIT) and 7 partners with male leaders (UNICA, ENAS, FORESTAS, ENSH, UNIAS, POLIVA, INRA), while among the partner responsible persons there are 18 males and 5 females. During the project lifetime a strong effort will be made (WP1) to increase the number of female researchers.

[23] G.M. Sechi & A. Sulis, 2009. Water System Management through a Mixed Optimization-Simulation Approach. Journal of Water Resources Planning and Management, 135(3), 160-170.

1.4 Ambition

Despite ET being the leading loss term of the soil water balance, there persists a general lack of knowledge persists about the relationship between ET and the plant survival strategies for the different plant functional types under water stress in forestry and agricultural systems. With this in mind, we propose an innovative methodology based on the coupled use of eddy covariance measurements, sap flux sensors, high resolution satellite images and a 2D foot-print model for estimating total ET, its components and its relationship with sm. In semi-arid and arid regions, a key contribution of tree transpiration has been neglected by hydrologists, which is the water uptake of roots in the rock storage (up to 70-90% of total ET), so that a new challenge in ecohydrology becomes the "ecohydrology of roots in rocks" (Schwinning, 2010). We propose an innovative approach that uses geophysics methods (e.g., ground-penetrating radar, electrical resistivity tomography, electromagnetic induction), water-isotopic methods and root sapflow sensors for measuring the flux in the roots directly, and EC, sm and sapflow sensors for land surface ET.

We propose to develop a new and innovative transnational Mediterranean river monitoring network for gathering and sharing data, which will be available through an online database. This river monitoring network will provide for the first time the possibility to share, cooperate and improve scientific progress across the wide range of climates and biome of the Mediterranean basin spanning a large gradient of mean annual rainfall (from 35 to 935 mm/year), including the two main Mediterranean islands located on the west (Sardinia) and east (Cyprus) areas of the sea basin.

Furthermore, the development of an innovative data assimilation system, able to assimilate the remote sensing information and field monitoring data into the developed distributed ecohydrologic models, will provide an innovative approach for the water resources management and planning. The use of the proposed assimilation system will allow to develop innovative strategies for environmental planning to increasing the resilience of the agrosilvopastoral systems, also for future drier climate scenarios. In this way we will develop the essential future scenarios and provide the basis for the development of quantitative – informed decision – making tools, useful for authorities and policy-makers both at basin and regionale scales, who need to elaborate and revise the water resources planning.

2. Impact

2.1 Expected impacts

The proposal will have positive social and economic impacts. The project objectives respond to common priorities on societal challenges of most of the international organizations dealing with the protection of the planet's natural renewable resources and food security, which are enhanced due to the increase of human pressure and of climatic changes on fresh water (European Environment Action Programme, Horizon 2020), the FAO, the GEOSS Water Cycle Integrator, Group on Earth Observations - GEO, the IPCC, the WFD 2000/60, World Council for Sustainable Development, the Protocollo di Milano for EXPO2015, Pope enciclycal "Laudato Si". The project economic impact will be significant for agricultural development and its sustainability since it will increase the system efficiency and decrease the overall costs. Stakeholders will be involved and will have a main role in the project. The project will provide to the stakeholders the scientific approach and results for defining the planning and management strategies for both current and future climates. A main part of the project will be the dissemination of the results to the stakeholders and to the society in general, considering the impact on social customs and traditions.

In most Mediterranean regions water and environmental plans are missing and, when available, they do not properly include future scenario impacts. The future scenarios are predicting

decrease of water availability with the consequence that existing water resources plan are in general too optimistic as they assume water inputs (surface and groundwater) that will soon be no longer available. At the same time, environmental plans need to consider the climate change effect for both CO_2 budget and water resources use of vegetation and water resources availability to vegetation growth, which can impact on species type (i.e., selection of species more resistant to drier conditions) and their spatial distribution (less water implies less density). Our proposed methodology allows to adequately develop water resources and environmental planning also for future climate change scenarios. The strong international cooperation of this project is a crucial aspect. Climate change is affecting water resources in the Mediterranean region, and there is the need to strengthen international cooperation in water research between Mediterranean countries, in order to develop strategies that are actually effective and concrete as they take into account the real and varying conditions across areas that present extremely heterogeneous conditions. In the project, European partners will collaborate with North African partners providing a unique opportunity to knowledge and experience exchanges. Indeed, the broad, diverse and international partnerships of SWATCH are key points of the project. All the academic partners have strong expertise developed at the best international schools, which aspire to collaborate for knowledge and experience exchanges. Experts of a wide range of complimentary fields, e.g. hydrology, hydraulics, ecology, forestry, agronomy, micrometeorology, and geophysics, are involved, providing an excellent opportunity to advance water resources science of semi-arid and arid Mediterranean regions. The project addresses case studies covering a wide range of spatial scales and ecosystems, and a large rainfall gradient. This project offers a unique opportunity for exchanges of research and knowledge, which is the base for increasing the research development in water resources. Only by analyzing sites with very different spatial scales, vegetation covers and climate conditions, it is possible to understand deeply the complex ecohydrologic processes, and the strongly nonlinear dynamics between soil, vegetation and atmosphere, which is the key element of environmental planning strategies for optimizing the water use and increase the resilience of agrosilvopastoral systems. To prove the international scientific interest on the proposal project, word-renowned professors from top USA Universities (Ram Oren and Gaby Katul at Duke University, and John Albertson at Cornell University) are also cooperating as scientific staff in the project.

2.2 Measures to maximise impact

a) Dissemination and exploitation of results

Project results will be made available to stakeholders (local, regional and national water and environmental authorities, environmental NGOs, farmers, consortia, etc.) in their own language and to the scientific community, thus allowing the development of multidisciplinary activities with interests in the context of hydrology, climatology, hydraulic construction, environmental sciences, water resources management and irrigation management.

In the draft plan for the dissemination and exploitation of the project's results (PEDR) we distinguish the dissemination actions and the exploitation of the results.

Draft of the dissemination plan

Dissemination activities are designed to maximize the impact of project results, and will provide information to the scientific communities and relevant stakeholders involved in the project in three areas:

1. Scientific and technical results through
    a. Scientific publications
    b. Conference talks
    c. Workshops, providing updates on the project results

d. Reports to and feedback from Committees and Boards

2. Products through dissemination of
   a. Datasets and accompanying material (e.g. descriptions, meta data)
   b. Algorithms
   c. Graphics and animations
3. Progress information through provision of
   a. Newsletters (digital and print)
   b. Public Deliverables
   c. Dissemination Materials (brochures, posters, flyers)

Dissemination targets are summarized in the following table.

Target audience	**Dissemination Means**
Water, environmental and agricultural international and European associations	- Workshops and resulting reports - Strategic Research Agendas - Policy briefs - Project news/ Newsletters - Tailored updates on the results - Website
National authorities	- Workshops - Trainings - Policy briefs - Website
Regional authorities	- Workshops - Trainings - Policy briefs - Website
Local authorities	- Workshops - Policy briefs - Website
Scientific community, academics or non-academics, students, , engineers	- Peer-reviewed scientific papers - Data portal - Workshops - Conferences - Strategic Research Agendas - Newsletters - Trainings - User manuals
Farmers, irrigation consortia, technology providers, industrial	- Targeted publication material - Representation at relevant conferences and fairs - Newsletters
General public	- General Information Material - website - Project news/ Newsletters - Dissemination Material - Press releases

Dissemination Instruments

Below are summarized the tools and channels that will be adopted to reach the target audiences and how this will help achieve the expected project impact.

SWATCH website and internet dissemination actions

The SWATCH website will serve as the main dissemination instrument for the project. It will contain various sections both for the general public as well as specifically targeted towards stakeholders including the scientific community. Events as well as technical resources will be published on the website together with regular news updates and access to data sets. The website will also host the data portal, providing an interface to the distributed data and products made available by the project and is therefore also a major dissemination instrument. A "google" research page, a "Facebook" page and an "Instagram" page will be also developed for a strong and innovative dissemination and transfer of the results.

Journals, Conferences and Workshops

Strong engagement with the academic sector will promote the work performed and at the same time follow the scientific developments taking place outside the consortium. This exchange of information and knowledge will be through attendance of scientific conferences, organization of specific sessions and related topic, for instance, at the annual meeting of the European Geophysical Union, and presenting seminars and engaging in discussion at universities and research institutes. Publication in scientific journals will play a major role as this allows a rigorous peer-review to take place, ensuring that SWATCH results are relevant to the community.

In addition, regular conference and workshop publications and attendance with talks on topics from SWATCH will complement these publications. Three workshops will be organized open to the wider community to discuss, document and learn from the various efforts outside the project. The workshop will be 1) at the start of the project in Italy, 2) after 1.5 years in Tunisia and 3) at the end of the project in Spain. The workshops will involve worldwide experts. In addition, technical studies will be realized to lead a major effort to specific technical aspects of the project.

Flyers, posters and brochures

Flyers, posters and brochures on SWATCH activities will be realized to disseminate information to broad audiences in a comprehensive and visually-appealing way. Press releases, flyers, posters and brochures will be available throughout the whole duration of the project, and will be distributed by the participants of the project during congresses, workshops and meetings. Press releases, flyers, posters and brochures will be also sent to policymakers and academic institutions.

Newsletters

Newsletters will be produced on a 6-monthly basis, covering the start-up phase of the project and introducing the project to the wider community. The newsletters will provide updates on the progress of the project and provide selected highlights in more detail.

Plan of Exploitation Findings

The exploitation activities of SWATCH will ensure the transfer of project results to appropriate stakeholders and decision-makers thus getting integrated in their current activities, opening them to the SWATCH aims and topics.

Exploitable Products	• Innovative Methods for Evapo Transpiration (ET) measurements • Impacts of vegetation and crop types on the soil water balance, surface runoff, and water use under current and past Mediterranean climates

	• Methods to combine satellite observations, ecosystem monitoring and eco-hydrologic modeling • Predictions of the impact of future climate on soil water balance, runoff and water use effects of land use and climate change in the Mediterranean area. • Land cover strategies planning for climate change scenarios to optimize the use of water resources
Exploitation Activities during the Project	• Scientific papers • Review state-of-the art
Exploitation Activities after the end of the Project	• Use of the SWATCH model data product and scenarios by SWATCH inverse modelers, and for management and planning purposes • Scientific papers • Expand the approach developed in SWATCH to different basins • Further developments, integration into other services
Consortium-wide/Joint Exploitation	• Longer-term goal would be operationalization of SWATCH strategies for climate change studies in the Mediterranean area • Definition of a stable eco-hydrologic monitoring in the Mediterranean area. • Definition of a global echohydrological monitoring network within the Mediterranean

The exploitation activities of SWATCH will be developed by a direct involvement of end-user representatives in the project consortium, and by networks established by the partners in the participating countries and beyond, using several communication and technical materials that will be produced for this purpose. WP7 will take care that all stakeholders will be regularly informed and updated. Our communication strategy, which plays a key role in the project, maintain the connection between past and future activities, and will guide the dissemination of information in a reliable and professional way.
Scientific publications, participation to the main international meetings (e.g., EGU and AGU), a final report of the activities and three public workshops will be used to disseminate and communicate the results at the scientific community. A project web site, a “google” research page and a “facebook” page will be developed for a strong and innovative communication and transfer of the results. The project results will have implications in the operative water management of single farmer, irrigation consortia and water basin authorities. Hence, several stakeholders are involved in the project and support the project (see Table 2 for the list).
Databases, and reaserch data published by the consortium will be public domain, allowing widest possible re-use of the result data. All the specifics about ownership and access to key knowledge (IPR) will be included in the Consortium Agreement (CA). Detail on open access rules and the ownership and access to key knowledge will be specified in the Consortium Agreement, which will be signed by all beneficiaries prior to initiation of the project.
On the project web site monitored data will be collected as well as their elaborations providing an innovative web-based database that will be available for the website visitors. The exploitation activities are made with the intent to be implemented throughout the life-cycle of

the project as well as after the project conclusion, by the inclusion of the project results into a permanent and visible Network.
We will follow the Green Open Access for scientific publications developing an electronic repository for scientific publications, ensuring open access to publications. Databases, and reaserch data published by the consortium will be public domain, allowing widest possible re-use of the result data. Indeed, project results will be published on scientific journals, and these will be disseminated through open access. All the specifics about ownership and access to key knowledge (IPR) will be included in the Consortium Agreement (CA).
SWATCH project will create a large amount of different types of data and hence a detailed Data Management Plan (DMP) will be included in the project in the first six months of the project and be responsible for its adherence by all partners. The DMP will determine the main data uses and users and explore the rules related to the Intellectual Property Rights management (IPR) in accord to the Consortium Agreement. Monitoring of experimental fields is a main term of the research project and therefore a great amount of data will consist on the observed environmental variables measured in the experimental sites. The project also includes a modeling phase that aims to explore the effects of changes in climate conditions (including more frequent extremes), crop features and land use that will require the use a large variety of other data sets, including land use, climate change projections based on relevant IPCC scenarios geological and vegetation map, when available. The products of remote sensing and data assimilation analyses will produce large datasets. Furthermore, future climate change scenarios maps, land cover strategies maps and planning strategies for optimal utilization of water resources use and increasing the resilience of agricultural and forestry systems are valuable data assets by themselves.
The above-mentioned data, together with the scientific publications, will be stored in the Common Project Server of SWATCH (CPSS), which will be set up within the first three months. The preservation of CPSS information will be guaranteed by weekly back-up to local servers managed by the support of professional assistance. The data stored in the CPSS will be indexed and a reach data description, detailed provenance and license use will be included.
The CPSS will be accessible for all the consortium members by a password protect link within the project web site. The information available for the stakeholders will be managed within a dedicated area from the web site and different levels of accessibility will be defined depending on the type of data. Open access rules for each type of data that could be subjected to property rights from external consortium members (property of public administrations, companies, industries, etc.), will be defined in Consortium Agreement. The open accessible data can be, mined, exploited, reproduced, and disseminated free of charge to all users.
SWATCH publications will be deposited in an appropriate repository for scientific publications (such as OpenAIRE) open access and will be disseminated following the Green Open Access for scientific publications.
The Intellectual Property Rights will be regulated by the Consortium Agreement that will address use and dissemination of results and access rights, background and foreground knowledge, ownership, protected third party components of the products and protection.
The principle of confidentiality within all the consortium members, employees and external personnel, will be implemented. The overall principle of IPR management is to maximize the impact and market relevance of the knowledge generated in the project.

b) Communication activities

Communication will include several actions targeted for local, regional, national, European and International level as to efficiently enhance the understanding and reliability on the activities and the results of the project. Communication actions during the project will be ensured by the active role of the consortium members, and project participants. The project members will

organize communication actions such as stakeholder workshops, training sessions and materials, and will be actively involved on communication activities such as workshops and seminars, conference papers and presentations, and attending national and international conferences.

Target audience will be referred to the project web site, which will be established within the first three months with the support of professional assistance. The web site will be updated weekly with the project activities and events, project results and its progresses. Through a dedicated internal web site portal, password-protected, the audience will be encouraged to request or provide information. Also the download page will be devoted to a private area, where confidential documents and information could be shared.

The main functionalities of the web site are:

- link to technical social media in order to be attractive
- overview of the concept, objectives, the partnership and the activities of the project
- a consortium member dedicated access, which will provide a collaborative space for sharing information and documents

Communication to the general public will be also reached by press-releases for journal articles, which will be promoted on the public information area of the website and social media (with all its interactive material). Useful gadgets and materials with the project name and logo, will be distributed at the main events organized within the SWATCH project, and during the congresses and meeting where the project members will be involved. Additional communication instruments, such us Facebook, Google, and Twitter will be used to promote the project main events, and main project progresses. The Twitter profile will be linked to the SWATCH web site, and will be update during the project stages to present all the activities where the SWATCH project is involved (meeting, conferences, etc.) through Tweets, pictures and comments. A logo will be designed to provide a visual identity to the SWATCH project. It will be a simple combination of letters and symbols for allowing people to quickly recognize the main themes of SWATCH project. The logo will be will be impressed on gadgets and materials. In addition, other important communication activities will be:

- **Conferences and Workshops:** will provide the opportunity exchange of information and knowledge as to endorse and increase the diffusion of the project impacts.
- **Flyers, posters and brochures:** will communicate in a more general way the primary objectives of the project in a comprehensive and visually-appealing way
- **Peer-reviewed articles:** publication in scientific journals will play a major role because allows a rigorous peer-review to take place, ensuring that SWATCH results are relevant to the community.
- **Participation to the main international meetings**: will ensure the promotion and facilitate the diffusion of the project impacts.
- **Final report of the activities:** will ensure the communication of reached results.

The impact of communication actions will be ensured by a constant verification of the number of participants involved in seminars, events and workshops, the number of participants involved in the training courses, number of internet search results and media publications referring to SWATCH project, number of people asking for feedback or more information, trends in website visit and number of references in scientific publications.

3. Implementation

3.1 Work plan — Work packages, deliverables

3.1.1 Brief presentation of the overall structure of the work plan

The 7 specific objectives described in section 1.1 will be achieved through 7 Workpackages (WPs), which concepts, rationale and methods are described in section 1.3. The interaction between the WPs is illustrated in the PERT Chart (Fig. 2). The WP1 (Coordination) and WP7 (Quantifying benefits and sharing methodologies with stakeholders and dissemination) will guarantee full synergy and integration among project participants and stakeholders, ensuring the successful progress of the project within the agreed timeline, budget availability and technical quality standards, dissemination and communication of SWATCH activities and results. The other 5 WPs will provide the answers and results to the scientific questions and objectives of SWATCH:

1. with the hydrologic monitoring of experimental fields and basins using most modern and innovative techniques along the Mediterranenan region and establishing a transnational Mediterranean river monitoring system (WP2);
2. the development of innovative ecohydrologic models at several spatial scales (WP3);
3. the development of robust data assimilation system for the assimilation of remote sensing observations in ecohydrologic models (WP4);
4. the development of land cover change strategies under actual and future climate change scenarios for optimizing the use of water resources (WP5);
5. the development and mprovement of water management and planning systems for the optimization of the water infrastructures and uses (WP6).

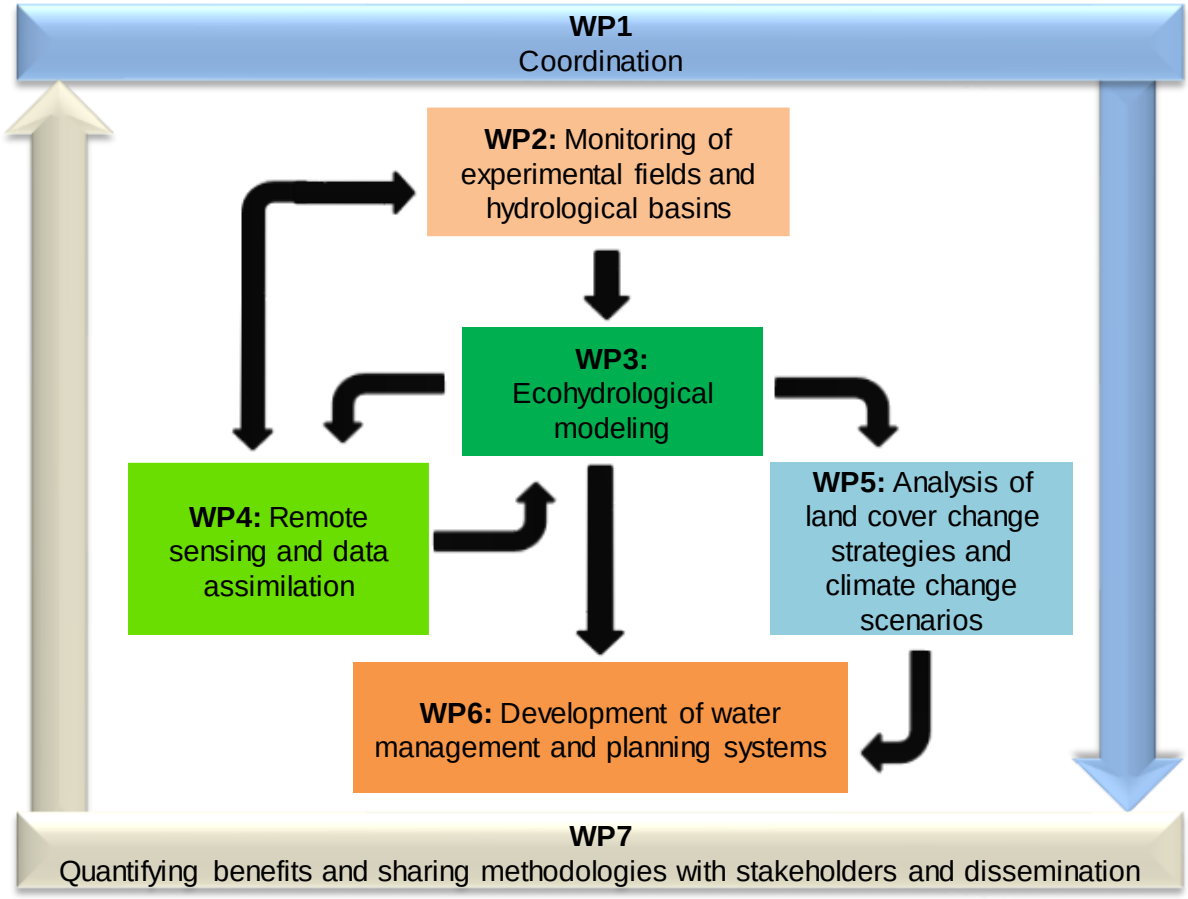


Figure 2. SWATCH PERT chart

3.1.2 Timing of the different work packages and their components (Gantt chart)

Workpackage/Task		Year 1												Year 2												Year 3											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
WP1	*Task 1.1*	D1.1.1	D1.1.4	MS1															D1.1.2	D1.1.4																	D1.1.3
	Task 1.2						D1.2																														
WP2	*Task 2.1*																			D2.1		MS2															D2.1
	Task 2.2																				D2.2.2																D2.2
	Task 2.3																																				D2.3
WP3	*Task 3.1*																D3.1					MS3															
	Task 3.2												D3.2																								
	Task 3.3																														D3.3						
	Task 3.4																														D3.4						
WP4	*Task 4.1*																					D4.1	MS4														

Workpackage/Task		Year 1												Year 2												Year 3											
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
	Task 4.2																								D4.2.1										D4.2.2		
	Task 4.3																		D4.3.1																D4.3.2		
WP5	*Task 5.1*																						D5.1	MS5													
	Task 5.2																										D5.2										
	Task 5.3																																		D5.3		
WP6	*Task 6.1*																								D6.1	MS6											
	Task 6.2																																				D6.2
WP7	*Task 7.1*							D7.1.1																											D7.1.2		
	Task 7.2			D7.2.1	MS7				D7.2.2												D7.2.2																D7.2.2

Table 3.1a: List of work packages

Work package No	Work Package Title	Lead Participant No	Lead Participant Short Name	Person-Months	Start Month	End Month
1	Coordination	1	UNICA	41.4	1	36
2	Monitoring of experimental fields and hydrological basins	9 and 4	INRA and ENSH	170	1	36
3	Ecohydrological modeling	7 and 10	POLIVA and ENIT	102	1	30
4	Remote sensing and data assimilation	1 and 10	UNICA and ENIT	82	1	34
5	Analysis of land cover change strategies and climate change scenarios	7 and 6	POLIVA and UNIAS	86	4	34
6	Development of water management and planning systems	5 and 9	CyI and INRA	70	11	36
7	Quantifying benefits and sharing methodologies with stakeholders and dissemination.	1	UNICA	35	1	36
				586.4		

Table 3.1b: Work package description

Work package number	1	Lead beneficiary			UNICA		
Work package title	Management and Coordination (short: Coordination)						
Participant number	1	4	5	6	7	9	10
Short name of participant	UNICA	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	30	1	1	1	4.4	3	1
Start month	1			End month		36	

Objectives

This work package is concerned with the overall financial, administrative and operational management of the project as well as coordinating activities across work packages.

The specific objectives are:

- overall coordination
- to perform daily management of the project (monitoring of progress; communication with partners and with PRIMA-IS; financial management; reporting; decision making; conflict management)
- to ensure that all milestones and deliverables are successfully achieved and submitted
- to organise meetings and workshops and produce minutes of meetings (Annual General Assembly meetings, Executive Board meetings)
- to identify possible problems, evaluating their relevance and possible negative impacts and adopting actions for solving the problems

Description of work

The project coordination of UNICA will be carried out through meetings for sharing partner results and stakeholder observations and recommendations. For speeding the coordination activity all social and fast communication media will be used. For instance, monthly conference calls using “Skype” will be organized, a “whatsapp” chat will be added for fast exchange, and a “slack.com” site will be created and used for facilitating day to day collaboration. UNICA will control that database will be collected as well as their elaborations in a web-based database. The coordination activity includes the development of a project web site, a “Google” research page, a “Researchgate” page, and a “Facebook” page, and a “Twitter” page.

Task 1.1 organization structure and supervision of the results (leader: UNICA)

A common baseline for task and responsibility allocation will be established. The project management team will take measures to guarantee control, validation and verification of the project results, ensure that plans are fulfilled and implementing necessary corrective actions as described in “Management structure and procedures”, section 3.2

Specific activities of management will include:

- define, divide and supervise tasks and activities within each task
- daily management of the project and consortium including financial, administrative and operational management
- monitoring of progress

- coordinate the preparation of reports and implementation plan
- organization of the Project Meetings: there will be 3 General assembly meetings (one in Italy, one in Tunisia, and the last in Spain). The last General Assembly meeting will be organised in conjunction with the final conference.
- arrangement of regular web- or teleconference with the consortium
- advise and direct the partners on the project developments necessary for the project
- motivate and support all partners to consider the gender balance and to recruit and engage qualified female researchers and stakeholders
- follow the organization and updating of the project website
- collecting and quality assurance of deliverables
- interim and final reporting to National funding bodies and PRIMA-IS.
- deliver the data management plan

Task 1.2 administrative management (leader: UNICA)
The main goals associated with this task are to ensure punctual provision of periodic management reports and cost statements, and to handle payment issues with National funding bodies.
Specific activities will include:
- daily management of administrative consortium activities within the consortium and toward National funding bodies.
- follow up of the implementation and update of the Consortium Agreement
- check the progress of administrative work
- coordinate the administrative bodies of the different participant institutions
- coordinate the preparation of financial reports

The management of risks and corrective actions to be taken will be handled for the entire duration of the project to identify, quantify, track and mitigate risks within the project. This activity will also enable the Consortium to monitor and control the overall level of risk throughout the project. A detailed description of significant risks and associated contingency plans is given in Section 3.2.3 Table 3.2b.

Deliverables
D1.1.1- Task 1.1: Kick-off meeting and its minutes. Month 1
D1.1.2- Task 1.1: Mid term project meeting and its minutes. Month 18
D1.1.3- Task 1.1: Final project meeting and its minutes. Month 36
D1.1.4- Task 1.1: Updated schedules of activities and tasks allocation. Months 2, 19
D1.2- Task 1.2: Data management plan. Month 6

Work package number	2	Lead beneficiary			INRA and ENSH		
Work package title	Monitoring of experimental fields and hydrological basins						
Participant number	1	3	4	5	6	7	9	10
Short name of participant	UNICA	FORESTAS	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	32	1	21	5	10	20	60	21
Start month	1				End month		36	

Objectives

This WP answers two main proposal objectives:

OB1: to develop and implement innovative methodologies for EvapoTranspiration (ET) measurements in typical heterogeneous Mediterranean agrosilvopastoral systems and agricultural environments;

OB2: to improve the eco-hydrologic monitoring in ephemeral rivers and wadis along the Mediterranean biome and climate types, establishing a transnational Mediterranean river monitoring system.

Description of work

Task 2.1: monitoring of experimental fields (leader: INRA)

We will distinguish the sites that are already instrumented to the sites that will be instrumented using meteorological or micrometeorological and sm sensors (Table 2).

In the sites already instrumented:

- historical data will be collected and uploaded to the online Common Project Server of SWATCH;
- check and calibration test of the sensors will be made, and eventually sensors that will not work properly will be send for maintenance and correction or in the extrem case will be replaced;

In the sites that will be instrumented:

- instrumented will be acquired, and all instruments and software will be first tested at the laboratory; power supply will be provided by solar panels for environmental sustainability;
- instruments will be installed at the sites and the first month will be used for for testing the instrument performance, trial-period.
- data will be collected every week and will be checked the accuracy with appropriate tests according to standard quality control criteria (e.g. raw data despiking, correcting for high and low pass filtering biases, applying a stationarity test); then data will be uploaded to the SWATCH on line database;
- maintenance and calibration tests of the sensors will be made yearly.

Data will be collected and recorded on dataloggers (e.g., CR3000 Campbell Sci.) at 30 min time step at least.

LAI measurements will be conducted periodically (15 days) using Accupar LP80 ceptometer and Licor LAI 2000. Measurement frequency will be increased (weekly) during the growth seasons (spring).

In some test sites (Table 2) geophysics methods (e.g., ground-penetrating radar and electrical resistivity tomography) and water-isotopic methodology will be used.

Sapflow sensors both in the stems and roots are already installed in some sites (Table 2), and will be installed in other sites. Granier – type sapflow sensors will be made in the laboratories of UNICA and INRA. Sapflow sensors will be installed at the start of the project, and frequently (weekly) checked and eventually replaced, due to their weakness.

Task 2.2: monitoring of hydrologic basins (leader: ENSH)
- Rain and streamflow will be monitored in all the investigated basins (some gage stations are already operative, Table 2).
- data will be collected, and checked for the accuracy; then data will be uploaded to the SWATCH on line database;
- in the basins already monitored, hystorical hydrological data will be collected and uploaded to the online Common Project Server of SWATCH.
- historical data of precipitation and temperature will be also collected from European Centre for Medium-Range Weather Forecasts (ECMWF). Accuracy of this database will be tested comparing with data of the gage stations, for evaluating the possibility to use ECMWF data in basins with short database, and amplify the database.
- sm and vegetation will be also monitored at the watershed scale, and will be compared with remote sensing observations (see WP4).

Task 2.3: analysis of field observation data (leader: INRA)
Analysis and data elaboration will be performed for:
- Control and quality check of data.
- estimate of ET components in agricultural and natural environments
- estimate of relationships between ET and soil moisture in different field sites
- estimate of uptake of root in the rocks

Deliverables (brief description and month of delivery)
D2.1 - Task 2.1: database from Task 2.1. Months 19, 36
D2.2 - Task 2.2: database from Task 2.2. Months 20, 36
D2.3 - Task 2.3: 2 submitted publications about data analysis. Month 36

Work package number	3	Lead beneficiary			POLIVA and ENIT		
Work package title	Ecohydrological modeling						
Participant number	1	4	5	6	7	9	10
Short name of participant	UNICA	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	22	14	2	8	16	20	20
Start month	1			End month		30	

Objectives

WP3 aims to:

1) implement coupled VDM-LSM models to simulate land surface flux, energy flux, ET, infiltration, runoff formation, sm, CO_2 budget, LAI dynamics of different species at the field scale,

2) develop distributed ecohydrologic models with vegetation dynamics, and runoff and base flow propagation at the basin scale,

3) identify a computationally-light and robust model for identifying the vegetation, climate and land use features crucial for the correct determination of the key ecohydrological variables.

Description of work

Task 3.1: LSM-VDM calibration and validation at field scale (Leader: ENIT)

LSM-VDM models (e.g. UNICA model, TETIS-VEG, INRA model) will be implemented for predictions of energy balance terms, soil moisture and LAI evolution. The model will be calibrated at all the case studies, comparing observed and simulated time series of the energy balance terms, sm, and LAI through a trial-and-error procedure. The model will be calibrated using data of the first 6 months and then will be validated using data of the subsequent 6 months.

Task 3.2: Distributed ecohydrologic model at basin scale (Leader: POLIVA)

- development of a distributed version of LSM-VDM model.
- inclusion of modules for runoff propagation by using a modified version of the Muskingum –Cunge method (Montaldo et al., 2004; Montaldo et al. (2007) and base flow.

The model will be also coupled with remote sensing observations (WP4) for:

- computing surface energy balance terms at the basin scale
- estimating ET at the basin scale

The model will be implemented for all the experimental basins included in SWATCH.

Task 3.3: LSM-VDM calibration and validation at basin scale (Leader: ENIT)

Model calibration by comparing the simulated runoff data with historical runoff through a trial-and-error procedure. The length of the calibration and simulation periods will be different for each monitored basin according to the length of historical data.

Task 3.4: model intercomparison and optimazion (Leader: POLIVA)

- models both at field and basin scales will be compared at the case studies.
- model sensitivity to time scale and parameterization for the different climate and environmental conditions of the case studies

Deliverables

D3.1 - Task 3.1: calibration and validation of LSM-VDM models at field scale for the experimental sites. Month 16

D3.2 - Task 3.2: developed distributed LSM-VDM models at basin scale. Month 12

D3.3 - Task 3.3: 2 submitted publications about modeling at basin scale. Month 30

D3.4 - Task 3.4: submitted publication about model intercomparison and optimization. Month 30

Work package number	4	Lead beneficiary			UNICA and ENIT			
Work package title	Remote sensing and data assimilation							
Participant number	1	2	4	5	6	7	9	10
Short name of participant	UNICA	ENAS	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	25	1	6	2	7	10	12	19
Start month	1			End month			34	

Objectives

OB3: to develop data assimilation systems for assimilating remotely sensed and field data into ecohydrological models at the watershed or agricultural district scales for optimal characterization of soil water balances (water content, storages and transfers) and the underlying water use efficiency;

Description of work

Task 4.1: acquisition of satellite images (Leader: UNICA)

The aim of this task will be the acquisition of the satellite multispectral images for Ts and LAI estimates, listed below:

- Landsat: spatial resolution 30 m, temporal resolution 16 days
- ASTER: spatial resolution 15 m, temporal resolution 16 days
- Quickbird: spatial resolution 1-3 m, temporal resolution 3 days
- SENTINEL 2: spatial resolution 10 m, temporal resolution 3 days
- NOAA AVHRR: 1spatial resolution 1 km, temporal resolution 1 day
- SEVIRI: spatial resolution 1 km, temporal resolution 15 min

Task 4.2: estimation and validation of Ts and LAI (Leader: ENIT)

- LAI will be estimated from NDVI using satellite near-infrared and visible bands
- Ts will be obtained from satellite thermal infrared bands
- Ts and LAI estimates will be tested with the observations of the field campaigns (WP2).

Task 4.3: development of a data assimilation system (Leader: UNICA)

- the Ensemble Kalman filter (Enkf) will be implemented in the VDM LSM for assimilating Ts observations. First it will be implemented at the field case studies using the observations of the thermal infrared sensors. After this first step, it will be implemented at the basin scale using Ts observations from remote sensors.
- the Ensemble Kalman filter (Enkf) will be implemented in the VDM LSM for assimilating LAI observations obtained from remote sensors at the basin scale.
- sensitivity analysis of the data assimilation system to frequency of assimilation and to spatial resolution of satellite images.

Deliverables (brief description and month of delivery)

D4.1 - Task 4.1: remote sensing images database. Month 21
D4.2.1- Task 4.2: LAI and Ts estimates from satellite images. Month 24
D4.2.2 - Task 4.2: 1 submitted publication about estimates from satellite images. Month 34
D4.3.1 – Task 4.3: data assimilation system. Month 18.
D4.3.2 - Task 4.3: 1 submitted publication about data assimilation system. Month 34

Work package number	5	Lead beneficiary			POLIVA and UNIAS		
Work package title	Analysis of land cover change strategies and climate change scenarios						
Participant number	1	4	5	6	7	9	10
Short name of participant	UNICA	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	20	11	3	14	12	10	16
Start month	4			End month		34	

Objectives

OB4: to identify the impacts of contrasting vegetation and crop types on the soil water balance, surface runoff, and water use under current and past Mediterranean climates;
OB5: to predict the impact of future climate scenarios on soil water balance, runoff, and water use;
OB6: to develop a set of land cover change strategies (e.g. forestations/deforestation, use of more water use efficient crops and woody vegetation) for climate change scenarios that optimize the use of water resources and increase the resilience of agricultural and agrosilvopastoral systems;
A further specifi objective of the WP is to analyze the precipitation and runoff gradient across the Mediterranean basins, and the effect of the typical Mediterranean precipitation seasonality on the runoff in the wide range of basins

Description of work

Task 5.1: analysis of historical hydrologic data (leader: UNIAS)

- computation of annual, seasonal, monthly and daily statistical series for precipitation, runoff, and temperature for case studies at basin scale.
- Statistical tests for detecting trend and change on the hystorical hydrologic data across the Mediterranean gradient;
- correlation between hydrologic time series and NAO;

Task 5.2: generation of the future climate change scenarios (Leader: POLIVA)

- acquisition of future climate scenarios of IPCC
- selection of IPCC climate models for future scenarios through comparison of hystorical climate model outputs with observed actual data in each investigated region.
- generation of future climate scenarios from historical climate data perturbed with IPCC future climate scenarios through a stochastic generator.

Task 5.3: effects of land cover changes strategies and climate change scenarios (Leader: UNIAS)

- evaluation of land cover changes and spatial distribution changes of competiting vegetations on water resources and CO_2 budgets and water uses under current climates;
- evaluation of future climate change scenarios on water resources and CO_2 budgets;
- development of land cover strategies for optimizing the water resources use and increasing the resilience of agricultural and forestry systems using future climate scenarios

Deliverables (brief description and month of delivery)

D5.1 - Task 5.1: submitted publication on historical data analysis. Month 22
D5.2 - Task 5.2: multiple future climate scenarios to be included in the project database. Month 26
D5.3 - Task 5.3: 2 submitted publications about the effect of land cover strategies and climate change scenarios. Month 34

Work package number	6	Lead beneficiary			CyI and INRA		
Work package title	Development of water management and planning systems						
Participant number	1	4	5	6	7	9	10
Short name of participant	UNICA	ENSH	CyI	UNIAS	POLIVA	INRA	ENIT
Person months per participant	18	6	5	8	3	16	14
Start month	11			End month		36	

Objectives

OB7: to improve the multipurpose and multiuser water resources management and planning systems for the optimization of the water infrastructure (e.g., reservoirs, groundwater recharge, water harvesting) and uses (irrigation, animal production systems, drinking and industrial activities), and management and planning under current and future climate change scenarios while preserving natural ecosystems.

Description of work

Task 6.1: water resources management models for case studies (Leader: CyI)

- improvement of existing water resources management models
- use of the outputs of WP5 in the water resources management models for application of the models for case studies.

Task 6.2: strategies for water resources optimization under current and future climate scenarios (Leader: INRA)

- development of strategies for the optimization of water infrastructure and uses for current climate conditions
- development of strategies for the optimization of water infrastructure and uses for future climate scenarios

Deliverables (brief description and month of delivery)

D6.1 - Task 6.1: scientific manuscript with description of water resources management model application in 7 Mediterranean watersheds (case study sites). Month 24

D6.2 - Task 6.2: submitted publications about strategies for water resources oprtimization. Month 36

Work package number	7	Lead beneficiary					UNICA			
Work package title	Quantifying benefits and sharing methodologies with stakeholders, dissemination and communication									
Participant number	1	2	3	4	5	6	7	8	9	10
Short name of participant	UNICA	ENAS	FORESTAS	ENSH	CyI	UNIAS	POLIVA	GVA	INRA	ENIT
Person months per participant	12	1	1	3	2	1	3	2	7	3
Start month	1					End month			36	

Objectives

OB7: to ensure the communication of project's benefits to the stakeholder during the project progress and to implement the strategies to ensure efficient communication and dissemination. The specific objectives are:

- to develop, maintain and improve the project web site and web platform
- to promote and ensure the communication with stakeholders
- to disseminate information on SWATCH activities

Description of work

Task 7.1: project web site and the other online communication systems (Leader: UNICA)

- development and maintenance of SWATCH web site
- development and maintenance of a "Google" research page
- development and maintenance of a "Researchgate" page
- development and maintenance of a "Facebook" page
- development and maintenance of a "Twitter" page

Task 7.2: engagement with scientific community and stakeholders (Leader: UNICA)

- Final communication and dissemination plan will be developed.
- organization of participatory seminaries, by including the multiple actors involved in the making up of water governance territory
- identify acceptable scenarios in view of simulated impacts, among the set of realistic modulations; conduct participatory seminaries for discussing possible configurations that are out of current prospective, and to foresee the possible interests/consequences
- share methodological developments, by setting a common toolbox where academic partners exchange former and newly developed approaches;
- deliver monitoring results and disseminate outcomes.
- Project results will be made available to the scientific community, thus allowing the development of multidisciplinary activities with interests in the context of hydrology, climatology, hydraulic construction, environmental sciences, water resources management and irrigation management.
- Project results wil be made available to the stakeholders in the project: ENAS (Sardinian water authority), FORESTAS (Forestry authority in Sardinia), REMOC-MENBO (Spain), Jucar River Water Authority (Spain), GVA, Algerian National Hydric Resources Agency, Smurfit-Kappa and

AFORCE (France), Forestry, Agriculture and Water Development Dept. (Cyprus), Regional crop office (Tunisia), etc. (see Table above for the list)

Deliverables (brief description and month of delivery)
D7.1.1 - Task 7.1: dissemination and communication plan (DCP). Month 7
D7.1.2 - Task 7.1: technical reports from participative seminars Month 34
D7.2.1: Project web site. Month 3
D7.2.2 - Task 6.3: reports from multidisciplinary activities/training sessions. Months 8, 20, 36

Table 3.1c: List of Deliverables

Deliverable (number) [24]	Deliverable name	Work package number	Short name of lead participant	Type[25]	Dissemination level[26]	Delivery date (in months)
D1.1.1	Kick-off meeting and its minutes	1	UNICA	OTHER	CO	1
D1.1.2	Mid term project meeting and its minutes	1	UNICA	OTHER	CO	18
D1.1.3	Final project meeting and its minutes	1	UNICA	OTHER	CO	36
D1.1.4	Updated schedules of activities and tasks allocation	1	UNICA	R	CO	2,19
D1.2	Data management plan	1	UNICA	R	CO	6
D2.1	dataset from Task 2.1	2	INRA	OTHER	CO	19,36
D2.2	dataset from Task 2.2	2	ENSH	OTHER	CO	20,36
D2.3	submitted publications about data analysis	2	INRA	R	PU	36
D3.1	calibration and validation of LSM-VDM models at field scale for the experimental sites	3	ENIT	OTHER	PU	16

[24] Deliverable numbers in order of delivery dates using the numbering convention:
<WP number>.<number of deliverable within that WP>
[25] Nature of the deliverable using one of the following codes:
R: Document, report (excluding the periodic and final reports)
DEC: Websites, patents filing, press & media actions, videos, etc.
OTHER: Software, technical diagram, etc.
[26] It is expected that most of the deliverables will be publicly available. Dissemination level using one of the following codes:
PU = Public, fully open, e.g. web
CO= Confidential, restricted under conditions set out in Model Grant Agreement

D3.2	developed distributed LSM-VDM models at basin scale	3	POLIVA	OTHER	PU	12
D3.3	submitted publications about modeling at basin scale	3	ENIT	R	PU	30
D3.4	submitted publication about model intercomparison and optimization	3	POLIVA	R	PU	30
D4.1	remote sensing images database	4	UNICA	OTHER	CO	21
D4.2.1	LAI and Ts estimates from satellite images	4	ENIT	OTHER	CO	24
D4.2.2	1 submitted publication about estimates from satellite images	4	ENIT	R	PU	34
D4.3.1	data assimilation system	4	UNICA	OTHER	PU	18
D4.3.2	submitted publication about data assimilation system	4	UNICA	R	PU	34
D5.1	Submitted publication on hystorical data analysis	5	UNIAS	R	PU	22
D5.2	multiple future climate scenarios to be included in the project database	5	POLIVA	OTHER	PU	26
D5.3	2 submitted publications about the effect of land cover strategies and climate change scenarios	5	UNIAS	R	PU	34
D6.1	scientific manuscript with description of water resources management model application in 7 Mediterranean watersheds (case study sites)	6	CyI	R	PU	24
D6.2	submitted publications about	6	INRA	R	PU	36

	strategies for water resources oprtimization					
D7.1.1	dissemination and communication plan	7	UNICA	R	PU	7
D7.1.2	Report of partecipative seminars	7	UNICA	R	PU	34
D7.2.1	Project website	7	UNICA	DEC	PU	3
D7.2.2	Report of multidisciplinary activities/training sessions	7	UNICA	R	PU	8, 20, 36

3.2 Management structure, milestones and procedures

3.2.1 Management Structure

The management structure of the SWATCH project (Fig. 3) has the main role to ensure an easy cooperation between all the partners, and ensure, through a professional control, the progress of the activities within the project lifetime. The SWATCH consortium includes 10 partners from 7 European countries, and they will work for the execution of seven interconnected WPs within the duration of the project. The communication will be mainly guaranteed by exchanges of email and documents trough internet, the "slack.com" site that will be created and used for facilitating day to day collaboration, videoconferences and workshops, and general assemblies. The organizational structure of the consortium will comprise the following bodies:

- **The General Assembly (GA)**: a decision-making body of the consortium.
- **Coordinator:** coordinate and manage the project
- **Technical Management Team (TMT):** support the coordinator in all the project aspects needed for the execution of the project.
- **Executive Board (EB)**: for implementing the project strategy.
- **Work package leaders**: manage and coordinate tasks and activities within the WP activities.
- **Expert Advisory Committee (EAC)**: commission composed by external experts.

General Assembly

The General Assembly (GA) is the decision body of the consortium, and it shall consist of one representative of each consortium member, the project coordinator and the Assistant Project Manager. Each General Assembly member shall be deemed to be duly authorised to deliberate, negotiate and decide on all matters listed below. The coordinator shall chair all meetings of the General Assembly. The Parties agree to abide by all decisions of the General Assembly. The General Assembly shall be free to act on its own initiative to formulate proposals and take decisions in accordance with the procedures described below.

The General Assembly shall be free to act on its own initiative to formulate proposals and take decisions in accordance with the procedures set out in the Consortium Agreement. Hence, the General Assembly is also the decision-making body for any issue concerning the Consortium and will resolve any project disputes arising between partners. The approval by the General Assembly shall be ensured by mail vote with a simple majority required. For a decision to be

binding, at least two-thirds of the General Assembly must have cast a vote or had the opportunity to do so, while the coordinator will decide the vote when no majority is agreed.

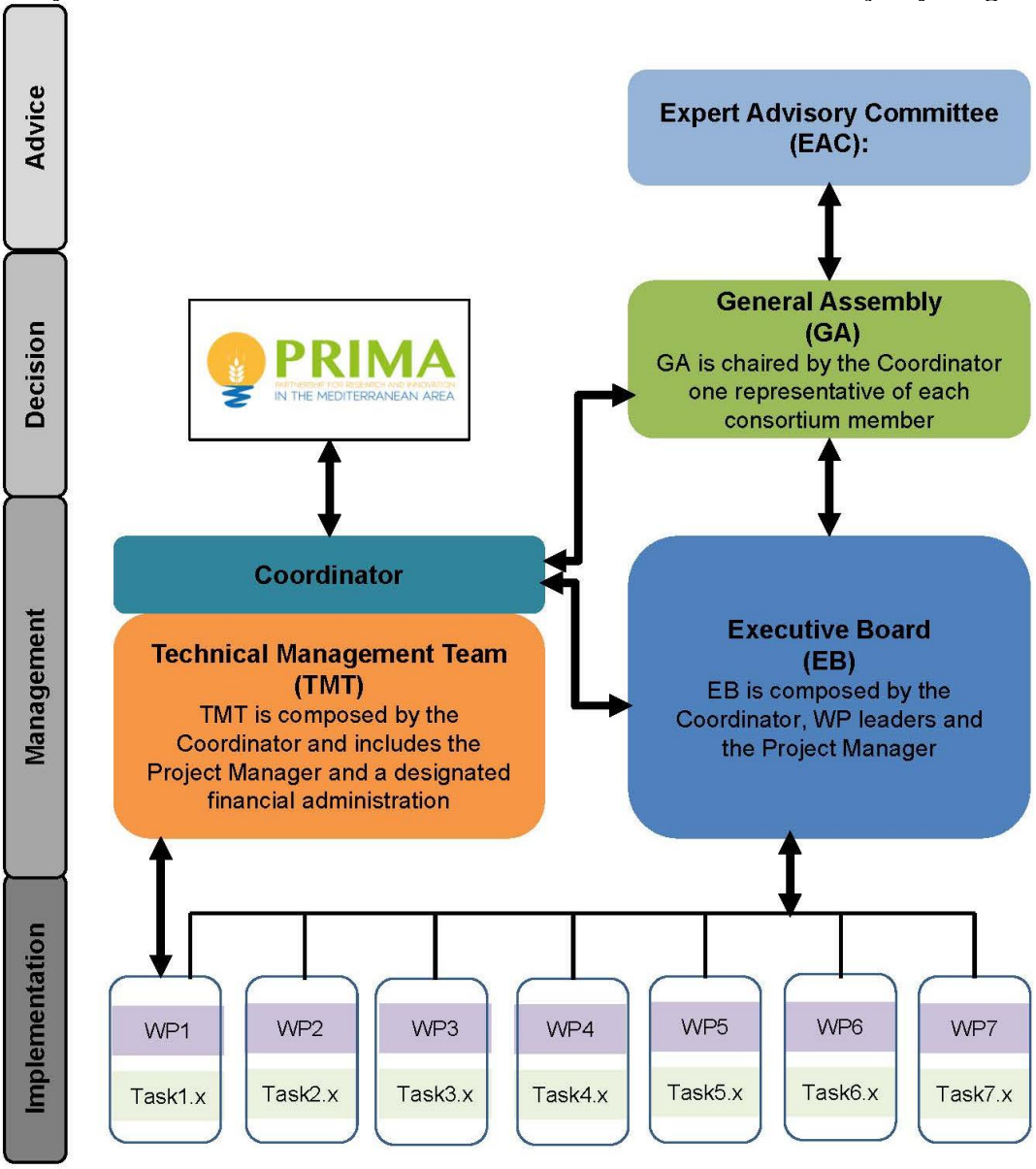


Figure 3. SWATCH governance structure

The following decisions shall be taken by the General Assembly:

- Declaration of a partner to be a Defaulting partner
- Corrective actions and measures for a Defaulting partner
- Suspension of all or part of the Project
- Adherence of the Consortium to Open Access requirements and appropriate data management.
- Any alterations of the Consortium Agreement;
- final decisions during the project

The decision and problem resolving process will be defined in detail in a Consortium Agreement.

Coordinator

The coordinator is the scientific coordinator of the project and is the responsible entity for administrative and managerial aspects. The scientific coordinator will monitor the progress of the project, and will also verify the quality of participant contributions, and ensure that deadlines will be met. The coordinator is responsible for maintaining contacts with PRIMA, the General Assembly (Fig. 3), ensuring a transparent development of the project.

Technical Management Team

The Technical Management Team will assist the coordinator in the day-to-day management of the Project including both legal and economic aspects. Moreover, the TMT will support the Coordinator and the Executive Board in executing the decisions of the General Assembly (Fig. 3). Head of the TMT will be the Coordinator. The TMT will also include an Assistant Project Manager and a designated financial administration. The Assistant Project Manager (APM) will assist the Coordinator with executive management tasks (organization of meetings and workshops, coordinating the preparation of reports, follow-up of planning schedule, issue reminders for task initiation or completion, scientific and technical, financial and administrative reporting, etc.). The financial relationships with each National funding bodies will be carried out by the administrative staff of each partner, but the supervision and control of the financial administration of the project will be carried out by Administration staff of UNICA. The TMT will be strongly involved in the implementation of the project, and will follow closely project management activities and procedures. In particular, the APM will 1) help the Coordinator in the administrative management of the project, keeping financial overview of effort allocation, 2) control the implementation of the Consortium Agreement, 3) manage possible conflicts and risks, and 4) help the Consortium for legal and ethical issues. The responsibilities of the TMT will be to:

- verify compliance by the partners with their commitments
- collecting, reviewing to verify consistency and submitting reports, other deliverables
- submitt the mid term and final reports (Month 18 and 36, respectively)
- day to day coordination of the project and monitoring project planning and progress
- communication within the project, to users, and to the general public
- organization of meetings and internal reviews
- keeping the address list of partners and other contact persons updated and available

Executive board

The Executive Board (EB) will include the Scientific Coordinator, the WP leaders and the APM. The EB role will be to perform the project strategy defined by GA (Fig. 3). The EB will meet at least ones per year. The EB will coordinate the WPs to ensure their communication and interactions. In addition, the EB will guarantee the constant connection with the GA by the communication of all project results, project status (risk, status, changes, etc.). The EB will monitor each step of the project and will decide to call technical meetings or redirect the working methods. The EB will guarantee a direct control on project deliverables and manage the project risk by the implementation of solutions to project risks. The proposed solutions will be referred to the GA that has to make the final decision.

Work package leaders

For each Work Package, a leader will ensure good communication within the WP (Fig. 3). The main activities of the WP leader are listed below:

- coordination of tasks and activities towards the WP objectives;
- manage and reaching the respective deliverables and milestones of the WP;

- ensure communication, coordination and interrelation with other Work Packages, including dissemination of the results generated within their WP;
- monitor the progress of tasks with respect to task goals and the acceptability of results;
- report to TMT of any possible deviations identified due to scheduling, unsuitability or risks affecting the quality of project results and/or objectives;
- direct connection with researchers.

The communications between the participants and the institutions within of the Work Packages will be ensured by the WP Leaders through web-based tools (Skype, "slack.com" site, etc.), telephone, email contact, and when needed, teleconferences and meetings. The WP leaders are reported in Table 3.1.a.

Expert Advisory Committee

The Expert Advisory Committee (EAC) is composed of external scientific international experts and and professional users, which will be actively involved for an external evaluation and validation of project. The main function of EAC will be:

- advising on the project scientific approach and orientation
- advising and assist on the project knowledge dissemination
- ensure a link to related activities both inside and outside Europe;

The communication with EAC will be guaranteed every six months (Fig. 3), and the EAC members will be constantly informed of the project progress. The members of EAC are listed below:

- Professor Marco Mancini: Politecnico di Milano (Italy).
- Professor Amilcare Porporato: Princeton University (USA).
- Dr. Teodoro Estrela, Head of the Planning Office of the Jucar Basin Authority.

3.2.2 Procedures

Within the entire duration of the project, the SWATCH partners shall cooperate and shall focus their capacities on the common goal: ensure the progress of the project and reach the objectives. The Coordinator shall guarantee that each partner and player within the consortium have all the necessary tools needed to contribute to the project. Moreover, the coordinator ensures a high level of communication within the consortium as to avoid lack of communication or problems in the project management.

The internal organization of the project shall be included in the Consortium Agreement (CA). In particular, the CA will contain the specifics about the following points:

- the internal organization of the Consortium, its governance structure, and decision-making processes;
- measures for the distribution of the Community Financial Contributions among Partners and among activities type;
- provisions for the settlement of disputes within the partnership;
- definition of specific measures concerning intellectual property rights to be applied among the Partners and their affiliates, in compliance with the general arrangements stipulated in the contract;
- procedures for changes in the consortium composition;
- rights, rules for joint ownership, access rights to project results for participants and 3rd parties;
- rules on dissemination and use;
- rules for managing confidentiality and approving public presentations and publications;
- the repartition of the tasks between partners;
- any specific requirements from a funding body.

The CA also includes details on the organization of project meetings (e.g. General Assemblies), meeting minutes, and voting rules. The main basis of a proposal for these operational procedures is described below.

Project meetings

Meeting of the consortium shall be convened by the chairperson that shall convene additional meetings when he reaches an extraordinary request of a consortium member. The chairperson, through a detailed program, shall inform of a meeting the consortium members, within a minimum number of days preceding the meeting, to be fixed. The decision within the consortium may also be taken without a meeting, if the chairperson circulates to all members a written document which is then signed by the defined majority of members. In addition, the meeting may be held by tele/video conference. The GA will be held at the start, in the middle and at the end of the project, and specific tele/video conferences will be scheduled to occur 2-3 weeks in advance of each GA.

Voting rules

The consortium voting establish that the consortium shall not deliberate unless a suggested two-thirds (2/3) of its members are present or represented (quorum). Each member of the consortium present or represented in the meeting shall have one vote, except the General Assembly, which members shall have a number of votes equaling the percentage of its Project Cost Share in the total cost of the Project. Defaulting partners may not vote. Decisions shall be taken by a majority of two-thirds (2/3) of the votes. The Consortium Agreement should also define the rules for any veto rights.

Minutes of meetings

Written minutes of each meeting, where are included the decisions taken, shall be made by the chairperson. He has also the responsibility to send the draft minutes to all consortium members within the time established in the CA. In addition, the chairperson shall send the accepted minutes to the project coordinator and to all members of the consortium.

Management of knowledge

The consortium agreement will establish the rules to manage the ownership and access to key knowledge (IPR, research data etc.). The SWATCH project will fully follow the Green Open Access for scientific publications, and each partner will ensure the published products are appropriately acknowledged, and provided with Green Open Access, including bibliographic metadata. The knowledge produced in the project will be made fully available to all the interested scientists.

3.2.3 Risk analysis and risk mitigation

The identification of risks is a constant process within the project life, begin during the proposal phase and it is regularly updated when the project starts.

Through the risk analyses, the risk attributes are evaluated and prioritized. Hence it is possible to evaluate the probability of risk occurrence (Likelihood of Occurrence) and its impact on the project, and determine risk responsibility and best actions to eliminate or mitigate them. The coordinator is responsible for the risk analysis and mitigation process and establishes the risk management procedures. Each WP leader is requested to provide for the work package in which is included a risk evaluation plan of where the risk identification, risk analysis, risk responsibility and a mitigation purpose. The preliminaries risk evaluation plans provided by the WP leaders, will be distributed to the consortium members and will be analyzed by the Executive Board. A preliminary risk assessment table with critical risks identified and mitigating actions is in table 3.2b.

Table 3.2b: Critical risks for implementation

Description of risk (indicate level of likelihood: Low/Medium/High)	Work package(s) involved	Proposed risk-mitigation measures
Coordination and/or management of SWATCH fails (Low/Medium)	1	The project coordinators as well as most of the consortium members have exhaustive experience in managing and running research projects, and the assistant project manager will plan and pro-actively avoid deviations and failures.
Disputes between partners (Low/Medium)	All	All the partners agree to try to resolve in the best friendly manner any dispute arising among them in relation to the implementation of the project. In this sense, all the partners agree to bring the dispute at the appropriate management body level. Failing to reach an amicable settlement, the dispute shall be finally handled according to the dispute resolution rules provided in the Consortium Agreement
A partner decides to drop out of the project (Low)	All	The issue will be discussed in the GA, which will decide if it is necessary to re-allocate work to other partners or suppress work without reducing the scientific quality of the project.
Not suitable quality of deliverables (Low/ High)	All	Revision and reorganizzation of each deliverable, and, for specific cases, reinforce partners participating in the deliverable
Deliverables not delivered on time – delays in project.	All	Day-to-day communication between coordinator and WP leaders and Executive board and TMT will ensure the reduction of potential delays in the project by the definition of clear protocols of internal communication.
Quality of monitored data is not satisfactory (Low/medium)	WP 2, 4	Quality control on observed data will be constantly implemented. In case of relevant quality problems will be detected, remedial actions will be defined and executed
Uncertainty in the model predictions of climate change scenarios. (Low/medium)	WP 5,6	To minimize the risk of inconsistency of model results, uncertainty will be carefully assessed by sensitivity analyses, both for today climate and for future projections
Uncertainty in the deployed strategies for optimizing the water infrastucture (Low/medium)	WP 6	To minimize the risk of the planned strategies, sensitivity analyses wil be carried out both for current climate conditions and for future climate scenarios
Dissemination of the project results is not sufficient to create impact (Low/medium)	WP 6	The consortium is strongly determined to create sustaining impact. In addition, a dedicated tasks for dissemination, and comunication will plan and execute this goal and prevent this risk
Political instability in study sites countries	All	The consortium will verify the existence of potential problems and will decide alternative or other potential most stable study site in the involved countries.

3.2.4 Project milestones

Project milestones have been evaluated within the project duration and they are listed in the table 3.2a. In addition, the milestones are indicated in the GANTT chart.

Table 3.2a: List of milestones

Milestone number	Milestone name	Related work package(s)	Due date (in month)	Means of verification
MS1	Project kick-off	1	3	Meeting report is available on the website
MS2	Database completion	2	21	Data quality validation. Data published in the website
MS3	Full version of operational models	3	21	Model validation by users
MS4	Database completion	4	22	Data quality validation. Data published in the website
MS5	Inclusion of scenarios in the project database	5	23	Publication in the project web site
MS6	Database update with water resources optimization strategies	6	25	Publication in the project web site
MS7	Web site	7	4	Website up and running, available on line for public access.

3.3 Consortium as a whole

The strong international cooperation of this project is a central issue. Climate change is affecting water resources in Mediterranean region, and there is the need to develop international cooperation in water research between Mediterranean countries. In the project European partners will collaborate with African partners providing a unique opportunity to knowledge and experience exchanges. Indeed, the wide and international partnership of SWATCH is a key point of the project. All the academic partners have strong expertise formed at the best international schools, which aspire to collaborate for knowledge and experience exchanges. Experts of a wide range of complimentary fields, e.g. hydrology, hydraulic, ecology, forestry, agronomy, micrometeorology, and geophysics are involved providing an excellent opportunity to advance water resources science of semi-arid and arid Mediterranean regions. This project offers a unique opportunity of exchanges of research and knowledge, which is the base for increasing the research development in water resources. Only analyzing sites with contrasting spatial scales, vegetation covers and climate is possible to understand deeply the complex ecohydrologic processes, and the strongly nonlinear dynamics between soil, vegetation and atmosphere, which is the key element of environmental planning strategies

for optimizing the water use and increase the resilience of agrosilvopastoral systems. The consortium composition is a balanced mix of 5 Universities, 2 Regional agencies, 5 National reasearch institutes, 1 local Authorithy. The inclusion of the Universities and National research institutus offers a unique opportunity of exchanges of research and knowledge, and ensures involvement and training of PhD students and postdoc scientists. The inclusion of local and regional authorities in the Consortium is the best way to involve actively the principal stakeholders in project decisions and in the application of the project results for water resources management systems. To prove the international scientific interest on the proposal project, word-renowned professors from best USA Universities (Ram Oren and Gaby Katul at Duke Univ., and John Albertson at Cornell Univ.) are also cooperating as scientific staff in the project.
This international cooperation will enhance the dissemination of project results and will help to make developed tools and methodologies truly international. The SWATCH consortium contains all the needed expertises to ensure the achievement of the objectives, and ensures a multidisciplinary cooperation between the experts of water resources sytem management, policymakers and the public society. The role of the SWATCH partners in the fulfilment of tasks in different work packages, is specified in the table below:

Partecipant n.	Partner	Key expertise/Competences	Main role in the project
1	UNICA	Coordination. Expertises in the fields of water resources planning and management, ecohydrology, micrometeorology, geophysic, geology, and design of hydraulic infrastructures	UNICA will act as SWATCH coordinator. It will also lead the tasks on the Echohydrological modeling, remote sensing and analysis of historical hydrologic data. UNICA will also lead the communication and dissemination activities.
2	ENAS	Expertise in integrated planning of water use, planning of water resources distribution, direct design and control of construction of large hydraulic works.	ENAS will provide input data and constructive feedback during the development of the proposed products and support the implementation of this project to the extent of its competence and capability.
3	FORESTAS	Expertise in sustainable forest management, natural resource and historical heritage management, silvicultural research and knowledge, oil conservation and hydraulic planning and managing of watersheds	FORESTAS Agency will contribute with its data, know how, networks and facilities to the development of the project.
4	ENSH	Expertise in climate change, water resources, erosion and solid transport, watershed management, and urban hydraulics and hydrotechnical structures.	ENSH will contribute to all WPs, and will have a main role on monitoring of hydrologic basins as co-leader of WP2**.**
5	CyI	Expertise in ecohydrology, climate, evapotranspiration, field monitoring, water resources, and stakeholder facilitation. Experience in sapflow measurements.	CYI will contribute to all WPs, and will have a main role in water resources management models and scenarios as co-leader of WP6

6	UNIAS	Expertise in physical environment related to water sciences.	UNIAS will contribute to all WPs, and will have a main role in eco-hydrological model calibration as co-leader of WP5.
7	POLIVA	Expertise in scientific and technical research in the field of water and environment, semiarid watershed hydrology, geology, ecology.	POLIVA will be involved in all WPs, and specifically in the mathematical modelling at the basin scale and the development of land cover strategies for optimizing the water resources use as co-leader.
8	GVA	Expertise in the development of Mediterranean forests, forest fires, erosion control, forest hydrology, climate change impacts and adaptation	GVA will support the implementation of this project to the extent of its competence and capability
9	INRA	Expertice in functional ecology, greenhouse gases, eco-hydrology, stable isotope geochemistry, forestry and agronomy	INRA will contribute to all WPs, with key role in monitoring of experimental fields, as co-leader of WP2 and WP6.
10	ENIT	Expertice in statistical hydrology, quantitative hydrology, climatology, geostatistics, data analysis, water resources management	ENIT will contribute to all WPs, having main roles on the calibration of the eco-hydrological models and the estimation of Ts and LAI from satellite images as co-leader of WP3 and WP4

3.4 Resources to be committed

Table 3.4a: Summary of staff effort

	WP1	WP2	WP3	WP4	WP5	WP6	WP7	Total Person-Months per Participant
Participant 1/ UNICA	30	32	22	25	20	18	12	159
Participant 2/ ENAS	0	0	0	1	0	0	1	2
Participant 3/ FORESTAS	0	1	0	0	0	0	1	2
Participant 4/ ENSH	1	21	14	6	11	6	3	62
Participant 5/ CyI	1	5	2	2	3	5	2	20
Participant 6/ UNIAS	1	10	8	7	14	8	1	49
Participant 7/ POLIVA	4.4	20	16	10	12	3	3	68.4
Participant 8/ GVA	0	0	0	0	0	0	2	2
Participant 9/ INRA	3	60	20	12	10	16	7	128
Participant 10/ ENIT	1	21	20	19	16	14	3	94
Total Person Months	41.4	170	102	82	86	70	35	586.4

Table 3.4b: 'Other direct cost' items (travel, equipment, other goods and services, large research infrastructure)

Coordinator/UNICA	Cost (€)	Justification
Travel	40000	Project Coordination meetings (WP7) Field campaigns (WP2) Partecipation of scientific Symposium (WP7)
Equipment	33000	Instrumentation for the stations (WP2)
Other goods and Services	20000	Organisation of workshop (WP7) Publications (WP1, WP2, WP3)
Total	93000	

3/ENSH	Cost (€)	Justification
Travel	20000	Project Coordination Meetings (WP1) Mobility (WP7) Field campaigns (WP2)
Equipment	40000	Meteo towers and instruments (WP2) Sensors for sap flux measurement(WP2) Data loggers(WP2)
Other goods and Services	2000	Participation to meetings and seminars for dissemination (WP7) Laboratory consumables(WP2) Experts and consultant fees (temporary expert/researcher)(WP2)
Total	62000	

4/CyI	Cost (€)	Justification
Travel	4100	Project Coordination Meetings (WP1) Mobility (WP7)
Equipment	0	
Other goods and Services	600	Participation to meetings and seminars for dissemination (WP7)
Total	4700	

5/UNIAS	Cost (€)	Justification
Travel	18000	Mobility (WP7) Project Coordination Meetings (WP1) Field campaigns (WP2) Attend Conferences
Equipment	24000	Meteorological stations (WP2) Data loggers (WP2)

		Workstation for data processing and statistical analysis (WP4, WP3)
Other goods and Services	2200	Participation to meetings and seminars for dissemination (WP7)
Total	44200	

6/POLIVA	**Cost (€)**	**Justification**
Travel	25000	Project Coordination Meetings (WP1) Mobility (WP7) Field campaigns (WP2)
Equipment	29000	EC station (WP2) Workstation for data processing and statistical analysis (WP4, WP3)
Other goods and Services	6000	Participation to meetings and seminars for dissemination (WP7) Organization of workshop (WP7)
Total	47541	

8/INRA	**Cost (€)**	**Justification**
Travel	14000	Project Coordination Meetings (WP1) Mobility (WP7) Field campaigns (WP2) Attend Conferences (AGU, EGU, ESA)
Equipment	12000	Sensors and dataloggers for sap flux measurement (WP2) Workstation for data processing and statistical analysis (WP5)
Other goods and Services	6000	Participation to meetings and seminars for dissemination, subcontracts to analyse soil samples (WP7)
Total	32000	

9/ENIT	**Cost (€)**	**Justification**
Travel	14673	Project Coordination Meetings (WP1) Mobility (WP7) Field campaigns (WP2)
Equipment	49190	Meteorological instruments (WP2) Soil moisture sensors (WP2) Data loggers(WP2) Personal computers (WP2 and WP3)
Other goods and Services	12495	Organization of workshop (WP7) Subcontracting (temporary expert/researcher) (WP2)
Total	76358	

Section 4: Members of the consortium

4.1. Participants (applicants)

Participant 1 (Coordinator): Dipartimento di Ingegneria civile, ambientale ed architettura, Università di Cagliari (UNICA)

Description of the organization

The Department of Civil and Environmental Engineering and Architecture is the polytechnic expression of the University of Cagliari. Scientific culture of project, planning, preservation, restoration and enhancement of environment and landscape, architectural, historical and archaeological heritages, structural and infrastructural assets, land and geological resources in the broadest sense are the aims that the Department proposes. It is the place of training for architects, civil and environmental engineers, with important projections to applied geosciences, professionals and researchers in planning and land management. Expertises inside the Department, such as environmental protection, sustainability, energy efficiency, Cultural Heritage, ICT, are key themes for the third millennium model of development in advanced societies. The hydraulic and hydrology group aims to promote projects and studies mainly related with the hydraulic risk evaluation, protection of the environment, protection of the marine environment, environmental hydraulic and soil–atmosphere interactions. Design of civil structure/infrastructures, hydrological networks, design of maritime structures and Hydraulic System Design are also the main themes promoted. The expertises in the fields of water resources planning and management, ecohydrology, micrometeorology, geophysic, and design of hydraulic infrastructures allow to address the activities and the objectives of the proposal and match the tasks.

CV Responsible persons

Nicola Montaldo (male) is associate professor of Hydrology and water resources at the University of Cagliari (Italy). He graduated in Civil Engineering at the University of Cagliari in 1995, obtained a Ph.D. in Hydrology at the Politecnico di Milano (Italy) in 2000 and was research associate at University of Virginia in 2000. He was assistant professor at Politecnico di Milano from 2003 to June 2006 and visiting professor at University of Virginia (USA) in 2001, at Duke University (USA) in 2002, 2004, 2005, 2013 and 2017, at the Swedish University of Agricultural Sciences in 2014, and Cornell University (USA) in 2015. Research interests: distributed hydrological modeling (flood forecasting and water balance), unsaturated zone hydrology, Land-atmosphere exchange, eco-hydrology, and remote sensing and Data assimilation in hydrological modeling. On these topics he was funded for research support as PI by many italian and European institutions, as Italian Spatial Agency, Italian Ministry of University, European Community “Programme Italie/France ‘Maritime' 2007-2013”, Sardegna ricerche, Regional Sardinian authority (LR 7/2007). He is author of more than 100 publications.
Giulio Vignoli (male) graduated in Physics at the University of Ferrara and received a PhD in Applied Geophysics from the same institution with a thesis focusing on inversion strategies. He is currently Associate Professor at the University of Cagliari and Adjunct Senior Researcher at the Geological Survey of Denmark and Greenland (GEUS). Before that, he worked at Aarhus University (Denmark), KFUPM (Saudi Arabia), the University of Padua (Italy), and the University of Utah (USA). His research interests include near-surface characterization especially with airborne electromagnetic and seismic surface wave methods
Andrea Saba (male) is Assistant Professor at University of Cagliari in water resources. His research activity is mainly related to design and optimation of hydraulic infrastructures.
Giovanni M. Sechi (male) is Associate Professor at University of Cagliari in hydrology and water resources. His research activity is mainly related to water resources management and

planning, optimization of water infrastructure and uses for water resources management in dry climates. He is author of more than 50 international scientific publications.

5 relevant publications

1) Montaldo N, Albertson J. D, M. Mancini, "Dynamic Calibration with an Ensemble Kalman Filter based data assimilation approach for root zone moisture predictions". *Journal of Hydrometeorology*, vol. 8, p. 910-921, ISSN: 1525-755X, 2007.
2) Montaldo N., J. D. Albertson and M. Mancini, "Vegetation dynamics and soil water balance in a water-limited Mediterranean ecosystem on Sardinia, Italy", *Hydrol. Earth Syst. Sci.*, 12, 1257–1271, 2008.
3) Montaldo N, Corona R, J D Albertson. "On the Separate Effects of Soil and Land Cover on Mediterranean Ecohydrology: Two Contrasting Case Studies in Sardinia, Italy". *Water Resources Research*, ISSN: 0043-1397, doi: DOI: 10.1029/2012WR012171, 2013.
4) Montaldo, Nicola, Sarigu, Alessio. "Potential links between the North Atlantic Oscillation and decreasing precipitation and runoff on a Mediterranean area". *Journal of Hydrology*, 553, 419-437, 2017
5) Montaldo, N., & Oren, R. "Changing seasonal rainfall distribution with climate directs contrasting impacts at evapotranspiration and water yield in the western Mediterranean region". *Earth's Future*, 6. https://doi.org/10.1029/2018EF000843, 2018.

5 relevant previous projects or activities

1) IDROSAR: Remote sensing soil moisture estimation and data assimilation system (CRP2_708, LR 7/2007) (C)
2) CLIMB: Climate Induced Changes on the Hydrology of Mediterranean Basins: Reducing Uncertainty and Quantifying Risk through an Integrated Monitoring and Modeling System, "7th Framework Programme", call FP7-ENV-2009-1, topic ENV.2009.1.1.5.2 (P).
3) Monitoring and modeling for water resources estimate in the Flumendosa basin under climate and land use change scenarios (CRP2_708, LR 7/2007) (P);
4) Micrometeorological and remote sensing measurements integration within distributed hydrological modelling for the evapotranspiration assessment (FIRB, LR7/2007) (P);
5) SEDEMED II: Dryness and Turning into a desert in the Mediterranean basin, Interreg IIIB MEDOCC (P).

Description of significant infrastructure and technical equipment

Three eddy covariance – based towers with 3D sonic anemometers, gas analyzers, net radiometers, rain gauges, meteorological sensors, data loggers. Sapflow sensors, soil moisture sensors, soil water potential sensors, data server, flow meters, leaf water potential meter, Accupar ceptometer for leaf area index measurements, soil physics laboratory, facility for chemical analysis, hydraulic laboratory. Several ground penetrating radar antennas allowing surveys at different resolutions and depth of investigation, frequency and time – domain electromagnetic devices (GEM-2, CMD-4 and miniexplorer), equipment for 2D and 3D electrical resistivity tomography (SyscalPro).

Participant 2: Ente Acque della Sardegna (ENAS)

Description of the organization

The ENAS, Ente Acque della Sardegna (the Sardinian Water Authority) is the nation's largest public water utility based on multipurpose dams; it was established to construct and manage a freshwater supply system for the sustainable and rational use of water resources on the regional scale. The system comprises works and infrastructure for the collection, storage and conveyance of water. The demand nodes serve a population of 1.6 million, about 160,000 ha of irrigated farmland and 11 industrial zones. This system, based on the use of surface water resources, accounts for about 75% of the water resources currently available in Sardinia.

In particular, ENAS carries out the following activities:

- integrated planning of water use and development of preliminary studies for environmental, territorial, socio-economic and engineering aspects for the construction of water schemes and multi-sectoral distribution;
- direct design and control of construction of large hydraulic works, irrigation tools and the related environmental studies;
- design and construction of plants for energy production also from renewable sources with the aim of reducing production costs and distribution of water for agricultural purposes;
- operational management of complex water systems with a high level of interconnection;
- planning of water resources distribution quantity and quality;
- promotion, development and participation in international cooperation projects in the thematic areas of water and environmental issues, water reuse in Tunisia, Morocco, Palestine, Bulgaria, Albania, Jordan, Afghanistan, Serbia, Kosovo, Bosnia, Venezuela, Ghana, etc.

Enas provides raw water to the treatment plants and water for irrigation and industrial purposes. Enas manages the multi-sector water system.

Enas will provide input data and constructive feedback during the development of the proposed products and support the implementation of this project to the extent his competence and capability.

CV Responsible persons

Giovanni Sistu (male) General manager, Associate Professor at the Department of Social Sciences and Institutions (DISSI), University of Cagliari; Main Research Interests at the moment: Environmental policies and local development, tourism specialization and territorial changes, water and waste management in the Mediterranean Region

Maria Antonietta Dessena (female) geologist, specialized on remote sensing and pedology, for land planning and monitoring of water resources. Since 1996 she works at the ENAS where she was responsible for various projects of International Cooperation (Interreg Medocc PROGECO, Italian Space Agency, APQ Mediterranean and Balkans, Ghana SOURCE, WATSAM Ethiopia etc.). She is the author of over 84 scientific publications

5 relevant publications

1) Lai F, Sistu G (2012). Environnement et tourisme dans les territoires fragiles: le cas des zones humides de la Sardaigne. ANUAC, vol. 1, p. 25-39, ISSN: 2239-625X.

2) Earth Observation data for Improved Water Quality Products in freshwater reservoirs. (Mariano Bresciania, Claudia Giardinoa, Paola Buscarinub, Maria A. Dessenab, et al.)2018. International Congresso of AIT - July 2018.

3) PERELLI C, PINNA P, SISTU G (2011). Mining Heritage, Local Development and Identity: The Case of Sardinia. In: AA VV. (a cura di): MICHAEL CONLIN, LEE JOLLIFFE, Mining Heritage and Tourism. A Global Synthesis. vol. 1, p. 203-213, LONDON:Routledge, ISBN: 978-0-415-56090-0

4) Book pub. “Applied Rempte sensing”. By M.A. Dessena e M.T. Melis. Ed. Mako edizioni, 2006.
5) The hydrographic system Flumendosa-Mulargia: the waters, soils and erosion. (G. Rodolfi, M.A. Dessena, S. Vacca). Book published by funds from EU Project ARSGISIP.
On the estimate of the leaf area index by remote sensing in the Mulargia basin, Sardegna. (N. Montaldo, M. Detto, M. Mancini, G. d’Urso, M. Minacapilli, M.A. Dessena). Congress “Earth observation for vegetation monitoring and water management”, Napoli 2005.

5 relevant previous projects or activities
1) Space-O: Space Assisted Water Quality Forecasting Platform for Optimized Decision Making in Water Supply Services. Horizon 2020/2016-2020.
2) AQUASTRESS: Mitigation of water stress problems through an integrated approach using technical, economical, and institutional management tools. This project was funded by the European Union in the context of the 6th Framework program. 2005-2009.
3) TOUR MED EAU – Tunisia and Morocco: Gestion durable de l’eau dans les territoires touristique de la Méditerranée. CIUDAD Program - Cooperation In Urban Development And Dialogue financed by European Neighourhood Partnership Instrument (ENPI) – 2010-2012.
4) Ghana S.O.U.R.C.E. Strengthening Organisational Units on water and sanitation Governance in the Rural and Coastal Environment of Ghana. (ACP Water & Sanitation Sector EuropeAid/129510/C/ACT/Multi - 2012-2014).
5) WARSAM ETHIOPIA. Support to Arba Minch Town water utility and Municipality in the water & sanitation sector through capacity building and partnership development with Italian water organizations. Partnerships for Capacity Development in the ACP Water & Sanitation Sector EuropeAid/129510/C/ACT/Multi - 2012-2015).

Description of significant infrastructure and technical equipment
Through its own biological-chemical laboratory, the Enas conducts water quality control operations. The Service also provides on regular basis the collection of samples and the chemical, physical, biological, and eco-toxicological and limnology analysis of water, soil, and sediment for the purposes of ensuring better utilization of the water resources available and distributed to users. The Service currently consists of 8 human resources with degrees in chemistry, biology, and chemical experts and; another 14 external associates provide support in the sampling and analysis.
Another important Service is represented by the SPT (Planning and remote control of water resouces Service). The Service centralizes the information coming from the network of sensors in the field, ie supplied by the Services of the technical areas, of all the quantitative and qualitative quantities of the regional hydraulic system and provides real-time information to the operational services of the General Water Authority. It takes care of the water balance of the artificial reservoirs and keeps the database of water flows and the quality levels of the hydraulic systems up-to-date. It establishes and keeps updated the hydrological, meteorological and hydrological data archives of the volumes supplied to the users, taking care of the accessibility of the other services and of the users. In collaboration with the Directorate General, it elaborates and updates the program for the transfer of resources to and from the various water systems managed by the Authority, the hydroelectric production plan, the utility supply program, according to the quali-quantitative status of the water present in the artificial reservoirs, and puts it into operation through the remote control in collaboration with the Management Services.

Participant 3: Agenzia forestale regionale per lo sviluppo del territorio e l'ambiente della Sardegna (FORESTAS)

Description of the organization

The Sardinian Forest Agency (Agenzia **FORESTAS**) – named *Ente Foreste della Sardegna* up to 2016 - is the main public agency involved in forest and natural resource management in Sardinia. The Agency manages over 220.000 hectares of land, including the most ancient forests and sites of high natural value (Natura2000), although its activities span the whole island (24.000 sq. km), and employs more than 6000 workers. With a special focus on sustainable forest management, its main fields of activity concern: 1) natural resource and historical heritage management; 2) forest health and pest control; 3) fire prevention, detection and suppression; 4) silvicultural research and knowledge transfer; 5) plant nurseries for reforestation, habitat and species conservation; 6) consultancy in all areas of forest management; 7) civil protection and disaster management; 8) soil conservation and hydraulic planning and managing of watersheds (mostly in an exstensive way); 8) forest fire fighting and prevention. The Forestas Agency will play a key role in the project, contributing with its data, know how, networks and facilities to the development of the project.

CV Responsible persons

Giuliano Patteri (male) is General Director of the Agency and head of the Technical Department of the Sardinian Forest Agency. He graduated in Hydraulic Engineering in 1998 and in 2007 he entered the Ente Foreste della Sardegna (now Agenzia Forestas) as a public officer. He coordinates the Agency's central offices dealing with forest planning and management, biodiversity and wildlife conservation, risk management assessment and management, economic valorization of woody and non wood forest products.

Massimo d'Angelo (male) graduated in Forest Science in 1984 at the University of Padua. In 1986 he specialized in "Aerial photography and remote sensing for the management of the Territorial Resources" at the Faculty of Engineering (University of Florence). From 1988 to 1994 he worked as researcher and scientific manager in various national and international research projects. From 1995 to 1999 he worked as researcher and professor on contract at the Desertification Research Centre (University of Sassari). In 1999 he entered the FORESTAS as a public Officer carrying on the academic activity at the University of Sassari. From 2005 to 2007 he was appointed as technical coordinator of the working group that drafted the Environmental and Forestry Regional Plan (PFAR) of the Region of Sardinia and since 2008 he is part of the Regional Coordination Office for the implementation of PFAR.

5 relevant publications

Casula A, Patteri G, Maltoni SL, Caddeo C, Pintus A, d'Angelo M (2015). Management constraints in coastal stone pine stands in Sardinia and suggestions for an improved management. In: Proceedings of the 10th SISEF National Congress "Sostenere il pianeta, boschi per la vita - Ricerca e innovazione per la tutela e la valorizzazione delle risorse forestali" (Travaglini D, Rossi P, Bucci G eds). Firenze (Italy) 15-18 Sep 2015. Abstract-book, Paper #c10.9.8. [online] URL: http://www.sisef.it/sisef/x-congresso/

Lovreglio R., Campus S., Scotti R., Mura M., Piredda I., d'Angelo M., (2014). Pre and post fire regeneration dynamics and silvicultural management for the coastal stone pine (Pinus pinea L.) in Arborea (Sardinia). ATTI del Secondo Congresso Internazionale di Selvicoltura Progettare il futuro per il settore forestale Firenze, 26-29 Novembre 2014.

5 relevant previous projects or activities

220.000 Hectares of forests managed, including many nature 2000 sites

2011 -2016 - "Program for the restoration and active conservation of coastal forest pine stands in Sardinia". Financed by the Sardinian Region with EU funds (POR 2007-2013). The activities were

carried out in 6 territories: Alta Gallura, Baronie, Ogliastra (on the East coast) and Linas-Marganai, Sinis-Arborea e Nurra-Sassarese (on the West coast). Web site: http://www.sardegnaambiente.it/j/v/152?s=266175&v=2&c=1562&t=1
2015 - LIFE 2014 2020 “Future for coppices”, defining best management approaches for the sustainability of coppice forests. In collaboration with Parteners. Forest Agency, 2 Universities one Research center and two regional forest agencies. Website: http://www.futureforcoppices.eu/en/

Description of significant infrastructure and technical equipment
The Agency has several buildings within the forests for hosting technical meetings, workshops and field trips, plant nurseries, etc. The Agency has a website www.sardegnaforeste.it to carry out information and communication activities and technical equipment for spatial data analysis (GIS).

Participant 4: Ecole Nationale Supérieure d'Hydraulique (ENSH)

Description of the organization

The Higher National School of Hydraulics of BLIDA (ENSH), is a public institution of higher education under the supervision of the Ministry of Higher Education and Scientific Research, created in 1972. The ENSH offers training in graduation and postgraduate degree: Engineer's degree in hydraulics, Master's degree in water engineering, Magister's diploma and PhD degree. Since its creation, it has trained hundreds of Algerian and foreign engineers and researchers. Our institution participates in many national and international research and cooperation projects. The research axes are multiple. They concern climate change, water resources, erosion and solid transport, watershed management, and urban hydraulics and hydrotechnical structures. ENSH is involved in European projects such as: ERANTMED, TASSILI, AUF (University Agency of Francophonie) and IRD France. Laboratory of Water Engineering and Environment brings expertise on agrohydrology, agrometeorology, irrigation water management, agricultural hydraulics, soil physics and chemistry, surface and groundwater hydrology, modelling, remote sensing and GIS in agriculture, climate variability, Drought.

ENSH has been working for many years on the plain of Mitidja surface awater and Groundwater in tremens of a availibilty and quality. This plain is knoun by his agricultural production. During the last decads, drought as a negative impact on disponibility owter water of irrigation. Our work will be focused on: - define strategies for the water sustainability under current and future climate change scenarios, optimizing water infrastructure (e.g., reservoirs, wells network design) and water use; - Estimate evapotranspiration, the main parameter of the water budget in our region. To do so we use advanced technical tools (remote sensing observations); - Analysis of climate and land use scenarios wich gives the inputs for the water resources management and planning to optimally use both surface water and groundwater.

CV Responsible persons

Dr. Mohamed MEDDI (male) is Professor in Hydraulics and hydrology in the National Higher School of Hydraulics. He has worked on climate change and drought. He works on the assessment of climate change impacts on crop productivity using climate, water and crop yield models. He is also working on soil moisture for better irrigation management. He conducted researches on sediment transport and the application of the information theory in hydraulics especially in river monitoring. For the last over 15 years has coordinated and/or participated in over 10 national and international research projects (PNR, CNEPRU, AUF ERANTMED, TASSILI). He supervises Phd students at the ENSH. He teaches Hydrology at ENSH for Graduation students. He participated in several scientific committees of national and international conferences, and published several scientific papers and conference presentations.

Dr Abdelmadjid BOUFEKANE (male) is an Assistant Professor in Hydraulics at the National Higher School of Hydraulics. He continues his researches towards water resources and watershed modeling. He conducted researches on climate change, scenario, evapotranspiration and underground water.

Dr. MEDDI Hind (male) is Doctor in hydrology from the University of Sciences and Techniques of Oran in Algeria. Director of the Research Laboratory. She is leading a national research project on Climate Change, Water and Soil Resources in Northern Algeria.

5 relevant publications

1) B Habibi, M Meddi, PJJF Torfs, M Remaoun, HAJ Van Lanen (2018). Characterisation and prediction of meteorological drought using stochastic models in the semi-arid Chéliff–Zahrez basin (Algeria). Journal of Hydrology: Regional Studies 16, 15-31

2) Abdelaaziz Merabti, Mohamed Meddi, Diogo S. Martins & Luis S. Pereira (2018) : Comparing SPI and RDI Applied at Local Scale as Influenced by Climate. Water Resour Manage (2018) 32:1071–1085. https://doi.org/10.1007/s11269-017-1855-7 Science (2017).

3) Zeroual A., Assani A.A., Meddi M. & Alkama R. (2018). Assessment of climate change in Algeria from 1951 to 2098 using the Köppen–Geiger climate classification schem. Climate Dynamics.

4) BOUFEKANE A. & SAIGHI O. (2018). Application of Groundwater Vulnerability Overlay and Index Methods to the Jijel Plain Area (Algeria). Ground Water Vol. 56 Issue 1, p p 143–156, https://doi.org/10.1007/s00382-018-4128-0

5) Zeroual A., Assani Ali A. and Meddi M. (2017). Combined analysis of temperature and rainfall variability as they relate to climate indices in Northern Algeria over the 1972–2013 period. Hydrology Research | 48.2 | 2017.

5 relevant previous projects or activities

1) RHOLEX deals with the sediment transport in the largest river of the country, which regime has been hugely modified due to dams. In Algeria sediment trsnaport is regularly sampled by regional agencies. Tis will help setting the interannual variability, and to compare it with the sedimentation rates obtained from sediment cores sampled in the near estuary area, which help going back into time of several decades. This is the only place in Magrheb where such a study is possible.

2) SIGMED in Algeria and Morocco focused on tools to be developed to assess the variability of hydrosedimentary regimes linked with land use change, at the scale of large rivers. We developed studies using remote sensing and GIS approaches, in two sites in Algeria and Morocco where dams are built on the main river course.

3) MAGHLAG in Morocco, Algeria and Tunisia, was developed to create a regional group of study of coastal lagoons, for biological and morphosedimentary surveys.

4) MEDFRIEND with UNESCO is helping to built and keep functioning over time, a regional community of researchers on specific topics. In MEDFRIEND we particularly develop the topics linked to Erosion and Solid Transport, Water Quality and Coastal Ecohydrology.

5) ERANTMED focused on water quality for irrigation in Mitidja plain

Description of significant infrastructure and technical equipment

Software: ArcGIS, Hydrus, Mike She. Sensors: A complete climate station for high resolution recordings and climate measurements, Soil moisture sensors, Soil moisture profiler, DataHogs, Data logger. Equipment for soil physics: Richards apparatus, infiltration-meters, Equipment for chemical analyses in soil and water, Laboratory equipment for soil geochemistry, laser granulometer, Table to determine pF

Participant 5: Energy, Environment and Water Research Center, The Cyprus Institute (CyI)

Description of the organization

The Cyprus Institute is a non-profit research and educational institution with a strong scientific and technological orientation, created in 2005. It is an issue-orientated institution, emphasizing international collaborations and cross-disciplinary research and education. The CYI has established three interdisciplinary research centres that are developed in partnership with leading institutions in their respective thematic areas. Since its foundation CYI actively participated in several EU projects (including an ERC) and it is ranked as the first Institute in Cyprus (normalized by its personnel) in EU grants. The Energy, Environment and Water Research Center (EEWRC) of the Institute, which was launched in 2007, was developed in partnership with the Massachusetts Institute of Technology and is guided by an international Scientific Expert Panel, chaired by Prof. Ghislain de Marsily. Research at EEWRC deals with societally relevant issues related to energy, environment, climate and water. EEWRC's overarching mission is the understanding of and preparing for the major challenges and changes in the environment, socio-economic structures and societies in the Eastern Mediterranean in the 21st century. Problems of national and regional importance and global significance are addressed with an emphasis on their specific regional, Eastern Mediterranean manifestations. The Center has also a PhD program in Energy, Environmental and Atmospheric Sciences. EEWRC is involved in various European and national funded projects related to water and natural resource management, environmental observations, and climate change modelling, impact assessments and adaptation. EEWRC cooperates with various government organizations and local enterprises on water, climate and environmental research.

In SWATCH, CYI will monitor and model ecohydrologic processes at field and watershed level in a semi-arid watershed under forest and agricultural land use. CYI will cooperate closely with governmental stakeholders (Department of Forest, Agriculture Department, Water Development Department, all under the Ministry of Agriculture, Rural Development, and Environment) and non-governmental stakeholders (environmental organizations, farmer unions), rural communities and local land users.

CV Responsible persons

Adriana Bruggeman (female) is an Associate Professor in Hydrology and Water Management at the Energy, Environment & Water Research Center of CYI. She has long-term experience in hydrological monitoring and modelling, agricultural water management and participatory research. She is the head of the Water Division, an interdisciplinary group of environmental researchers, who are working on national and EU-funded water, natural resource management, rural development and climate adaptation research projects. Prior to joining The Cyprus Institute, she worked as an Agricultural Hydrologist at the International Center for Agricultural Research in the Dry Areas (ICARDA), based in Aleppo, Syria, (1998-2009). In that capacity, she coordinated and cooperated in integrated natural resource management projects with research and development stakeholders throughout the Central Asia, West Asia and North Africa region. She also worked for 10 years in Virginia, USA, on monitoring and modelling studies for assessing the impact of management practices on surface water and groundwater quality (1988-1998). She has authored and co-authored more than 50 peer-reviewed journal publications (Web of Science h-index 13) and many other refereed and non-refereed publications. She has an MSc in Hydrology and Water Management from Wageningen University, The Netherlands, and a PhD in Biological Systems Engineering from Virginia Polytechnic Institute and State University, USA.

Hakan Djuma (male) is a Postdoctoral Research Fellow in Hydrology and Land Management at the Energy, Environment and Water Research Center of CYI. He has an MSc in Earth and

Environmental Sciences, University of Amsterdam, The Netherlands (2008) and a PhD in Environment and Atmospheric Sciences, The Cyprus Institute, Cyprus (2017). He has also worked as Geotechnical/Geohydrological Advisor at Mos Grondmechanica, Rotterdam, The Netherlands (2008-2009). His research focusses on the monitoring and modeling of hydrologic and environmental processes; fate of compounds in soil and sediment; water quality; erosion and soil conservation. He has been involved in various European Projects and has authored and co-authored 7 peer-reviewed papers in leading international scientific journals. He has coordinated and taught Geosciences and Environmental Management BS and MSc field courses and supervised MSc students. He has also coordinated EU-funded environmental civil society projects.

5 relevant publications

1) Eliades, M., A. Bruggeman, M. Lubczynski, A. Christou, C. Camera, H. Djuma. 2018. The water balance components of Mediterranean pine trees on a steep mountain slope during two hydrologically contrasting years. J. Hydrology 562: 712-724. https://doi.org/10.1016/j.jhydrol.2018.05.048
2) Djuma, H., C. Camera, A. Bruggeman, M. Eliades, K. Kostarelos. 2017. The impact of a check dam on groundwater recharge and sedimentation in an ephemeral stream. Water 9(10), 813. http://dx.doi.org/10.3390/w9100813
3) Camera, C., Z. Zomeni, J. Noller, A.M. Zissimos, I.C. Christoforou, A. Bruggeman. 2017. A high resolution map of soil types and physical properties for Cyprus: A digital soil mapping optimization. Geoderma 285: 35-49. http://dx.doi.org/10.1016/j.geoderma.2016.09.019
4) Zoumides, C., A. Bruggeman, E. Giannakis, C. Camera, H. Djuma, M. Eliades and K. Charalambous. 2017. Community-based rehabilitation of mountain terraces in Cyprus. Land Degradation and Development 28(1): 95–105. http://dx.doi.org/10.1002/ldr.2586
5) Djuma, H., A. Bruggeman, C. Camera, C. Zoumides. 2017. Combining qualitative and quantitative methods for soil erosion assessments: an application in a sloping Mediterranean watershed, Cyprus. Land Degradation and Development 28(1): 243–254. http://dx.doi.org/10.1002/ldr.2571

5 relevant previous projects or activities

1) BINGO (H2020, 2015-2019): Bringing Innovation to ongoing water management—a better future under climate change
2) RECARE (FP7, 2013-2018): Preventing and remediating degradation of soils in Europe through land care
3) BEWATER (FP7, 2013-2017): Making society an active participant in water adaptation to global change
4) INNOMED (ERA-NET WaterWorks2015 Water JPI & FACCE JPI joint program, 2017-2020): Innovative Options for Water Resources Management in the Mediterranean
5) 3PRO-TROODOS (Cyprus RPF, 2018-2021): Proactive Producer and Processor Networks for Troodos Mountains Agriculture

Description of significant infrastructure and technical equipment

Sapflow sensors, soil moisture sensors, soil water potential sensors, rain gauges, meteorological sensors, data loggers, data server, flow meters, sediment traps, soil leaf water potential meter, water quality sensors, soil physics laboratory, facility for chemical analysis, High Performance Computing Facility, access to fenced forestry research site (Cyprus Department of Forests) and agricultural fields of many cooperative farmers.

Participant 6: Irrigation and Hydraulics Dept., Faculty of Engineering, Ain Shams University (UNIAS)

Description of the organization

The Faculty of Engineering, Ain Shams University, is a public institution of higher education under the supervision of the Ministry of Higher Education and Scientific Research and was founded on 1950. The mission of the irrigation and hydraulics department is to develop technical expertise capable of understanding the physical environment related to water sciences and its application to the benefit of Egypt. The department aims to develop well-educated civil engineers with a special expertise in water-related engineering projects who can enrich the water resources and public works field. The department also aims to prepare its graduates to appreciate sustainable integrated water systems and environment-related issues. The Irrigation and Hydraulics department offers training in graduation and postgraduate degree: B.Sc. degree in water engineering, M.Sc., Ph.D.and Diploma in different water engineering branches (i.e. hydraulics, hydrology, marine, coastal,…). The department is involved in many national and international research and acadmic projects concerning water scince (i.e. Flood management, water resources, watershed management, River engineering and urban hydraulics). UNIAS is involved in European projects such as: EXCEED, TEMPUS and others.

CV Responsible persons

Prof. Ashraf M. Elmoustafa (male), is professor of engineering hydrology at the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University. His work focuses on the Hydrology, hydro-informatics, River Engineering, and GIS application in water engineering. He teaches a few water related topics at Ain Shams university for both graduate and post graduate classes. He launched a YouTube channel of educational material for engineering hydrology in Arabic language to help the student and young professionals in Egypt and the ME working in this field. He is the GM of consulting unit (since 2006), specialized in water engineering, flood protection, wet infrastructure, hydrodynamics studies and had carried out several related project in the ME and Africa of mega and medium scale using advanced (1D and 2D) modelling techniques. He has participated and is now involved in multinational projects with academic infinities in Germany, Turkey, USA, Jordan, Netherlands and many ME and African countries.

Prof. Ahmed A. Hassan (male) is Professor of Environmental Hydrology at the Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University. His work focuses on the Hydrology, Environmental Protection and Numerical Modelling. He conducted research on water resources management, flood control and inundation studies, storm water management in arid environment, hydrologic and hydraulic studies/analysis. He had published several manuscripts in related peer reviewed journals through his work and post graduate studies under his supervision. He Also Conducted advanced studies and modelling for hydraulic simulation, water quality for several entities using the most up-to-date tools and techniques in such filed. He teaches water related topics (i.e. Environmental Hydrology, Groundwater Hydrology, Environmental Impact Assessment for Water Projects and others) for both graduate and post graduate classes. Prof. Ahmed has participated and is now involved in a multinational project with academic infinities in Germany, Turkey, Jordan and many African and Asian countries.

Dr. Mona Hagras (female) is Associate Professor, Irrigation and Hydraulics Department, Faculty of Engineering, Ain Shams University. She teaches Hydraulics, Hydrology and Groundwater for both undergraduate and post graduate students and supervises MSc and PhD students. She published several scientific papers.

5 relevant publications

1) Omar H. Zohny, Ashraf M. El Moustafa, Mohamed A. Gad (2018): A GIS Automated Hydrologic Model for Engineering Applications. Journal of Al-Azhar University Engineering Sector, p-ISSN: 1110-6409 (July 2018)
2) Ahmed Hassan, Sherine S. Ismail, Ashraf Elmoustafa, Shaimaa Khalaf (2017). Evaluating Evaporation Rates Using Numerical Model (Delft3D). Current Science International, ISSN: 2077-4435, Vol. 6, No 2, 20
3) Mona A. Hagras 1 & Rasikh Habib (2017). Hydrological Modelling of Haro River Watershed, Pakistan. IJRRAS :30 (1) January
4) Mona A. Hagras, Ashraf M. Elmoustafa, Ahmed Kotb (2013). Flood Plain Mitigation in Arid Regions-Case Study: South of Al-Kharj City, Saudi Arabia. IJRRAS: 16 (1) July
5) Mona A. Hagras (2013). Water Quality Assessment and Hydrochemical Characteristics of Groundwater in Punjab, Pakistan. IJRRAS :16 (2) August

5 relevant previous projects or activities

1) EXCEED (2009-Now) consists of a network of 30 full member institutions worldwide. A renowned scientist who has his research focus on water problems represents each of these institutions. The project considers cooperation, education, capacity building and knowledge transfer within the water research and management area to be an indispensable condition for solving present and, in particular, further water-related problems.
2) JST - JICA Collaborative Research project "Flash Floods Integrated Management Considering Climate Change for Secured Development in Wadi Basins". (2018-2020) The aim of this project is to develop the sustainable system for flash floods integrated management including prediction, mitigation and water harvesting.
3) Flood Assessment for Tabarjal City, KSA (2017). Carrying out a hydrological study of North KSA region. Followed by assessment of existing protection works within the vicinity of Tabrajal city. After that a new flood control system was proposed for the city to allow for water storage in natural depressions.
4) Joint research project U.S.-Egypt Science & Technology Joint Fund Program "Flood Risk Map for Sinai Governorates" at Iowa Flood Center at IIHR-Hydro science and Engineering (2012).
5) Tempus project; "Technology Management and Integrated Modelling in Natural Resources" (2009-2011). Developing of curricula and courses for Hydro-informatics Masters at the Irrigation and Hydraulic department, Faculty of Engineering Ain Shams University.

Description of significant infrastructure and technical equipment

Water Quality lab; including devices for chemical and physical analysis like PH meter, B.O. meter, turbidity meter, dedicated filter photometer, Bench top Spectrophotometer, TSS system, reverse osmosis lab-scale unit. GIS lab; including high performance computing facility and Softwares (i.e. GIS, Bently Package for networks, HECs, MIKE SHE). The lab offers training courses for several computer applications. Hydraulic laboratory equipped with open channels, pipe flow apparatus, wave generator, flow meters, soil moisture sensors, data loggers, and sediment traps.

Participant 7: Research Institute of Water and Environmental Engineering, Universitat Politècnica de València (POLIVA)

Description of the organization

The Polytechnic University of Valencia is a non-profit public higher education institution. According to Times Higher Education Ranking it is the best technological university in Spain. POLIVA has as main tasks: i) lead scientific and technical research in the field of water and environment; ii) promote the transfer and dissemination of knowledge, scientific advances and research results in the areas of activity of the Institute; iii) support the creation of networks and platforms and other articulated structures to promote collaboration and transfer of research results; iv) satisfy, in the field of water and the environment, the training needs of companies and society in general, through specialized training and postgraduate courses. POLIVA staff has participated in many European programs as INTERREG, 4th, 5th, 6th and 7th FP, ERANET, LIFE, Climate-Kic and H2020. IIAMA coordinates the Spanish network of Water Research Institutes (RIAMA), is a member of the Spanish Technology Platform (PTEA) and the European WssTP and participates in 3 Action Groups of the EIP-Water. This profile makes POLIVA a partner capable to address the diferent objectives and WP's in the proposal, as key research groups from the Institute will be involved: Forest Science and Technology and Environmental and Hydrological Modelling. This research team has accumulated an extensive experience on semiarid watershed hydrology, physical and mathematical modelling of hydrologyc systems and flow phenomena, plant-soil-atmosphere relationships, forest restoration, soil biogeochemistry, development of hydro-economic models with applications to the water-energy-land-climate nexus, climate change impacts and adaptation, water economics, etc.

CV Responsible persons

Antonio D del Campo (male) Associate professor. Higher Technical School of Agronomic and Environmental Engineering. Research institute of water and environmental engineering. Universitat Politécnica de Valencia. Leader of the research group Re-ForeST. Research interests are forest eco-hydrology and forest restoration. The manipulation and optimization of the water-carbon (energy) nexus through forest management can play an enormous role in achieving current policies and goals on sustainable development and bio-economy. Water, carbon, climate resilience, as well as their mutual relationships and linkages also modulate most of the goods and services provided by forest ecosystems and watersheds. These issues have been developed in different research projects supported by the Valencia Regional Government, the Spanish National Government, private companies and the European Union. Over 20 research projects , 15 of which as PI, summing up a budget over 1000 K€. About 100 publications in peer reviewed journals, book chapters and congress proceedings.

Prof. Félix Francés (male) Full Professor at the Polytechnic University of Valencia in the Department of Hydraulic Engineering and Environment, leader of the Research Group of Hydrological and Environmental Modelling, Vice-president of the Spanish Water Technological Platform. Since 1988, he has participated and managed more than one hundred research projects and engineering studies in the fields of urban hydraulic modelling, distributed hydrological and environmental modelling, ecohydrology, flood forecasting systems, flood hazard and risk mapping, flood frequency analysis, erosion and sediment yield and water resources evaluation. These projects have been mainly supported by the City Council of Valencia, the Valencia Regional Government, the Spanish National Government, the European Union and private companies. From all these projects it can be underlined the "Flood Risk Regional Assessment

and Master Plan", for the Valencia Regional Government, the development of the distributed hydro-environmental model TETIS (used by Tagus, Jucar and Vasc Water Authorities). He published 67 research papers and 33 books and book chapters, and more than two hundred congress communications.

5 relevant publications

1) del Campo, A.D., González-Sanchis, M., Lidón, A., Ceacero, C., García-Prats, A., 2018. Rainfall partitioning after thinning in two low-biomass semiarid forests: impact of meteorological variables and forest structure on the effectiveness of water-oriented treatments. Journal of Hydrology. DOI: j.jhydrol.2018.08.013
2) García-Prats, A., Gonzalez-Sanchis, M., del Campo, A.D., and Lull, C. 2018. Hydrology-oriented forest management trade-offs. A modeling framework coupling field data, simulation results and Bayesian Networks. Science of the Total Environment 639: 725–741
3) G. Ruiz-Pérez, J. Koch, S. Manfreda, K. Caylor and F. Francés (2017). Calibration of a parsimonious distributed ecohydrological daily model in ungauged basins using exclusively the spatio-temporal variation of NDVI. *Hydrol. Earth Syst. Sci*., 21 (12), 6235–6251.
4) Ruiz-Pérez, G., González-Sanchis, M., del Campo, A.D., Francés, F., 2016. Can a simple model implemented with satellite data be used for modelling the vegetation dynamics and water cycle in water-controlled environments? Ecological Modelling, 324: 45–53. DOI: 10.1016/j.ecolmodel.2016.01.002
5) del Campo, A.D., Fernandes, T.J.G., Molina, A.J., 2014. Hydrology-oriented (adaptive) silviculture in a semiarid pine plantation: How much can be modified the water cycle through forest management? European Journal of Forest Research, 133(5): 879-894. DOI 10.1007//s10342-014-0805-7.

5 relevant previous projects or activities relevant to the proposed work

1) 2018-2022. Coupling water, fire and climate resilience with biomass production in Forestry to adapt watersheds to climate change. LIFE RESILIENT FORESTS (LIFE17 CCA/ES/000063) Total project budget: 2,013,973 €. PI/coordinator: AdC
2) 2018-2020. Incorporation of eco-hydrological criteria and resilience against climatic and fire disturbances in forest planning and management in Mediterranean basins (CGL2017-86839-C3-2-R, CEHYRFO-MED, 108,000 €) funded by the Spanish Ministry of Science and Innovation and FEDER funds. PI: AdC
3) 2015-2018. SILWAMED (CGL2014-58127-C3-2-R), Development of criteria and concepts for an ecohydrologic-based forest management in response to global change, 133 000 €, funded by the Spanish Ministry of Science and Innovation and FEDER funds. PI: AdC
4) 2012-2015. INTEGRA (CGL2011-28776-C02), Modeling the interactions between sediment, vegetation and water quality in semiarid Mediterranean forests at plot and basin scales, 336.680 €, funded by the Spanish Ministry of Science and Innovation and FEDER funds coordinated by Dr. Félix Francés
5) 2010-2014. SCARCE: Assessing and Predicting Effects on Water Quantity and Quality in Iberian Rivers caused by Global Change (ref.: CSD2009-00065, 338.078 €), funded by the Spanish Ministry of Science and Innovation and FEDER funds, PI by Dr. Félix Francés

Description of significant infrastructure and technical equipment

POLIVA owns intrumented research sites in different agrosylvopastoral contexts in the Valencia region. The technical equipment consists in a large number of instruments and sensors (> 100 per experimental site) that continuously register ecohydrological variables (sapflow sensors, soil FDR, meteorological station, piezometers, runoff collectors, cosmic ray probe, etc.).

Participant 8: Conselleria de Agricultura, Medio Ambiente, Cambio Climático y Desarrollo Rural. D.G. Medio Natural, Evaluación Ambiental (GVA)

Description of the organization

The Generalitat Valenciana is a public institution that performs the functions of the Spanish State on environmental matters in the Valencia Region, as established by the Constitution, The Statute Autonomy, and Transfer Law since 1984.

The Directorate-General for Environmental Management is responsible for planning, controlling, coordinating and monitoring the activity of services such as: Forest Management, Management of Protected Natural Areas and Biodiversity.

In regard to forest management, the Directorate-General for Environmental Management is responsible for maintaining the biodiversity, productivity, regeneration capacity, vitality of forests, as well as to potentiate their ecological, economic and environmental functions. This has a special incidence on forest regulatory services: soil conservation and erosion control, aquifer recharge, flood control, local regulation of rainfall regime, mitigation of desertification and global climate change mitigation.

The Directorate-General staff has many years of experience working in collaboration with both private companies and public organizations and has participated in many European programs, basically focused on Mediterranean regions (INTERREG, MED program, LIFE).

These collaborations have accumulated an extensive experience on Mediterranean forests development different subjects as forest fires, erosion control, forest hydrology, climate change impacts and adaptation, etc, which general goal is the conservation and sustainable management facing global warming.

CV Responsible persons

Pilar Ara Lázaro (female) Jefa de Sección de Estudios y Planificación Forestal

- Coordination, management and monitoring of forests managed by Generalitat, specially focused on "Catálogo de Montes de Utilidad Pública de la Comunidad Valenciana".

The "Catálogo de Montes de Utilidad Pública de la Comunitat Valenciana" is an administrative record of forests that fulfill a public service due to their ecological, social, hydrological, etc. characteristics. This catalog is the guarantor of the preservation of this natural heritage. At this moment there are included 447 forests with a surface of 382.445 ha.

- Coordination, management and monitoring of projects within the Forestry management department. From 1990, elaboration of European programme sections dealing with forest projects, including ERDF, EAGGF, ESF and Cohesion funds. Coordination, monitoring and management of these funds. There have been processed more than 247 projects of investment in forests managed by Generalitat, related with erosion control and restoration of degraded ecosystems to protect and restoration of the equilibrium of the water-soil-vegetation resources and the hydrological cycle conceived in an integral way.

Institutional relations with National and European organisms.

At national level, she is member of Forestry Information Working Group, and of Forestry Cartography Working Group. Both created by National Government and integrated by all Spanish regions. There are groups of coordination of national policies and definition of commons indicators and standards on forest issues.

At European Level, in 2007 she realised Structural training in European Commission. Agriculture and Rural Development. Horizontal aspects of rural development. F6 Bioenergy, biomass, forestry and climate change.

previous projects or activities relevant to the proposed work

Elaboration, coordination and management of projects financed under Interreg III B and III C, MED, LIFE. Some of these co-operation projects and their topics are: the effects of ozone on

the forest vegetation (Interreg III B Medocc FORMEDOZONE), restoration of the "Via Augusta" trail by constructing a natural trail parallel to ancient roman road (Interreg III B Medocc VREM), exchange of information on pilot studies on the Mediterranean region (Interreg III B Medocc RECOFORME), creation of a Mediterranean forest seed bank network (Interreg III B Medocc GENMEDOC), Promotion of residual forestry biomass in the Mediterranean basin (PROFORBIOMED), Innovative tecniques for mine restoration (TECMINE).

Description of significant infrastructure and technical equipment

The Generalitat Valenciana is entrusted with the management of public forests belonging to the Generalitat or other public bodies that are included in the "Catálogo de Montes de Utilidad Pública de la Comunitat Valenciana". Said Department also manages the forests affected by a consortium or agreement, during the time stipulated, as well as the forests belonging to Generalitat Valenciana not included in "Catálogo de Montes de Utilidad Pública de la Comunitat Valenciana". The "Catálogo de Montes de Utilidad Pública de la Comunitat Valenciana" is an administrative record of forests that fulfill a public service due to their ecological, social, hydrological, etc. characteristics. This catalog is the guarantor of the preservation of this natural heritage. In total, the Generalitat manages a total of 576 forest with an area of 430.223 ha, which is one third of the Valencian forest territory.All this infrastructure of forests with its wide range of ecological and natural features constitutes the best base to develop the project.

Participant 9: INRA Bordeaux Sciences Agro UMR 1391 (INRA)

Description of the organization

The Research Unit "Atmosphere Plant Soil Interactions" (ISPA) is a joint INRA– Bordeaux Sciences Agro research unit (UMR) located in Bordeaux. INRA-TCEM has 73 permanent staff (35 researchers/teachers and 28 staff and technicians). Scientists from INRA –ISPA are also members of the executive committee of the experimental research cluster XyloForest. TCEM is also a member of the LABEX (Laboratory of Excellence) "*COTE"* ("Continental to coastal ecosystems") that was graded A+ by the AERES after le last evaluation). ISPA gathers competences in functional ecology, greenhouse gases, eco-hydrology, stable isotope geochemistry, forestry and agronomy. Our research aims are to understand better the physiological responses and short- and long-term adaptation of terrestrial ecosystems to environmental changes, management practices and extreme climatic events. We are also interested in understanding what the repercussions of management and environmental change will have on plant productivity as well as the water, CO_2 and energy budgets at the Earth's surface. The main goals of this research unit is to contribute to the sustainable management of terrestrial ecosystems. Its two main research axes are 1) process----based modeling of fluxes of water, carbon and nutrients from soil to plants, 2) modeling of biogeochemical cycling in croplands, pastures and forests, and 3) energy in anthropised, agricultural and forest ecosystems. Our work aims to assess the sustainability of agro-ecosystems in a changing climate and anthropogenic stresses in order toensure a sustainable crop production in quantity and quality, and preserve the environment. Several ISPA scientists are associated with the Doctoral School from the University of Bordeaux (Life Sciences, geosciences, sciences for environment) and are therefore habilitated to host and supervise graduate students.

CV Responsible persons

Jean-Christophe Domec (male) received his PhD from Oregon State university. He did his postdoctoral work at Oregon State University. In 2011, he joined Bordeaux Sciences Agro as a full Professor in sustainable forestry. Jean-Christophe's experience lies in plant physiology, plant water transport modeling, and wáter fluxes at several scales. His goal as a researcher is to improve the fundamental science understanding of how plants and terrestrial ecosystems respond to climate changes, and to provide tree breeders with policy-relevant information. He has carried out research on interactions between soil water and plant water use in contrasting ecosystems. Domec is also co-investigator of a cluster site of edyflux towers in North Carolina. For the last five years he has been working on plant physiological acclimation to changing climate and thus this project directly relates to his on-going research. Within the last 10 years, Domec (H-index = 43) has been lead PI and Co-PI on several international projects and has published over 110 peer reviewed scientific papers.

Denis Loustau (male) is a Scientist in Forest Ecology and Tree Ecophysiology, INRA, since 1988, and a rechearch director since 2001. D. Loustau was the head of INRA-ISPA research center for 5 years between 2007 and 2012. D. Loustau has over 16,000 citations (H-index = 53) has been lead PI and Co-PI on several international projects and has published over 150 peer reviewed scientific papers. For his involvement in one IPCC Good Practice Guidance for LULUCF from 2002 to 2005, D. Loustau was awarded the Nobel Peace Prize in 2007 commonly with the IPCC scientific community. He has been coordinator of the Ecosystem national branch of the ICOS European infrastructure since 2009 and coleads the ICOS Ecosystem Thematic Center. He currently managed the eddyflux site that will be used in the proposed research.

5 relevant publications

1) McDowell N.G., Williams A.P., Xu C., Pockman W., Dickman L.T., Sevanto S., Pangle R., Limousin J., Plaut J., Mackay D.S., Ogee J., Domec J.C., Allen C.D., Fisher R. A., Jiang X., Muss J. D., Breshears D. D., Rauscher S.A. and Koven C. 2016. Multi-scale predictions of massive conifer mortality due to chronic temperature rise. *Nature Climate Change* 6:295-300.
2) Manoli, G., Domec, J.-C., Novick, K., Oishi, A. C., Noormets, A., Marani, M. and Katul, G. 2016. Soil-plant-atmosphere conditions regulating convective cloud formation above Southeastern US pine plantations. *Global Change Biology* 6: 2238-2254. doi:10.1111/gcb.13221
3) Domec, J-C, King, JS, Ward, E, Christopher Oishi, A, Palmroth, S, Radecki, A, Bell, DM, Miao, G, Gavazzi, M, Johnson, DM, McNulty, SG, Sun, G, and Noormets, A. 2015. Conversion of natural forests to managed forest plantations decreases tree resistance to prolonged droughts. *Forest Ecology and Management* 355: 58-71.
4) Luyssaert, S., Jammet, M., Stoy, P. C., Estel, S., Pongratz, J., Ceschia, E., Churkina, G., Don, A., Erb, K., Ferlicoq, M., Gielen, B., Grunwald, T., Houghton, R. A., Klumpp, K., Knohl, A., Kolb, T., Kuemmerle, T., Laurila, T., Lohila, A., Loustau, D., et al., 2014. Land management and land-cover change have impacts of similar magnitude on surface temperature. *Nature Climate Change* 4: 389-393.
5) Sun G., Caldwell P., Noormets A., McNulty S.G, Cohen E., Moore Myers J., Domec J.-C., Treasure E. Mu Q., Xiao J., Ranjeet J., Chen J. 2011. Upscaling key ecosystem functions across the conterminous United States by a water-centric ecosystem model. *Journal of Geophysical Research* 116, No. null, G00J05.

5 relevant previous projects or activities

1) Domec J.-C. (France), Katul G., Johnson D. (USA) – The dynamics of embolism formation and repair in xylem conduits: from bubble scale to loss in plant hydraulic transport capacity; 2017-2020; ANR/NSF- Division Of Integrative Organismal Systems (€412 983).
2) Tor-ngern P. (Thailande), Domec J.-C. (France), Hasselquist NJ. (Suède) – Assessments of vulnerability of mature and secondary forests to climatic water stress in Southeast Asia 2017-2020; Southeast Asia – Europe Joint Funding Scheme for Research and Innovation (€ 800 234 total, €189,000 awarded to JC Domec).
3) Katul G., Marani M. (US-Duke University); Domec J.-C. (France) –The direct and indirect effects of plantation forestry expansion on usable water in the southeastern US; 2015-2018; US National Science Foundation – EAR Division of Earth Science ($421 109).
4) Roupsard O., Loustau D., Domec J.-C. Modelling to accompany stakeholders towards adaptation of forestry and agroforestry systems to global change. 2014-2018; Projet MACACC - ANR-Agrobiosphère, (€973 420; 3 million euros budget).
5) Noormets A., Domec J.-C., King JS. –Ameriflux core site cluster; 2014-2016; US Department of Energy, ($745 000).

Description of significant infrastructure and technical equipment

INRA has been managing flux tower sites and long term manipulative experiments on maritime pine forests since 1987. A number of modelling tools and approaches have been developed in INRA. Currently INRA manages one eddy covariance tower with 3D sonic anemometers, gas analyzers, net radiometers, rain gauges, meteorological sensors, data loggers and soil moisrure content (TDRs). In addition, leaf area index measurements, soil texture and biomass production are also measured monthly.

Participant 10: Ecole Nationale d'Ingénieurs de Tunis, University of Tunis El Manar (ENIT)

Description of the organization

ENIT is an engineering school of Tunisia, launched in 1969. It belongs to Tunis El Manar University (UTM) which is the first University in Tunisia, ranked 703 in Shangai classification (2017-2018). UTM is ranked 9 in Africa according to the same classification. ENIT has several Master degrees and PhD studies. ENIT research laboratories developed a lot of national and international scientific projects with France, Germany, Portugal, Spain, Canada, USA, Japan, etc. The team participating to this project includes researchers from the ENIT Civil engineering department and involves also a collaborative action on groundwater renewal with a researcher from the Faculty of Sciences of Tunis (FST). The water research laboratory of ENIT was launched in 1999. It involves a staff of 50 researchers. The team participating to this proposal has activities in hydrology and climate issues, using deterministic as well as statistical modelling. Climate data sets recorded by the Tunisian hydrological and meteorological offices are studied and more and more, the team adopts also satellite data in the modelling approaches. ENIT has a strong financial department that helps researchers to achieve the equipments acquisition, mobility, young researcher's salaries etc. ENIT has also a rigorous management of engineering and Master degrees and PhD studies, applying the national rules and the rules of the hosting university (UTM) for curricula and mobility programs. The PRIMA project presents a great opportunity for the ENIT team to enhance its expertise in climate and hydrological studies.

CV Responsible persons

Zoubeida Kebaili Bargaoui (female) is professor of Hydrology at the University of Tunis El Manar (Tunisia) (ENIT). She graduated in Hydraulic Engineering at ENIT in 1980, obtained a Doctorat Thesis in Applied Mechanics in 1983 at the University of Toulouse (France), and a Doctorate of Sciences thesis in Earth Sciences at the Faculty of Sciences of Tunis (Tunisia) in 1990. She was visiting professor at University of Québec (Canada) (INRS-ETE) with Professeur Bernard Bobée for a three-month period in 2006, University of Stuttgart (Germany) (IWS, with Prof. Andràs Bardossy for one month-period with DAAD support in 2013), University of Stockholm (Sweden) (MISU with Assistant Professor Dr Abdelwahb Hannachi, a week in 2017 and 2018). Research interests: Statistical Hydrology, Quantitative Hydrology, Climatology, Geostatistics, Data Analysis, Water Resources Management. On these topics she was funded for research support as PI by many international projects, as She is author of 45 publications (https://orcid.org).

Rym Ouachani (female) graduated in 2003 in Civil Engineening (Hydraulics as specialization) at ENIT. She obtained a Master's Degree in Modeling in Hydraulics and Environment in 2004 and she received a PhD (2016) in Hydraulics from the same institution. Since 2011, she holds the position of Assistant professor in Civil Engineering at Carthage University, the National School of Architecture and Urbanism. She had several visits to the University of Quebec (Canada), supported by AUF projects. Her research interests include hydrology especially with hydrological prediction and forecasting.

5 relevant publications

1) Bargaoui Z., Houcine A., (2010), sensitivity to calibration data of simulated soil moisture related drought indices. Revue Sécheresse, Vol. 21(4). 1-7.

2) Ouachani, R., Bargaoui, Z. and Ouarda, T.: Power of teleconnection patterns on precipitation and streamflow variability of upper Medjerda Basin. International journal of Climatology, 33: 58–76. doi: 10.1002/joc.3407, 2013

3) Bargaoui Z., Tramblay Y., Lawin E. A. et E. Servat (2013). Seasonal precipitation variability in regional climate simulations over northern basins of Tunisia. Int. J. Climatol. DOI: 10.1002/joc3683.
4) Abid N., Z. Bargaoui & C. M. Mannaerts (2018). Remote-sensing estimation of the water stress coefficient and comparison with drought evidence. International Journal of Remote Sensing. P1-24. 10.1080/01431161.2018.1430917.
5) Ouachani R., Bargaoui Z. , Ouarda T. (2007). Intégration d'un filtre de Kalman dans le modèle hydrologique HBV pour la prévision des débits, Hydrological Sciences Journal, 52: 2, 318 — 337. DOI: 10.1623/hysj.52.2.318; URL: http://dx.doi.org/10.1623/hysj.52.2.318

5 relevant previous projects or activities
1) 2013-2016: PEER project of the National Academy of Sciences of USA for the MENA region (http://sites.nationalacademies.org/pga/PEER/PEERscience/PGA_084029).
2) 2015-2016: PHC Utique projects *Evaluation of RCM CORDEX outputs northern Tunisia* French research program ENVIMED with HSM Montpellier and University Caddy Ayyad, Morocco
3) 2010- 2012: *Estimation and Mapping of rainfall extreme events in Tunis region,* bilateral scientific cooperation with University of Versailles (France), with Prof. Cécile Mallet.
4) 2006-2008 : *Extreme value analysis for rainfall and floods* funded by AUF in cooperation with INRS-ETE (Canada, Prof. Bernard Bobée), EMI (Morrocco, Prof. Ahmed Bouziane) and University of Abomey Calavi (Benin, with Prof. Abel Afouda)
5) 2001-2003: *Water Management in a changing institutional and legal environment, case studies in Tunisia and Portugal*, funded by Secretary of Research, Tunisia in collaboration with ISEC of Coimbra, Portugal, Prof. Maria Da Cunha.

Description of significant infrastructure and technical equipment
Scientific infrastructure includes 3 meteorological stations belonging to ENIT (two already functiunning and one under acquisition), equipment of soil moisture measurement (WaterMark meter), equipment for groundwater analysis (Ph, conductivity), and GIS localisation (trumble instruments), equipment of river discharge measurement (small discharges), computers and personal computers.

4.2. Third parties involved in the project (including use of third party resources)

No third parties involved

Section 5: Ethics and Security

5.1 Ethics

No ethical issues

5.2 Security[27]

Please indicate if your project will involve:

□ activities or results raising security issues: NO
□ 'EU-classified information' as background or results: NO

[27] See article 37 of the PRIMA Model Grant Agreement